Easergy MiCOM P14x
(P141, P142, P143 & P145)

Feeder Management Relay

P14x/EN M/MI8

Software Version	B4
Hardware Suffix	L (P141, P142 & P143) & M (P145)
Date	07/2017

Technical Manual

Note The technical manual for this device gives instructions for its installation, commissioning, and operation. However, the manual cannot cover all conceivable circumstances or include detailed information on all topics. In the event of questions or specific problems, do not take any action without proper authorization. Contact the appropriate Schneider Electric technical sales office and request the necessary information.

Any agreements, commitments, and legal relationships and any obligations on the part of Schneider Electric including settlements of warranties, result solely from the applicable purchase contract, which is not affected by the contents of the technical manual.

This device MUST NOT be modified. If any modification is made without the express permission of Schneider Electric, it will invalidate the warranty, and may render the product unsafe.

CONTENTS

Date:	07/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142 & P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

Important ***Previous versions of this manual supported these products: MiCOM P141, P142, P143, P144 and P145.***
As from Software Version 46Y, the P144 product is no longer supported. Accordingly, any references to the P144 product do not apply to any software later than 46Y. A list of software releases is given in the Version History chapter.

SAFETY INFORMATION

CHAPTER SI

<table>
<tr><td>Date:</td><td colspan="2">12/2017</td></tr>
<tr><td>Products covered by this chapter:</td><td colspan="2">This chapter covers the specific versions of the MiCOM products listed below. This includes only the following combinations of Software Version and Hardware Suffix.</td></tr>
<tr><td>Hardware Suffix:</td><td colspan="2">All MiCOM Px4x products</td></tr>
<tr><td>Software Version:</td><td colspan="2">All MiCOM Px4x products</td></tr>
<tr><td>Connection Diagrams:</td><td>P14x (P141, P142, P143 & P145):
10P141xx (xx = 01 to 02)
10P142xx (xx = 01 to 05)
10P143xx (xx = 01 to 11)
10P145xx (xx = 01 to 11)
P24x (P241, P242 & P243):
10P241xx (xx = 01 to 02)
10P242xx (xx = 01)
10P243xx (xx = 01)
P341:
10P341xx (xx = 01 to 12)
P34x (P342, P343, P344, P345 & P391):
10P342xx (xx = 01 to 17)
10P343xx (xx = 01 to 19)
10P344xx (xx = 01 to 12)
10P345xx (xx = 01 to 07)
10P391xx (xx = 01 to 02)
P445:
10P445xx (xx = 01 to 04)
P44x (P442 & P444):
10P44201 (SH 1 & 2)
10P44202 (SH 1)
10P44203 (SH 1 & 2)
10P44401 (SH 1)
10P44402 (SH 1)
10P44403 (SH 1 & 2)
10P44404 (SH 1)
10P44405 (SH 1)
10P44407 (SH 1 & 2)
P44y (P443 & P446):
10P44303 (SH 01 and 03)
10P44304 (SH 01 and 03)
10P44305 (SH 01 and 03)
10P44306 (SH 01 and 03)
10P44600
10P44601 (SH 1 to 2)
10P44602 (SH 1 to 2)
10P44603 (SH 1 to 2)</td><td>P54x (P543, P544, P545 & P546):
10P54302 (SH 1 to 2)
10P54303 (SH 1 to 2)
10P54400
10P54404 (SH 1 to 2)
10P54405 (SH 1 to 2)
10P54502 (SH 1 to 2)
10P54503 (SH 1 to 2)
10P54600
10P54604 (SH 1 to 2)
10P54605 (SH 1 to 2)
10P54606 (SH 1 to 2)
P547:
10P54702xx (xx = 01 to 02)
10P54703xx (xx = 01 to 02)
10P54704xx (xx = 01 to 02)
10P54705xx (xx = 01 to 02)
P64x (P642, P643 & P645):
10P642xx (xx = 01 to 10)
10P643xx (xx = 01 to 06)
10P645xx (xx = 01 to 09)
P74x (P741, P742 & P743):
10P740xx (xx = 01 to 07)
P746:
10P746xx (xx = 00 to 21)
P841:
10P84100
10P84101 (SH 1 to 2)
10P84102 (SH 1 to 2)
10P84103 (SH 1 to 2)
10P84104 (SH 1 to 2)
10P84105 (SH 1 to 2)
P849:
10P849xx (xx = 01 to 06)</td></tr>
</table>

CONTENTS

Notes:

1 INTRODUCTION

This document and the relevant equipment documentation provide full information on safe handling, installation, testing, commissioning and operation of this equipment. This document also includes reference to typical equipment label markings.

Documentation for equipment ordered from Schneider Electric is dispatched separately from manufactured goods and may not be received at the same time as the equipment. Therefore, this guide is provided to ensure that printed information which may be present on the equipment is fully understood by the recipient.

The technical data in this document provides typical information and advice, which covers a variety of different products. You must also refer to the Technical Data section of the relevant product publication as this includes additional information which is specific to particular equipment.

Warning	**Before carrying out any work on the equipment, you should be familiar with the contents of the Safety Information chapter/Safety Guide SFTY/5L M/L11 or later issue, the Technical Data chapter and the ratings on the equipment rating label.**

You also need to make reference to the external connection diagram(s) before the equipment is installed, commissioned or serviced.

Language-specific, self-adhesive User Interface labels are provided in a bag for some equipment.

The manuals within the MiCOM P40 range include notices, which contain safety-related information. These are ranked in terms of their importance (from high to low) as follows:

DANGER	**THIS INDICATES AN IMMINENTLY HAZARDOUS SITUATION WHICH, IF NOT AVOIDED, WILL RESULT IN DEATH OR SERIOUS INJURY.**
WARNING	**This indicates an potentially hazardous situation which, if not avoided, can result in death or serious injury.**
Caution	**This indicates an potentially hazardous situation which, if not avoided, can result in minor or moderate injury.**
Important	**This indicates an potentially hazardous situation which, if not avoided, can result in equipment damage.**
Note	*This indicates an explanation or gives information which is useful to know, but which is not directly concerned with any of the above.*

These may appear with relevant Symbols (possibly electrical hazard, safety alert, disposal concern, etc) to denote the nature of the notice.

These notices appear at the relevant place in the remainder of this manual.

2 HEALTH AND SAFETY

The information in this part of the equipment documentation is intended to ensure that equipment is properly installed and handled in order to maintain it in a safe condition.

People

Schneider Electric assume that everyone who will be associated with installing, testing, commissioning, operating or working on the equipment (and any system to which it may be connected) will be completely familiar with the contents of the Safety Information chapter and the Safety Guide. We also assume that everyone working with the equipment (and any connected systems) will have sufficient qualifications, knowledge and experience of electrical systems. We also assume that they will work with a complete understanding of the equipment they are working on and the health and safety issues of the location in which they are working. All people must be able to perform tasks in accordance with accepted safety engineering practices. They must also be suitably authorised to energize and de-energize equipment and to isolate, ground (earth) and label it. Given the risks of working on electrical systems and the environments in which they may be located, they must be trained in the care and use of safety apparatus in accordance with safety engineering practices; and they should be trained in emergency first aid procedures.

Receipt, Handling, Storage and Unpacking Relays

Although relays are of a robust construction, we recommend that you become familiar with the Installation chapter, as this describes important issues associated with receiving, handling, storage and unpacking relays.

Planning

We recommend that a detailed plan is developed before equipment is installed into a location, to make sure that all of the work can be done safely. Such a plan needs to determine how relevant equipment can be isolated from the electrical supply in such as way that there is no possibility of accidental contact with any electrical live equipment, wiring or busbars. It also needs to take into account the requirements for people to work with tools/equipment a safe distance away from any hazards. The plan also needs to be aware of the risk of falling devices; such as equipment being knocked over, units being accidentally dropped or protruding units being knocked out of rack-mounted cabinets. Safety shoes are recommended, as well as other protective clothing such as safety hats and gloves.

Live and Stored Voltages

When electrical equipment is in operation, dangerous voltages will be present in certain parts of the equipment. Even if electrical power is no longer being supplied, some items of equipment may retain enough electrical energy inside them to pose a potentially serious risk of electrocution or damage to other equipment.

Important	**Remember that placing equipment in a “test” position does not normally isolate it from the power supply or discharge any stored electrical energy.**

Warnings and Barricades

Everyone must observe all warning notices. This is because the incorrect use of equipment, or improper use may endanger personnel and equipment and also cause personal injury or physical damage.
Unauthorized entry should also be prevented with suitably marked fixed barricades which will notify people of any dangers and screen off work areas.

People should not enter electrical equipment cubicles or cable troughs until it has been confirmed that all equipment/cables have been isolated and de-energised.

Electrical Isolation

Before working in the terminal strip area, all equipment which has the potential to provide damaging or unsafe levels of electrical energy must be isolated. You will need to isolate and de-energize the specific item of equipment which is being worked on.

Depending on the location, you may also need to isolate and de-energize other items which are electrically connected to it as well as those which are close enough to pose a risk of electrocution in the event of accidental physical or electrical contact.
Remember too that, where necessary, both load and line sides should be de-energized.
Before you make contact with any equipment use an approved voltage detection device to reduce the risk of electric shock.

Risk of Accidental Contact or Arc Flash

Be aware of the risk of accidental contact with hands, long hair, tools or other equipment; and be aware of the possibility of the increased risk of arc flash from areas of high voltage.
Always wear appropriate shock and arc flash personal protective equipment while isolating and de-energizing electrical equipment and until a de-energized state is confirmed.

Temporary Protection

Consider the use of temporary protective Earthing Clamps. This is required to establish and maintain de-energization when electrical equipment operates at greater than 1000 volts or there is potential for back-feed at any voltage.
Temporary protective earthing can be accomplished by installing cables designed for that purpose or by the use of intrinsic earthing clamp equipment. Temporary protective earthing clamp equipment must be able to carry maximum fault current available and have an impedance low enough to cause the applicable protective device to operate.

Restoring Power

To reduce the risks, the work plan should have a check list of things which must be completed and checks made before electrical power can be restored.
Be aware of the risk that electrical systems may have power restored to them at a remote location (possibly by the customer or a utility company). You should consider the use of lockouts so that the electrical system can be restored only when you unlock it. In any event, you should be aware of and be part of the process which determines when electrical power can be restored; and that people working on the system have control over when power is restored.
Inspect and test the electrical equipment to ensure it has been restored to a “safe” condition prior re-energizing. Replace all devices, doors and covers before turning on the power to any device.

Qualified Personnel

Proper and safe operation of the equipment depends on appropriate shipping and handling, proper storage, installation and commissioning, and on careful operation, maintenance and servicing. For this reason only qualified personnel may work on or operate the equipment.
Qualified personnel are individuals who:

- Are familiar with the installation, commissioning, and operation of the equipment and of the system to which it is being connected
- Are able to safely perform switching operations in accordance with accepted safety engineering practices and are authorized to energize and de-energize equipment and to isolate, ground, and label it
- Are trained in the care and use of safety apparatus in accordance with safety engineering practices
- Are trained in emergency procedures (first aid)

Documentation

The equipment documentation gives instructions for its installation, commissioning, and operation. However, the manuals cannot cover all conceivable circumstances or include detailed information on all topics. In the event of questions or specific problems, do not take any action without proper authorization. Contact the appropriate Schneider Electric technical sales office and request the necessary information.

3 SYMBOLS AND LABELS ON THE EQUIPMENT

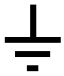
For safety reasons the following symbols and external labels, which may be used on the equipment or referred to in the equipment documentation, should be understood before the equipment is installed or commissioned.

3.1 Symbols

Caution: refer to equipment documentation

Caution: risk of electric shock

Protective Conductor (*Earth) terminal



Functional/Protective Conductor (*Earth) terminal

Note	*This symbol may also be used for a Protective Conductor (Earth) Terminal if that terminal is part of a terminal block or sub-assembly e.g. power supply.*

***CAUTION**	**The term “Earth” used throughout this technical manual is the direct equivalent of the North American term “Ground”.**

3.2 Labels

See Safety Guide (SFTY/5L M) for typical equipment labeling information.

4 INSTALLING, COMMISSIONING AND SERVICING

Manual Handling

Plan carefully, identify any possible hazards and determine whether the load needs to be moved at all. Look at other ways of moving the load to avoid manual handling. Use the correct lifting techniques and Personal Protective Equipment to reduce the risk of injury.

Many injuries are caused by:

- Lifting heavy objects
- Lifting things incorrectly
- Pushing or pulling heavy objects
- Using the same muscles repetitively

Follow the Health and Safety at Work, etc Act 1974, and the Management of Health and Safety at Work Regulations 1999.

Equipment Connections

Personnel undertaking installation, commissioning or servicing work for this equipment should be aware of the correct working procedures to ensure safety.

The equipment documentation should be consulted before installing, commissioning, or servicing the equipment.

Terminals exposed during installation, commissioning and maintenance may present a hazardous voltage unless the equipment is electrically isolated.

The clamping screws of all terminal block connectors, for field wiring, using M4 screws shall be tightened to a nominal torque of 1.3 Nm.

Equipment intended for rack or panel mounting is for use on a flat surface of a Type 1 enclosure, as defined by Underwriters Laboratories (UL).

Any disassembly of the equipment may expose parts at hazardous voltage, also electronic parts may be damaged if suitable ElectroStatic voltage Discharge (ESD) precations are not taken.

If there is unlocked access to the rear of the equipment, care should be taken by all personnel to avoid electric shock or energy hazards.

Caution	*Voltage and current connections shall be made using insulated crimp terminations to ensure that terminal block insulation requirements are maintained for safety.*

Watchdog (self-monitoring) contacts are provided in numerical relays to indicate the health of the device. Schneider Electric strongly recommends that these contacts are hardwired into the substation's automation system, for alarm purposes.

To ensure that wires are correctly terminated the correct crimp terminal and tool for the wire size should be used.

The equipment must be connected in accordance with the appropria connection diagram.

Protection Class I Equipment

- Before energizing the equipment it must be earthed using the protective conductor terminal, if provided, or the appropriate termination of the supply plug in the case of plug connected equipment.
- The protective conductor (earth) connection must not be removed since the protection against electric shock provided by the equipment would be lost.
- When the protective (earth) conductor terminal (PCT) is also used to terminate cable screens, etc., it is essential that the integrity of the protective (earth) conductor is checked after the addition or removal of such functional earth connections. For M4 stud PCTs the integrity of the protective (earth) connections should be ensured by use of a locknut or similar.

The recommended minimum protective conductor (earth) wire size is 2.5 mm^2 (3.3 mm^2 for North America) unless otherwise stated in the technical data section of the equipment documentation, or otherwise required by local or country wiring regulations.

The protective conductor (earth) connection must be low-inductance and as short as possible.

All connections to the equipment must have a defined potential. Connections that are pre-wired, but not used, should preferably be grounded when binary inputs and output relays are isolated. When binary inputs and output relays are connected to common potential, the pre-wired but unused connections should be connected to the common potential of the grouped connections.

Pre-Energization Checklist

Before energizing the equipment, the following should be checked:

- Voltage rating/polarity (rating label/equipment documentation)
- CT circuit rating (rating label) and integrity of connections
- Protective fuse rating
- Integrity of the protective conductor (earth) connection (where applicable)
- Voltage and current rating of external wiring, applicable to the application

Accidental Touching of Exposed Terminals

If working in an area of restricted space, such as a cubicle, where there is a risk of electric shock due to accidental touching of terminals which do not comply with IP20 rating, then a suitable protective barrier should be provided.

Equipment Use

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Removal of the Equipment Front Panel/Cover

Removal of the equipment front panel/cover may expose hazardous live parts, which must not be touched until the electrical power is removed.

UL and CSA/CUL Listed or Recognized Equipment

To maintain UL and CSA/CUL Listing/Recognized status for North America the equipment should be installed using UL or CSA Listed or Recognized parts for the following items: connection cables, protective fuses/fuseholders or circuit breakers, insulation crimp terminals and replacement internal battery, as specified in the equipment documentation.

For external protective fuses a UL or CSA Listed fuse shall be used. The Listed type shall be a Class J time delay fuse, with a maximum current rating of 15 A and a minimum d.c. rating of 250 Vd.c., for example type AJT15.

Where UL or CSA Listing of the equipment is not required, a high rupture capacity (HRC) fuse type with a maximum current rating of 16 Amps and a minimum d.c. rating of 250 Vd.c. may be used, for example Red Spot type NIT or TIA.

Equipment Operating Conditions

The equipment should be operated within the specified electrical and environmental limits. This includes humidity as well as temperature limits.

Current Transformer Circuits

Do not open the secondary circuit of a live CT since the high voltage produced may be lethal to personnel and could damage insulation. Generally, for safety, the secondary of the line CT must be shorted before opening any connections to it.

For most equipment with ring-terminal connections, the threaded terminal block for current transformer termination has automatic CT shorting on removal of the module. Therefore external shorting of the CTs may not be required, the equipment documentation should be checked to see if this applies.

For equipment with pin-terminal connections, the threaded terminal block for current transformer termination does NOT have automatic CT shorting on removal of the module.

External Resistors, including Voltage Dependent Resistors (VDRs)

Where external resistors, including Voltage Dependent Resistors (VDRs), are fitted to the equipment, these may present a risk of electric shock or burns, if touched.

Battery Replacement

Where internal batteries are fitted they should be replaced with the recommended type and be installed with the correct polarity to avoid possible damage to the equipment, buildings and persons.

Insulation and Dielectric Strength Testing

Insulation testing may leave capacitors charged up to a hazardous voltage. At the end of each part of the test, the voltage should be gradually reduced to zero, to discharge capacitors, before the test leads are disconnected.

Insertion of Modules and PCB Cards

Modules and PCB cards must not be inserted into or withdrawn from the equipment whilst it is energized, since this may result in damage.

Insertion and Withdrawal of Extender Cards

Extender cards are available for some equipment. If an extender card is used, this should not be inserted or withdrawn from the equipment whilst it is energized. This is to avoid possible shock or damage hazards. Hazardous live voltages may be accessible on the extender card.

External Test Blocks and Test Plugs

Great care should be taken when using external test blocks and test plugs such as the Easergy Test Block, Easergy Test Plug and MiCOM P99x types, as hazardous voltages may be accessible when using these. CT shorting links must be in place before the insertion or removal of Easergy test plugs, to avoid potentially lethal voltages.

**Note:*	*When a MiCOM P992 Test Plug is inserted into the MiCOM P991 Test Block, the secondaries of the line CTs are automatically shorted, making them safe.*

Fiber Optic Communication

Where fiber optic communication devices are fitted, these use laser light. These laser-light sources should not be viewed directly, as they can cause permanent damage to eyesight. Optical power meters should be used to determine the operation or signal level of the device.

Cleaning

The equipment may be cleaned using a lint free cloth dampened with clean water, when no connections are energized. Contact fingers of test plugs are normally protected by petroleum jelly, which should not be removed.

5 DE-COMMISSIONING AND DISPOSAL

De-Commissioning

The supply input (auxiliary) for the equipment may include capacitors across the supply or to earth. To avoid electric shock or energy hazards, after completely isolating the supplies to the equipment (both poles of any dc supply), the capacitors should be safely discharged via the external terminals prior to de-commissioning.

Disposal

It is recommended that incineration and disposal to water courses is avoided. The equipment should be disposed of in a safe manner. Any equipment containing batteries should have them removed before disposal, taking precautions to avoid short circuits. Particular regulations within the country of operation, may apply to the disposal of the equipment.

6 TECHNICAL SPECIFICATIONS FOR SAFETY

Unless otherwise stated in the equipment technical manual, the following data is applicable.

6.1 Protective Fuse Rating

The recommended maximum rating of the external protective fuse for equipments is 16A, High Rupture Capacity (HRC) Red Spot type NIT, or TIA, or equivalent. Unless otherwise stated in equipment technical manual, the following data is applicable. The protective fuse should be located as close to the unit as possible.

DANGER **CTs must NOT be fused since open circuiting them may produce lethal hazardous voltages.**

6.2 Protective Class

IEC 60255-27: 2005	Class I (unless otherwise specified in the equipment documentation).
EN 60255-27: 2006	This equipment requires a protective conductor (earth) connection to ensure user safety.

6.3 Installation Category

IEC 60255-27: 2013	Installation Category III (Overvoltage Category III)
EN 60255-27: 2014	Distribution level, fixed installation.

Equipment in this category is qualification tested at 5 kV peak, 1.2/50 µs, 500 Ω, 0.5 J, between all supply circuits and earth and also between independent circuits.

6.4 Environment

The equipment is intended for indoor installation and use only. If it is required for use in an outdoor environment then it must be mounted in a specific cabinet of housing which will enable it to meet the requirements of IEC 60529 with the classification of degree of protection IP54 (dust and splashing water protected).

Pollution Degree	Pollution Degree 2 Compliance is demonstrated by reference to safety standards.
Altitude	Operation up to 2000m

7 TECHNICAL SPECIFICATIONS FOR FUNCTIONAL SAFETY

7.1 Technical Specifications for Functional Safety

The following information is applicable when the MiCOM P130C, P132, P139, P14x, P24x, P34x is used as an element in an automated safety function that is specified to achieve a Safety Integrity Level (SIL).

The reliability of the MiCOM P130C, P132, P139, P14x, P24x, P34x has been analyzed in accordance with IEC 61508 for use in SIL applications.

The information in this Safety Guide is intended to support the safety system integration phase in accordance with IEC 61508 (and to be available to those performing the system 'lifecycle phases' that follow) to enable the safety function(s) achieve the specified SIL. The information only applies to the specified products; the actual SIL achieved will depend on many system considerations that are outside the scope of this safety manual.

7.2 General Conditions or Restrictions for use in SIL Applications

1. Safety functions are intended to be automated. Any non-specified manual interaction that could interfere with the safety function during operation should be protected from inadvertent use.
2. The MiCOM P130C, P132, P139, P14x, P24x, P34x are not to be used in environments beyond claimed specification.
3. The instructions contained in this Safety Guide (or referred to in associated user documentation) should be strictly complied with to provide the correct level of systematic safety integrity.
4. Failure modes of the MiCOM P130C, P132, P139, P14x, P24x, P34x that are classified as 'dangerous detected' (quantified by the value λDD) shall result in a safe action with respect to the hazard(s) being controlled or be repaired within the time assumed in the PFD calculations.

7.3 Proof Testing

The MiCOM P130C, P132, P139, P14x, P24x, P34x shall be periodically proof tested, preferably in the installation, by a qualified person familiar with the operation of the device, to verify all aspects of the functional specification required for the application when it is used in 'low demand' safety functions. Low demand is defined in IEC 61508-4 as a demand to act less frequently than once a year.

A suitable proof test interval (T1) should be used to achieve the required average probability of failure on demand (PFDAVG). A nominal interval of 8,760 hrs (1 year) and Mean Time To Repair (MTTR) of 8 hours has been used in the calculations for PFDAVG illustration purposes.

7.4 Functional Safety Parameters

The following MiCOM P30 and P40 Protection Relays have been assessed by CML (EU Notified Body no. 8175 for ATEX 2014/34/EU) and found to meet the requirements of IEC 61508-2: 2010 clauses 7.4.4.3 (Route 2H) and 7.4.10 (Route 2S / 'proven in use') for use in SIL 1 safety functions when used in accordance with the user documentation:

Feeder management and Bay Control relays:	P130C, P132, P139	All versions since 2011
Feeder management relays:	P141, P142, P143, P144, P145	All versions since 2011
Motor protection relays:	P241, P242, P243	All versions since 2011
Generator protection relays:	P341, P342, P343, P344, P345	All versions since 2011
Element safety function (common to all relays):	To monitor the current supplied to electrical equipment in a hazardous area and isolate the equipment if a fault condition occurs that may lead to an ignition source.	
Product specification:	Refer to Technical Manual for each product type.	
Random hardware failures:	The assessment confirms the following quantitative reliability data (failure rates in h-1)	

7.5 Random Hardware Failures (h^{-1})

Product [Note 1]	**Dangerous failure rate λ_D** [Note 2]	**Diagnostic coverage** [Note 3]	**Dangerous Undetected failure rate λ_{DU}**	**Dangerous Detected failure rate λ_{DD}**	**PFD_{AVG}** [Note 4]
P130C	1.48 E^{-06}	60%	5.93 E^{-07}	8.90 E^{-07}	2.60 E^{-03}
P132	1.23 E^{-06}	60%	4.92 E^{-07}	7.38 E^{-07}	2.16 E^{-03}
P139	1.81 E^{-06}	60%	7.25 E^{-07}	1.09 E^{-06}	3.18 E^{-03}
P14x	7.01 E^{-07}	60%	2.80 E^{-07}	4.21 E^{-07}	1.23 E^{-03}
P24x	7.66 E^{-07}	60%	3.07 E^{-07}	4.60 E^{-07}	1.35 E^{-03}
P34x	8.81 E^{-07}	60%	3.52 E^{-07}	5.29 E^{-07}	1.55 E^{-03}

Note 1	*Refer to full list of products (‘Product Identification’ above) in scope where “x” appears*
Note 2	*Worst case assumptions have been used to classify a “dangerous failure”*
Note 3	*Diagnostic coverage is conservatively estimated by analysis of the design*
Note 4	*Calculated assuming proof test interval 8,760 hours and MTTR 8 hours*

7.6 Parameters Common to All Products in Scope

Safe failure fraction (SFF):	Not assessed. The SFF parameter is not required for the 'Route 2H' compliance option in IEC 61508-2
Diagnostic coverage (DC):	60% (proportion of dangerous failures in the product that are self-diagnosed)
Type classification (A/B):	'Type B' in accordance with IEC 61508-2, 7.4.4.1.3 (contains some complex components whose fault behavior cannot be completely determined)
Architectural constraints:	SIL 1 in accordance with the Route 2H method with a hardware fault tolerance (HFT) = 0
Systematic capability:	SC 1 which limits an application that uses this product to no higher than SIL 1
Demand mode:	Safety function applications are expected to be low demand (greater than 1 year between demands)
Restrictions, conditions and general information:	• Refer to information in this Safety Guide and the relevant product Technical Manual for all conditions, restrictions in use, installation, maintenance, test and all other functional safety related information. • It is the responsibility of the system designer, installer and end user to ensure a specified safety integrity level (SIL) is achieved by reference to the data in this document and adhering to all the conditions and restrictions herein. Use of this data to ensure safety functions meet a specified SIL should only be made by persons who are competent in the functional safety activities they are performing. • Cyclic diagnostic test intervals assume the process safety time is 50ms (although in some cases trip time can increase due to intentional time delays within the protection function). • The watchdog relay is energized during normal operation and is de-energized with its contacts closed (for monitoring by the SCADA system) in the event of a fault.
Restrictions when using the P30 and P40 in hazardous area applications:	• No use shall be made of binary inputs to ensure the safety function is not interfered with. • No reliance of data from communication interfaces shall be made to perform the safety function. • Tripping of the circuit breaker shall be made directly using an output contact from the IED. (As contact allocation is configurable it is possible to assign multiple contacts to this tripping function to mitigate risk of contact failure as the external contact operation is not directly able to be monitored). • Unauthorised access to the device configuration shall be prevented through the use of physical protection and/or password control. • Protection functions using data from thermal or other sensors are not considered as safety functions. (RTD or CLIO inputs).

7.7 Fault Reporting

Any goods returned to Schneider Electric will require an RMA number which can be initiated by contacting a Technical Support Representative or the local country Sales Representative.

If a fault has been determined with a product the following details are required by Technical Support

- Contact name, email address and phone number
- Company name
- Serial number of unit(s)
- Model number of unit(s)
- Brief description of the problem(s)
- Invoice address
- Shipping address (if it is not the same as above)

A form with the assigned RMA number, along with details of the problem will be emailed to the contact email provided. All information on the form should be verified, the form should be included with the product(s) being returned. The RMA number must be marked on the outside of the box.

Schneider Electric warranty does not cover failures due to incorrect installation, misuse, abnormal operating conditions or lack of routine maintenance.

Notes:

INTRODUCTION

CHAPTER 1

Date:	07/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142 & P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

CONTENTS

TABLES

FIGURES

Notes:

1 DOCUMENTATION STRUCTURE

This manual provides a functional and technical description of this MiCOM device, and gives a comprehensive set of instructions for it's use and application. A summary of the different chapters of this manual is given here:

	Description	Chapter Code
SI	**Safety Information**	**Px4x/EN SI**
	A guide to the safe handling, commissioning and testing of equipment. This provides typical information and advice which covers a range of MiCOM Px4x products. It explains how to work with equipment safely.	
1	**Introduction**	**P14x/EN IT**
	A guide to the MiCOM range of relays and the documentation structure. General safety aspects of handling Electronic Equipment are discussed with particular reference to relay safety symbols. Also a general functional overview of the relay and brief application summary is given.	
2	**Technical Data**	**P14x/EN TD**
	Technical data including setting ranges, accuracy limits, recommended operating conditions, ratings and performance data. Compliance with norms and international standards is quoted where appropriate.	
3	**Getting Started**	**P14x/EN GS**
	A guide to the different user interfaces of the IED describing how to start using it. This chapter provides detailed information regarding the communication interfaces of the IED, including a detailed description of how to access the settings database stored within the IED.	
4	**Settings**	**P14x/EN ST**
	List of all relay settings, including ranges, step sizes and defaults, together with a brief explanation of each setting.	
5	**Operation**	**P14x/EN OP**
	A comprehensive and detailed functional description of all protection and non-protection functions.	
6	**Application Notes**	**P14x/EN AP**
	This section includes a description of common power system applications of the relay, calculation of suitable settings, some typical worked examples, and how to apply the settings to the relay.	
7	**Using the PSL Editor**	**Px4x/EN SE**
	This provides a short introduction to using the PSL Editor application.	
8	**Programmable Logic**	**P14x/EN PL**
	Overview of the Programmable Scheme Logic (PSL) and a description of each logical node. This chapter includes the factory default and an explanation of typical applications.	
9	**Measurements and Recording**	**P14x/EN MR**
	Detailed description of the relays recording and measurements functions including the configuration of the event and disturbance recorder and measurement functions.	
10	**Product Design**	**P14x/EN PD**
	Overview of the operation of the relay's hardware and software. This chapter includes information on the self-checking features and diagnostics of the relay.	
11	**Commissioning**	**P14x/EN CM**
	Instructions on how to commission the relay, comprising checks on the calibration and functionality of the relay.	
12	**Test and Setting Records**	**P14x/EN RC**
	This is a list of the tests made and the settings stored on the MiCOM IED.	

	Description	Chapter Code
13	**Maintenance** A general maintenance policy for the relay is outlined.	**Px4x/EN MT**
14	**Troubleshooting** Advice on how to recognize failure modes and the recommended course of action. Includes guidance on whom within Schneider Electric to contact for advice.	**Px4x/EN TS**
15	**SCADA Communications** This chapter provides an overview regarding the SCADA communication interfaces of the relay. Detailed protocol mappings, semantics, profiles and interoperability tables are not provided within this manual. Separate documents are available per protocol, available for download from our website.	**P14x/EN SC**
16	**Installation** Recommendations on unpacking, handling, inspection and storage of the relay. A guide to the mechanical and electrical installation of the relay is provided, incorporating earthing recommendations.	**Px4x/EN IN**
17	**Connection Diagrams** A list of connection diagrams, which show the relevant wiring details for this relay.	**P14x/EN CD**
18	**Cyber Security** An overview of cyber security protection (to secure communication and equipment within a substation environment). Relevant cyber security standards and implementation are described too.	**Px4x/EN CS**
19	**Dual Redundant Ethernet Board** Information about how MiCOM products can be equipped with Dual Redundant Ethernet Boards (DREBs) and the different protocols which are available. Also covers how to configure and commission these types of boards.	**Px4x/EN REB**
20	**Parallel Redundancy Protocol (PRP) Notes** Includes an introduction to Parallel Redundancy Protocols (PRP) and the different networks PRP can be used with. Also includes details of PRP and MiCOM functions.	**Px4x/EN PR**
21	**High-availability Seamless Redundancy (HSR)** Introduction to the High-availability Seamless Redundancy (HSR); and how it is implemented on MiCOM-based products manufactured by Schneider Electric.	**Px4x/EN HS**
22	**Rapid Spanning Tree Protocol (RSTP) Notes** This section gives an introduction to the Rapid Spanning Tree Protocol (RSTP); and how it is implemented on MiCOM-based products manufactured by Schneider Electric.	**Px4x/EN TP**
23	**Process Bus Notes (PB)** This section gives an introduction to the Process Bus Board (PB); and how it is implemented on MiCOM-based products manufactured by Schneider Electric.	**Px4x/EN PB**
24	**Version History (of Firmware and Service Manual)** This is a history of all hardware and software releases for this product.	**P14x/EN VH**
SG	**Symbols and Glossary** List of common technical terms, abbreviations and symbols found in this documentation.	**Px4x/EN SG**

Some of these chapters are *Specific* to a particular MiCOM product. Others are *Generic* – meaning that they cover more than one MiCOM product. The generic chapters have a Chapter Code which starts with Px4x.

2 INTRODUCTION TO MiCOM

About MiCOM Range

MiCOM is a comprehensive solution capable of meeting all electricity supply requirements. It comprises a range of components, systems and services from Schneider Electric.

Central to the MiCOM concept is flexibility. MiCOM provides the ability to define an application solution and, through extensive communication capabilities, integrate it with your power supply control system.

The components within MiCOM are:

- P range protection relays
- C range control products
- M range measurement products for accurate metering and monitoring
- S range versatile PC support and substation control packages

MiCOM products include extensive facilities for recording information on the state and behaviour of the power system using disturbance and fault records. They can also provide measurements of the system at regular intervals to a control centre enabling remote monitoring and control to take place.

For up-to-date information, please see:

www.schneider-electric.com

Note	*During 2011, the International Electrotechnical Commission classified the voltages into different levels (IEC 60038). The IEC defined LV, MV, HV and EHV as follows: LV is up to 1000V. MV is from 1000V up to 35 kV. HV is from 110 kV or 230 kV. EHV is above 230 KV.* *There is still ambiguity about where each band starts and ends. A voltage level defined as LV in one country or sector, may be described as MV in a different country or sector. Accordingly, LV, MV, HV and EHV suggests a possible range, rather than a fixed band. Please refer to your local Schneider Electric office for more guidance.*

3 PRODUCT SCOPE

The P14x feeder management relay has been designed for the protection of a wide range of overhead lines and underground cables from distribution to transmission voltage levels. The relay includes a comprehensive range of non-protection features to aid with power system diagnosis and fault analysis. The P14x offers integral overcurrent and earth-fault protection and is suitable for application on solidly grounded, impedance grounded, Petersen coil grounded and isolated systems. The P145 relay model is especially suitable where a complete scheme solution is required and has 10 function keys for integral scheme or operator control functionality such as circuit breaker control, auto-reclose control and remote communications control.

3.1 Functional Overview

The P14x feeder management relay contain a wide variety of control protection and monitoring functions. These are summarized below:

PROTECTION FUNCTIONS OVERVIEW		P14x
50/51/67	Six overcurrent measuring stages are provided for each phase and are selectable to be either non-directional, directional forward or directional reverse. Stages 1, 2 and 5 may be set Inverse Definite Minimum Time (IDMT) or Definite Time (DT); stages 3, 4 and 6 may be set DT only.	X
50N/51N/67N	Three independent earth fault elements are provided; derived, measured and sensitive earth fault protection. Each element is equipped with four stages which are independently selectable to be either non-directional, directional forward or directional reverse. Either Zero sequence or negative sequence polarizing are available for the earth fault elements.	X
67N/67W	The Sensitive Earth Fault (SEF) element can be configured as an $I\cos\phi$, $I\sin\phi$ or $VI\cos\phi$ (Wattmetric) element for application to isolated and compensated networks.	X
51V	Voltage dependent over current which can be set as voltage controlled or restrained overcurrent functionality is available on the first two stages of the overcurrent function. It provides backup protection for remote phase to phase faults by increasing the sensitivity of stages 1 and 2 of the overcurrent protection.	X
YN	Neutral admittance protection - operates from either the SEF CT or EF CT to provide single stage admittance, conductance and susceptance elements.	X
64	Restricted Earth Fault (REF) is configurable as a high impedance or low impedance element.	X
BOL	Blocked Overcurrent Logic (BOL) is available on each stage of the overcurrent and earth fault, including sensitive earth fault elements. This consists of start outputs and block inputs that can be used to implement busbar blocking schemes for example.	X
SOL	Selective Overcurrent Logic (SOL) provides the capability of temporarily altering (e.g. raise) the time settings of stages 3 and 4 of the phase overcurrent, earth fault and sensitive earth fault elements.	X
CLP	Cold Load Pick-up (CLP) may be used to transiently raise the settings, for both overcurrent and earth fault protection elements, following closure of the circuit breaker.	X
46	Four stages are provided and can be selected to be either non-directional, directional forward or directional reverse and provides remote backup protection for both phase to earth and phase to phase faults.	X
49	RMS thermal overload (single/dual time constant) protection that provides thermal characteristics, which is suitable for both cables and transformers. Both Alarm and trip stages are provided.	X
37P/37N	Phase, neutral and sensitive earth fault undercurrent elements are available for use with for example the circuit breaker fail function.	X

PROTECTION FUNCTIONS OVERVIEW		P14x
27	Undervoltage 2-stage element, configurable as either phase to phase or phase to neutral measuring. Stage 1 may be selected as either IDMT or DT and stage 2 is DT only.	X
59	Overvoltage (2-stage), configurable as either phase to phase or phase to neutral measuring. Stage 1 may be selected as either IDMT or DT and stage 2 is DT only.	X
59N	Residual overvoltage (Neutral displacement) is a two-stage element selectable as either IDMT or DT.	X
47	Negative sequence overvoltage protection with a definite time delayed element, to provide either a tripping or interlocking function upon detection of unbalanced supply voltages.	X
81U/O/R	A 4-stage underfrequency and 2-stage overfrequency.	X
81U/O (Adv)	9-stage underfrequency and 9-stage overfrequency (advanced).	X
81R (Adv)	9-stage advanced rate of change of frequency element (df/dt) (advanced).	X
81RF (Adv)	9-stage Frequency supervised rate of change of frequency element (f + df/dt) (advanced).	X
81RAV (Adv)	9-stage Average rate of frequency (f + ΔF / Δt) (advanced).	X
	9-stage automatic Frequency based load restoration (advanced).	X
46BC	Broken conductor (open jumper) used to detect open circuit faults using the ratio of I2/I1.	X
32R/32L/32O	Phase Segregated Under/Over Power Protection Two stages of power protection are provided and each stage can be independently configured to operate as Over power or Under Power and Forward or Reverse direction. The relays provide a standard 3 phase power protection element and also a single phase power protection element.	X
	Sensitive Power Protection.	X
	A 2-stage rate of change of voltage (dv/dt) protection.	X
50BF	A 2-stage circuit breaker failure with 1 or 3 pole initiation inputs.	X
VTS	Voltage transformer supervision is provided (1, 2 & 3 phase fuse failure detection) to prevent mal-operation of voltage dependent protection elements upon loss of a VT input signal.	X
CTS	Current transformer supervision to prevent mal-operation of current dependent protection elements upon loss of a CT input signal.	X
49SR	Silicon rectifier overload protection.	X
79	4 shot three pole auto-reclose with check sync., external initiation and sequence co-ordination capability. (P142/P143/P144/P145 only).	X
25	Check synchronizing (2-stage) with advanced system spilt features and breaker closing compensation time (P143 and P145 models only).	X
	2nd Harmonic Blocking.	X
	Programmable function keys P145 model only.	10
	Programmable LEDs (P145 offers tri-color LEDs).	Up to 18
	Digital inputs (model and order option dependent).	8 to 32

PROTECTION FUNCTIONS OVERVIEW		P14x
	Output relays with an option for Hi speed/Hi break contacts (model and order option dependent).	7 to 32
	Front communication port (EIA(RS)232)	X
	Rear communication port (KBUS/EIA(RS)485).	X
	Rear communication port (Fiber Optic).	Option
	Rear IEC 61850 Ethernet communication port.	Option
	Rear Redundant Ethernet port (optical).	Option
	Second rear communication port (EIA(RS)232/EIA(RS)485).	Option
	InterMiCOM teleprotection for direct relay-relay communication. EIA(RS)232 for MODEM links up to 19.2 kbit/s.	Option
	Time synchronization port (IRIG-B modulated/un-modulated).	Option
	A facility is provided using an offline graphical programmable curve tool. This enables the user to configure a customized multiples of a current setting versus operating time curve and an associated reset curve. The curves can be defined as a number of curve points or a user defined formula. The curves can then be downloaded to the relay and can also be extracted from the relay. To find out how to use the tool, see the Px4x/EN UPCT/A11 document.	X
	Load Blinder	X

Table 1 - Functional overview

The relay supports these relay management functions as well as the ones shown above.

- Measurement of all instantaneous & integrated values
- Circuit breaker, status & condition monitoring
- Programmable Scheme Logic (PSL)
- Trip circuit and coil supervision (using PSL)
- Alternative setting groups
- Programmable function keys
- Control inputs
- Programmable allocation of digital inputs and outputs
- Sequence of event recording
- Comprehensive disturbance recording (waveform capture)
- Fault recording
- Fully customizable menu texts
- Power-up diagnostics and continuous self-monitoring of relay
- Commissioning test facilities
- Real time clock/time synchronization - time synchronization possible from IRIG-B input, opto input or communications
- Simple password management:
  CSL0 - No Security Administration Tool (SAT) required
- Advanced Cyber Security:
  CSL1 - Security Administration Tool (SAT) required
- Read only mode

3.2 Process Bus

The Process Bus board interfaces to IEC 61850-9-2LE (80 samples/cycle) and IEC61869-9 (F4800S2I4U4) compliant Merging Units (MU). The Process Bus board replaces the conventional analogue inputs (analogue module) and is available in these Easergy protection relays:

- P141, P142, P143, P145 (feeder protection)
- P442, P443, P445 and P446 (distance protection)
- P543, P546 (line differential protection)
- P642, P643 and P645 (transformer protection)
- P746 (busbar protection)
- P841(multifunction line terminal IED)

Process bus is mainly used to communicate the primary values of current and voltage to a protection relay via an Ethernet network. Merging Units form the data acquisition layer in the network. They connect to the primary sensor, determining the instantaneous primary measurements and publishing them on the process bus.

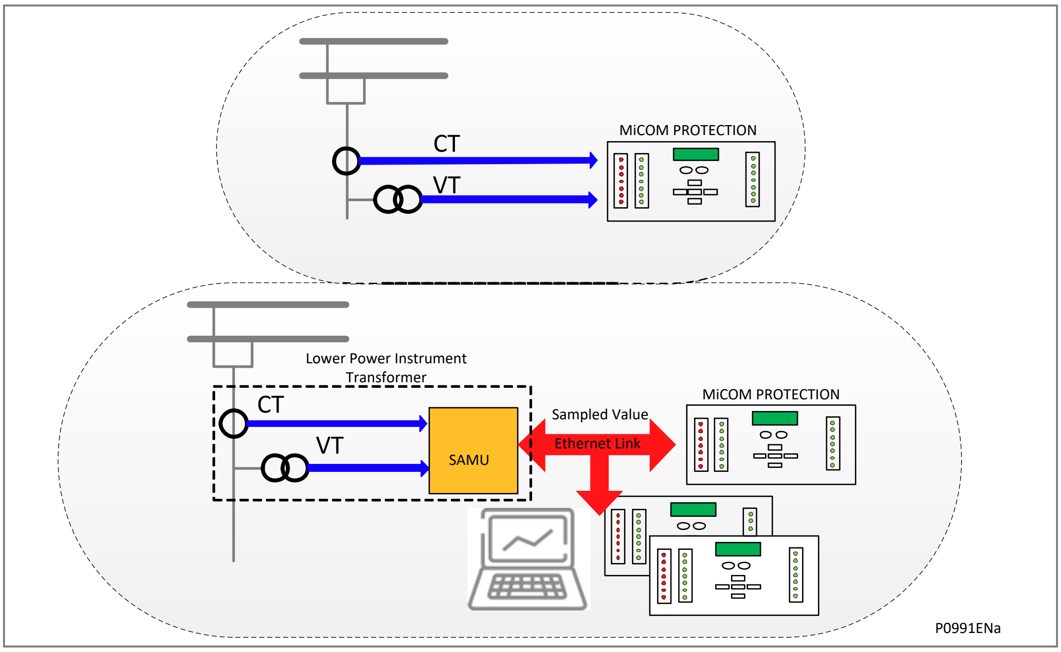


Figure 1 - Process Bus principle

The Process Bus philosophy is to be able to isolate from the secondary system such as protection or control IEDs the primary interfaces such as the breakers, isolators by interposing Breaker IED or Switch IED and/or CTs or VTs by interposing new primary equipment called LPIT (Low Power Instrument Transformers), previously known as NCIT (Non-Conventional Instrument Transformers) or Stand Alone Merging Units (SAMU). The Stand Alone Merging Unit (SAMU) converts 1/5A and 100/110V signals to process bus measurements (called Sampled Values). One feature that is mandatory for the Merging Unit is a very accurate clock source. Time is unique and common in the "analogue world" but is not in the digital world. Sampled values must be synchronized via IEC61850-9-3 (refer to IEC 61588/IEEE1588 Precision Time Protocol) or 1 Pulse Per Second (PPS) signal. The measurement values provided must be suitable for the protection application. This performance is ensured by the selection of primary sensors meeting the CT requirements of the protection application. These requirements must now be met by both the primary CT and the Merging Unit.

The IMU can embed other digital functionality, sending information such as position of breaker and isolators and receiving digital information such as close, open, trip or reclose commands over the process bus.

The process bus links allow multiple measurement streams as well as the digital information to be sent over common ethernet link which saves on the installation of secondary wiring. Also, the same stream can be utilized by multiple relays reducing the number of primary sensors required. This does, however, expose the system to a greater outage due to a link or switch failure. In most cases, redundancy such as IEC62439 PRP will be required to ensure system availability.

3.3 Application Overview

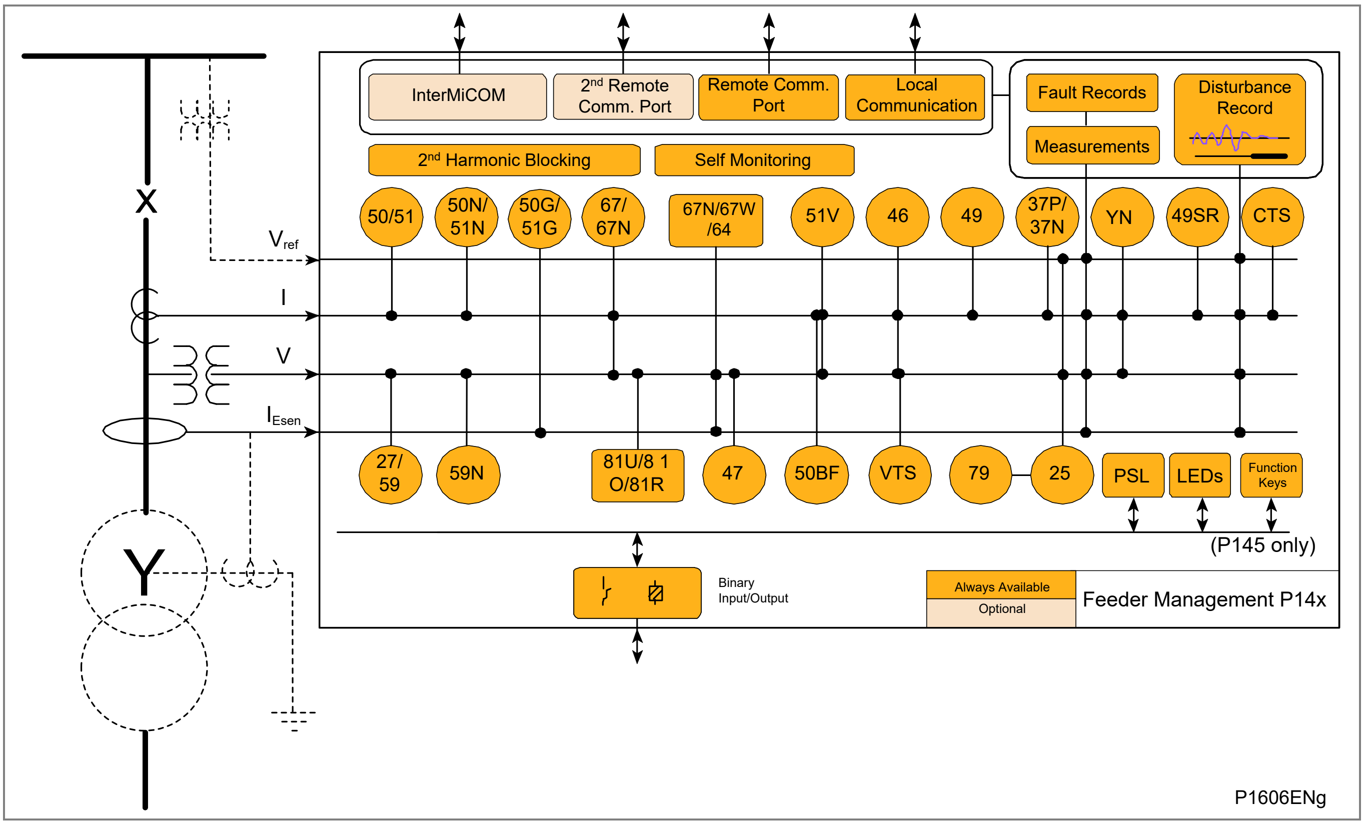


Figure 2 - Functional diagram

Note	*A summary of ANSI codes for protection devices is given in the Symbols and Glossary chapter.*

4 ORDERING OPTIONS

4.1 Information Required with Order - Software Version B4

For each product, there are range of ordering options. The options vary from one product to another, and from one Software Version to another.

The information required with your order is given in these sections

- P141 Feeder Management Relay
- P142 Feeder Management Relay
- P143 Feeder Management Relay
- P145 Feeder Management Relay

Note	*The Cortec table(s) list the options available as of the date of this documentation. The most up-to-date versions of these tables can be found on our web site (www.schneider-electric.com). It may not be possible to select ALL of the options shown here within a single item of equipment.*

4.2 P141 Feeder Management Relay

Feeder Management	P141										
Vx Auxiliary Rating											
24 - 32Vdc		9									
48 - 110Vdc		2									
110 - 250Vdc (100 - 240Vac)		3									
In/Vn Rating											
In = 1/5A, Vn = 100 - 120Vac			1								
In = 1/5A, Vn = 380 - 480Vac (Min 196Vac Max 560Vac)			2								
Hardware Options											
Standard - None				1							
IRIG-B - (Modulated) Only				2							
Fibre Optic Port (ST) for SCADA Protocols (Courier,Modbus,IEC60870-5-103 or DNP3)				3							
Fibre Optic Port (ST) for SCADA Protocols (Courier,Modbus,IEC60870-5-103 or DNP3) + IRIG-B (Modulated)				4							
Ethernet (10 Mbps)				5							
Ethernet (100 Mbps)				6							
Courier Rear Port				7							
IRIG-B (Modulated) & Courier Rear Port				8							
InterMiCOM + Courier Rear Port				E							
InterMiCOM + Courier Rear Port + IRIG-B modulated				F							
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 2 LC ports + 1 RJ45 port + Modulated/Un-modulated IRIG-B				Q							
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 3 RJ45 ports + Modulated/Un-modulated IRIG-B				R							
Ethernet (100Mbit/s), 1 RJ45 port + Modulated/Un-modulated IRIG-B				S							
Product Specific Option											
8 logic inputs & 7 relay outputs					A						
8 logic inputs & 8 relay outputs					N						
Protocol / Communications Options											
K-Bus with simple password management - CSL0						1					
Modbus with simple password management - CSL0						2					
IEC 60870-5-103 (VDEW) with simple password management - CSL0						3					
DNP3.0 with simple password management – CSL0						4					
IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485 with simple password management - CSL0						6					
IEC 61850 Edition 1 / 2 and CS103 via rear port RS485 with simple password management - CSL0						7					
IEC 61850 Edition 1 / 2 and DNPoE and DNP3 Serial with simple password management - (CSL0)						B					
IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required						G					
IEC 61850 Edition 1 / 2 and CS103 via rear port RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required						H					
IEC 61850 Edition 1 / 2 and DNPoE and DNP3 Serial with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required						L					

Feeder Management	P141										
Mounting Option											
Flush Panel Mounting							M				
Multilingual Language Option											
English, French, German, Spanish								0			
English, French, German, Russian								5			
Chinese, English or French via HMI, with English or French only via Communications port								C			
Software Issue									**B3**		
Customisation											
Default										8	
Customer specific										9	
Design Suffix											
Phase 3 CPU											L

Table 2 - Ordering options for P141

4.3 P142 Feeder Management Relay

Feeder Management	P142										
Vx Auxiliary Rating											
24 - 32Vdc		9									
48 - 110Vdc		2									
110 - 250Vdc (100 - 240Vac)		3									
In/Vn Rating											
In = 1/5A, Vn = 100 - 120Vac			1								
In = 1/5A, Vn = 380 - 480Vac (Min 196Vac Max 560Vac)			2								
Hardware Options											
Standard - None				1							
IRIG-B Only (Modulated)				2							
Fibre Optic Port (ST) for SCADA Protocols (Courier,Modbus,IEC60870-5-103 or DNP3)				3							
Fibre Optic Port (ST) for SCADA Protocols (Courier,Modbus,IEC60870-5-103 or DNP3) + IRIG-B modulated				4							
Courier Rear Port				7							
IRIG-B (Modulated) & Courier Rear Port				8							
InterMiCOM + Courier Rear Port				E							
InterMiCOM + Courier Rear Port + IRIG-B modulated				F							
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 2 LC ports + 1 RJ45 port + Modulated/Un-modulated IRIG-B				Q							
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 3 RJ45 ports + Modulated/Un-modulated IRIG-B				R							
Ethernet (100Mbit/s), 1 RJ45 port + Modulated/Un-modulated IRIG-B				S							
Product Specific Option											
8 logic inputs & 7 relay outputs					A						
12 logic inputs & 11 relay outputs					B						
16 logic inputs & 7 relay outputs					C						
8 logic inputs & 15 relay outputs					D						
8 logic inputs & 11 relay outputs (including 4 High Break)					H						
Protocol / Communications Options											
K-Bus with simple password management - CSL0						1					
Modbus with simple password management - CSL0						2					
IEC 60870-5-103 (VDEW) with simple password management - CSL0						3					
DNP3.0 with simple password management - CSL0						4					
IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485 with simple password management - CSL0						6					
IEC 61850 Edition 1 / 2 and CS103 via rear port RS485 with simple password management - CSL0						7					
IEC 61850 Edition 1 / 2 and DNPoE and DNP3 Serial with simple password management - (CSL0)						B					
IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required						G					
IEC 61850 Edition 1 / 2 and CS103 via rear port RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required						H					
IEC 61850 Edition 1 / 2 and DNPoE and DNP3 Serial with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required						L					

Feeder Management	P142									
Mounting Option										
Flush Panel Mounting,						M				
Multilingual Language Option										
English, French, German, Spanish							0			
English, French, German, Russian							5			
Chinese, English or French via HMI, with English or French only via Communications port							C			
Software Issue								**B3**		
Customisation										
Default									8	
Customer specific									9	
Design Suffix										
Phase 3 CPU										L

Table 3 - Ordering options for P142

4.4 P143 Feeder Management Relay

Feeder Management	P143										
Vx Auxiliary Rating											
24 - 32Vdc		9									
48 - 110Vdc		2									
110 - 250Vdc (100 - 240Vac)		3									
In/Vn Rating											
In = 1/5A, Vn = 100 - 120Vac			1								
In = 1/5A, Vn = 380 - 480Vac (Min 196Vac Max 560Vac)			2								
Hardware Options											
Standard - None				1							
IRIG-B Only (Modulated)				2							
Fibre Optic Port (ST) for SCADA Protocols (Courier,Modbus,IEC60870-5-103 or DNP3)				3							
Fibre Optic Port (ST) for SCADA Protocols (Courier,Modbus,IEC60870-5-103 or DNP3) + IRIG-B modulated				4							
Rear Comms				7							
IRIG-B (Modulated) & Rear Comms				8							
InterMiCOM + Courier Rear Port				E							
InterMiCOM + Courier Rear Port + IRIG-B modulated				F							
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 2 LC ports + 1 RJ45 port + Modulated/Un-modulated IRIG-B				Q							
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 3 RJ45 ports + Modulated/Un-modulated IRIG-B				R							
Ethernet (100Mbit/s), 1 RJ45 port + Modulated/Un-modulated IRIG-B				S							
Product Specific Options											
60TE Case, 16 logic inputs & 14 relay outputs					A						
60TE Case, 24 logic inputs & 14 relay outputs					C						
60TE Case, 16 logic inputs & 22 relay outputs					D						
60TE case, 24 logic inputs & 22 relay outputs					E						
60TE case, 32 logic inputs & 14 relay outputs					F						
60TE Case, 16 logic inputs & 30 relay outputs					G						
60TE Case, 16 logic inputs & 18 relay outputs (including 4 High Break)					H						
60TE Case, 24 logic inputs & 18 relay outputs (including 4 High Break)					J						
60TE Case, 16 logic inputs & 26 relay outputs (including 4 High Break)					K						
60TE Case, 16 logic inputs & 22 relay outputs (including 8 High Break)					L						
80TE Case, 32 logic inputs & 32 relay outputs					M						
Protocol / Communications Options											
K-Bus with simple password management - CSL0						1					
Modbus with simple password management - CSL0						2					
IEC 60870-5-103 (VDEW) with simple password management - CSL0						3					
DNP3.0 with simple password management - CSL0						4					
IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485 with simple password management - CSL0						6					
IEC 61850 Edition 1 / 2 and CS103 via rear port RS485 with simple password management - CSL0						7					

Feeder Management	P143									
IEC 61850 Edition 1 / 2 and DNPoE and DNP3 Serial with simple password management - (CSL0)					B					
IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required					G					
IEC 61850 Edition 1 / 2 and CS103 via rear port RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required					H					
IEC 61850 Edition 1 / 2 and DNPoE and DNP3 Serial with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required					L					
Mounting Option										
Flush Panel Mounting						M				
Rack Mounting, (80TE only)						N				
Multilingual Language Option										
English, French, German, Spanish							0			
English, French, German, Russian							5			
Chinese, English or French via HMI, with English or French only via Communications port							C			
Software Issue								**B3**		
Settings/Customisation										
Default									8	
Customised									9	
Design Suffix										
Phase 3 CPU										L

Table 4 - Ordering options for P143

4.5 P145 Feeder Management Relay

Directional Phase O/C and E/F with Auto-Reclose and Check Synch with Extended Function User Interface	P145										
Vx Auxiliary Rating											
24-32Vdc		9									
48-110Vdc		2									
110-250Vdc (100-240Vac)		3									
In/Vn Rating											
In = 1/5A, Vn = 100 - 120Vac			1								
In = 1/5A, Vn = 380 - 480Vac (Min 196Vac Max 560Vac)			2								
Hardware Option											
None				1							
IRIG-B Only				2							
Fibre Optic Port (ST) for SCADA Protocols (Courier,Modbus,IEC60870-5-103 or DNP3)				3							
Fibre Optic Port (ST) for SCADA Protocols (Courier,Modbus,IEC60870-5-103 or DNP3) + IRIG-B				4							
Courier Rear Port				7							
IRIG-B (Modulated) & Courier Rear Port				8							
InterMiCOM + Courier Rear Port				E							
InterMiCOM + Courier Rear Port + IRIG-B modulated				F							
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 2 LC ports + 1 RJ45 port + Modulated/Un-modulated IRIG-B				Q							
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 3 RJ45 ports + Modulated/Un-modulated IRIG-B				R							
Ethernet (100Mbit/s), 1 RJ45 port + Modulated/Un-modulated IRIG-B				S							
Product Specific Option											
16 logic inputs and 16 relay outputs					A						
12 logic inputs and 12 relay outputs with ANSI Symbol Terminal labelling					B						
24 logic inputs and 16 relay outputs					C						
16 logic inputs and 24 relay outputs					D						
24 logic inputs and 24 relay outputs					E						
32 logic inputs and 16 relay outputs					F						
16 logic inputs and 32 relay outputs					G						
16 logic inputs and 20 relay outputs (including 4 High Break)					H						
24 logic inputs and 20 relay outputs (including 4 High Break)					J						
16 logic inputs and 28 relay outputs (including 4 High Break)					K						
16 logic inputs and 24 relay outputs (including 8 High Break)					L						
Comms Protocol											
K-Bus with simple password management - CSL0						1					
Modbus with simple password management - CSL0						2					
IEC 60870-5-103 (VDEW) with simple password management - CSL0						3					
DNP3.0 with simple password management - CSL0						4					
IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485 with simple password management - CSL0						6					
IEC 61850 Edition 1 / 2 and CS103 via rear port RS485 with simple password management - CSL0						7					

Directional Phase O/C and E/F with Auto-Reclose and Check Synch with Extended Function User Interface	P145									
IEC 61850 Edition 1 / 2 and DNPoE and DNP3 Serial with simple password management - (CSL0)						B				
IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required						G				
IEC 61850 Edition 1 / 2 and CS103 via rear port RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required						H				
IEC 61850 Edition 1 / 2 and DNPoE and DNP3 Serial with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required						L				
Case Size / Mounting / Livery										
Flush Panel Mounting							M			
Language Option										
Multilingual - English/French/German/Spanish								0		
Multilingual - English/French/German/Russian								5		
Chinese, English or French via HMI, with English or French only via Communications port *								C		
* NB: Chinese etc. HMI is not available with 12 logic inputs and 12 relay outputs with ANSI Symbol Terminal labelling										
Software Issue									B3	
Customisation										
Default										8	
Customised										9	
Hardware Design Suffix										
Phase 3 Extended CPU										M

Table 5 - Ordering options for P145

TECHNICAL DATA

CHAPTER 2

Date:	07/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142 & P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

CONTENTS

Page (TD) 2-

Notes:

1 MECHANICAL SPECIFICATIONS

1.1 Design

Modular MiCOM Px40 platform relay

- P141-40TE (206 mm (8“)) case
- P142-40TE (206 mm (8“)) case
- P143-60TE (309.6 mm (12“)) case
- P143-80TE (413.2 mm (16“)) case
- P145-60TE (309.6 mm (12“)) case

Mounting is front of panel flush mounting, or 19“ rack mounted (ordering options).

1.2 Enclosure Protection

Per IEC 60529:

- IP 52 Protection (front panel) against dust and dripping water.
- IP 50 Protection for the rear and sides of the case against dust.
- IP 10 Product safety protection for the rear due to live connections on the terminal block.

1.3 Weight

Case 40TE: approx. 7.3 kg
Case 60TE: approx. 9.2 kg
Case 80TE: approx. 11.0 kg

2 TERMINALS

2.1 AC Current and Voltage Measuring Inputs

Located on heavy duty (black) terminal block:
Threaded M4 terminals, for ring terminal connection.
CT inputs have integral safety shorting, upon removal of the terminal block.

2.2 General Input/Output Terminals

For power supply, opto inputs, output contacts and RP1, COM1 and optional COM2 rear communications.
Located on general purpose (grey) blocks:
Threaded M4 terminals, for ring lug/terminal connection.

2.3 Case Protective Earth Connection

Two rear stud connections, threaded M4.
Must be earthed (grounded) using the protective (earth) conductor for safety, minimum earth wire size $2.5mm^2$.

2.4 Front Port Serial PC Interface

EIA(RS)-232 DCE, 9 pin D-type female connector Socket SK1.
Courier protocol for interface to MiCOM S1 Studio software.
Isolation to SELV/ELV (Safety/Extra Low Voltage) level / PEB (Protective Equipotential Bonded).
Maximum cable length 15m.

2.5 Front Download/Monitor Port

EIA(RS)-232, 25 pin D-type female connector Socket SK2.
For firmware and menu text downloads.
Isolation to SELV/PEB level.

2.6 Rear Communications Port

EIA(RS)-485 signal levels, two wire connections located on general purpose block, M4 screw.
For screened twisted pair cable, multidrop, 1000 m max.
For Courier (K-Bus), IEC-60870-5-103, MODBUS (not for P14x/P445/P44x/P44y/P54x/P547/P841) or DNP3.0 protocol (not for P24x) (ordering options).
Isolation to SELV (Safety Extra Low Voltage) level. Ethernet (copper and fibre).

2.7 Optional Second Rear Communications Port

EIA(RS)-232, 9 pin D-type female connector, socket SK4.
Courier protocol: K-Bus, EIA(RS)-232, or EIA(RS)485 connection.
Isolation to SELV level.
Maximum cable length 15m.

2.8 Optional Rear IRIG-B Interface modulated or un-modulated

BNC plug
Isolation to SELV level.
50 ohm coaxial cable.

2.9 Optional Rear Fiber Connection for SCADA/DCS

BFOC 2.5 -(ST)-interface for multi-mode glass fiber type 62.5, as for IEC 874-10.
850nm short-haul fibers, one Tx and one Rx. For Courier, IEC-60870-5-103, MODBUS or DNP3.0 (but, see different ordering options for each model).

2.10 Optional Rear Ethernet Connection for IEC 61850 or DNP3.0

2.10.1 Optional Redundant Rear Ethernet Connection (optical)

2.10.1.1 10BaseT/100BaseTX Communications

Interface in accordance with IEEE802.3 and IEC 61850

Isolation:	1.5 kV
Connector type:	RJ45
Cable type:	Screened Twisted Pair (STP)
Max. cable length:	100 m

2.10.1.2 100 Base FX Interface

Interface in accordance with IEEE802.3 and IEC 61850

Wavelength:	1310 nm
Fiber:	multi-mode 50/125 µm or 62.5/125 µm
Connector type:	LC Connector Optical Interface

3 RATINGS

3.1 AC Measuring Inputs

Nominal frequency:	50 and 60 Hz (settable)
Operating range:	45 to 66 Hz
Phase rotation:	ABC or ACB

3.2 AC Current

Nominal current (In): 1A and 5A dual rated. (1A and 5A inputs use different transformer tap connections, check correct terminals are wired).

Nominal burden per phase:	< 0.15 VA at In (1A)	
Nominal burden per phase:	< 0.30 VA at In (5A)	
Thermal withstand:	continuous 4 In	for 10 s: 30 In for 1 s; 100 In

Linear to 64 In (non-offset AC current).

3.3 AC Voltage

Nominal voltage (Vn):	100 to 120 V or 380 to 480 V phase-phase (min. 196 Vac, max. 560 Vac).
Nominal burden per phase:	< 0.02 VA at Vn.
Thermal withstand:	continuous 2 Vn for 10 s: 2.6 Vn

4 POWER SUPPLY

4.1 Auxiliary Voltage (Vx)

Three ordering options:
(i) Vx: 24 to 32 Vdc
(ii) Vx: 48 to 110 Vdc,
(iii) Vx: 110 to 250 Vdc, and 100 to 240 Vac (rms).

4.2 Operating Range

(i) 19 to 38V (dc only for this variant)
(ii) 37 to 150V (dc only for this variant)
(iii) 87 to 300V (dc), 80 to 265 V (ac).

With a tolerable ac ripple of up to 15% for a dc supply, per EN / IEC 60255-11, EN / IEC 60255-26.

4.3 Nominal Burden

Quiescent burden:	11 W. (Extra 1.25 W when fitted with second rear Courier)	
Additions for energized binary inputs/outputs:		
Per opto input:	0.09 W	(24 to 54 V)
	0.12 W	(110/125 V)
	0.19 W	(220/120 V)
Per energized output relay:	0.13 W	

4.4 Power-up Time

Time to power up	<25 s
Ethernet Communications	<70 s

4.5 Power Supply Interruption

Per IEC60255-26: 2013

The relay will withstand a 20 ms interruption in the DC auxiliary supply, without deenergizing except process bus relays operating between 37 and 43V which have a 10 ms withstand.

The relay will withstand a 20 ms interruption in an AC auxiliary supply, without deenergizing.

4.6 Battery Backup

Front panel mounted.
Type ½ AA, 3.6 V Lithium Thionyl Chloride (SAFT advanced battery reference LS14250).
Battery life (assuming relay energized for 90% time) >10 years.

4.7 Field Voltage Output

Regulated 48 Vdc
Current limited at 112 mA maximum output

4.8 Digital ("Opto") Inputs

Universal opto inputs with programmable voltage thresholds (24/27, 30/34, 48/54, 110/125, 220/250 V). May be energized from the 48 V field voltage, or the external battery supply.

Rated nominal voltage:	24 to 250 Vdc
Operating range:	19 to 265 Vdc
Withstand:	300 Vdc, 300 Vrms.

Peak current of opto input when energized is 3.5 mA (0-300 V)

Nominal pick-up and reset thresholds:

Pick-up approx 70% of battery nominal set

Reset approx 66% of battery nominal set

Nominal battery 24/27:	60 - 80% DO/PU
(logic 0) <16.2	(logic 1) >19.2
Nominal battery 24/27:	50 - 70% DO/PU
(logic 0) <12.0	(logic 1) >16.8
Nominal battery 30/34:	60 - 80% DO/PU
(logic 0) <20.4	(logic 1) >24.0
Nominal battery 30/34:	50 - 70% DO/PU
(logic 0) <15.0	(logic 1) >21.0
Nominal battery 48/54:	60 - 80% DO/PU
(logic 0) <32.4	(logic 1) >38.4
Nominal battery 48/54:	50 - 70% DO/PU
(logic 0) <24.0	(logic 1) >33.6
Nominal battery 110/125:	60 - 80% DO/PU
(logic 0) <75.0	(logic 1) >88.0
Nominal battery 110/125:	50 - 70% DO/PU
(logic 0) <55.0	(logic 1) >77.0
Nominal battery 220/250:	60 - 80% DO/PU
(logic 0) <150.0	(logic 1) >176.0
Nominal battery 220/250:	50 - 70% DO/PU
(logic 0) <110	(logic 1) >154

Recognition time:

<2 ms with long filter removed.
<12 ms with half cycle ac immunity filter on.

5 OUTPUT CONTACTS

5.1 Standard Contacts

General purpose relay outputs for signaling, tripping and alarming:

Continuous Carry Ratings (Not Switched):

Maximum continuous current:	10 A (UL: 8 A)
Short duration withstand carry:	30 A for 3 s or 250A for 30ms
Rated voltage:	300 V

Make & Break Capacity:

DC:	50 W resistive	
DC:	62.5 W inductive	(L/R = 50 ms)
AC:	2500 VA resistive	(cos ϕ = unity)
AC:	2500 VA inductive	(cos ϕ = 0.7)

Make, Carry:

30 A for 3 secs, dc resistive, 10,000 operations (subject to the above limits of make/break capacity and rated voltage)

Make, Carry & Break:

30 A for 200 ms, ac resistive, 2,000 operations (subject to the above limits of make/break capacity & rated voltage)
4A for 1.5 secs, dc resistive, 10,000 operations (subject to the above limits of make/break capacity & rated voltage)
0.5 A for 1 sec, dc inductive, 10,000 operations (subject to the above limits of make/break capacity & rated voltage)
10 A for 1.5 secs, ac resistive/inductive, 10,000 operations (subject to the above limits of make/break capacity & rated voltage)

Durability:

Loaded contact:	10 000 operations minimum
Unloaded contact:	100 000 operations minimum
Operate Time	Less than 5 ms
Reset Time	Less than 5 ms

5.2 High Break Contacts

Continuous Carry Ratings (Not Switched):

Maximum continuous current:	10 A dc
Short duration withstand carry:	30 A dc for 3 s
	250A dc for 30ms
Rated voltage:	300 V

Make & Break Capacity:

DC:	7500 W resistive	
DC:	2500 W inductive	(L/R = 50 ms)

Make, Carry:

30 A for 3 secs, dc resistive, 10,000 operations (subject to the above limits of make/break capacity & rated voltage)

Make, Carry & Break:

30 A for 3 secs, dc resistive, 5,000 operations (subject to the above limits of make/break capacity & rated voltage)

30 A for 200 ms, dc resistive, 10,000 operations (subject to the above limits of make/break capacity & rated voltage)

10 A (*), dc inductive, 10,000 operations (subject to the above limits of make/break capacity & rated voltage)

*Typical for repetitive shots - 2 minutes idle for thermal dissipation

Voltage	Current	L/R	No. of Shots in 1 sec
65 V	10 A	40 ms	5
150 V	10 A	40 ms	4
250 V	10 A	40 ms	2
250 V	10 A	20 ms	4

MOV protection: Max Voltage 330 V dc

Durability:
Loaded contact: 10,000 operations minimum
Unloaded contact: 100,000 operations minimum
Operate Time: Less than 0.2 ms
Reset Time: Less than 8 ms

5.3 Watchdog Contacts

Non-programmable contacts for relay healthy or relay fail indication:
Breaking capacity: DC: 30 W resistive
DC: 15 W inductive (L/R = 40 ms)
AC: 375 VA inductive (cos ϕ = 0.7)

5.4 IRIG-B 12X Interface (Modulated)

External clock synchronization to IRIG standard 200-98, format B12x
Input impedance 6 kΩ at 1000 Hz
Modulation ratio: 3:1 to 6:1
Input signal, peak-peak: 200 mV to 20 V

5.5 IRIG-B 00X Interface (Un-modulated)

External clock synchronization to IRIG standard 200-98, format B00X.
Input signal TTL level
Input impedance at dc 10 kΩ

6 ENVIRONMENTAL CONDITIONS

6.1 Ambient Temperature Range

Per EN 60068-2-1 & EN / IEC 60068-2-2
Operating temperature range: -25°C to +55°C (or -13°F to +131°F)
Storage and transit: -25°C to +70°C (or -13°F to +158°F)

6.2 Ambient Humidity Range

Per EN /IEC 60068-2-78:
56 days at 93% relative humidity and +40 °C
Per EN / IEC 60068-2-14
5 cycles, -25°C to +55 °C
1°C / min rate of change
Per EN / IEC 60068-2-30
Damp heat cyclic, six (12 + 12) hour cycles, +25 to +55°C

6.3 Corrosive Environments

Per EN / IEC 60068-2-60, Part 2, Test Ke, Method (class) 3
Industrial corrosive environment/poor environmental control, mixed gas flow test.
21 days at 75% relative humidity and +30°C
Exposure to elevated concentrations of H_2S, (100 ppb), NO_2, (200 ppb) & Cl_2 (20 ppb).
Per EN / IEC 60068-2-52 Salt mist (7 days)
Per EN / IEC 60068-2-43 for H_2S (21 days), 15 ppm
Per EN / IEC 60068-2-42 for SO_2 (21 days), 25 ppm

7 TYPE TESTS

7.1 Insulation

Per EN / IEC 60255-27:
Insulation resistance > 100 MΩ at 500 Vdc
(Using only electronic/brushless insulation tester).

7.2 Creepage Distances and Clearances

Per EN / IEC 60255-27:
Pollution degree 3, Overvoltage category III,

7.3 High Voltage (Dielectric) Withstand

(EIA RS-232 ports excepted and normally-open contacts of output relays excepted).

(i) As for EN / IEC 60255-27:

2 kV rms AC, 1 minute:
Between all independent circuits.
Between independent circuits and case earth (ground).
1 kV rms AC for 1 minute, across open watchdog contacts.
1 kV rms AC for 1 minute, across open contacts of changeover output relays.
1 kV rms AC for 1 minute for all D-type EIA(RS)-232 or EIA(RS)-485 ports between the communications port terminals and protective (earth) conductor terminal.
1 kV rms AC for 1 minute between RJ45 ports and the case earth (ground).

(ii) As for ANSI/IEEE C37.90:

1.5 kV rms AC for 1 minute, across open contacts of normally open output relays.
1 kV rms AC for 1 minute, across open watchdog contacts.
1 kV rms AC for 1 minute, across open contacts of changeover output relays.

7.4 Impulse Voltage Withstand Test

As for EN / IEC 60255-27:

(i) Front time: 1.2 µs, Time to half-value: 50 µs,

Peak value: 5 kV, 0.5 J
Between all independent circuits.
Between independent circuits and case earth ground.

(ii) Front time: 1.2 µs, Time to half-value: 50 µs,

Peak value: 1.5kV, 0.5 J
Between RJ45 ports and the case earth (ground).
EIA(RS)-232 & EIA(RS)-485 ports and normally open contacts of output relays excepted.

8 ELECTROMAGNETIC COMPATIBILITY (EMC)

8.1 1 MHz Burst High Frequency Disturbance Test

As for EN / IEC 60255-22-1, Class III,

Common-mode test voltage:	2.5 kV,
Differential test voltage:	1.0 kV,
Test duration:	2 s,
Source impedance:	200 Ω

(EIA(RS)-232 ports excepted).

8.2 100 kHz and 1 Mhz Damped Oscillatory Test

EN / IEC 61000-4-18:	Level 3
Common mode test voltage:	2.5 kV
Differential mode test voltage:	1 kV

8.3 Immunity to Electrostatic Discharge

As for EN / IEC 60255-22-2, EN / IEC 61000-4-2:

15kV discharge in air to user interface, display, communication ports and exposed metalwork.
6kV contact discharge to the screws on the front of the front communication ports.
8kV point contact discharge to any part of the front of the product.

8.4 Electrical Fast Transient or Burst Requirements

As for EN / IEC 60255-22-4, Class B:

±4.0 kV, 5kHz and 100kHz applied to all inputs / outputs excluding communication ports
±2.0 kV, 5kHz and 100kHz applied to all communication ports

As for EN / IEC 61000-4-4, severity level 4:

±2.0 kV, 5kHz and 100kHz applied to all inputs / outputs and communication ports excluding power supply and earth.
±4.0 kV, 5kHz and 100kHz applied to all power supply and earth port

Rise time of one pulse:	5 ns
Impulse duration (50% value):	50 ns
Burst duration:	15 ms or 0.75ms
Burst cycle:	300 ms
Source impedance:	50 Ω

8.5 Surge Withstand Capability

As for IEEE/ANSI C37.90.1:
4 kV fast transient and 2.5 kV oscillatory
applied directly across each output contact, optically isolated input, and power supply circuit.

8.6 Surge Immunity Test

As for EN / IEC 61000-4-5, EN / IEC 60255-26:

Time to half-value:	1.2 to 50 µs,
Amplitude:	4 kV between all groups and case earth (ground),
Amplitude:	2 kV between terminals of each group.
Amplitude:	1kV for LAN ports

8.7 Immunity to Radiated Electromagnetic Energy

Per EN / IEC 61000-4-3 and EN / IEC 60255-22-3, Class 3

Test field strength, frequency band 80 to 1000 MHz and

1.4 GHz to 2.7GHz:	10 V/m,
Test using AM:	1 kHz / 80%
Spot tests at:	80, 160, 450, 900, 1850, 2150 MHz

Per IEEE/ANSI C37.90.2:

80MHz to 1000MHz, zero and 100% square wave modulated.
Field strength of 35V/m.

8.8 Radiated Immunity from Digital Communications

As for EN / IEC61000-4-3, Level 4:
Test field strength, frequency band 800 to 960 MHz,
and 1.4 to 2.0 GHz: 30 V/m, Test using AM: 1 kHz/80%.

8.9 Radiated Immunity from Digital Radio Telephones

As for EN / IEC 61000-4-3: 10 V/m, 900 MHz and 1.89 GHz.

8.10 Immunity to Conducted Disturbances Induced by Radio Frequency Fields

As for EN / IEC 61000-4-6, Level 3, Disturbing test voltage: 10 V.

8.11 Power Frequency Magnetic Field Immunity

As for EN / IEC 61000-4-8, Level 5,
100 A/m applied continuously, 1000 A/m applied for 3 s.
As for EN / IEC 61000-4-9, Level 5,
1000 A/m applied in all planes.
As for EN / IEC 61000-4-10, Level 5,
100 A/m applied in all planes at 100 kHz and 1 MHz with a burst duration of 2 s.

8.12 Conducted Emissions

As for CISPR 22 Class A:
Power supply:
0.15 - 0.5 MHz, 79 dBμV (quasi peak) 66 dBμV (average)
0.5 - 30 MHz, 73 dBμV (quasi peak) 60 dBμV (average)
Permanently connected communications ports:
0.15 - 0.5MHz, 97dBμV (quasi peak) 84dBμV (average)
0.5 - 30MHz, 87dBμV (quasi peak) 74dBμV (average)

8.13 Radiated Emissions

As for CISPR 22 Class A:
30 to 230 MHz, 40 dBμV/m at 10m measurement distance
230 to 1 GHz, 47 dBμV/m at 10 m measurement distance.
1 – 3GHz, 76dBμV/m (peak), 56dBμV/m (average) at 3m measurement distance.
3 – 5GHz, 80dBμV/m (peak), 60dBμV/m (average) at 3m measurement distance.

9 EU DIRECTIVES

9.1 EMC Compliance

2004/30/EU:
Compliance to the European Commission Directive on EMC is claimed via the Technical Construction File route. Product Specific Standards were used to establish conformity:
EN 60255-26

9.2 Product Safety

2014/35/EU:
Compliance to the European Commission Low Voltage Directive (LVD) is demonstrated using a Technical File. A product-specific standard was used to establish conformity.

EN 60255-27

9.3 ATEX Compliance

ATEX Potentially Explosive Atmospheres directive 2014/34/EU, for equipment.
The equipment is compliant with Article 1 of European directive 2014/34/EU.

II (2) G

It is approved for operation outside an ATEX hazardous area. It is however approved for connection to Increased Safety, “Ex e”, motors with rated ATEX protection, Equipment Category 2, to ensure their safe operation in gas Zones 1 and 2 hazardous areas.

Caution	**Equipment with this marking is not itself suitable for operation within a potentially explosive atmosphere.**

Compliance demonstrated by Notified Body certificates of compliance.

10 MECHANICAL ROBUSTNESS

10.1 Vibration Test

Per EN / IEC 60255-21-1	Response Class 2 Endurance Class 2

10.2 Shock and Bump

Per EN / IEC 60255-21-2	Shock response Class 2 Shock withstand Class 1 Bump Class 1

10.3 Seismic Test

Per EN / IEC 60255-21-3:	Class 2

11 P14X THIRD PARTY COMPLIANCES

11.1 Underwriters Laboratory (UL)

File Number: E347697
(Complies with Canadian and US requirements).

11.2 Energy Network Association (ENA)

Notice of Conformity: No 0168

12 PROTECTION FUNCTIONS

12.1 Three Phase Overcurrent Protection

Accuracy

Additional tolerance X/R ratios:	±5% over X/R 1…90
Overshoot:	<30 ms

12.2 Inverse Time Characteristic

Accuracy

DT Pick-up:	Setting ±5% *
Minimum IDMT trip level:	1.05 x setting ±5% *
Drop-off:	0.95 x setting ±5% *
IDMT shape:	±5% or 40 ms whichever is greater *
IEEE reset:	±5% or 50 ms whichever is greater *
DT operation:	±2% or 50 ms, whichever is greater *
DT reset:	±5% *
Directional boundary (RCA ±90%):	±2% hysteresis 2^{o}
Characteristic:	UK curves IEC 60255-3 …1998
US curves:	IEEEC37.112…1996

* Reference conditions TMS = 1, TD = 1 and IN1> setting of 1 A operating range 2-20 In

12.3 Earth/Sensitive Fault Protection

12.3.1 Earth Fault 1

DT Pick-up:	Setting ±5%
Minimum IDMT trip level:	1.05 x Setting ±5%
Drop-off:	0.95 x Setting ±5%
IDMT shape:	±5% or 40 ms whichever is greater
IEEE reset:	±5% or 50 ms whichever is greater
DT operation:	±2% or 50 ms whichever is greater
DT reset:	±5%
Repeatability:	2.5%

Reference conditions TMS = 1, TD = 1 and IN1> setting of 1 A operating range 2-20 In

12.3.2 Earth Fault 2

DT Pick-up:	Setting ±5%
Minimum IDMT Trip level:	1.05 x Setting ±5%
Drop-off:	0.95 x Setting ±5%
IDMT shape:	±5% or 40 ms whichever is greater
IEEE reset:	±10% or 40 ms whichever is greater
DT operation:	±2% or 50 ms whichever is greater
DT reset:	±2% or 50 ms whichever is greater
Repeatability:	±5%

Reference conditions TMS = 1, TD = 1 and IN1> setting of 1A, operating range 2-20 In

12.3.3 SEF

DT Pick-up:	Setting ±5%
Minimum IDMT Trip level:	1.05 x Setting ±5%
Drop-off:	0.95 x Setting ±5%
IDMT shape:	±5% or 40 ms whichever is greater
IEEE reset:	±7.5% or 60 ms whichever is greater
DT operation:	±2% or 50 ms whichever is greater
DT reset:	±5%
Repeatability:	±5%

Reference conditions TMS = 1, TD = 1 and IN > setting of 100 mA, operating range 2-0 In

12.3.4 REF

Pick-up:	Setting formula ±5%
Drop-off:	0.80 x setting formula ±5%
Operating time:	<60 ms
High pick up:	Setting ±5%
High operating time:	<30 ms
Repeatability:	<15%

12.3.5 Wattmetric SEF

Pick-up: For P=0W	ISEF> ±5% or P> ±5%
Drop off: For P>0W	(0.95 x ISEF>) ±5% or 0.9 x P> ±5%
Boundary accuracy:	±5% with 1° hysteresis
Repeatability:	5%

12.3.6 SEF Cos(PHI)/

Pick-up:	Setting ±5% for angles RCA±60°
Drop-off:	0.90 x Setting
IDMT shape:	±5% or 50ms whichever is greater
IEEE reset:	±7.5% or 60ms whichever is greater
DT operation:	±2% or 50ms whichever is greater
DT reset:	±5%
Repeatability:	2%

Reference conditions TMS = 1, TD = 1 and IN > setting of 100 mA, operating range 2-0 In

12.3.7 SEF Sin(PHI)

Pick-up:	Setting ±5% for angles from RCA±60° to RCA±90°
Drop-off:	0.90 x Setting
IDMT shape:	±5% or 50 ms whichever is greater
IEEE reset:	±7.5% or 60 ms whichever is greater
DT operation:	±2% or 50 ms whichever is greater
DT reset:	±5%
Repeatability:	2%

Reference conditions TMS = 1, TD = 1 and IN > setting of 100 mA, operating range 2-0 In

12.3.8 Zero Polarizing

Operating pick-up:	±2%° of RCA ±90%
Hysteresis:	<3°
VN > Pick-up:	Setting ±10%
VN > Drop-off:	0.9 x Setting ±10%

12.3.9 Negative Polarizing

Operating Pick-up:	±2% of RCA ±90%
Hysteresis:	$<3^{o}$
V2 > Pick-up:	Setting ±10%
V2 > Drop-off:	0.9 x Setting ±10%
I2 > Pick up:	Setting ±10%
I2 > Drop-off:	0.9 x Setting ±10%

12.4 Negative Sequence Overcurrent

Accuracy

DT Pick-up:	Setting ±5%
Minimum IDMT trip level:	1.05 x Setting ±5%
Drop-off:	0.95 x Setting ±5%
IDMT shape:	±5% or 40 ms whichever is greater
IEEE reset:	±5% or 50 ms whichever is greater
DT operation:	±2% or 50 ms, whichever is greater
DT reset:	±5%
Directional boundary (RCA ±90%):	±2% hysteresis 2^{o}
Characteristic:	UK curves IEC 60255-3 …1998
US curves:	IEEEC37.112…1996

12.5 Reverse/Low Forward/Overpower Protection

Accuracy

Pick-up: Setting	±10%
Reverse/Overpower drop off:	0.95 x Setting ±10%
Low forward Power drop off:	1.05 x Setting +10%
Angle variation pick-up:	Expected pick-up angle ±2 degree
Angle variation drop-off:	Expected drop-off angle ±2.5 degree
Operating time:	±2% or 50 ms whichever is greater
Repeatability:	<5%
Disengagement time:	<50 ms
tRESET:	±5%
Instantaneous operating time:	< 50 ms

12.6 Sensitive Reverse/Low Forward/Overpower (1 Phase)

Accuracy

Pick-up:	Setting ±10%
Reverse/Overpower Drop-off:	0.9 of setting ±10%
Low forward power Drop-off:	1.1 of Setting ±10%
Angle variation Pick-up:	Expected pick-up angle ±2 degree
Angle variation Drop-off:	Expected drop-off angle ±2.5% degree
Operating time:	±2% or 50 ms whichever is greater
Repeatability:	<5%
Disengagement time:	<50 ms
tRESET:	±5%
Instantaneous operating time:	<50 ms

12.7 Undervoltage Protection

Accuracy

DT Pick-up:	Setting ±5%
IDMT Pick-up:	Setting ±5%
Drop-off:	1.02 x Setting ±5%
IDMT shape:	±2% or 50 ms whichever is greater
DT operation:	±2% or 50 ms whichever is greater
Reset:	<75 ms
Repeatability:	<1%

12.8 Overvoltage Protection

Accuracy

DT Pick-up:	Setting ±5%
IDMT Pick-up:	Setting ±5%
Drop-off:	0.98 x Setting ±5%
IDMT shape:	±2% or 50 ms whichever is greater
DT operation:	±2% or 50 ms whichever is greater
Reset:	<75 ms
Repeatability:	<1%

12.9 Rate of Change of Voltage ‘dv/dt’ Protection

Accuracy for 110 V VT

Tolerance:	1% or 0.07, whichever is greater
Pick-up:	Setting ± tolerance
Drop-off:	(Setting - 0.07) ± tolerance for positive direction
Drop-off:	(Setting + 0.07) ± tolerance for negative direction
Operating time@50 Hz:	[(Avg.cycle*20)+60]ms
Reset time@50 Hz:	40 ms

12.10 Neutral Displacement/Residual Voltage

Accuracy

Pick-up:	Setting ±5% or 1.05 x Setting ±5%
Drop-off:	0.95 x Setting ±5%
IDMT shape:	±5% or 65 ms whichever is greater
DT operation:	±2% or 20 ms whichever is greater <55 ms
Reset:	<35 ms
Repeatability:	<10%

12.11 Underfrequency Protection

Accuracy

Pick-up:	Setting ±0.025 Hz
Drop-off:	1.05 x Setting ±0.025 Hz
DT operation:	±2% or 50 ms whichever is greater *

* The operating time will also include a time for the relay to frequency track (20 Hz/second)

12.12 Overfrequency Protection

Accuracy

Pick-up:	Setting ±0.025 Hz
Drop-off:	0.95 x Setting ±0.025 Hz
DT operation:	±2% or 50 ms whichever is greater *

* The operating will also include a time for the relay to frequency track (20 Hz/ second)

12.13 Advanced Over/Underfrequency 'f+t' Protection [81U/81O]

Accuracy

Pick-up:	Setting±10 mHz
Drop-off:	Setting +20mHz, ±10mHz (underfrequency) Setting -20mHz, ±10mHz (overfrequency)
Operating timer:	±2% or 50 ms whichever is greater

12.13.1 Operating & Reset Time

Operating time (underfrequency):	<100 ms for Fs/Ff ratios less than 2 <160 ms for Fs/Ff ratios less than 6 <230 ms otherwise
Operating time (overfrequency):	<125 ms for Fs/Ff ratios less than 2 <150 ms for Fs/Ff ratios less than 30 <200 ms otherwise
Reset time:	<200 ms
Fs/Ff ratios as stated, where:	Fs = start frequency - frequency setting Ff = frequency setting - end frequency
Reference conditions:	Tested using step changes in frequency with Freq.Av.Cycles setting = 0 and no intentional time delay.

12.14 Advanced Frequency Supervised Rate of Change of Frequency 'f+df/dt' Protection [81RF]

Accuracy

Pick-up:
- Setting±10 mHz (frequency threshold)
- Setting ±3% or ±10 mHz/s, whichever is greater (df/dt threshold)

Drop-off (frequency threshold):
- Setting +20 mHz, ±10 mHz (underfrequency)
- Setting -20 mHz, ±10 mHz (overfrequency)

Drop-off (df/dt threshold, falling frequency):
- Setting +0.005 Hz/s, ±10 mHz/s (for settings between 0.01 Hz/s and 0.1Hz/s).
- Setting +0.05 Hz/s, ±5% or ±55 mHz/s, whichever is greater (for settings greater than 0.1 Hz/s).

Drop-off (df/dt threshold, rising frequency):
- Setting -0.005 Hz/s, ±10 mHz/s (for settings between 0.01Hz/s and 0.1 Hz/s).
- Setting -0.05 Hz/s, ±5% or ±55 mHz/s, whichever is greater (for settings greater than 0.1 Hz/s).

12.14.1 Operating & Reset Time

Instantaneous operating time:	<125 ms for Freq.Av.Cycles setting = 0
Reset time:	<400 ms for df/dt.Av.Cycles setting = 0

12.15 Advanced Independent Rate of Change of Frequency 'df/dt+t' Protection [81R]

Accuracy

Pick-up:	Setting ±3% or ±10 mHz/s, whichever is greater
Drop-off (falling frequency):	Setting +0.005 Hz/s, ±10 mHz/s (for settings between 0.01 Hz/s and 0.1Hz/s) Setting +0.05 Hz/s, ±5% or ±55 mHz/s, whichever is greater (for settings greater than 0.1 Hz/s)
Drop-off (rising frequency):	Setting -0.005 Hz/s, ±10 mHz/s (for settings between 0.01 Hz/s and 0.1Hz/s) Setting -0.05 Hz/s, ±5% or ±55 mHz/s, whichever is greater (for settings greater than 0.1 Hz/s)
Operating timer:	±2% or 50 ms whichever is greater

12.15.1 Operating & Reset Time

Operating time:	<200 ms for ramps 2x setting or greater <300 ms for ramps 1.3x setting or greater
Reset time:	<250 ms

Reference conditions: Tested with df/dt.Av.Cycles setting = 0, for df/dt settings greater than 0.1 Hz/s (positive or negative, as relevant) and no intentional time delay.

12.16 Advanced Average Rate of Change of Frequency 'f+Df/Dt' Protection [81RAV]

Accuracy

Pick-up:	Setting±10 mHz (frequency threshold) Setting ±0.1 Hz/s (Df/Dt threshold)*
Drop-off:	Setting +20 mHz, ±10mHz (falling frequency) Setting -20 mHz, ±10 mHz (rising frequency)
Operating timer:	±2% or 30 ms whichever is greater
Reference conditions:	To maintain accuracy the minimum time delay setting, Dt, should be: Dt > 0.375 x Df + 0.23 (for Df setting < 1 Hz) Dt > 0.156 x Df + 0.47 (for Df setting ≥ 1 Hz)

12.16.1 Operating Time

Typically <125 ms with Freq.Av.Cycles = 0

12.17 Advanced Load Restoration

Accuracy

Pick-up:	Setting±10 mHz
Drop-off:	Setting -20 mHz, ±10 mHz
Restoration timer:	±2% or 50 ms whichever is greater
Holding timer:	±2% or 50 ms whichever is greater

12.18 Broken Conductor Logic

Accuracy

Pick-up:	Setting ±2.5%
Drop-off:	0.95 x Setting ±2.5%
DT operation:	±2% or 40 ms whichever is greater

12.19 Thermal Overload

Accuracy

Thermal alarm pick-up:	Calculated trip time ±10%
Thermal overload pick-up:	Calculated trip time ±10%
Cooling time accuracy:	±15% of theoretical
Repeatability:	<5%

Operating time measured with applied current of 20% above thermal setting.

12.20 Voltage Dependent Overcurrent

Accuracy

VCO / VRO threshold Pick-up:	Setting ±5%
Overcurrent Pick-up:	(K factor x Setting) ±5%
VCO / VRO threshold Drop-off:	1.05 x Setting ±5%
Overcurrent Drop-off:	0.95 x (K factor x Setting) ±5%
Operating time:	±5% or 60 ms whichever is greater
Repeatability:	<5%

12.21 Cold Load Pick-up Setting

Accuracy

Time delay:	±0.5% or 40 ms whichever is greater

12.22 Negative Sequence Overvoltage Protection

Accuracy

Pick-up:	Setting ±5%
Drop-off:	0.95 x Setting ±5%
DT operation:	±2% or 50 ms whichever is greater
Repeatability:	<5%

12.23 Admittance, Conductance and Susceptance

Accuracy

YN, BN and BN measurements:	±5%
YN, BN, BN Pick-up:	Setting ±5%
YN, BN, BN Drop-off:	>0.85 x Setting
Operating time:	Start <100 ms Trip Setting ±2% or 50 ms
Operating boundary:	±2°
VN:	Setting ±5%

12.24 Selective Overcurrent Protection

Accuracy

Fast block operation:	<25 ms
Fast block reset:	<30 ms
Time delay:	Setting ±2% or 20 ms whichever is greater

13 SUPERVISION FUNCTIONS

13.1 Voltage Transformer Supervision (VTS)

Accuracy

Fast block operation:	<25 ms
Fast block reset:	<30 ms
Time delay: Setting	±2% or 20 ms whichever is greater

13.2 Current Transformer Supervision (CTS)

Accuracy

In> Pick-up:	Setting ±5%
VN< Pick-up:	Setting ±5%
In> Drop-off:	0.9 x Setting ±5%
VN< Drop-off:	(1.05 x Setting) ±5% or 1 V whichever is greater
Time delay operation:	Setting ±2% or 20 ms whichever is greater
CTS block operation:	<1 cycle
CTS reset:	<35 ms

13.3 CB Fail

Accuracy

I < Pick-up:	Setting ±5% or 20 mA whichever is greater
I < Drop-off:	100% of setting ±5% or 20 mA whichever is greater
Timers:	±2% or 50 ms whichever is greater
Reset time:	<25 ms without DC offset <30 ms with DC offset

14 PROGRAMMABLE SCHEME LOGIC

Output conditioner timer:	Setting ±2% or 50 ms whichever is greater
Dwell conditioner timer:	Setting ±2% or 50 ms whichever is greater
Pulse conditioner timer:	Setting ±2% or 50 ms whichever is greater

15 MEASUREMENTS AND RECORDING FACILITIES

15.1 Measurements

Current:	0.05… 3 In
Accuracy:	±1.0% of reading
Voltage:	0.05…2 Vn
Accuracy:	±1.0% of reading
Power (W):	0.2…2 Vn 0.05…3 In
Accuracy:	±5.0% of reading at unity power factor
Reactive Power (Vars):	0.2…2 Vn, 0.05…3 In
Accuracy:	±5.0% of reading at zero power factor
Apparent Power (VA):	0.2…2 Vn 0.05…3 In
Accuracy:	±5% of reading
Energy (Wh):	0.2…2 Vn 0.2…3 In
Accuracy:	±5% of reading at zero power factor
Energy (Varh):	0.2…2 Vn 0.2…3 In
Accuracy:	±5% of reading at zero power factor
Phase accuracy:	0°…360°
Accuracy:	±0.5°
Frequency:	45…65 Hz
Accuracy:	±0.025 Hz

15.2 Real Time Clock

Real time clock accuracy: < ±2 seconds/day

15.3 Disturbance Records

Accuracy

Magnitude and relative phases:	±5% of applied quantities
Duration:	±2%
Trigger position:	±2% (minimum Trigger 100 ms)

15.4 Plant Supervision

Accuracy

Broken current accuracy: ±5%

Timer Accuracy

Timers:	±2% or 40 ms whichever is greater
Reset time:	<30 ms

15.5 Ethernet Data

15.5.1 100 Base FX Interface

15.5.1.1 Transmitter Optical Characteristics (LC)

Parameter	Sym	Min.	Typ.	Max.	Unit
Output Optical Power 62.5/125 µm, NA = 0.275 Fiber	PO	-20	-17.0	-14	dBm avg.
Output Optical Power 50/125 µm, NA = 0.20 Fiber	PO	-23.5	-20.0	-14	dBm avg.
Optical Extinction Ratio				10	dB
Output Optical Power at Logic “0” State	PO (“0”)			-45	dBm avg.

Table 1 - Transmitter optical characteristics (LC)

15.5.1.2 Receiver Optical Characteristics (LC)

Parameter	Sym	Min.	Typ.	Max.	Unit
Input Optical Power	PIN	-31		-14	dBm avg.
Note: The 10BaseFL connection will no longer be supported as IEC 61850 does not specify this interface.					

Table 2 - Receiver optical characteristics (LC)

16 SETTINGS LIST

16.1 Global Settings (System Data)

Language:	English/French/German/Spanish English/French/German/Russian Chinese/English/French
Frequency:	50/60 Hz
IEC61850 Edition	1 or 2
ETH COMM Mode	Dual IP, PRP or HSR

16.2 Circuit Breaker Control (CB Control)

CB Control by:	Disabled / Local / Remote / Local+Remote / Opto / Opto+local / Opto+Remote / Opto+Rem+local
Close Pulse Time:	0.10…50.00 s
Trip Pulse Time:	0.10…5.00 s
Man Close t max:	0.01…9999.00 s
Man Close Delay:	0.01…600.00 s
CB Healthy Time:	0.01…9999.00 s
Check Sync. Time:	0.01…9999.00 s
Reset Lockout by:	User Interface/CB Close
Man Close RstDly:	0.10…600.00 s
CB Status Input:	None / 52A / 52B / 52A & 52B

16.3 Date and Time

IRIG-B Sync:	Disabled/Enabled
Battery Status:	data
Battery Alarm:	Disabled/Enabled
LocalTime Enable:	Disabled/Fixed/Flexible
LocalTime Offset:	-720 min…720 min
DST Enable:	Disabled/Enabled
DST Offset:	30 min…60 min
DST Start:	First/Second/Third/Fourth/Last
DST Start Day:	Sun/Mon/Tues/Wed/Thurs/Fri/Sat
DST Start Month:	Jan/Feb/Mar/Apr/May/Jun/Jul/Aug/Sept/Oct/Nov/Dec
DST Start Mins:	0 min…1425 min
DST End:	First/Second/Third/Fourth/Last
DST End Day:	Sun/Mon/Tues/Wed/Thurs/Fri/Sat
DST End Month:	Jan/Feb/Mar/Apr/May/Jun/Jul/Aug/Sept/Oct/Nov/Dec
DST End Mins:	0 min…1425 min
RP1 Time Zone:	UTC/Local
RP2 Time Zone:	UTC/Local
Tunnel Time Zone:	UTC/Local

16.4 Configuration

Setting Group:	Select via Menu or Select via Opto
Active Settings:	Group 1/2/3/4
Setting Group 1:	Disabled/Enabled
Setting Group 2:	Disabled/Enabled
Setting Group 3:	Disabled/Enabled
Setting Group 4:	Disabled/Enabled

System Config:	Invisible/Visible
Overcurrent:	Disabled/Enabled
Negative Sequence O/C:	Disabled/Enabled
Broken Conductor:	Disabled/Enabled
Earth Fault 1:	Disabled/Enabled
Earth Fault 2:	Disabled/Enabled
SEF/REF1 Prot:	Disabled/Enabled
Residual O/V NVD:	Disabled/Enabled
Thermal Overload:	Disabled/Enabled
Neg. Sequence O/V:	Disabled/Enabled
Cold Load Pick-up:	Disabled/Enabled
Selective Logic:	Disabled/Enabled
Admit. Protection:	Disabled/Enabled
Power Protection:	Disabled/Enabled
Volt Protection:	Disabled/Enabled
Freq. Protection:	Disabled/Enabled
CB Fail:	Disabled/Enabled
Supervision:	Disabled/Enabled
Fault Locator:	Disabled/Enabled
System Checks2:	Disabled/Enabled
Auto-Reclose3:	Disabled/Enabled
Input Labels:	Invisible/Visible
Output Labels:	Invisible/Visible
Adv. Freq. Prot’n:	Disabled/Enabled
CT & VT Ratios:	Invisible/Visible
Record Control:	Invisible/Visible
Disturb Recorder:	Invisible/Visible
Measure’t Setup:	Invisible/Visible
Comms Settings:	Invisible/Visible
Commission Tests:	Invisible/Visible
Setting Values:	Primary/Secondary
Control Inputs:	Invisible/Visible
Ctrl I/P Config:	Invisible/Visible
Ctrl I/P Labels:	Invisible/Visible
Direct Access:	Disabled/Enabled
InterMiCOM:	Disabled/Enabled
Function Key4:	Invisible/Visible
RP1 Read Only:	Disabled/Enabled
RP2 Read Only:	Disabled/Enabled
NIC Read Only:	Disabled/Enabled
LCD Contrast:	(Factory pre-set)

16.5 CT and VT Ratios

Main VT Primary:	100 V...1 MV
Main VT Sec'y:	80...140 V
C/S VT Primary2:	100 V...1 MV
C/S VT Secondary:	80...140 V
NVD VT Primary5:	100 V...1 MV
NVD VT Secondary:	80...140 V
Phase CT Primary:	1 A…30 kA
Phase CT Sec'y:	1 A/5 A
E/F CT Primary:	1 A…30 kA
E/F CT Sec'y:	1 A/5 A
SEF CT Primary:	1 A…30 kA
SEF CT Sec'y:	1 A/5 A
I Derived Phase5:	IA / IB / IC / None
C/S Input2:	A-N / B-N / C-N / A-B / B-C / C-A
Main VT Location2:	Line/Bus

16.6 Sequence of Event Recorder (Record Control)

Alarm Event: Disabled/Enabled
Relay O/P Event: Disabled/Enabled
Opto Input Event: Disabled/Enabled
General Event: Disabled/Enabled
Fault Rec. Event: Disabled/Enabled
Maint. Rec. Event: Disabled/Enabled
Protection Event: Disabled/Enabled
DDB 31 - 0:(up to): DDB 1279 - 1248 (DDB 2047):
Binary function link strings, selecting which DDB signals will be stored as events, and which will be filtered out

16.7 Oscillography (Disturbance Recorder)

Duration: 0.10…10.50 s
Trigger Position: 0.0…100.0%
Trigger Mode: Single/Extended
Analog Channel 1: (up to):
Analog Channel 9: Disturbance channels selected from:
VA / VB / VC / Vchecksync. / IA / IB / IC / IN / IN Sensitive

Digital Input 1: (up to):
Digital Input 128:

Selected binary channel assignment from any DDB status point within the relay (opto input, output contact, alarms, starts, trips, controls, logic…).

Input 1 Trigger: (up to):
Input 128 Trigger: No Trigger Trigger L/H Trigger H/L

16.8 Measured Operating Data (Measure't. Setup)

Default Display: 3Ph + N Current / 3Ph Voltage / Power / Date and Time / Description / Plant Reference / Frequency

Access Level

Local Values: Primary/Secondary
Remote Values: Primary/Secondary
Measurement Ref: VA/VB/VC/IA/IB/IC
Measurement Mode: 0/1/2/3
Fix Dem. Period: 1…99 mins
Roll Sub Period: 1…99 mins
Num. Sub Periods: 1…15
Distance Unit: Miles/Kilometers
Fault Location: Distance Ohms % of Line
Remote2 Values: Primary/Secondary

16.9 Communications

RP1 Protocol:	Courier / IEC870-5-103 / DNP 3.0
RP1 Address: (Courier or IEC870-5-103):	0…255
RP1 Address: (DNP3.0):	0…65519
RP1 InactivTimer:	1…30 mins
RP1 Baud Rate: (IEC870-5-103):	9600 / 19200 bits/s
RP1 Baud Rate: (DNP3.0):	1200 / 2400 4800 / 9600 19200 / 38400 bits/s
RP1 Parity:	Odd/Even/None
RP1 Meas Period:	1…60 s
RP1 PhysicalLink:	Copper Fiber Optic (IEC870-5-103, DNP3.0, Courier, MODBUS) K-Bus (Courier only)
RP1 Time Sync:	Disabled/Enabled
DNP Need Time:	1…30 m
DNP App Fragment:	100…2048
DNP App Timeout:	1…120
DNP SBO Timeout:	1…10
DNP Link Timeout:	0…120
RP1 CS103 Blocking:	Disabled / Monitor Blocking / Command Blocking
RP1 Port Config. (Courier):	K Bus / EIA(RS)485
RP1 Comms. Mode:	IEC60870 FT1.2 Frame 10-Bit No Parity

MAC Addr 1:	This is set during manufacturing process as the MAC Address for Interface 1
MAC Addr 2:	This is set during manufacturing process as the MAC Address for Interface 2
Redundancy Conf:	The redundant agency device configuration is used for the SNMP server.
MAC Address:	Set during manufacturing process as the MAC address 3 for redundant agency device .
IP Address:	A default IP address is 169.254.2.zzz, zzz = mod (The last byte of MAC3, 128) + 1.
Subnet Mask:	0.0.0.0
Gateway:	0.0.0.0

16.10 Optional Additional Second Rear Communication (Rear Port2 (RP2))

RP2 Protocol:	Courier (fixed)
RP2 Port Config:	Courier over EIA(RS)232 / Courier over EIA(RS)485 / K-Bus
RP2 Comms. Mode:	IEC60870 FT1.2 Frame / 10-Bit NoParity
RP2 Address:	0…255
RP2 InactivTimer:	1…30 mins
RP2 Baud Rate:	9600 / 19200 / 38400 bits/s

Note *If RP2 Port Config is K Bus the baud rate is fixed at 64 kbits/s*

16.11 Optional Ethernet Port

NIC Tunl Timeout:	1...30 mins
NIC Link Report:	Alarm/Event/None
NIC Link Timeout:	0.1...60 s

16.12 Commission Tests

Monitor bit 1: (up to): Monitor bit 8:	Binary function link strings, selecting which DDB signals have their status visible in the Commissioning menu, for test purposes
Test Mode:	Disabled Test Mode Blocked Contacts
Test Pattern:	Configuration of which output contacts are to be energized when the contact test is applied
Static Test Mode:	Disabled/Enabled

16.13 Circuit Breaker Condition Monitoring (CB Monitor Setup)

Broken I^:	1.0…2.0
I^ Maintenance:	Alarm Disabled/Enabled
I^ Maintenance:	1…25000
I^ Lockout:	Alarm Disabled/Enabled
I^ Lockout:	1…25000
No. CB Ops Maint:	Alarm Disabled/Enabled
No. CB Ops Maint:	1…10000
No. CB Ops Lock:	Alarm Disabled/Enabled
No. CB Ops Lock:	1…10000
CB Time Maint:	Alarm Disabled/Enabled
CB Time Maint:	0.005…0.500 s
CB Time Lockout:	Alarm Disabled/Enabled
CB Time Lockout:	0.005…0.500 s
Fault Freq. Lock:	Alarm Disabled/Enabled
Fault Freq. Count:	1…9999
Fault Freq. Time:	0…9999 s

16.14 Optocoupled Binary Inputs (Opto Config.)

Global Nominal V: 24 – 27 V / 30 – 34 V / 48 – 54 V / 110 – 125 V / 220 – 250 V / Custom

Opto Input 1: (up to):

Opto Input #. (# = max. opto no. fitted):

Custom options allow independent thresholds to be set for each opto, from the same range as above.

Opto Filter Control: Binary function link string, selecting which optos have an extra 1/2 cycle noise filter, and which do not.

Characteristics: Standard 60% - 80% / 50% - 70%

Time stamping accuracy: + 1 msec

16.15 Control Inputs into PSL (Ctrl. I/P Config.)

Hotkey Enabled: Binary function link string, selecting which of the control inputs are driven from Hotkeys.

Control Input 1 (up to):
Control Input 32: Latched/Pulsed

Ctrl Command 1 (up to):
Ctrl Command 32: On/Off / Set/Reset / In/Out / Enabled/Disabled

16.16 EIA(RS)232 Teleprotection (InterMiCOM Comms.)

Source Address: 1…10
Received Address: 1…10
Data Rate: 600 / 1200 / 2400 / 4800 / 9600 / 19200 baud
Loopback Mode: Disabled/Internal/External
Test Pattern: Configuration of which InterMiCOM signals are to be energized when the loopback test is applied.

16.17 InterMiCOM Conf.

IM Msg Alarm Lvl: 0…100.0%
IM1 Cmd Type: (up to):
IM4 Cmd Type: Disabled/Direct/Blocking
IM5 Cmd Type: (up to):
IM8 Cmd Type: Disabled/Permissive/Direct
IM1 FallBackMode: (up to):
IM8 FallBackMode: Default/Latched
IM1 DefaultValue: (up to):
IM8 DefaultValue: 0/1
IM1 FrameSyncTim: (up to):
IM8 FrameSyncTim: 10 ms…1.50 s

16.18 Function Keys

Fn. Key Status 1 (up to) 10: Disable / Lock / Unlock / Enable
Fn. Key 1 Mode (up to) 10: Toggled/Normal
Fn. Key 1 Label (up to) 10: User defined text string to describe the function of the particular function key.

16.19 IED CONFIGURATOR

Switch Conf. Bank:	No Action/Switch Banks
IP Address 1	0.0.0.0. The default IP address is encoded from the MAC address. 169.254.0.xxx, xxx = mod (The last byte of MAC1, 128) + 1.
Subnet Mask 1	255.255.255.0
Gateway 1	169.254.0.250
IP Address 2	0.0.0.0. The default IP address is encoded from the MAC address. 169.254.1.yyy, yyy = mod (The last byte of MAC2, 128) + 1.
Subnet Mask 2	255.255.255.0
Gateway 2	169.254.1.250

16.20 IEC61850 GOOSE

GoEna:	0000000000000000(bin)... 1111111111111111(bin)
Pub.Simul.Goose:	0000000000000000(bin)... 1111111111111111(bin)
Sub.Simul.Goose:	No/Yes

16.21 Control Input User Labels (Ctrl. I/P Labels)

Control Input 1:	User defined text string
(up to):	to describe the function
Control Input 32:	of the particular control input

17 SETTINGS IN MULTIPLE GROUPS

Note	*All settings here onwards apply for setting groups # = 1 to 4.*

18 PROTECTION FUNCTIONS (IN MULTIPLE GROUPS)

Note *All settings here onwards apply for setting groups # = 1 to 4.*

18.1 System Config.

Phase Sequence:	Standard ABC / Reverse ACB
2NDHARM BLOCKING:	Disabled / Enabled
2ndHarm Thresh:	5…70 %
I>lift 2H:	4…32 A

18.2 Phase Overcurrent (Overcurrent)

I>1 Function:	Disabled / DT / IEC S Inverse / IEC V Inverse / IEC E Inverse / UK LT Inverse / UK Rectifier / RI / IEEE M Inverse / IEEE V Inverse / IEEE E InverseUS Inverse / US ST Inverse / Def User Curve 1 / Def User Curve 2 / Def User Curve 3 / Def User Curve 4
I>1 Direction:	Non-Directional or Directional Fwd or Directional Rev
I>1 Current Set:	0.08…4.00 In
I>1 Time Delay:	0.00…100.00 s
I>1 TMS:	0.025…1.200
I>1 Time Dial:	0.01…100.00
I>1 K (RI):	0.10…10.00
I>1 DT Adder:	0.00…100.00
I>1 Reset Char.:	DT/Inverse
I>1 tRESET:	0.00…100.00 s
I>2 Status (up to):	
I>2 tRESET	All settings and options chosen from the same ranges as per the first stage overcurrent, I>1.
I>3 Status:	Disabled or Enabled
I>3 Direction:	Non-Directional or Directional Fwd or Directional Rev
I>3 Current Set:	0.08…32.00 In
I>3 Time Delay:	0.00…100.00 s
I>4 Status (up to):	
I>4 Time Delay	All settings and options chosen from the same ranges as per the third stage overcurrent, I>3.
I>Char Angle:	-95…95º
I>5 Status (up to):	
I>5 tRESET	All settings and options chosen from the same ranges as per the first stage overcurrent, I>1.
I>6 Status (up to):	
I>6 Time Delay	All settings and options chosen from the same ranges as per the third stage overcurrent, I>3.

I>Blocking:
Binary function link string, selecting which overcurrent elements (stages 1 to 6) will be blocked if VTS detection of fuse failure occurs.
Binary function link string, selecting which overcurrent elements (stages 1 to 6) will be blocked if 2nd Harmonic Block is enabled with an option of choosing 1PH block.

18.3 Voltage Dependent Overcurrent

V DEPENDANT O/C
V Dep OC Status
VCO Disabled
VCO I>1
VCO I>2
VCO I>1 & I>2
VCO I>5
VCO I>1 & I>2 & I>5
VCO I>1 & I>5
VC0 I>2 & I>5
VRO I>1
VRO I>2
VRO I>5
VRO I>1 & I>2
VRO I>1 & I>5
VRO I>2 & I>5
VRO I>1 & I>2 & I>5

V Dep OC V<1 Set
10…120 V (100/120 V)
40…480 V (380/440 V)

V Dep OC V<2 Set
10…120 V (100/120 V)
40…480 V (380/440 V)

18.4 Load Blinder

Blinder Status:	Disabled/Enabled
Blinder Function:	3Ph/1Ph
Blinder Mode:	Both/Forward/Reverse
FWD Z Impedance:	0.1…100 ohm
FWD Z Angle:	5…85 deg
REV Z Impedance:	0.1…100 ohm
REV Z Angle:	5…85 deg
Binder V<Block:	10…120 V
Binder I2>Block:	0.8…4 A
PU cycles:	0…50
DO cycles:	0…50

18.5 Negative Sequence Overcurrent

I2>1 Function:	Disabled / DT / IEC S Inverse / IEC V Inverse / IEC E Inverse / UK LT Inverse / IEEE M Inverse / IEEE V Inverse / IEEE E Inverse / US Inverse / US ST Inverse
I2>1 Direction:	Non-Directional or Directional Fwd or Directional Rev
I2>1 Current Set:	0.08…4.00 In
I2>1 Time Delay:	0.00…100.00 s
I2>1 TMS:	0.025…1.200
I2>1 Time Dial:	0.01…100.00
I2>1 DT Adder:	0.00…100.00
I2>1 Reset Char.:	DT/Inverse
I2>1 tRESET:	0.00…100.00 s
I2>2 Status (up to):	I2>2 tRESET All settings and options chosen from the same ranges as per the first stage overcurrent, I2>1.
I2>3 Status:	Disabled/Enabled
I2>3 Direction:	Non-Directional or Directional Fwd or Directional Rev
I2>3 Current Set:	0.08…32.00 In
I2>3 Time Delay:	0.00…100.00 s
I2>4 Status (up to):	I2>4 Time Delay All settings and options chosen from the same ranges as per the third stage overcurrent, I2>3.

I2> VTS Blocking:

Binary function link string, selecting which Neg. Seq. O/C elements (stages 1 to 4) will be blocked if VTS detection of fuse failure occurs.

Binary function link string, selecting which Neg. Seq. O/C elements (stages 1 to 4) will be blocked if 2nd Harmonic Block is enabled.

I2> Char Angle:	-95…95º
I2> V2pol Set:	0.5…25.0 (100 – 110 V): 2…100 (380 – 480 V):

18.6 Broken Conductor

Broken Conductor:	Disabled/Enabled
I2/I1 Setting:	0.20…1.00
I2/I1 Time Delay:	0.0…100.0 s

18.7 Ground Overcurrent (Earth Fault 1 & 2)

IN1>1 Function	Disabled / DT / IEC S Inverse / IEC V Inverse / IEC E Inverse / UK LT Inverse / RI / IEEE M Inverse / IEEE V Inverse / IEEE E Inverse / US Inverse / US ST Inverse / IDG / Def User Curve 1 / Def User Curve 2 / Def User Curve 3 / Def User Curve 4
IN1>1 Directional	Non-Directional or Directional Fwd or Directional Rev
IN1>1 Current Set:	0.08…4.00 In
IN1>1 IDG Is:	1.0…4.0 In
IN1>1 Time Delay:	0.00…200.00 s
IN1>1 TMS:	0.025…1.200
IN1>1 Time Dial:	0.01…100.00
IN1>1 K(RI):	0.10..10.00
IN1>1 IDG Time:	1.00…2.00
IN1>1 DT Adder:	0.00…100.00
IN1>1 Reset Char.:	DT/Inverse
IN1>1 tRESET:	0.00…100.00 s
IN1>2 Status	(up to):
IN1>2 tRESET	All settings and options chosen from the same ranges as per the first stage ground overcurrent, IN>1.
IN1>3 Status:	Disabled or Enabled
IN1>3 Directional:	Non-Directional or Directional Fwd or Directional Rev
IN1>3 Current Set:	0.08…32.00 In
IN1>3 Time Delay:	0.00…200.00 s
IN1>4 Status (up to):	IN1>4 Time Delay All settings and options chosen from the same ranges as per the third stage ground overcurrent, IN>3.
IN1> Blocking:	Binary function link string, selecting which ground overcurrent elements (stages 1 to 4) will be blocked if VTS detection of fuse failure occurs. Binary function link string, selecting which ground overcurrent elements (stages 1 to 4) will be blocked if 2nd Harmonic Block is enabled.
IN1> Char Angle:	-95…95º
IN1> Polarization:	Zero Sequence or Neg. Sequence
IN1> VNpol Set:	0.5…80.0 V (100 – 110 V) 2…320 V (380 – 480 V)
IN1> V2pol Set:	0.5…25.0 V (100 – 110 V) 2…100 V (380 – 480 V)
IN1> I2pol Set:	0.08…1.00 In

18.8 Sensitive Earth Fault Protection/ Restricted Earth Fault Protection

SEF/REF Options:	SEF / SEF cos (PHI) / SEF sin (PHI) / Wattmetric / Hi Z REF / Lo Z REF / Lo Z REF + SEF / Lo Z REF + Wattmetric
ISEF>1 Function:	Disabled / DT / IEC S Inverse / IEC V Inverse / IEC E Inverse / UK LT Inverse / RI / IEEE M Inverse / IEEE V Inverse / IEEE E Inverse / US Inverse / US ST Inverse / IDG / Def User Curve 1 / Def User Curve 2 / Def User Curve 3 / Def User Curve 4
ISEF>1 Directional:	Non-Directional or Directional Fwd or Directional Rev.
ISEF>1 Current Set:	0.005…0.01 In
ISEF>1 IDG Is:	1.0…4.0 In
ISEF>1 Time Delay:	0.00…200.00 s
ISEF>1 TMS:	0.025…1.200
ISEF>1 Time Dial:	0.5…100.0
IN1>1 K(RI):	0.10..10.00
ISEF>1 IDG Time:	1.00..2.00
ISEF>1 DT Adder:	0.00…100.00
ISEF>1 Reset Char:	DT/Inverse
ISEF>1 tRESET:	0.00…100.00 s
ISEF>2 Status (up to):	ISEF>2 tRESET All settings and options chosen from the same ranges as per the first stage ground overcurrent, IN>1.
ISEF>3 Status:	Disabled / Enabled
ISEF>3 Directional:	Non-Directional or Directional Fwd or Directional Rev
ISEF>3 Current Set:	0.005….2.000 In
ISEF>3 Time Delay:	0.00…200.00 s
ISEF>4 Status (up to): ISEF>4 Time Delay	All settings and options chosen from the same ranges as per the third stage ground overcurrent, IN>3.
ISEF> Blocking:	Binary function link string, selecting which ground overcurrent elements (stages 1 to 4) will be blocked if VTS detection of fuse failure occurs. Binary function link string, selecting which ground overcurrent elements (stages 1 to 4) will be blocked if 2nd Harmonic Block is enabled.
ISEF> Char. Angle:	-95…95º
ISEF> VNpol Set:	0.5…80.0V (100 – 110 V) or 2…320V (380 – 480 V)

18.8.1 WATTMETRIC SEF:

PN> Setting:	0…20 W (1A, 100/120 V)
PN> Setting:	0…100 W (5A, 100/120 V)
PN> Setting:	0 …80 W (1A, 380/440 V)
PN> Setting:	0…400 W (5A, 380/440 V)

18.8.1.1 Restricted Earth-Fault (Low Impedance)

IREF > K1:	0 …20%
IREF > K2:	0 …150%
IREF > Is1:	0.08…1.00 In
IREF > Is2:	0.1…1.50 In

18.8.1.2 Restricted Earth-Fault (High Impedance)

IREF > K1:	0.05…1.00 In

18.9 Neutral Voltage Displacement (Residual O/V NVD)

VN>1 Function:	Disabled / DT / IDMT
VN>1 Voltage Set:	1…50 V
VN>1 Time Delay:	0.00…100.00 s
VN>1 TMS:	0.5…100.0
VN>1 tReset:	0.00…100.00 s
VN>2 Status:	Disabled/Enabled
VN>2 Voltage Set:	1…80 V (100/110 V)
	4…320 V (380/440 V)
VN>2 Time Delay:	0.00…100.00 s

18.10 Thermal Overload

Characteristic:	Disabled / Single / Dual
Thermal Trip:	0.08…4.00 In
Thermal Alarm:	50…100%
Time Constant 1:	1…200 mins
Time Constant 2:	1…200 mins

18.11 Negative Sequence Overvoltage Protection

V2> Status:	Disabled/Enabled
V2> Voltage Set:	1V…110 V (100/120 V)
	4V – 440 V (380/440 V)
V2> Time Delay:	0.00…100.00 s

18.12 Cold Load Pick- up Setting

tcold Time Delay:	0…14 400 s
tclp Time Delay:	0…14 400 s

18.13 Selective Overcurrent Logic

Overcurrent	
I>3 Time Delay:	0.00…100.00 s
I>4 Time Delay:	0.00…100.00 s
Earth Fault1	
IN1>3 Time Delay:	0.00…200.00 s
IN1>4 Time Delay:	0.00…200.00 s
Earth Fault2	
IN2>3 Time Delay:	0.00…200.00 s
IN2>4 Time Delay:	0.00…200.00 s
Sensitive E/F	
ISEF>3 Time Delay:	0.00…200.00 s
ISEF>4 Time Delay:	0.00…200.00 s
Overcurrent	
I>6 Time Delay:	0.00…100.00 s

18.14 Neutral Admittance Protection

VN Threshold:	1…40 V (100/120 V) or 4…160 V (380/440 V)
CT Input Type:	SEF CT / E/F CT
Correction angle:	30…30°

18.14.1 Over Admittance

YN Status:	Disabled/Enabled
YN> Set (SEF):	0.1…10 mS (100/110 V) 0.025…2.5 mS (380/440 V)
YN> Set (EF):	1…100 mS (100/110 V) 0.25…25 mS (380/440 V)
YN> Time Delay:	0.05 s…100.00 s
YN> tRESET:	0.00…100.00 s

18.14.2 Over Conductance

GN Status:	Disabled/Enabled
GN>Direction	Non-Directional or Directional Fwd or Directional Rev.
GN> Set (SEF):	0.1…5 mS (100/110 V) or 0.25…1.25 mS (380/440 V)
GN> Set (E/F):	1…50 mS (100/110 V) or 0.25…12.5 mS (380/440 V)
GN> Time Delay:	0.05 s…100 s
GN>tRESET:	0 s…100 s

18.14.3 Over Susceptance

BN Status:	Disabled/Enabled
GN>Direction:	Non-Directional or Directional Fwd or Directional Rev
BN> Set (SEF):	0.1…5 mS (100/110 V) 0.025…1.25 mS (380/440 V)
BN> Set (E/F):	1…50 mS (100/110 V) 0.25…12.5 mS (380/440 V)
BN> Time Delay:	0.05…100 s
BN> tRESET:	0 s…100 s

18.15 Undervoltage Protection

V< Measur't. Mode:	Phase-Phase / Phase-Neutral
V< Operate Mode:	Any Phase / Three Phase
V<1 Function:	Disabled / DT / IDMT
V<1 Voltage Set:	10…120 V (100/110 V) 40…480 V (380/440 V)
V<1 Time Delay:	0.00…100.00 s
V<1 TMS:	0.5…100.0
V<1 Poledead Inh:	Disabled/Enabled
V<2 Status:	Disabled/Enabled
V<2 Voltage Set:	10…120 V (100/110 V) 40…480 V (380/440 V)
V<2 Time Delay:	0.00…100.00 s
V<2 Poledead Inh:	Disabled/Enabled

18.16 Overvoltage Protection

V> Measur't. Mode:	Phase-Phase or Phase-Neutral
V> Operate Mode:	Any Phase or Three Phase
V>1 Function:	Disabled / DT / IDMT
V>1 Voltage Set:	60…185 V (100/110 V) 240…740 V (380/440 V)
V>1 Time Delay:	0.00…100.00 s
V>1 TMS:	0.5…100.0
V>2 Status:	Disabled/Enabled
V>2 Voltage Set:	60…185 V (100/110 V) 240…740 V (380/440 V)
V>2 Time Delay:	0.00…100.00 s

18.17 dv/dt Protection

dv/dt Meas. Mode:	Phase-Phase / Phase-Neutral
dv/dt1 Function:	Disabled / Negative / Positive / Both
dv/dt1 Oper Mode:	Any Phase / Three Phase
dv/dt1 AvgCycles:	5…50
dv/dt1 Threshold:	0.5…200
dv/dt1 TimeDelay:	0…100 s
dv/dt1 tRESET:	0…100 s
dv/dt2 Function:	Disabled / Negative / Positive / Both
dv/dt2 Oper Mode:	Any Phase / Three Phase
dv/dt2 AvgCycles:	5…50
dv/dt2 Threshold:	0.5…200
dv/dt2 TimeDelay:	0…100 s
dv/dt2 tRESET:	0…100 s

18.18 Underfrequency Protection

F<1 Status:	Disabled/Enabled
F<1 Setting:	45.00…65.00 Hz
F<1 Time Delay:	0.00…100.00 s
F<2 Status (up to):	F<4 Time Delay

All settings and options chosen from the same ranges as per the 1st stage.

F< Function Link:	Binary function link string, selecting which frequency elements (stages 1 to 4) will be blocked by the pole-dead logic.

18.19 Overfrequency Protection

F>1 Status:	Disabled/Enabled
F>1 Setting:	45.00…65.00 Hz
F>1 Time Delay:	0.00…100.00 s
F>2 Status (up to):	
F>2 Time Delay	

All settings and options chosen from the same ranges as per the 1st stage.

18.20 Advanced Over/Underfrequency Protection (f+t [81U/81O])

Stage 1 f+t Status:	Disabled / Enabled
1 (f+t) f:	40.10…69.90 Hz
1 (f+t) t:	0.00…100.00 s
Stage 2 f+t Status (up to):	9 (f+t)t

All settings and options chosen from the same ranges as per the first stage over/underfrequency, Stage 1 f+t.

18.21 Advanced Frequency Supervised Rate of Change of Frequency Protection (f+df/dt [81RF]

Stage 1 f+df/dt Status:	Disabled / Enabled
1 (f+df/dt) f:	40.10…69.90 Hz
1 (f+df/dt) df/dt:	0.01…10.0 Hz/s
Stage 2 f+df/dt Status (up to):	9 (f+df/dt) df/dt

All settings and options chosen from the same ranges as per the first stage frequency supervized rate of change of frequency, Stage 1 f+df/dt.

18.22 Advanced Independent Rate of Change of Frequency Protection (df/dt+t [81R])

Stage 1 df/dt+t Status:	Disabled / Negative / Positive
1 (df/dt+t) df/dt:	0.01…10.00 Hz/s
1 (df/dt+t) t:	0.00…100.00 s
Stage 2 df/dt+t Status (up to):	9 (df/dt+t) t

All settings and options chosen from the same ranges as per the first stage independent rate of change of frequency, Stage 1 df/dt+t.

18.23 Advanced Average Rate of Change of Frequency Protection (f+Df/Dt [81RAV])

Stage 1 f+Df/Dt Status:	Disabled / Enabled
1 (f+Df/Dt) f:	40.10…69.90 Hz
1 (f+Df/Dt) Df:	0.2…10.0 Hz
1 (f+Df/Dt) Dt:	0.02…2.00 s
Stage 2 f+Df/Dt Status (up to):	9 (f+Df/Dt) Dt

All settings and options chosen from the same ranges as per the first stage average rate of change of frequency, Stage 1 f+Df/Dt.

18.24 Advanced Load Restoration

Restore1 Status:	Disabled / Enabled
Restore1 Freq.:	40.10…69.90 Hz
Restore1 Time:	0…7200 s
Restore2 Status (up to):	Restore9 Time

All settings and options chosen from the same ranges as per the first stage load restoration, Restore1.

18.25 Circuit Breaker Fail

CB Fail 1 Status:	Disabled/Enabled				
CB Fail 1 Timer:	0.00…10.00 s				
CB Fail 2 Status:	Disabled/Enabled				
CB Fail 2 Timer:	0.00…10.00 s				
Volt Prot. Reset:	I< Only	or	CB Open & I<	or	Prot. Reset & I<
Ext Prot. Reset:	I< Only	or	CB Open & I<	or	Prot. Reset & I<

18.26 Undercurrent

I< Current Set:	0.02…3.20 In
IN< Current Set:	0.02…3.20 In
ISEF< Current Set:	0.001…0.800 In

18.27 Blocked O/C

Remove I> Start:	Disabled/Enabled
Remove IN> Start:	Disabled/Enabled

18.28 Fuse Failure (VT Supervision)

VTS Status:	Blocking/Indication
VTS Reset Mode:	Manual/Auto
VTS Time Delay:	1.0…10.0 s
VTS I> Inhibit:	0.08…32.00 In
VTS I2> Inhibit:	0.05…0.50 In

18.29 CT Supervision

CTS Status:	Disabled/Enabled
CTS VN< Inhibit:	0.5…22.0 V (100/110 V) 2…88 V (380/440 V)
CTS IN> Set:	0.08…4.00 In
CTS Time Delay:	0…10 s
VTS PickupThresh:	20…120 V

18.30 Fault Locator

Line Length (km):	0.001…1000.000 km
Line Length (mi):	0.20…625.00 mi
Line Impedance:	0.10…250.00 Ω
Line Angle:	20…85°
KZN Residual:	0.00…7.00
KZN Res. Angle:	-90…90°

18.31 Bus-Line Synchronizm and Voltage Checks (System Checks)

Voltage Monitors

Live Voltage:	1.0…132.0 V (100/110 V) 22…528 V (380/440 V)
Dead Voltage:	1.0…132.0 V (100/110 V) 22…528 V (380/440 V)

18.32 Synchrocheck (Check Sync.)

CS1 Status:	Disabled/Enabled
CS1 Phase Angle:	5…90°
CS1 Slip Control:	None / Timer / Frequency / Both
CS1 Slip Freq.:	0.01…1.00 Hz
CS1 Slip Timer:	0.0…99.0 s
CS2 Status (up to):	CS2 Slip Timer

All settings and options chosen from the same ranges as per the first stage CS1 element.

CS Undervoltage:	10.0…132.0 V (100/110 V) 40…528 V (380/440 V)
CS Overvoltage:	40.0…185.0 V (100/110 V) 160…740 V (380/440 V)
CS Diff Voltage:	1.0…132.0 V (100/110 V) 4…528 V (380/440 V)
CS Voltage Block:	None / Undervoltage / Overvoltage / Differential / UV & OV / UV & DiffV / OV & DiffV / UV, OV & DiffV

18.33 System Split

System Split

SS Status:	Disabled/Enabled
SS Phase Angle:	90…175°
SS Under V Block:	Disabled/Enabled
SS Undervoltage:	10.0…132.0 V (100/110 V) 40…528 V (380/440 V)
SS Timer:	0.0…99.0 s
CB Close Time:	0.000…0.500 s

18.34 Auto-reclose

AR Mode Select:	Command Mode or Opto Set Mode or User Set Mode or Pulse Set Mode
Number of Shots:	1…4
Number of SEF Shots:	0…4
Sequence Co-ord.:	Disabled/Enabled
CS AR Immediate:	Disabled/Enabled
Dead Time 1:	0.01…300.00 s
Dead Time 2:	0.01…300.00 s
Dead Time 3:	0.01…9999.00 s
Dead Time 4:	0.01…9999.00 s
CB Healthy Time:	0.01 s…9999.00 s
Start Dead t on:	Protection Resets/CB Trips
tReclaim Extend:	No Operation/On Prot. Start

Reclaim Time 1:	1.00…600.00 s
Reclaim Time 2:	1.00…600.00 s
Reclaim Time 3:	1.00…600.00 s
Reclaim Time 4:	1.00…600.00 s
AR Inhibit Time:	0.01…600.00 s
AR Lockout:	No Block/Block Inst. Prot.
EFF Maint. Lock:	No Block/Block Inst. Prot.
AR Deselected:	No Block/Block Inst. Prot.
Manual close:	No Block/Block Inst. Prot.

Trip 1 Main:	No Block/Block Inst. Prot.
Trip 2 Main:	No Block/Block Inst. Prot.
Trip 3 Main:	No Block/Block Inst. Prot.
Trip 4 Main:	No Block/Block Inst. Prot.
Trip 5 Main:	No Block/Block Inst. Prot.
Trip 1 SEF:	No Block/Block Inst. Prot.
Trip 2 SEF:	No Block/Block Inst. Prot.
Trip 3 SEF:	No Block/Block Inst. Prot.
Trip 4 SEF:	No Block/Block Inst. Prot.
Trip 5 SEF:	No Block/Block Inst. Prot.
Man. Close on Flt:	No Lockout/Lockout
Trip AR Inactive:	No Lockout/Lockout
Reset Lockout by:	User Interface/Select Non-Auto
AR on Man. Close:	Enabled/Inhibited
Sys. Check Time:	0.01…9999.00 s
AR Skip Shot 1:	Enabled/disabled

18.34.1 AR INITIATION

I>1, I>2:	No Action/Initiate Main AR
I>3 and I>4:	No Action/Initiate Main AR/Block AR
IN1>1 and IN1>2:	No Action/Main AR
IN1>3 and IN1>4:	No Action/Initiate Main AR/Block AR
IN2>1, IN2>2:	No Action/Initiate Main AR
IN2>3 and IN2>4:	No Action/Initiate Main AR/Block AR
ISEF>1, ISEF>2, ISEF>3 and ISEF>4:	No Action/Initiate Main AR/Initiate SEF AR/Block AR
YN/GN/ BN>:	No Action/Initiate Main AR
Ext. Prot.:	No Action/Initiate Main AR

18.34.2 SYSTEM CHECKS

AR with ChkSync:	Disabled/Enabled
AR with SysSync:	Disabled/ Enabled
Live/Dead Ccts:	Disabled/Enabled
No System Checks:	Enabled/Disabled
SysChk on Shot 1:	Disabled/ Enabled
I>5:	No Action/Initiate Main AR
I>6:	No Action/Initiate Main AR/Block AR

18.35 Opto Input Labels

Opto Input 1 to Opto Input 32:
User defined text string to describe the function of the particular opto input.

18.36 Output Labels

Relay 1: (up to): Relay 32:
User defined text string to describe the function of the particular relay output contact.

19 MEASUREMENTS LIST (IN MULTIPLE GROUPS)

Note	*All settings here onwards apply for setting groups # = 1 to 4.*

19.1 Measurements 1

Iφ Magnitude	
Iφ Phase Angle	Per phase (φ = A, B, C)
Current Measurements	
IN Measured Mag.	
IN Measured Ang.	
IN Derived Mag.	
IN Derived Angle	
ISEF Magnitude	
ISEF Angle	
I1 Magnitude	
I2 Magnitude	
I0 Magnitude	
Iφ RMS	Per phase (φ = A, B, C)
RMS current measurements	
Vφ-φ Magnitude	
Vφ-φ Phase Angle	
Vφ Magnitude	
Vφ Phase Angle	All phase-phase and phase-neutral voltages (φ = A, B. C)
VN Derived Mag.	
VN Derived Ang.	
V1 Magnitude.	
V2 Magnitude	
V0 Magnitude	
Vφ RMS	All phase-neutral voltages (φ = A, B, C)
Frequency	
C/S Voltage Mag.	
C/S Voltage Ang.	
C/S Bus-line Ang.	
Slip Frequency	
IM Magnitude	IM Phase Angle
I1 Magnitude	I1 Phase Angle
I2 Magnitude	I2 Phase Angle
I0 Magnitude	I0 Phase Angle
V1 Magnitude	V1 Phase Angle
V2 Magnitude	V2 Phase Angle
V0 Magnitude	V0 Phase Angle

19.2 Measurements 2

φ Phase Watts	
φ Phase VArs	
φ Phase VA	All phase segregated power measurements, real, reactive and apparent (φ = A, B, C).
3 Phase Watts	
3 Phase VArs	
3 Phase VA	
Zero Seq Power	
3Ph Power Factor	

φPh Power Factor	Independent power factor measurements for all three phases (φ = A, B, C).
3Ph WHours Fwd	
3Ph WHours Rev	
3Ph VArHours Fwd	
3Ph VArHours Rev	
3Ph W Fix Demand	
3Ph VArs Fix Dem	
Iφ Fixed Demand	Maximum demand currents measured on a per phase basis (φ = A, B, C).
3Ph W Roll Dem	
3Ph VArs Roll Dem	
Iφ Roll Demand	Maximum demand currents measured on a per phase basis (φ = A, B, C).
3Ph W Peak Dem	
3Ph VAr Peak Dem	
Iφ Peak Demand	Maximum demand currents measured on a per phase basis (φ = A, B, C).
Reset Demand:	Yes/No

19.3 Measurements 3

Highest Phase I		
Thermal State		
Reset Thermal		
IREF Diff.		
IREF Bias		
Admittance		
Conductance		
Susceptance		
Admittance		
Conductance		
Susceptance		
I2/I1 Ratio		
SEF Power		
IA 2nd Harmonic	IB 2nd Harmonic	IC 2nd Harmonic
APh Sen Watts		
APh Sen Vars		
APh Power Angle		
Z1 Imp Mag	Z1 Imp Ang	
Phase A Imp Mag	Phase A Imp Ang	
Phase B Imp Mag	Phase B Imp Ang	
Phase C Imp Mag	Phase C Imp Ang	

19.4 Stage Statistics (Advanced)

StgX f+t Sta
StgX f+t Trip
StgX f+df/dt Trp
StgX df/dt+t Sta
StgX df/dt+t Trp
StgX f+Df/Dt Sta
StgX f+Df/Dt Trp
StgX Revn Date
(X = 1, 2, 3, 4, 5, 6, 7, 8, 9)

19.5 Circuit Breaker Monitoring Statistics

CB Operations

CB φ Operations

Circuit breaker operation counters on a per phase basis (φ = A, B, C).

Total Iφ Broken

Cumulative breaker interruption duty on a per phase basis (φ = A, B, C).

CB Operate Time

CB CONTROL

Total Re-closures

19.6 Fault Record Proforma

The following data is recorded for any relevant elements that operated during a fault, and can be viewed in each fault record.

Time & Date	
Event Text	
Event Value	
Select Fault:	[0...n]
Started Phase:	A/B/C
Tripped Phase:	A/B/C
Overcurrent	Start I> 123456 or Trip I> 123456
Neg. Seq. O/C	Start I2> 1234 or Trip I2> 1234
Broken Conductor Trip	
Earth Fault 1	Start IN1> 1234 or Trip IN1> 1234
Earth Fault 2	Start IN2> 1234 or Trip IN2> 1234
Sensitive E/F	Start ISEF> 1234 or Trip ISEF> 1234
Restricted E/F	Trip IREF>
Residual O/V NVD	Start VN> 1 2 or Trip VN> 1 2
Thermal Overload:	Alarm/Trip
Neg. Seq. O/V	V2> Start Trip
U/Voltage Start	V< 1 2 AB BC CA
U/Voltage Trip	V< 1 2 AB BC CA
O/Voltage Start	V> 1 2 AB BC CA
O/Voltage Trip	V> 1 2 AB BC CA
Underfrequency	Start F< 1234 or Trip F< 1234
Overfrequency	Start F> 1 2 or Trip F> 1 2
Overadmittance	YN> Start Trip
Overconductance	GN> Start Trip
Oversusceptance	BN> Start Trip
Breaker Fail:	CB Fail 1 2
Supervision	VTS/CTS/VCO/CLP
A/R State:	Trip 1/2/3/4/5
Advanced Freq. Protection	Start >123456789
Advanced Freq. Protection	Trip >123456789
Adv. F+df/dt Protection	Trip >123456789
Adv. df/dt Protection	Start >123456789
Adv. df/dt Protection	Trip >123456789
Adv. DelF/DelT Protection	Start >123456789
Adv. DelF/DelT Protection	Trip >123456789
Faulted Phase:	A/B/C

Start Elements:
Trip Elements: Binary data strings for fast polling of which protection elements started or tripped for the fault recorded.
Fault Alarms: Binary data strings for fast polling of alarms for the fault recorded.
Fault Time:
Active Group: 1/2/3/4
System Frequency: Hz
Fault Duration: s
CB Operate Time: s
Relay Trip Time: s
Fault Location: km/miles/Ω/%
The current magnitudes and phase angles stored before the fault inception.
Iφ
Vφ:
Per phase record of the current and voltage magnitudes during the fault.
IN Measured
IN Derived
IN Sensitive
IREF Diff.
IREF Bias
VAN
VBN
VCN
VN Derived
Admittance
Conductance
Susceptance

GETTING STARTED

CHAPTER 3

Date:	07/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142 & P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

CONTENTS

TABLES

FIGURES

1 INTRODUCTION TO THE RELAY

Warning **Before carrying out any work on the equipment, you should be familiar with the contents of the latest issue of the Safety Guide, Safety Information and Technical Data chapters and the equipment rating label(s).**

1.1 User Interfaces and Menu Structure

The settings and functions of the MiCOM protection relay can be accessed both from the front panel keypad and LCD, and via the front and rear communication ports. Information on each of these methods is given in this section to describe how to start using the relay.

1.2 Front Panel

The following figure shows the front panel of the relay; the hinged covers at the top and bottom of the front panel are shown open. An optional transparent front cover physically protects the front panel. With the cover in place, access to the user interface is read-only. Removing the cover allows access to the relay settings and does not compromise the protection of the product from the environment.

When editing relay settings, full access to the relay keypad is needed. To remove the front cover:

1. Open the top and bottom covers, then unclip and remove the transparent cover. If the lower cover is secured with a wire seal, remove the seal.
2. Using the side flanges of the transparent cover, pull the bottom edge away from the relay front panel until it is clear of the seal tab.
3. Move the cover vertically down to release the two fixing lugs from their recesses in the front panel.

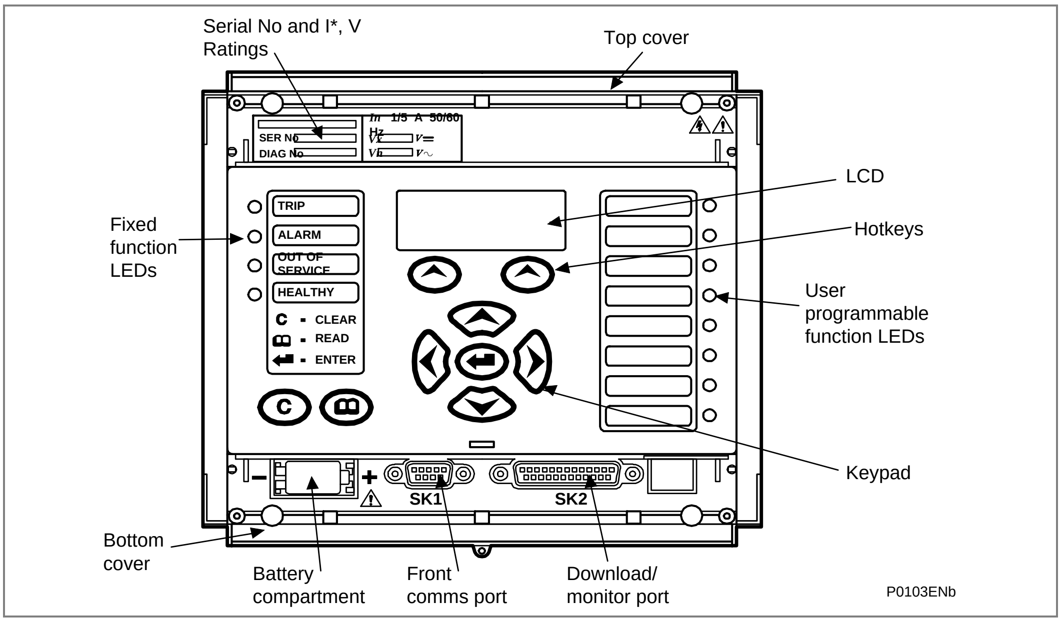


Figure 1 - Relay front view for P141/P142 models (40TE)

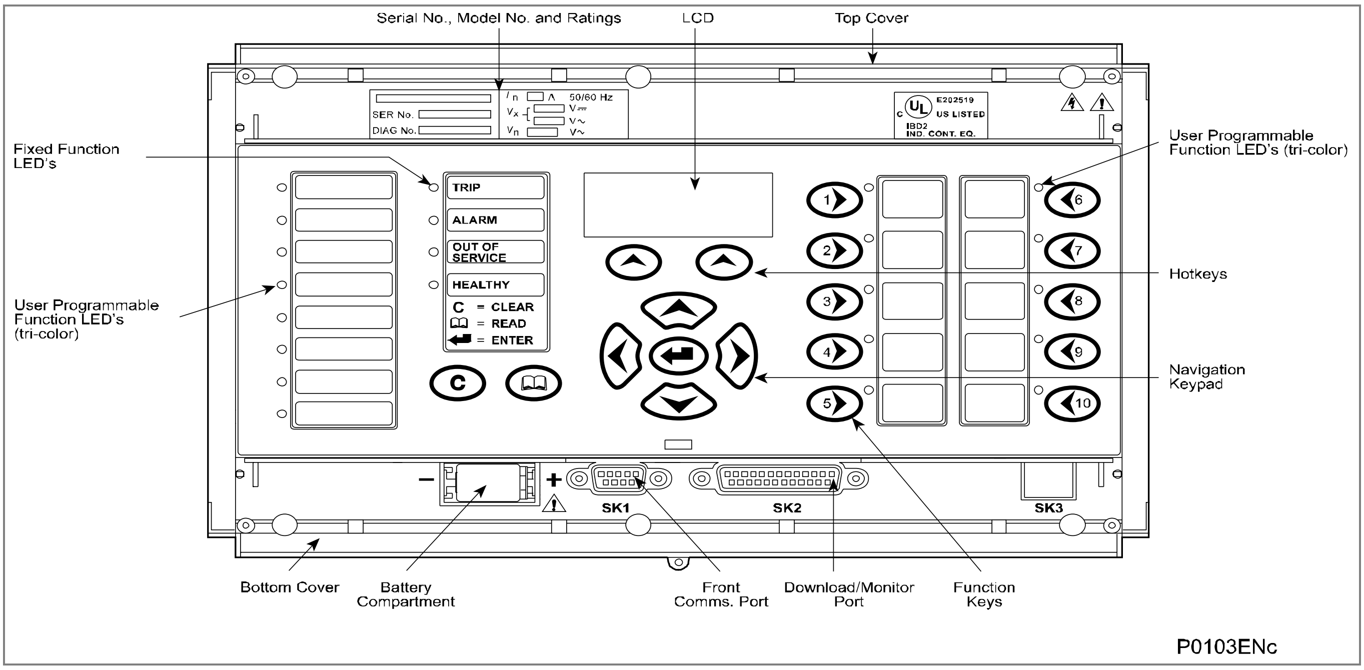


Figure 2 - Relay front view for P145 model (60TE)

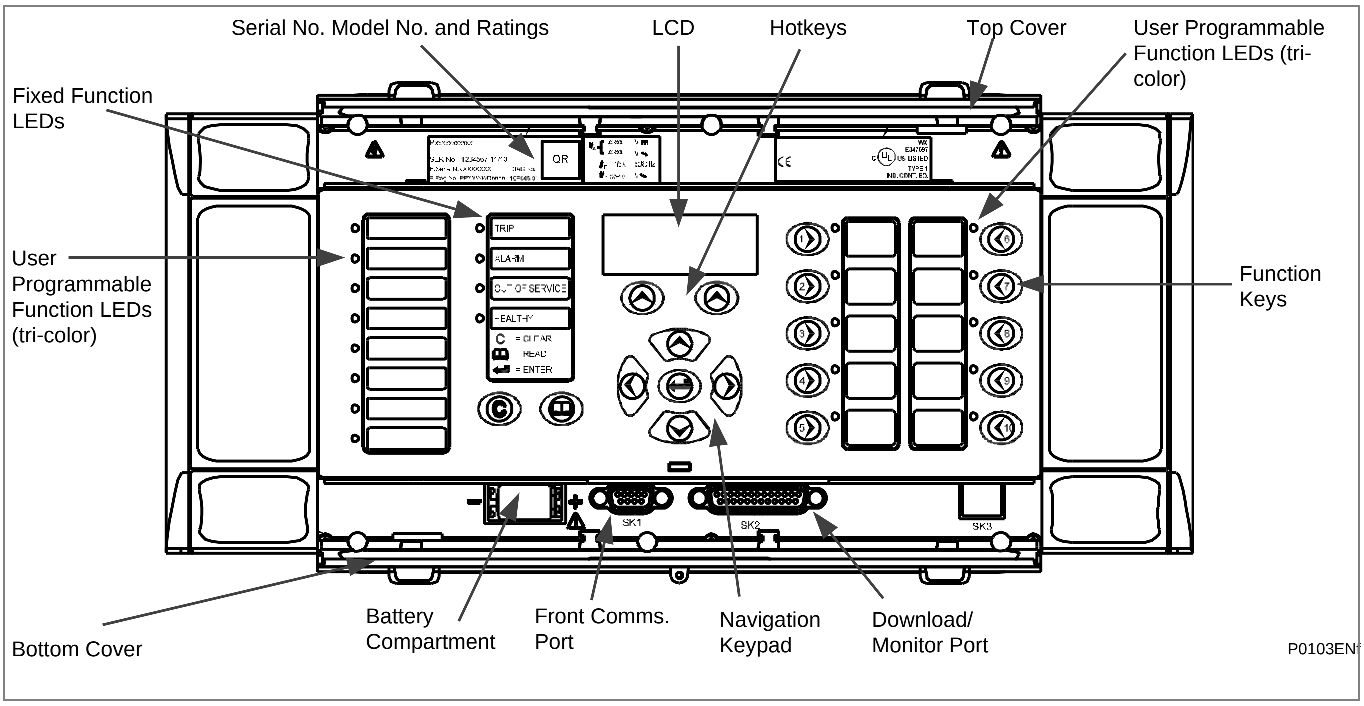


Figure 3 - Relay front view for P143 model (80TE)

The front panel of the relay includes the following, as shown in the previous figure:

- a 16-character by 3-line alphanumeric Liquid Crystal Display (LCD)
- a 19-key keypad comprising:
  - 4 arrow keys (◁ ▷ △ and ▽), an enter key (↵), a clear key (C), a read key (📖), 2 hot keys (7) and 10 (1 – 10) programmable function keys

Function key functionality (P145 model only):

- The relay front panel has control keys with programmable LEDs for local control. Factory default settings associate specific relay functions with these 10 direct-action keys and LEDs, e.g. Enable or Disable the auto-recloser function. Using programmable scheme logic, the user can change the default functions of the keys and LEDs to fit specific needs.
- Hotkey functionality:
  - **SCROLL** starts scrolling through the various default displays.
  - **STOP** stops scrolling the default display.

For control of setting groups, control inputs and circuit breaker operation

- P141/P142/P143 models: 12 LEDs; 4 fixed function LEDs on the left-hand side of the front panel and 8 programmable function LEDs on the right hand side
- P145 model: 22 LEDs; 4 fixed function LEDs, 8 tri-color programmable function LEDs on the left hand side of the front panel and 10 tri-color programmable function LEDs on the right hand side associated with the function keys

Under the top hinged cover:

- The relay serial number, and the relay's current and voltage rating information

Under the bottom hinged cover:

- Battery compartment to hold the 1/2 AA size battery which is used for memory back-up for the real time clock, event, fault and disturbance records
- A 9-pin female D-type front port for communication with a PC locally to the relay (up to 15m distance) via an EIA(RS)232 serial data connection
- A 25-pin female D-type port providing internal signal monitoring and high speed local downloading of software and language text via a parallel data connection

1.2.1 LED Indications

1.2.1.1 Fixed Function

The Fixed Function LEDs on the left-hand side of the front panel show these conditions:

- **Trip (Red)** switches ON when the relay issues a trip signal. It is reset when the associated fault record is cleared from the front display. Also the trip LED can be configured as self-resetting.
- **Alarm (Yellow)** flashes when the relay registers an alarm. This may be triggered by a fault, event or maintenance record. The LED flashes until the alarms have been accepted (read), then changes to constantly ON. When the alarms are cleared, the LED switches OFF.
- **Out of Service (Yellow)** is ON when the relay is not fully operational.
- **Healthy (Green)** is ON when the relay is in correct working order, and should be ON at all times. It goes OFF if the relay's self-tests show there is an error in the relay's hardware or software. The state of the healthy LED is reflected by the watchdog contacts at the back of the relay.

To adjust the LCD contrast, from the **CONFIGURATION** column, select **LCD Contrast**. This is only needed in very hot or cold ambient temperatures.

1.3 Relay Rear Panel

Examples of the rear panel of the relay are shown in the following figure. All current and voltage signals, digital logic input signals and output contacts are connected at the rear of the relay. Also connected at the rear is the twisted pair wiring for the rear EIA(RS)485 communication port; the IRIG-B time synchronising input is optional, the Ethernet rear communication board with copper and fiber optic connections or the second communication are optional.

Refer to the wiring diagrams in the 'Connection Diagrams' chapter for further details.

Note	*Figure 4 shows the IRIG-B time synchronizing input.* *Figure 5 shows the relay with optional Ethernet rear communications port with copper and fiber optic connections.*

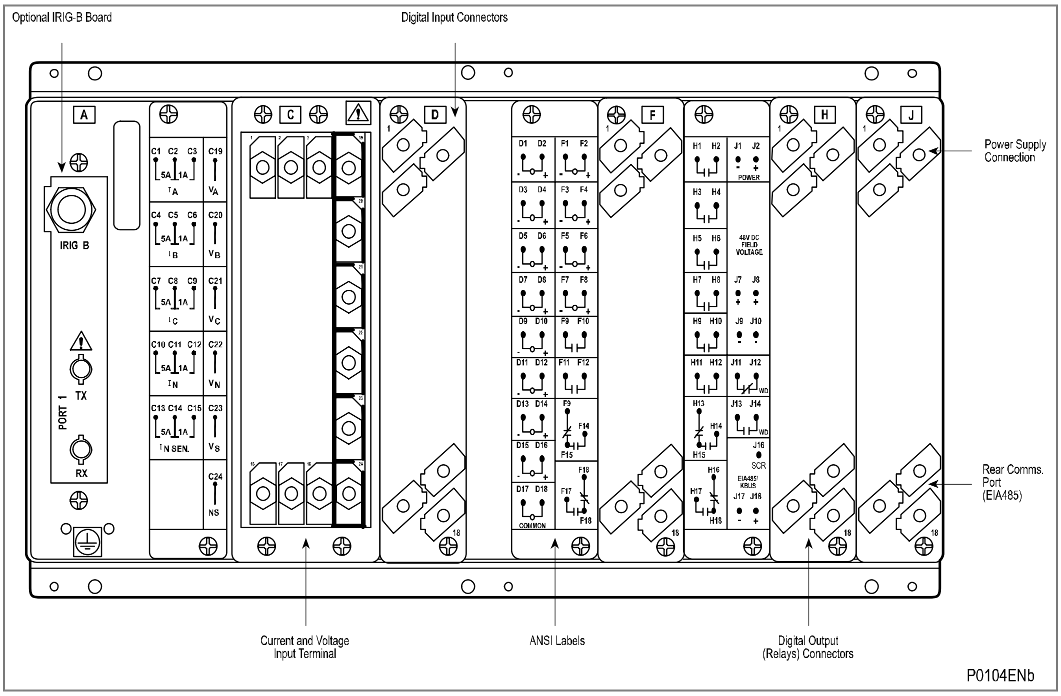


Figure 4 - IRIG-B time synchronizing input

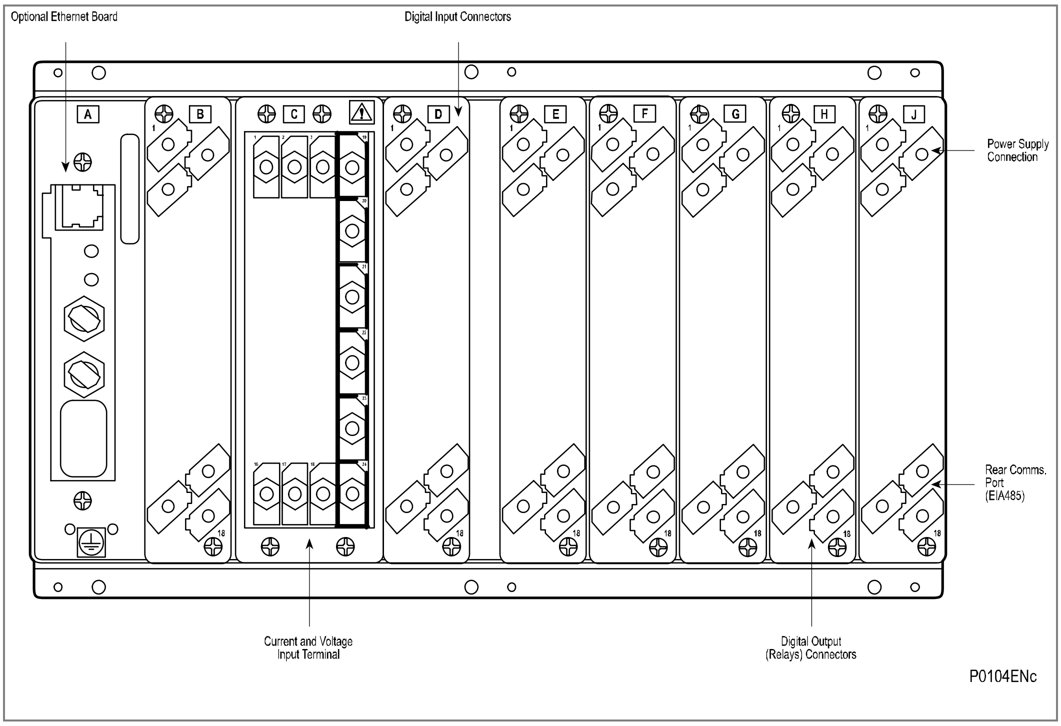


Figure 5 - Optional Ethernet rear comms port with copper & fiber optic connections

1.4 Relay Connection and Power-Up

Before powering-up the relay, confirm that the relay power supply voltage and nominal ac signal magnitudes are appropriate for your application. The relay serial number, and the relay's current and voltage rating, power rating information can be viewed under the top hinged cover. The relay is available in the auxiliary voltage versions shown in this table:

Nominal Ranges		Operative Ranges	
dc	ac	dc	ac
24 – 32 V dc	-	19 - 38 V dc	-
48 – 110 V dc	-	37 - 150 V dc	-
110 – 250 V dc **	100 – 240 V ac rms **	87 - 300 V dc	80 - 265 V ac
** rated for ac or dc operation			

Table 1 - Nominal and Operative dc and ac Ranges

Please note that the label does not specify the logic input ratings. These relays are fitted with universal opto isolated logic inputs that can be programmed for the nominal battery voltage of the circuit of which they are a part. See 'Universal Opto input' in the Product Design (Firmware) section for more information on logic input specifications.

Note *The opto inputs have a maximum input voltage rating of 300V dc at any setting.*

Once the ratings have been verified for the application, connect external power capable of delivering the power requirements specified on the label to perform the relay familiarization procedures. Previous diagrams show the location of the power supply terminals - please refer to the ***Installation*** and ***Connection Diagrams*** chapters for all the details, ensuring that the correct polarities are observed in the case of dc supply.

2 USER INTERFACES AND SETTINGS OPTIONS

The relay has these user interfaces:

- The front panel using the LCD and keypad
- The front port which supports Courier communication
- The rear port which supports one of these protocols:
  - Courier
  - MODBUS
  - IEC 60870-5-103
  - DNP3.0
- The optional Ethernet port supports IEC 61850-8-1 and DNP3.0
- A second optional rear port which supports Courier, KBUS or InterMiCOM communication
- A third optional rear port(SK5) which supports InterMiCOM for P14x products

The protocol for the rear port must be specified when the relay is ordered.

The measurement information and relay settings that can be accessed from the different interfaces are shown in this table.

	Keypad or LCD	Courier	MODBUS	IEC870-5-103	DNP3.0	IEC61850
Display & modification of all settings	Yes	Yes	Yes			
Digital I/O signal status	Yes	Yes	Yes	Yes	Yes	Yes
Display/extraction of measurements	Yes	Yes	Yes	Yes	Yes	Yes
Display/extraction of fault records	Yes	Yes	Yes	Yes	Yes	Yes
Extraction of disturbance records		Yes	Yes	Yes		Yes
Programmable scheme logic settings		Yes				
Reset of fault & alarm records	Yes	Yes	Yes	Yes	Yes	Yes
Clear event, fault & disturbance records	Yes	Yes	Yes		Yes	
Time synchronization		Yes	Yes	Yes	Yes	Yes
Control commands	Yes	Yes	Yes	Yes	Yes	Yes

Table 2 - Measurement information and relay settings

3 MENU STRUCTURE

The relay's menu is arranged in a table. Each setting in the menu is referred to as a cell, and each cell in the menu may be accessed using a row and column address. The settings are arranged so that each column contains related settings, for example all the disturbance recorder settings are contained within the same column. As shown in the following diagram, the top row of each column contains the heading that describes the settings contained within that column. Movement between the columns of the menu can only be made at the column heading level.

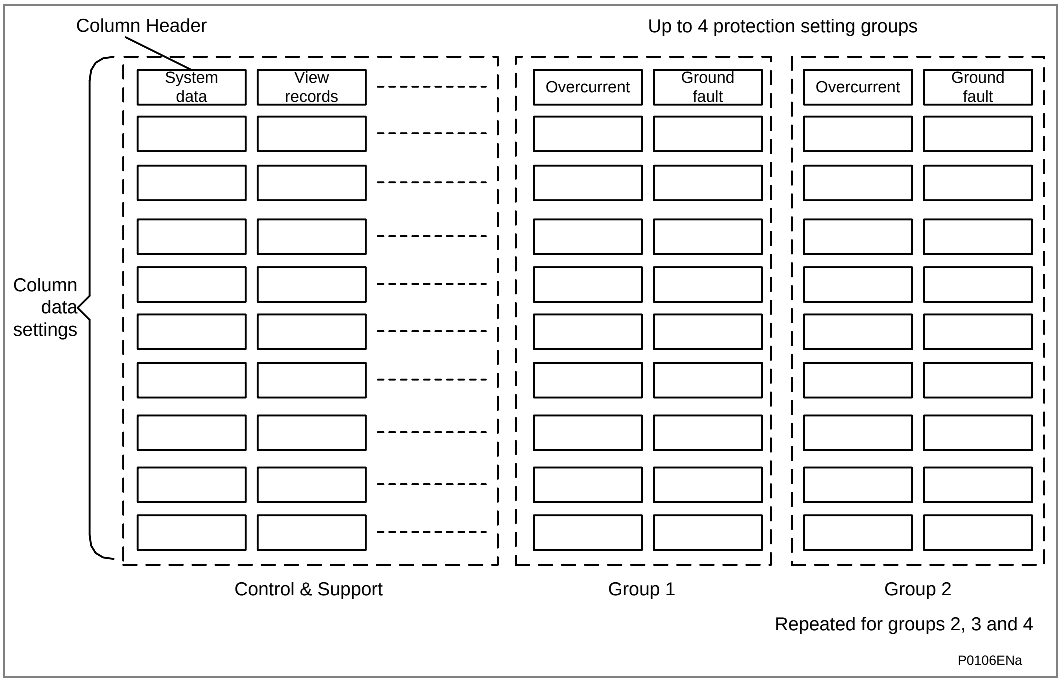


Figure 6 - Menu structure

The settings in the menu fall into one of these categories:

- Protection Settings
- Disturbance Recorder settings
- Control and Support (C&S) settings.

Different methods are used to change a setting depending on which category the setting falls into.

- C&S settings are stored and used by the relay immediately after they are entered.
- For either protection settings or disturbance recorder settings, the relay stores the new setting values in a temporary 'scratchpad'. It activates all the new settings together, but only after it has been confirmed that the new settings are to be adopted. This technique is employed to provide extra security, and so that several setting changes that are made within a group of protection settings will all take effect at the same time.

3.1 Protection Settings

The protection settings include the following items:

- Protection element settings
- Scheme logic settings
- Auto-reclose and check synchronization settings
- Fault locator settings

There are four groups of protection settings, with each group containing the same setting cells. One group of protection settings is selected as the active group, and is used by the protection elements.

3.2 Disturbance Recorder Settings

The Disturbance Recorder (DR) settings include the record duration and trigger position, selection of analogue and digital signals to record, and the signal sources that trigger the recording.

3.3 Control and Support Settings

The control and support settings include:

- Configuration settings
- Active setting group
- Password & language settings
- Communications settings
- Event & maintenance record settings
- User interface settings
- Commissioning settings

4 CYBER SECURITY

4.1 Cyber Security Settings

A detailed description of Schneider Electric Cyber Security features is provided in the *Cyber Security* chapter.

Important	***We would strongly recommend that you understand the contents of the Cyber Security chapter before you use any cyber security features or make any changes to the settings.***

Each MiCOM P40 IED includes a large number of possible settings. These settings are very important in determining how the device works.

A detailed description of the settings is given in the *Cyber Security* chapter.

4.2 Role Based Access Control (RBAC)

The Role Based Access Control (RBAC) is a method to restrict resource access to authorized users. RBAC is an alternative to traditional Mandatory Access Control (MAC) and Discretionary Access Control (DAC).

A key feature of RBAC model is that all access is through roles. A role is essentially a collection of permissions, and all users receive permissions only through the roles to which they are assigned, or through roles they inherit through the role hierarchy.

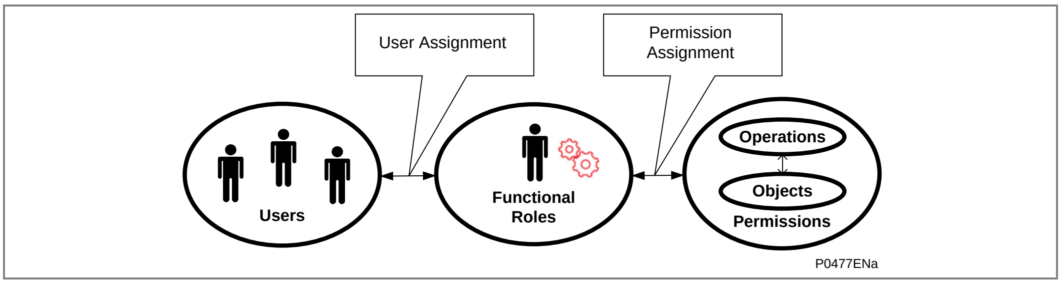


Figure 7 - RBAC Role structure

Roles are created for various job activities. The ***Permissions***, to perform certain operations, are assigned to specific roles. ***Users*** are assigned particular roles, and through those role assignments acquire the computer permissions to perform particular computer-system functions. Since ***users*** are not assigned permissions directly, but only acquire them through their role (or roles), management of individual user rights becomes a matter of simply assigning appropriate roles to the user's account; this simplifies common operations, such as adding a user, or changing user's account.

4.3 User Roles and Rights

Different named roles are associated with different access rights. Roles and Rights are setup in a pre-defined arrangement, according to the IEC62351 standard, but customized to the MiCOM Px4x equipment.

When the user tries to access an IED, they need to login using their own username and their own password. The username/password combination is then checked against the records stored on the IED. If they are allowed to login, a message appears which shows them what Role they have been assigned to. It is the role that defines their access to the relevant parts of the system.

In a similar way in which a set of pre-defined Roles have been created, a pre-defined set of Rights have been created.

These Rights give different permissions to look at what devices may be present, what those devices may contain, manage data within those devices (directly or by using files) and configure rights for other people.

5 RELAY CONFIGURATION

The relay is a multi-function device that supports numerous different protection, control and communication features. To simplify the setting of the relay, there is a configuration settings column which can be used to enable or disable many of the functions of the relay. The settings associated with any function that is disabled are made invisible, i.e. they are not shown in the menu. To disable a function change the relevant cell in the '**Configuration'** column from '**Enabled'** to '**Disabled'**.

The configuration column controls which of the protection settings groups is selected as active through the '**Active settings**' cell. A protection setting group can also be disabled in the configuration column, provided it is not the present active group. Similarly, a disabled setting group cannot be set as the active group.

6 FRONT PANEL USER INTERFACE (KEYPAD AND LCD)

When the keypad is exposed it provides full access to the menu options of the relay, with the information displayed on the LCD.

The ◁, ▷, △ and ▽ keys which are used for menu navigation and setting value changes include an auto-repeat function that comes into operation if any of these keys are held continually pressed. This can speed up both setting value changes and menu navigation; the longer the key is held depressed, the faster the rate of change or movement becomes.

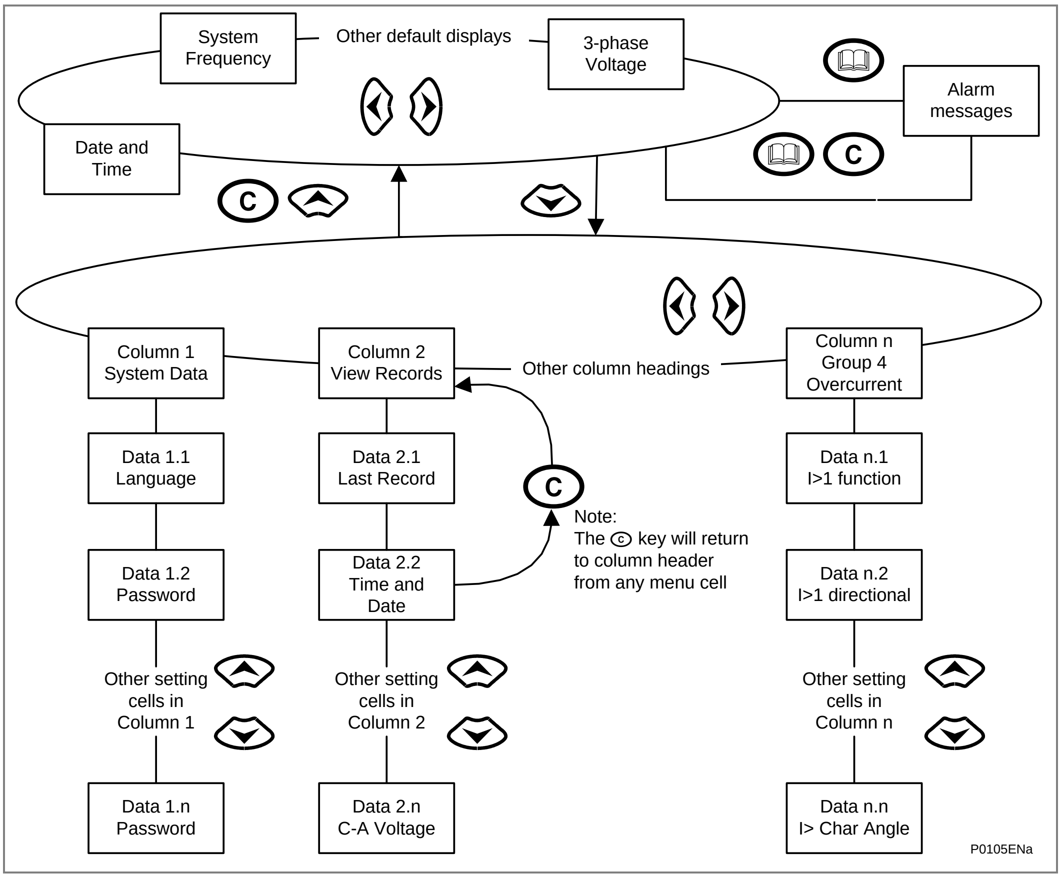


Figure 8 - Front panel user interface

6.1 Default Display and Menu Time-Out

The front panel menu has a default display. To change it, the Engineer Role will be required and the following items can be selected:

- Date and time
- Relay description (user defined)
- Plant reference (user defined)
- System frequency
- 3-phase voltage
- 3-phase and neutral current
- Power
- Access level

From the default display, the user can switch the default display to other default display items using the ◁ and ▷ keys. The default display will be saved as the last viewed items automatically. If the user tries to change the default display, Engineer Role will be requested (if the current access role is not that of an Engineer).

When user is browsing the relay menu structure with default access right, if there is no keypad activity for the 15 minutes (i.e. the timeout period), the default display will revert from the last viewed menu structure (can be any location from the menu structure) and the LCD backlight will turn off.

When user is logged in with Engineer Role, the menu timeout time may be shorter than 15 minutes. This depends on the value of inactive timer (e.g. if the inactive timer is set to shorter than 15 minutes). If menu timeout happens, any setting changes that have not been confirmed will be lost and the original setting values maintained.

Whenever there is an uncleared alarm present in the relay (e.g. fault record, protection alarm, control alarm etc.) the default display will be replaced by:

```
Alarms/Faults
Present
```

Entry to the menu structure of the relay is made from the default display and is not affected if the display is showing the Alarms/Faults present message.

6.2 Navigating Menus and Browsing Settings

Use the four arrow keys to browse the menu, following the menu structure shown above.

1. Starting at the default display, press the ▽ key to show the first column heading.
2. Use the ◁ and ▷ keys to select the required column heading.
3. Use the ▽ and △ keys to view the setting data in the column.
4. To return to the column header, either hold the △ key down or press the clear key Ⓒ once. It is only possible to move across columns at the column heading level.
5. To return to the default display, press the △ key or the clear key Ⓒ from any of the column headings. If you use the auto-repeat function of the △ key, you cannot go straight to the default display from one of the column cells because the auto-repeat stops at the column heading.
6. Press the △ key again to go to the default display.

6.3 Navigating the Hotkey Menu

To access the hotkey menu from the default display:

1. Press the key directly below the **HOTKEY** text on the LCD.
2. Once in the hotkey menu, use the ◁ and ▷ keys to scroll between the available options, then use the hotkeys to control the function currently displayed.
   If neither the ◁ or ▷ keys are pressed within 20 seconds of entering a hotkey sub menu, the relay reverts to the default display.
3. Press the clear key Ⓒ to return to the default menu from any page of the hotkey menu.

The layout of a typical page of the hotkey menu is as follows:

- The top line shows the contents of the previous and next cells for easy menu navigation
- The center line shows the function
- The bottom line shows the options assigned to the direct access keys

The functions available in the hotkey menu are listed in the following sections.

6.3.1.1 Setting Group Selection

The user can either scroll using <<NXT GRP>> through the available setting groups or <<SELECT>> the setting group that is currently displayed.

When the SELECT button is pressed a screen confirming the current setting group is displayed for 2 seconds before the user is prompted with the <<NXT GRP>> or <<SELECT>> options again. The user can exit the sub menu by using the left and right arrow keys.

For more information on setting group selection refer to “Setting group selection” section in the Operation chapter.

6.3.1.2 Control Inputs - User Assignable Functions

The number of control inputs (user assignable functions – USR ASS) represented in the hotkey menu is user configurable in the “CTRL I/P CONFIG” column. The chosen inputs can be SET/RESET using the hotkey menu.

For more information refer to the “Control Inputs” section in the Operation chapter.

6.4 How to Login

The password entry method varies slightly between CSL0 and CSL1 Versions.

6.4.1 Local Default Access

In CSL0 models the user can access the relay menu without the need to login.
In CSL1 models this can be enabled/disabled using SAT.
If the Local Default Access is enabled, the user may login to the front panel with associated roles.

See Table 3 for the applied cases.

6.4.2 Auto Login

Auto login means the user will login the IED automatically and no need to select the user name and enter the password. In this case, the user will be authorized with relevant rights. The auto login will be applied in these cases:

CS Version	Interface	RBAC/PW Cases	Login Process
CSL1	Front panel	Factory RBAC	Auto login with **EngineerLevel**
		Customized RBAC	Local Default Access Enabled: Login with **Local Default Access** Local Default Access Disabled: Login with **Prompt User List**
	Courier Interface	All cases	Login with **Prompt User List**
CSL0	Front panel	Factory RBAC	Auto login with **EngineerLevel**
		Password changed	**EngineerLevel** password is “AAAA” or is disabled/blank: Auto login with **EngineerLevel** **OperatorLevel** password is “AAAA” or is disabled/blank: Auto login with **OperatorLevel** **EngineerLevel** and **OperatorLevel** password changed: Auto login with **ViewerLevel Access**
	Courier Interface	Factory RBAC	Auto login with **EngineerLevel**
		Password changed	**EngineerLevel** password is “AAAA” or is disabled/blank: Auto login with **EngineerLevel** **OperatorLevel** password is “AAAA” or is disabled/blank: Auto login with **OperatorLevel** **EngineerLevel** and **OperatorLevel** password changed: Login with **Prompt User List**

Table 3 – Auto Login process

For more details about the Factory RBAC, please refer to the Cyber Security chapter.

6.4.3 Login with Prompt User List

This login process will happen if:

- The Auto login process is not applied.
- Or high authorization is required for the current operation.

In this case, the IED will prompt the user list, and the user needs to select proper user name and enter the password to login.

6.5 Reading and Clearing of Alarm Messages and Fault Records

One or more alarm messages appear on the default display and the yellow alarm LED flashes. The alarm messages can either be self-resetting or latched, in which case they must be cleared manually.

1. To view the alarm messages, press the read key. When all alarms have been viewed but not cleared, the alarm LED change from flashing to constantly ON and the latest fault record appears (if there is one).
2. Scroll through the pages of the latest fault record, using the key. When all pages of the fault record have been viewed, the following prompt appears.

```
Press clear to
reset alarms
```

3. To clear all alarm messages, press. To return to the display showing alarms or faults present, and leave the alarms uncleared, press.
4. Depending on the password configuration settings, you may need to enter a password before the alarm messages can be cleared. See the ***How to Access the IED/Relay*** section.
5. When all alarms are cleared, the yellow alarm LED switches OFF; also the red trip LED switches OFF if it was switched ON after a trip.
6. To speed up the procedure, enter the alarm viewer using the key, then press the key. This goes straight to the fault record display. Press again to move straight to the alarm reset prompt, then press again to clear all alarms.

6.6 Setting Changes

1. To change the value of a setting, go to the relevant cell in the menu, then press the enter key to change the cell value. A flashing cursor on the LCD shows the value can be changed. If a password is required to edit the cell value, a password prompt appears.
2. To change the setting value, press the or keys. If the setting to be changed is a binary value or a text string, select the required bit or character to be changed using the and keys.
3. Press to confirm the new setting value or the clear key to discard it. The new setting is automatically discarded if it is not confirmed in 15 minutes.
4. For protection group settings and disturbance recorder settings, the changes must be confirmed before they are used by the relay.
5. To do this, when all required changes have been entered, return to the column heading level and press the key. Before returning to the default display, the following prompt appears.

```
Update settings?
Enter or clear
```

6. Press to accept the new settings or press to discard the new settings.

Note	*If the menu time-out occurs before the setting changes have been confirmed, the setting values are also discarded.*

Control and support settings are updated immediately after they are entered, without the **Update settings**? prompt.

6.7 How to Logout (at the Front Panel)

If you have been configuring the IED, you should 'log out'. You do this by going up to the top of the menu tree. When you are at the default display level and you press the Cancel button, you may be prompted to log out with this display:

```
ENTER TO LOG OUT
CLEAR TO CANCEL
```

You will only be asked this question if your password level is higher than the fallback level.

If you confirm, the following message is displayed for 2 seconds:

```
LOGGED OUT
Access Level <x>
```

Where x is the current fallback level.

If you decide not to log out (i.e. you cancel), the following message is displayed for 2 seconds.

```
LOGOUT CANCELLED
Access Level <x>
```

Where x is the current access level.

7 FRONT COMMUNICATION PORT USER INTERFACE

The front communication port is provided by a 9-pin female D-type connector located under the bottom hinged cover. It provides EIA(RS)232 serial data communication and is intended for use with a PC locally to the relay (up to 15m distance) as shown in the following diagram. This port supports the Courier communication protocol only. Courier is the communication language developed by Schneider Electric to allow communication with its range of protection relays. The front port is particularly designed for use with the relay settings program Easergy Studio.

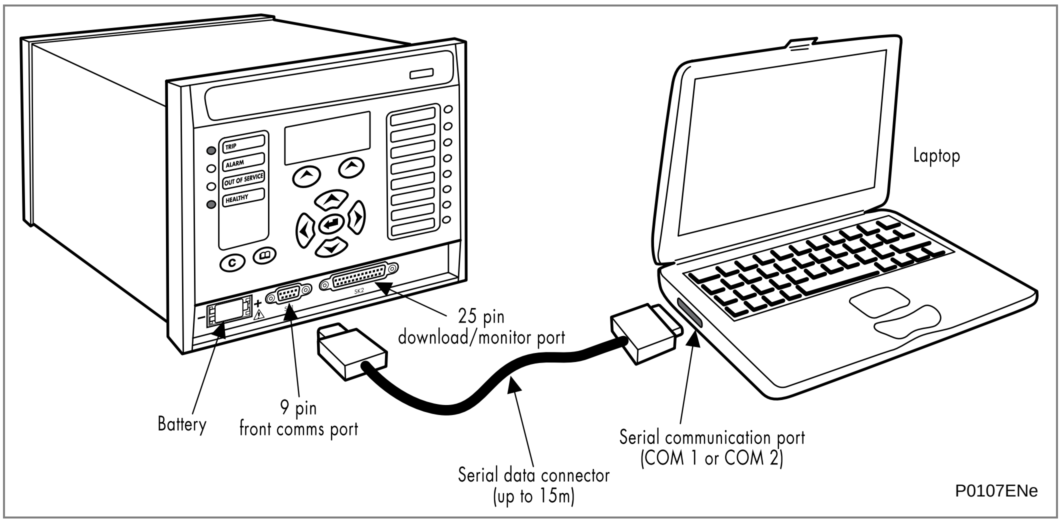


Figure 9 - Front port connection

The IED is a Data Communication Equipment (DCE) device. The pin connections of the 9-pin front port are as follows:

Pin no.	Description
2	Tx Transmit data
3	Rx Receive data
5	0V Zero volts common

Table 4 - 9-pin front port connections

None of the other pins are connected in the relay. The relay should be connected to the serial port of a PC, usually called COM1 or COM2. PCs are normally Data Terminal Equipment (DTE) devices which have a serial port pin connection as below (if in doubt check your PC manual):

Pin	25 Way	9 Way	Description
Pin no. 2	3	2	Rx Receive data
Pin no. 3	2	3	Tx Transmit data
Pin no. 5	7	5	0V Zero volts common

Table 5 - 25-way and 9-way serial pin connections

For successful data communication, the Tx pin on the relay must be connected to the Rx pin on the PC, and the Rx pin on the relay must be connected to the Tx pin on the PC, as shown in the diagram. Therefore, providing that the PC is a DTE with pin connections as given above, a ‘straight through’ serial connector is required, i.e. one that connects pin 2 to pin 2, pin 3 to pin 3, and pin 5 to pin 5.

Note	*A common cause of difficulty with serial data communication is connecting Tx to Tx and Rx to Rx. This could happen if a ‘cross-over’ serial connector is used, i.e. one that connects pin 2 to pin 3, and pin 3 to pin 2, or if the PC has the same pin configuration as the relay.*

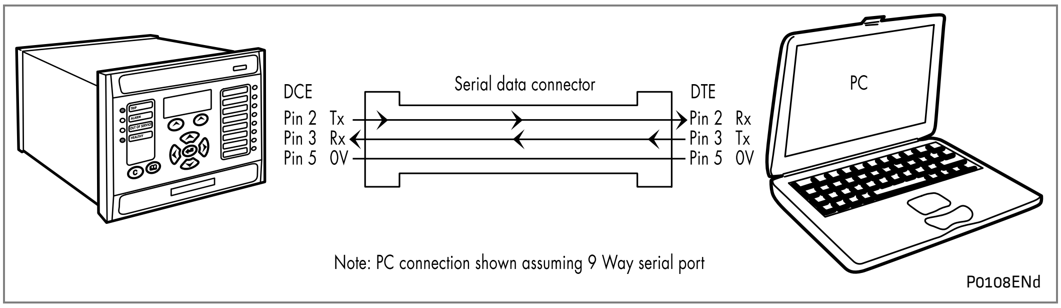


Figure 10 - PC - relay signal connection

Having made the physical connection from the relay to the PC, the PCs communication settings must be configured to match those of the relay. The relays communication settings for the front port are fixed as shown below:

Protocol	Baud rate	Courier address	Message format
Courier	19,200 bits/s	1	11 bit - 1 start bit, 8 data bits, 1 parity bit (even parity), 1 stop bit

Table 6 - Communication settings for front port

The inactivity timer for the front port is set at 15 minutes. This controls how long the relay will maintain its password access on the front port. If no messages are received on the front port for 15 minutes then any password access that has been enabled will be revoked.

7.1 Front Courier Port

The front EIA(RS)232 9-pin port supports the Courier protocol for one to one communication.

Note	*The front port is actually compliant to EIA(RS)574; the 9-pin version of EIA(RS)232, see www.tiaonline.org.*

The front port is designed for use during installation and commissioning/maintenance and is not suitable for permanent connection. Since this interface will not be used to link the relay to a substation communication system, some of the features of Courier are not implemented. These are as follows:

- Automatic Extraction of Event Records:
  - Courier Status byte does not support the Event flag
  - Send Event/Accept Event commands are not implemented
- Automatic Extraction of Disturbance Records:
  - Courier Status byte does not support the Disturbance flag
- Busy Response Layer: Courier Status byte does not support the Busy flag, the only response to a request will be the final data
- Fixed Address: The address of the front courier port is always 1, the Change Device address command is not supported.
- Fixed Baud Rate: 19200 bps

Note	*Although automatic extraction of event and disturbance records is not supported, this data can be manually accessed using the front port.*

8 EASERGY STUDIO COMMUNICATIONS BASICS

The EIA(RS)232 front communication port is particularly designed for use with the relay settings program Easergy Studio. Easergy Studio is the universal MiCOM IED Support Software and provide users a direct and convenient access to all stored data in any MiCOM IED using the EIA(RS)232 front communication port.

Easergy Studio provides full access to MiCOM Px10, Px20, Px30, Px40 and Mx20 measurements units.

The Easergy Studio product is updated periodically. These updates provide support for new features (such as allowing you to manage new MiCOM products, as well as using new software releases and hardware suffixes). The updates may also include fixes. **Accordingly, we strongly advise customers to use the latest Schneider Electric version of Easergy Studio.**

8.1 PC Requirements

The minimum and recommended hardware requirements for Easergy Studio (v7.0.0) are shown below. These include the Studio application and other tools which are included: UPCT, P746 RHMI, P74x Topology Tool:

Minimum requirements:				
Platform	**Processor**	**RAM**	**HDD (Note 1 & 3)**	**HDD (Note 2 & 3)**
Windows XP x86	1 GHz	512 MB	900 MB	1.5 GB
Windows 7 x86	1 GHz	1 GB	900 MB	1.9 GB
Windows 7 x64	1 GHz	2 GB	900 MB	2.1 GB
Windows Server 2008 x86 Sp1	1 GHz	512 MB	900 MB	1.7 GB

Recommended requirements:				
Platform	**Processor**	**RAM**	**HDD (Note 1 & 3)**	**HDD (Note 2 & 3)**
Windows XP x86	1 GHz	1 GB	900 MB	1.5 GB
Windows 7 x86	1 GHz	2 GB	900 MB	1.9 GB
Windows 7 x64	1 GHz	4 GB	900 MB	2.1 GB
Windows Server 2008 x86 Sp1	1 GHz	4 GB	900 MB	1.7 GB

Note 1	*Operating system with Windows Updates updated on 2015/05.*
Note 2	*Operating system without Windows Updates installed.*
Note 3	*Both configurations do not include Data Models HDD requirements. Data Models typically need from 1 GB to 15 GB of hard disk space.*

Screen resolution for minimum requirements: Super VGA (800 x 600).
Screen resolution for recommended requirements: XGA (1024x768) and higher.
Easergy Studio must be started with Administrator privileges.

Easergy Studio Additional components

The following components are required to run Easergy Studio and are installed by its installation package.

Component Type	Component
Package	.NET Framework 2.0 SP 1 (x64)
Package	.NET Framework 2.0 SP 1 (x86)
Package	.NET Framework 4.0 Client (x64)
Package	.NET Framework 4.0 Client (x86)
Package	Visual C++ 2005 SP1 Redistributable Package (x86)
Package	Visual C++ 2008 SP1 Redistributable Package (x86)
Merge modules	DAO 3.50
Merge modules	MFC 6.0
Merge modules	MFC Unicode 6.0
Merge modules	Microsoft C Runtime Library 6.0
Merge modules	Microsoft C++ Runtime Library 6.0
Merge modules	Microsoft Component Category Manager Library
Merge modules	Microsoft Data Access Components 2.8 (English)
Merge modules	Microsoft Jet Database Engine 3.51 (English)
Merge modules	Microsoft OLE 2.40 for Windows NT and Windows 95
Merge modules	Microsoft Visual Basic Virtual Machine 6.0
Merge modules	MSXML 4.0 - Windows 9x and later
Merge modules	MSXML 4.0 - Windows XP and later
Merge modules	Visual C++ 8.0 MFC (x86) WinSXS MSM
Merge modules	Visual C++ 8.0 MFC.Policy (x86) WinSXS MSM

8.2 Connecting to the Relay using Easergy Studio

This section is a quick start guide to using Easergy Studio and assumes this is installed on your PC. See the Easergy Studio online help for more detailed information.

1. Make sure the EIA(RS)232 serial cable is properly connected between the port on the front panel of the relay and the PC.
2. To start Easergy Studio, select **Start** > **All apps** > **Schneider Electric** > **Easergy Studio**.
3. Click the **Quick Connect** tab and select **Create a New System**.
4. Check the **Path to System file** is correct, then enter the name of the system in the **Name** field. To add a description of the system, use the **Comment** field.
5. Click **OK**.
6. Select the device type.
7. Select the communications port, and open a connection with the device.
8. Once connected, select the language for the settings file, the device name, then click **Finish**. The configuration is updated.
9. In the **Studio Explorer** window, select **Device** > **Supervise Device**… to control the relay directly. (User Login necessary)

8.3 Off-Line Use of Easergy Studio

Easergy Studio can also be used as an off-line tool to prepare settings, without access to the relay.

1. If creating a new system, in the Studio Explorer, select **create new** system. Then right-click the new system and select **New substation**.
2. Right-click the new substation and select **New voltage level**.
3. Then right-click the new voltage level and select **New bay**.
4. Then right-click the new bay and select **New device**.

   You can add a device at any level, whether it is a system, substation, voltage or bay.
5. Select a device type from the list, then enter the relay type. Click **Next**.
6. Enter the full model number and click **Next**.
7. Select the **Language** and **Model**, then click **Next**.
8. If the IEC61850 protocol is selected, and an Ethernet board with hardware option Q, R or S is selected, select IEC 61850 Edition:
   IEC 61850 Edition 2 Mode or
   IEC 61850 Edition 1 Compatible Mode.
9. Enter a unique device name, then click **Finish**.
10. Right-click the **Settings** folder and select **New File**. A default file **000** is added.
11. Right-click file **000** and select click **Open**. You can then edit the settings. See the Easergy Studio program online help for more information.

9 USER PROGRAMMABLE CURVE TOOL (UPCT) OPTION

The User Programmable Curve Tool (UPCT) allows the creation of user defined curves and flexible download and upload of these curves into/from the MiCOM Px4x relays. This tool can be used to create user programmable over current operating and reset curves. For example, its user friendly Graphical User Interface (GUI) allows easy creation and visualization of curves either by inputting a formula or data points.

9.1 Supporting Software Versions

The UPCT is supported for the following products:

Relay Type	Product	Software Version
Feeder Management relays	P14x	46 onwards
Motor Protection relays	P24x	57 onwards

Table 7 - UPCT supported products

9.2 Application Advantages of User Programmable Curves

- Provide specific protection characteristics of Customer schemes
- Match more closely to the withstand characteristics for electrical equipment than standard curves.
- Provide compatibility with older relays and different manufacturers relays for retrofit / refurbishment.
- Data can be exported for protection grading and testing purposes.

9.3 Main Features and Overview of User Configurable Curve Tool

- Allows the user to create new configuration curve files or edit existing curve files
- Allows the user to enter a defined number of curve points (up to 256 points) or a user defined formula.
- Allows the user to create and save multiple formulae
- Allows the user defined curve to be associated with a predefined curve Px4x template.
- Allows interpolation between curve points
- Allows the user to save curve formulae in XML format and configured curve points in CSV format, suitable for download into the relay.
- Enables easy upload of the curve data from the relay.
- Allows the user to input formula constants with user defined values
- Allows the user to set a Definite Minimum Time (DMT) in the formula defined curves
- Graphically displays curves with zoom, pan User and point on curve facilities.
- Color coding of multiple curves enables effective comparison
- Allows the user to print curves or save curves in a range of standard image formats.

Please refer to the User Programmable Curve Tool Guide (Px4x/EN UPCT) for more information.

SETTINGS

CHAPTER 4

Date:	07/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142 & P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

CONTENTS

Page (ST) 4-

TABLES

Notes:

1 INTRODUCTION

The IED must be configured to the system and the application by means of appropriate settings.

The sequence in which the settings are listed and described in this chapter will be the protection setting, control and configuration settings and the disturbance recorder settings.

The IED is supplied with a factory-set configuration of default settings.

Important	**The following tables provide information about the different settings for this range of MiCOM products. Unless otherwise stated in these tables, the settings apply to the whole range of products covered by this manual. Where a setting applies to anything other than the whole range, the individual products to which it applies are listed accordingly.**

2 IED SETTINGS

The IED is a multi-function device that supports numerous different control and communication features. The settings associated with any function that is disabled are made invisible; i.e. they are not shown in the menu. To disable a function change the relevant cell in the '**Configuration'** column from '**Enabled'** to '**Disabled'**.

To simplify the setting of the IED, there is a configuration settings column, used to enable or disable many of the IED functions. The aim of the configuration column is to allow general configuration from a single point in the menu.

The configuration column controls which of the four settings groups is selected as active through the '**Active settings**' cell. A setting group can also be disabled in the configuration column, provided it is not the present active group. Similarly, a disabled setting group cannot be set as the active group.

The column also allows all of the setting values in one group of settings to be copied to another group.

To do this firstly set the '**Copy from**' cell to the setting group to be copied, then set the '**Copy to**' cell to the group where the copy is to be placed. The copied settings are initially placed in the temporary scratchpad, and will only be used by the IED following confirmation.

2.1 Restore Default Settings

To restore the default values to the settings in any protection settings group, set the 'restore defaults' cell to the relevant group number. Alternatively, it is possible to set the 'restore defaults' cell to 'all settings' to restore the default values to all of the IEDs settings, not just the protection groups' settings. The default settings will initially be placed in the scratchpad and will only be used by the IED after they have been confirmed.

Important	***Restoring defaults to all settings includes the rear communication port settings, which may result in communication via the rear port being disrupted if the new (default) settings do not match those of the master station.***

Important	***If you restore settings, the settings for the IEC 61850 Edition and the Communications Mode will not be restored, even if "Restore All Settings" is set.***

3 CONFIGURATION MENU

Menu Text	Col	Row	Default Setting	Available Settings
Description				
CONFIGURATION	09	00		
This column contains all the general configuration options				
Restore Defaults	09	01	No Operation	0 = No Operation, 1 = All Settings, 2 = Setting Group 1, 3 = Setting Group 2, 4 = Setting Group 3, 5 = Setting Group 4
Setting to restore a setting group to factory default settings. To restore the default values to the settings in any Group settings, set the ‘restore defaults’ cell to the relevant Group number. Alternatively it is possible to set the ‘restore defaults’ cell to ‘all settings’ to restore the default values to all of the IED’s settings, not just the Group settings. The default settings will initially be placed in the scratchpad and will only be used by the IED after they have been confirmed by the user. Note: Restoring defaults to all settings includes the rear communication port settings, which may result in communication via the rear port being disrupted if the new (default) settings do not match those of the master station.				
Setting Group	09	02	Select via Menu	0 = Select via Menu or 1 = Select via PSL
Allows setting group changes to be initiated via Opto Input or via Menu				
Active Settings	09	03	Group 1	0 = Group 1, 1 = Group 2, 2 = Group 3, 3 = Group 4
Selects the active setting group.				
Save Changes	09	04	No Operation	0 = No Operation, 1 = Save, 2 = Abort
Saves all IED settings.				
Copy From	09	05	Group 1	0 = Group 1, 1 = Group 2, 2 = Group 3, 3 = Group 4
Allows displayed settings to be copied from a selected setting group				
Copy To	09	06	No Operation	0 = No Operation, 1 = Group 1, 2 = Group 2, 3 = Group 3
Allows displayed settings to be copied to a selected setting group				
Setting Group 1	09	07	Enabled	0 = Disabled or 1 = Enabled
Settings Group 1. If the setting group is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this setting.				
Setting Group 2	09	08	Disabled	0 = Disabled or 1 = Enabled
Settings Group 2. If the setting group is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this setting.				
Setting Group 3	09	09	Disabled	0 = Disabled or 1 = Enabled
Settings Group 3. If the setting group is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this setting.				
Setting Group 4	09	0A	Disabled	0 = Disabled or 1 = Enabled
Settings Group 4. If the setting group is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this setting.				
System Config	09	0B	Invisible	0 = Invisible, 1 = Visible
Sets the System Config. menu visible further on in the relay settings menu.				
Overcurrent	09	10	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Phase Overcurrent Protection function. I> stages: ANSI 50/51/67				
Neg Sequence O/C	09	11	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Negative Sequence Overcurrent Protection function. I2> stages: ANSI 46/67				
Broken Conductor	09	12	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Broken Conductor function. I2/I1> stage: ANSI 46				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Earth Fault 1	09	13	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the back up Earth Fault Protection function. IN >stages: ANSI 50N/51N/67N				
Earth Fault 2	09	14	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the back up Earth Fault Protection function. IN >stages: ANSI 50N/51N/67N				
SEF/REF Prot'n SEF Protection	09	15	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Sensitive Earth Fault/Restricted Earth fault Protection function. ISEF >stages: ANSI 50N/51N/67N. IREF>stage: ANSI 64.				
Residual O/V NVD	09	16	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Residual Overvoltage Protection function. VN>stages: ANSI 59N				
Thermal Overload	09	17	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Thermal Overload Protection function. ANSI 49.				
Neg Sequence O/V	09	18	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Negative Sequence Over Voltage Protection function. V2> stages: ANSI 47				
Cold Load Pickup	09	19	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Cold Load Pickup protection: ANSI 50/51/67 50N/51N/67N				
Selective Logic	09	1A	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Selective logic element.				
Admit Protection	09	1B	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Admittance protection function.				
Power Protection	09	1C	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Power protection function.				
Volt Protection	09	1D	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Voltage Protection (under/overvoltage/remote) function. V<, V> stages: ANSI 27/59				
Freq Protection	09	1E	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Frequency Protection (under/over frequency) function. F<, F> stages: ANSI 81.				
CB Fail	09	20	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Circuit Breaker Fail Protection function: ANSI 50BF.				
Supervision	09	21	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Supervision (VTS & CTS) functions: ANSI 47/27/46.				
Fault Locator	09	22	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Fault Locator.				
System Checks	09	23	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the System Checks (Check Sync. and Voltage Monitor) function: ANSI 25.				
Auto-Reclose	09	24	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Auto-reclose function. ANSI 79.				
Input Labels	09	25	Visible	0 = Invisible, 1 = Visible
Sets the Input Labels menu visible further on in the IED setting menu.				
Output Labels	09	26	Visible	0 = Invisible, 1 = Visible
Sets the Output Labels menu visible further on in the IED setting menu.				
Adv. Freq Prot'n	09	27	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Advanced Frequency Protection function.				
CT & VT Ratios	09	28	Visible	0 = Invisible, 1 = Visible
Sets the Current & Voltage Transformer Ratios menu visible further on in the IED settings menu.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Record Control	09	29	Invisible	0 = Invisible, 1 = Visible
Sets the Record Control menu visible further on in the IED settings menu.				
Disturb Recorder	09	2A	Invisible	0 = Invisible, 1 = Visible
Sets the Disturbance Recorder menu visible further on in the IED settings menu.				
Measure't Setup	09	2B	Invisible	0 = Invisible, 1 = Visible
Sets the Measurement Setup menu visible further on in the IED settings menu.				
Comms Settings	09	2C	Visible	0 = Invisible, 1 = Visible
Sets the Communications Settings menu visible further on in the IED settings menu. These are the settings associated with the 1st and 2nd rear communications ports				
Commission Tests	09	2D	Visible	0 = Invisible, 1 = Visible
Sets the Commissioning Tests menu visible further on in the IED settings menu.				
Setting Values	09	2E	Primary	0 = Primary, 1 = Secondary
This affects all protection settings that are dependent upon CT and VT ratios. All subsequent settings input must be based in terms of this reference.				
Control Inputs	09	2F	Visible	0 = Invisible, 1 = Visible
Activates the Control Input status and operation menu further on in the IED setting menu.				
Ctrl I/P Config	09	35	Visible	0 = Invisible, 1 = Visible
Sets the Control Input Configuration menu visible further on in the IED setting menu.				
Ctrl I/P Labels	09	36	Visible	0 = Invisible, 1 = Visible
Sets the Control Input Labels menu visible further on in the IED setting menu.				
Direct Access	09	39	Enabled	0 = Disabled or 1 = Enabled
Defines what CB control direct access is allowed. The front direct access keys that are used as a short cut function of the menu may be: Disabled – No function visible on the LCD. Enabled – All control functions mapped to the Hotkeys and Control Trip/Close are available. Hotkey Only – Only control functions mapped to the Hotkeys are available on the LCD. CB Ctrl Only – Only Control Trip/Control Close command will appear on the IED’s LCD.				
InterMiCOM	09	40	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) InterMiCOM.				
PB CONFIG	09	48	Visible	0 = Invisible or 1 = Visible
Sets the PB CONFIG menu visible in the relay setting menu.				
Function Key	09	50	Visible	0 = Invisible, 1 = Visible
Sets the Function Key menu visible further on in the IED setting menu.				
VIR I/P Labels	09	70	Invisible	0 = Invisible, 1 = Visible
VIR I/P Labels Visible/Invisible				
VIR O/P Labels	09	80	Invisible	0 = Invisible, 1 = Visible
VIR O/P Labels Visible/Invisible				
USR ALARM LABELS	09	90	Invisible	0 = Invisible, 1 = Visible
USR Alarm Labels Visible/Invisible				
RP1 Read Only	09	FB	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) Read Only Mode of Rear Port 1.				
RP2 Read Only	09	FC	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) Read Only Mode of Rear Port 2.				
NIC Read Only	09	FD	Disabled	0 = Disabled or 1 = Enabled
Ethernet versions only. To enable (activate) or disable (turn off) Read Only Mode of Network Interface Card.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
SettingValueBeh.	09	FE	Independent	0 = Independent or 1 = Locked Mode
Independent: cell [092E] Setting Values will be independent in each interface. For example, the Front Port can have [092E] set to Secondary and a remote port can have [092E] set to Primary. Locked Mode: cell [092E] Setting Values are locked to the same value for all interfaces. All interfaces have the same value for [092E]. Whichever interface selects Locked Mode will have its setting for [092E] applied to all interfaces. Any interface can then change [092E] and it will apply on all interfaces.				
LCD Contrast	09	FF	11	0 to 31 step 1
Sets the LCD contrast.				

Table 1 - Relay Settings Configuration

4 PROTECTION SETTINGS

The grouped protection settings include all the following items that become active once enabled in the configuration column of the relay menu database:

- Protection element settings
- Programmable Scheme Logic (PSL) that also includes InterMiCOM signals mapping
- Protection Schemes
- Auto-reclose and check synchronization settings
- Fault locator settings.

There are four groups of protection settings, with each group containing the same setting cells. One group of protection settings is selected as the active group, and is used by the protection elements. Only the settings for group 1 are shown in this chapter. The settings are discussed in the same order in which they are displayed in the menu.

4.1 System Config (Group 1) Menu

A general system configuration menu is available which allows the phase rotation of the system to be specified, and the following column is available for each of the setting groups in the relay:

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 SYSTEM CONFIG	30	00		
This column contains settings for System Configuration				
Phase Sequence	30	02	Standard ABC	0=Standard ABC 1=Reverse ACB
This setting allows the phase rotation to be set as a conventional rotation ABC or as areverse phase rotation ACB. This will affect the positve and negative sequence quantities calculated by the relay and will also affect functions that are dependant on phase quantities.				
2nd Harmonic	30	04	Disabled	0 = Disabled or 1 = Enabled
To enable(activate) or disable (turn off) the 2nd Harmonic blocking of the overcurrent protection.				
2ndHarm Thresh	30	05	20	From 5 to 70 step 1
\if the level of 2nd harmonic/fundimental in any phase current or neutral current exceeds the setting, the overcurrent protection will be blocked as selected.				
I>lift 2H	30	06	10	From 4 to 32 step 0.01
The 2nd harmonic blocking ia applied only when the fundimental current is above 2nd Harm Thresh and below I> lift setting. The reset levels are 95% of these thresholds.				

Table 2 - System Config - Group 1

4.2 Phase Overcurrent Protection

The overcurrent protection included in the relay provides six-stage non-directional/directional three-phase overcurrent protection with independent time delay characteristics. All overcurrent and directional settings apply to all three phases but are independent for each of the four stages.

The stages 1, 2 and 5 of overcurrent protection have time-delayed characteristics which are selectable between Inverse Definite Minimum Time (IDMT), or Definite Time (DT). The stages 3, 4 and 6 have DT characteristics only.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 OVERCURRENT	35	00		
This column contains settings for Overcurrent				
I>1 Function	35	23	IEC S Inverse	0=Disabled 1=DT 2=IEC S Inverse 3=IEC V Inverse 4=IEC E Inverse 5=UK LT Inverse 6=UK Rectifier 7=RI 8=IEEE M Inverse 9=IEEE V Inverse 10=IEEE E Inverse 11=US Inverse 12=US ST Inverse 13=User curve 1 14=User curve 2 15=User curve 3 16=User curve 4
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Direction	35	24	Non-Directional	0 = Non-Directional 1 = Directional Fwd 2 = Directional Rev
This setting determines the direction of measurement for first stage element.				
I>1 Current Set	35	27	1	From 0.08*In to 4.0*In step 0.01In
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	35	29	1	From 0s to 100s step 0.01s
Setting for the time-delay for the definite time setting if selected for first stage element.				
I>1 TMS	35	2A	1	From 0.025 to 1.2 step 0.005
Setting for the time multiplier setting to adjust the operating time of the IEC IDMT characteristic.				
I>1 Time Dial	35	2B	1	From 0.01 to 100 step 0.01
Setting for the time multiplier setting to adjust the operating time of the IEEE/US IDMT curves.				
I>1 k (RI)	35	2C	1	From 0.1 to 10 step 0.05
Setting for the time multiplier setting to adjust the operating time of the RI curve.				
I>1 DT Adder	35	2D	0	From 0s to 100s step 0.01s
Setting to add an additional fixed time delay to the IDMT operate characteristic.				
I>1 Reset Char	35	2E	DT	0=DT 1=Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	35	2F	0	From 0s to 100s step 0.01s
Setting that determines the reset/release time for definite time reset characteristic				
I>1 Usr Rst Char	35	30	DT	0 = DT 1=User Curve 1 2=User Curve 2 3=User Curve 3 4=User Curve 4
Setting to determine the type of reset/release characteristic of the User defined curves.				
I>2 Function	35	32	Disabled	0=Disabled 1=DT 2=IEC S Inverse 3=IEC V Inverse 4=IEC E Inverse 5=UK LT Inverse 6=UK Rectifier 7=RI 8=IEEE M Inverse 9=IEEE V Inverse 10=IEEE E Inverse 11=US Inverse 12=US ST Inverse 13=User curve 1 14=User curve 2 15=User curve 3 16=User curve 4
Setting for the tripping characteristic for the second stage overcurrent element.				
I>2 Direction	35	33	Non-Directional	0 = Non-Directional 1 = Directional Fwd 2 = Directional Rev

Menu Text	Col	Row	Default Setting	Available Settings
Description				
This setting determines the direction of measurement for second stage element.				
I>2 Current Set	35	36	1	From 0.08*In to 4.0*In step 0.01In
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	35	38	1	From 0s to 100s step 0.01s
Setting for the time-delay for the definite time setting if selected for second stage element.				
I>2 TMS	35	39	1	From 0.025 to 1.2 step 0.005
Setting for the time multiplier setting to adjust the operating time of the IEC IDMT characteristic.				
I>2 Time Dial	35	3A	1	From 0.01 to 100 step 0.01
Setting for the time multiplier setting to adjust the operating time of the IEEE/US IDMT curves.				
I>2 k (RI)	35	3B	1	From 0.1 to 10 step 0.05
Setting for the time multiplier setting to adjust the operating time of the RI curve.				
I>2 Reset Char	35	3D	DT	0=DT 1=Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>2 tRESET	35	3E	0	From 0s to 100s step 0.01s
Setting that determines the reset/release time for definite time reset characteristic				
I>2 Usr Rst Char	35	3F	DT	0 = DT 1=User Curve 1 2=User Curve 2 3=User Curve 3 4=User Curve 4
Setting to determine the type of reset/release characteristic of the User defined curves.				
I>3 Status	35	40	Disabled	0 = Disabled, 1 = Enabled
Setting that enables/disables the third overcurrent stage .				
I>3 Direction	35	41	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for third stage element.				
I>3 Current Set	35	44	20	From 0.08*In to 32.0*In step 0.01In
Pick-up setting for third stage overcurrent element.				
I>3 Time Delay	35	45	0	From 0s to 100s step 0.01s
Setting for the operating time-delay for third stage overcurrent element.				
I>4 Status	35	47	Disabled	0 = Disabled, 1 = Enabled
Setting that enables/disables the fourth overcurrent stage .				
I>4 Direction	35	48	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for fourth stage element.				
I>4 Current Set	35	4B	20	From 0.08*In to 32.0*In step 0.01In
Pick-up setting for fourth stage overcurrent element.				
I>4 Time Delay	35	4C	0	From 0s to 100s step 0.01s
Setting for the operating time-delay for fourth stage overcurrent element.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
I> Blocking	35	4E	0x003F 31	Bit 0=VTS Blocks I>1 Bit 1=VTS Blocks I>2 Bit 2=VTS Blocks I>3 Bit 3=VTS Blocks I>4 Bit 4=VTS Blocks I>5 Bit 5=VTS Blocks I>6 Bit 6=2H Blocks I>1 Bit 7=2H Blocks I>2 Bit 8=2H Blocks I>3 Bit 9=2H Blocks I>4 Bit 10=2H Blocks I>5 Bit 11=2H Blocks I>6 Bit 12=2H 1PH Block Bit 13=Not Used Bit 14=Not Used Bit 15=Not Used Bit 0=VTS Blocks I>1 Bit 1=VTS Blocks I>2 Bit 2=VTS Blocks I>3 Bit 3=VTS Blocks I>4 Bit 4=VTS Blocks I>5 Bit 5=VTS Blocks I>6 Bit 6=AR Blocks I>3 Bit 7=AR Blocks I>4 Bit 8=AR Blocks I>6 Bit 9=2H Blocks I>1 Bit 10=2H Blocks I>2 Bit 11=2H Blocks I>3 Bit 12=2H Blocks I>4 Bit 13=2H Blocks I>5 Bit 14=2H Blocks I>6 Bit 15=2H 1PH Block
Logic Settings that determine whether blocking signals from VT supervision, auto-reclose and 2nd harmonic affect certain overcurrent stages. VTS Block – only affects directional overcurrent protection. With the relevant bit set to 1, operation of the Voltage Transformer Supervision (VTS), will block the stage. A/R Block - the auto-reclose logic can be set to selectively block instantaneous overcurrent elements for each shot in auto-reclose. This is set in the auto-reclose column. When a block instantaneous signal is generated then only those overcurrent stages selected to '1' in the I> Function link will be blocked. 2nd Harmonic block - 2nd Harmonic Block logic can be set to selectively block phase overcurrent elements. This is set in the System Config column. When a block signal is generated then only those overcurrent stages selected to '1' in the I> Function link will be blocked.				
I> Char Angle	35	4F	45	From -95 to 95 step 1
Setting for the IED characteristic angle used for the directional decision.				
V DEPENDANT O/C	35	51		
V Dep OC Status	35	52	Disabled	0=Disabled 1=VCO I>1 2=VCO I>2 3=VCO I>1 & I>2 4=VCO I>5 5=VCO I>1&I>2&I>5 6=VCO I>1 & I>5 7=VCO I>2 & I>5 8=VRO I>1 9=VRO I>2 10=VRO I>5 11=VRO I>1 & I>2 12=VRO I>1 & I>5 13=VRO I>2 & I>5 14=VRO I>1&I>2&I>5
Allows selection of whether voltage control should be applied to each of the first or second stage overcurrent elements.				
V Dep OC V<1 Set	35	53	80	From 10 to 120 step 1
Sets the voltage V1 threshold at which the current setting of the overcurrent stage/stages becomes reduced, noting that this occurs on a per phase basis.				
V Dep OC k Set	35	54	0.25	From 0.1 to 1 step 0.05
Sets to determine the overcurrent multiplier factor used to reduce the pick-up overcurrent setting.				
V Dep OC V<2 Set	35	55	60	From 10 to 120 step 1
Sets the voltage V2 threshold at which the current setting of the overcurrent stage/stages becomes reduced, noting that this occurs on a per phase basis.				
I>5 Function	35	63	Disabled	0=Disabled 1=DT 2=IEC S Inverse 3=IEC V Inverse 4=IEC E Inverse 5=UK LT Inverse 6=UK Rectifier 7=RI 8=IEEE M Inverse 9=IEEE V Inverse 10=IEEE E Inverse 11=US Inverse 12=US ST Inverse 13=User curve 1 14=User curve 2 15=User curve 3 16=User curve 4

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Setting that enables/disables the fifth overcurrent stage .				
I>5 Direction	35	64	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
Setting that defines fifth stage overcurrent operating status.				
I>5 Current Set	35	67	1	From 0.08*In to 4.0*In step 0.01In
Pick-up setting for fifth stage overcurrent element.				
I>5 Time Delay	35	69	1	From 0s to 100s step 0.01s
Setting for the operating time-delay for fifth stage overcurrent element.				
I>5 TMS	35	6A	1	From 0.025 to 1.2 step 0.005
Setting for the time multiplier setting to adjust the operating time of the IEC IDMT characteristic.				
I>5 Time Dial	35	6B	1	From 0.01 to 100 step 0.01
Setting for the time multiplier setting to adjust the operating time of the IEEE/US IDMT curves.				
I>5 k (RI)	35	6C	1	From 0.1 to 10 step 0.05
Setting for the time multiplier setting to adjust the operating time of the RI curve.				
I>5 Reset Char	35	6E	DT	0=DT 1=Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>5 tRESET	35	6F	0	From 0s to 100s step 0.01s
Setting that determines the reset/release time for definite time reset characteristic				
I>5 Usr Rst Char	35	70	DT	0 = DT 1=User Curve 1 2=User Curve 2 3=User Curve 3 4=User Curve 4
Setting to determine the type of reset/release characteristic of the User defined curves.				
I>6 Status	35	71	Disabled	0 = Disabled, 1 = Enabled
Setting that enables/disables the sixth overcurrent stage .				
I>6 Direction	35	72	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for sixth stage element.				
I>6 Current Set	35	75	20	From 0.08*In to 32.0*In step 0.01In
Pick-up setting for sixth stage overcurrent element.				
I>6 Time Delay	35	76	0	From 0s to 100s step 0.01s
Setting for the operating time-delay for sixth stage overcurrent element.				
I> Blocking 2	35	8F	0x0	Bit 0=Blinder Blk I>1 Bit 1=Blinder Blk I>2 Bit 2=Blinder Blk I>5 Bit 3=unused
Logic Settings that determine whether blocking signals from the load blinder affect overcurrent stages I1, I2 or I5. Load blinder - with the relevant bit set to 1, operation of the Load blinder will block the corresponding overcurrent stage.				
LOAD BLINDER	35	90		
Blinder Status	35	91	Disabled	0 = Disabled, 1 = Enabled
Setting that enables/disables the load blinder blocking function.				
Blinder Function	35	92	3Ph(based on Z1)	0=3Ph(based on Z1) 1=1Ph(based on Z)
Setting that the load blinder to three /single phase blocking.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Blinder Mode	35	93	Both	0=Reverse 1=Forward 2=Both
Setting that the load blinder direction measurement.				
FWD Z Impedance	35	94	15	From 0.1 to 500 step 0.01
Forward Impedance setting for load blinder function.				
FWD Z Angle	35	95	30	From 5 to 85 step 1
Forward Angle setting for load blinder function.				
REV Z Impedance	35	97	15	From 0.1 to 500 step 0.01
Reverse Impedance setting for load blinder function.				
REV Z Angle	35	98	30	From 5 to 85 step 1
Reverse Angle setting for load blinder function.				
Blinder V< Block	35	9A	15	From 10 to 120 step 1
Under voltagethreshold for load blinder function.				
Blinder I2>Block	35	9B	0.2	From 0.08*I1 to 4*I1 step 0.01*I1
Negative sequence current threshold for load blinder function.				
Pick up Cycles	35	9C	1	From 0 to 50 step 0.5
Pickup count threshold for load blinder function.				
Drop-off Cycles	35	9D	1	From 0 to 50 step 0.5
Drop off count threshold for load blinder function.				

Table 3 - Phase Overcurrent Protection

4.3 Negative Sequence Overcurrent

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 NEG SEQ O/C	36	00		
This column contains settings for Negative Sequence overcurrent				
I2>1 Status	36	10	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the first stage negative sequence element.				
I2>1 Function	36	11	DT	0=DT 1=IEC S Inverse 2=IEC V Inverse 3=IEC E Inverse 4=UK LT Inverse 5=IEEE M Inverse 6=IEEE V Inverse 7=IEEE E Inverse 8=US Inverse 9=US ST Inverse 10=User Curve 1 11=User Curve 2 12=User Curve 3 13=User Curve 4
Setting for the tripping characteristic for the first stage negative sequence overcurrent element.				
I2>1 Direction	36	12	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for this element.				
I2>1 Current Set	36	15	0.2	0.08*In to 4*In step 0.01In
Pick-up setting for the first stage negative sequence overcurrent element.				
I2>1 Time Delay	36	17	10	From 0s to 100s step 0.01s
Setting for the operating time-delay for the first stage negative sequence overcurrent element.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
I2>1 TMS	36	18	1	0.025 to 1.2 step 0.005
Setting for the time multiplier setting to adjust the operating time of the IEC IDMT characteristic.				
I2>1 Time Dial	36	19	1	0.01 to 100 step 0.01
Setting for the time multiplier setting to adjust the operating time of the IEEE/US IDMT curves.				
I2>1 DT Adder	36	1B	0	From 0s to 100s step 0.01s
Setting to add an additional fixed time delay to the IDMT operate characteristic.				
I2>1 Reset Char	36	1C	DT	0 = DT or 1 = Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I2>1 tRESET	36	1D	0	From 0s to 100s step 0.01s
Setting that determines the reset/release time for definite time reset characteristic.				
I2>1 Usr Rst Char	36	1E	DT	0 = DT 1=User Curve 1 2=User Curve 2 3=User Curve 3 4=User Curve 4
Setting to determine the type of reset/release characteristic of the User defined curves.				
I2>2 Status	36	20	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the second stage negative sequence element.				
I2>2 Function	36	21	DT	0=DT 1=IEC S Inverse 2=IEC V Inverse 3=IEC E Inverse 4=UK LT Inverse 5=IEEE M Inverse 6=IEEE V Inverse 7=IEEE E Inverse 8=US Inverse 9=US ST Inverse 10=User Curve 1 11=User Curve 2 12=User Curve 3 13=User Curve 4
Setting for the tripping characteristic for the second stage negative sequence overcurrent element.				
I2>2 Direction	36	22	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for this element.				
I2>2 Current Set	36	25	0.2	0.08*In to 4*In step 0.01In
Pick-up setting for the second stage negative sequence overcurrent element.				
I2>2 Time Delay	36	27	10	From 0s to 100s step 0.01s
Setting for the operating time-delay for the second stage negative sequence overcurrent element.				
I2>2 TMS	36	28	1	0.025 to 1.2 step 0.005
Setting for the time multiplier setting to adjust the operating time of the IEC IDMT characteristic.				
I2>2 Time Dial	36	29	1	0.01 to 100 step 0.01
Setting for the time multiplier setting to adjust the operating time of the IEEE/US IDMT curves.				
I2>2 DT Adder	36	2B	0	From 0s to 100s step 0.01s
Setting to add an additional fixed time delay to the IDMT operate characteristic.				
I2>2 Reset Char	36	2C	DT	0 = DT or 1 = Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I2>2 tRESET	36	2D	0	From 0s to 100s step 0.01s
Setting that determines the reset/release time for definite time reset characteristic.				
I2>2 Usr Rst Char	36	2E	DT	0 = DT 1=User Curve 1 2=User Curve 2 3=User Curve 3 4=User Curve 4
Setting to determine the type of reset/release characteristic of the User defined curves.				
I2>3 Status	36	30	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the third stage negative sequence element.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
I2>3 Direction	36	32	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for this element.				
I2>3 Current Set	36	35	0.2	0.08*In to 32*In step 0.01In
Pick-up setting for the third stage negative sequence overcurrent element.				
I2>3 Time Delay	36	37	10	From 0s to 100s step 0.01s
Setting for the operating time-delay for the third stage negative sequence overcurrent element.				
I2>4 Status	36	40	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the fourth stage negative sequence element.				
I2>4 Direction	36	42	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for this element.				
I2>4 Current Set	36	45	0.2	0.08*In to 32*In step 0.01In
Pick-up setting for the fourth stage negative sequence overcurrent element.				
I2>4 Time Delay	36	47	10	From 0s to 100s step 0.01s
Setting for the operating time-delay for the fourth stage negative sequence overcurrent element.				
I2> Blocking	36	50	0x0F	Bit 0=VTS Blocks I2>1 Bit 1=VTS Blocks I2>2 Bit 2=VTS Blocks I2>3 Bit 3=VTS Blocks I2>4 Bit 4=2H Blocks I2>1 Bit 5=2H Blocks I2>2 Bit 6=2H Blocks I2> Bit 7=2H Blocks I2>4
Logic settings that determine whether VT supervision blocks selected negative sequence overcurrent stages. Setting ‘0’ will permit continued non-directional operation. 2nd Harmonic Bolcks - 2nd Harmonic Block logic can be set to selectively block Negative sequence overcurrent element stage 1. This is set in the System Data Column. When a block signal is generated then only those Negative sequence overvoltage stages selected to '1' in the I> Function link will be blocked.				
I2> Char Angle	36	51	-60	From -95 to 95 step 1
Setting for the IED characteristic angle used for the directional decision.				
I2> V2pol Set	36	52	5	From 0.5*V1 to 25*V1 step 0.5*V1
Setting determines the minimum negative sequence voltage threshold that must be present to determine directionality.				

Table 4 - Negative Sequence Overcurrent

4.4 Broken Conductor

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 BROKEN CONDUCTOR	37	00		
This column contains settings for Broken Conductor				
Broken Conductor	37	01	Enabled	0 = Disabled or 1 = Enabled
Enables or disables the broken conductor function.				
I2/I1 Setting	37	02	0.2	From 0.2 to 1 step 0.01
Setting to determine the pick- up level of the negative to positive sequence current ratio.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
I2/I1 Time Delay	37	03	60	From 0s to 100s step 0.1s
Setting for the function operating time delay.				

Table 5 - Broken Conductor

4.5 Earth Fault

The standard Earth Fault (EF) protection elements are duplicated within the relay and are referred to in the relay menu as “**Earth Fault 1**” (EF1) and “**Earth Fault 2**” (EF2). EF1 operates from earth fault current that is measured directly from the system; either by means of a separate CT located in a power system earth connection or via a residual connection of the three line CTs. The EF2 element operates from a residual current quantity that is derived internally from the summation of the three phase currents.

EF1 and EF2 are identical elements, each having four stages. The first and second stages have selectable IDMT or DT characteristics, whilst the third and fourth stages are DT only. Each stage is selectable to be either non-directional, directional forward or directional reverse. The timer hold facility, previously described for the overcurrent elements, is available on each of the first two stages.

The following table shows the relay menu for "**Earth Fault 1**" protection, including the available setting ranges and factory defaults. The menu for "**Earth Fault 2**" is identical to that for EF1 and so is not shown here.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 EARTH FAULT 1	38	00		
This column contains settings for Measured Earth Fault				
IN1> Input	38	01	Measured	Not Settable
Displays source of IN function				
IN1>1 Function	38	25	IEC S Inverse	0=Disabled 1=DT 2=IEC S Inverse 3=IEC V Inverse 4=IEC E Inverse 5=UK LT Inverse 6=RI 7=IEEE M Inverse 8=IEEE V Inverse 9=IEEE E Inverse 10=US Inverse 11=US ST Inverse 12=IDG 13=User curve 1 14=User curve 2 15=User curve 3 16=User curve 4
Setting for the tripping characteristic for the first stage earth fault element				
IN1>1 Direction	38	26	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for first stage element.				
IN1>1 Current	38	29	0.2	0.08*In to 4*In step 0.01In
Pick-up setting for first stage overcurrent element				
IN1>1 IDG Is	38	2A	1.5	1 to 4 step 0.1
This setting is set as a multiple of “IN>” setting for the IDG curve (Scandinavian) and determines the actual IED current threshold at which the element starts.				
IN1>1 Time Delay	38	2C	1	From 0s to 200s step 0.01s
Setting for the time-delay for first stage definite time element.				
IN1>1 TMS	38	2D	1	0.025 to 1.2 step 0.005
Setting for the time multiplier setting to adjust the operating time of the IEC IDMT characteristic.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
IN1>1 Time Dial	38	2E	1	0.01 to 100 step 0.01
Setting for the time multiplier setting to adjust the operating time of the IEEE/US IDMT curves.				
IN1>1 k (RI)	38	2F	1	From 0.1 to 10 step 0.05
Setting for the time multiplier setting to adjust the operating time of the AG1407.				
IN1>1 IDG Time	38	30	1.2	From 1s to 2s step 0.01s
Setting for the IDG curve used to set the minimum operating time at high levels of fault current.				
IN1>1 DT Adder	38	31	0	From 0s to 100s step 0.01s
Setting to add an additional fixed time delay to the IDMT operate characteristic.				
IN1>1 Reset Char	38	32	DT	0 = DT or 1 = Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
IN1>1 tRESET	38	33	0	From 0s to 100s step 0.01s
Setting that determines the reset/release time for definite time reset characteristic.				
IN1>1 Usr Rst Char	38	34	DT	0 = DT 1=User Curve 1 2=User Curve 2 3=User Curve 3 4=User Curve 4
Setting to determine the type of reset/release characteristic of the User defined curves.				
IN1>2 Function	38	36	Disabled	0=Disabled 1=DT 2=IEC S Inverse 3=IEC V Inverse 4=IEC E Inverse 5=UK LT Inverse 6=RI 7=IEEE M Inverse 8=IEEE V Inverse 9=IEEE E Inverse 10=US Inverse 11=US ST Inverse 12=IDG 13=User curve 1 14=User curve 2 15=User curve 3 16=User curve 4
Setting for the tripping characteristic for the second stage earth fault element				
IN1>2 Direction	38	37	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for second stage element.				
IN1>2 Current	38	3A	0.2	0.08*In to 4*In step 0.01In
Pick-up setting for second stage overcurrent element				
IN1>2 IDG Is	38	3B	1.5	1 to 4 step 0.1
This setting is set as a multiple of “IN>” setting for the IDG curve (Scandinavian) and determines the actual IED current threshold at which the element starts.				
IN1>2 Time Delay	38	3D	1	From 0s to 200s step 0.01s
Setting for the time-delay for second stage definite time element.				
IN1>2 TMS	38	3E	1	0.025 to 1.2 step 0.005
Setting for the time multiplier setting to adjust the operating time of the IEC IDMT characteristic.				
IN1>2 Time Dial	38	3F	1	0.01 to 100 step 0.01
Setting for the time multiplier setting to adjust the operating time of the IEEE/US IDMT curves.				
IN1>2 k (RI)	38	40	1	From 0.1 to 10 step 0.05
Setting for the time multiplier setting to adjust the operating time of the RI curve.				
IN1>2 IDG Time	38	41	1.2	From 1s to 2s step 0.01s
Setting for the IDG curve used to set the minimum operating time at high levels of fault current.				
IN1>2 DT Adder	38	42	0	From 0s to 100s step 0.01s
Setting to add an additional fixed time delay to the IDMT operate characteristic.				
IN1>2 Reset Char	38	43	DT	0 = DT or 1 = Inverse

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
IN1>2 tRESET	38	44	0	From 0s to 100s step 0.01s
Setting that determines the reset/release time for definite time reset characteristic.				
IN2>1 Usr Rst Char	38	45	DT	0 = DT 1=User Curve 1 2=User Curve 2 3=User Curve 3 4=User Curve 4
Setting to determine the type of reset/release characteristic of the User defined curves.				
IN1>3 Status	38	46	Disabled	0 = Disabled, 1 = Enabled
Setting to enable or disable the third stage definite time element. If the function is disabled, then all associated settings with the exception of this setting, are hidden.				
IN1>3 Direction	38	47	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for the earth fault overcurrent element.				
IN1>3 Current	38	4A	0.2	0.08*In to 32*In step 0.01In
Pick-up setting for third stage earth fault overcurrent element.				
IN1>3 Time Delay	38	4B	1	From 0s to 200s step 0.01s
Setting for the operating time-delay for third stage earth fault overcurrent element.				
IN1>4 Status	38	4D	Disabled	0 = Disabled, 1 = Enabled
Setting to enable or disable the fourth stage definite time element. If the function is disabled, then all associated settings with the exception of this setting, are hidden.				
IN1>4 Direction	38	4E	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for the earth fault overcurrent element.				
IN1>4 Current	38	51	0.2	0.08*In to 32*In step 0.01In
Pick-up setting for fourth stage earth fault overcurrent element.				
IN1>4 Time Delay	38	52	1	From 0s to 200s step 0.01s
Setting for the operating time-delay for fourth stage earth fault overcurrent element.				
IN1> Blocking	38	54	0x00F	Bit 0=VTS Blocks IN>1 Bit 1=VTS Blocks IN>2 Bit 2=VTS Blocks IN>3 Bit 3=VTS Blocks IN>4 Bit 4=2H Blocks IN>1 Bit 5=2H Blocks IN>2 Bit 6=2H Blocks IN>3 Bit 7=2H Blocks IN>4 Bit 8=Not Used Bit 9=Not Used Bit 10=Not Used Bit 0=VTS Blocks IN>1 Bit 1=VTS Blocks IN>2 Bit 2=VTS Blocks IN>3 Bit 3=VTS Blocks IN>4 Bit 4=AR Blocks IN>3 Bit 5=AR Blocks IN>4 Bit 6=2H Blocks IN>1 Bit 7=2H Blocks IN>2 Bit 8=2H Blocks IN>3 Bit 9=2H Blocks IN>4 Bit 10=Not Used
Logic Settings that determine whether blocking signals from VT supervision, auto-reclose and 2nd Harmonic blocks earth fault overcurrent stages. 2nd Harmonic block - 2nd Harmonic Block logic can be set to selectively block earth fault overcurrent elements. This is set in the System Config column. When a block signal is generated then only those earth fault overcurrent stages selected to '1' in the I> Function link will be blocked.				
IN1> POL	38	55		
IN1> Char Angle	38	56	-45	-95 to 95 step 1
Setting for the IED characteristic angle used for the directional decision.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
IN1> Pol	38	57	Zero Sequence	0=Zero Sequence 1=Neg Sequence
Setting that determines whether the directional function uses zero sequence or negative sequence voltage polarizing.				
IN1> VNpol Set	38	59	5 20	0.5V to 80V step 0.5V 2.0V to 200V step 2.0V
Setting for the minimum zero sequence voltage polarizing quantity for directional decision.				
IN1> V2pol Set	38	5A	5	0.5V to 25V step 0.5V 2.0V to 100V step 2.0V
Setting for the minimum negative sequence voltage polarizing quantity for directional decision.				
IN1> I2pol Set	38	5B	0.08	0.08*In to 1*In step 0.01In
Setting for the minimum negative sequence current polarizing quantity for directional decision.				

Table 6 - Earth Fault

4.6 Derived Earth Fault

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 EARTH FAULT 2	39	00		
This column contains settings for Derived Earth Fault				
IN2> Input	39	01	Derived	Not Settable
Displays source of IN function				
IN2>1 Function	39	25	IEC S Inverse	0=Disabled 1=DT 2=IEC S Inverse 3=IEC V Inverse 4=IEC E Inverse 5=UK LT Inverse 6=RI 7=IEEE M Inverse 8=IEEE V Inverse 9=IEEE E Inverse 10=US Inverse 11=US ST Inverse 12=IDG 13=User curve 1 14=User curve 2 15=User curve 3 16=User curve 4
Setting for the tripping characteristic for the first stage derived earth fault element				
IN2>1 Direction	39	26	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for first stage element.				
IN2>1 Current	39	29	0.2	0.08*In to 4*In step 0.01In
Pick-up setting for first stage overcurrent element				
IN2>1 IDG Is	39	2A	1.5	1 to 4 step 0.1
This setting is set as a multiple of “IN>” setting for the IDG curve (Scandinavian) and determines the actual IED current threshold at which the element starts.				
IN2>1 Time Delay	39	2C	1	From 0s to 200s step 0.01s
Setting for the time-delay for first stage definite time element.				
IN2>1 TMS	39	2D	1	0.025 to 1.2 step 0.005
Setting for the time multiplier setting to adjust the operating time of the IEC IDMT characteristic.				
IN2>1 Time Dial	39	2E	1	0.01 to 100 step 0.01
Setting for the time multiplier setting to adjust the operating time of the IEEE/US IDMT curves.				
IN2>1 k (RI)	39	2F	1	From 0.1 to 10 step 0.05

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Setting for the time multiplier setting to adjust the operating time of the RI curve.				
IN2>1 IDG Time	39	30	1.2	1s to 2s step 0.01s
Setting for the IDG curve used to set the minimum operating time at high levels of fault current.				
IN2>1 DT Adder	39	31	0	From 0s to 100s step 0.01s
Setting to add an additional fixed time delay to the IDMT operate characteristic.				
IN2>1 Reset Char	39	32	DT	0 = DT or 1 = Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
IN2>1 tRESET	39	33	0	From 0s to 100s step 0.01s
Setting that determines the reset/release time for definite time reset characteristic.				
IN2>1 Usr Rst Char	39	34	DT	0 = DT 1=User Curve 1 2=User Curve 2 3=User Curve 3 4=User Curve 4
Setting to determine the type of reset/release characteristic of the User defined curves.				
IN2>2 Function	39	36	Disabled	0=Disabled 1=DT 2=IEC S Inverse 3=IEC V Inverse 4=IEC E Inverse 5=UK LT Inverse 6=RI 7=IEEE M Inverse 8=IEEE V Inverse 9=IEEE E Inverse 10=US Inverse 11=US ST Inverse 12=IDG 13=User curve 1 14=User curve 2 15=User curve 3 16=User curve 4
Setting for the tripping characteristic for the second stage derived earth fault element				
IN2>2 Direction	39	37	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for second stage element.				
IN2>2 Current	39	3A	0.2	0.08*In to 4*In step 0.01In
Pick-up setting for second stage overcurrent element				
IN2>2 IDG Is	39	3B	1.5	1 to 4 step 0.1
This setting is set as a multiple of "IN>" setting for the IDG curve (Scandinavian) and determines the actual IED current threshold at which the element starts.				
IN2>2 Time Delay	39	3D	1	From 0s to 200s step 0.01s
Setting for the time-delay for second stage definite time element.				
IN2>2 TMS	39	3E	1	0.025 to 1.2 step 0.005
Setting for the time multiplier setting to adjust the operating time of the IEC IDMT characteristic.				
IN2>2 Time Dial	39	3F	1	0.01 to 100 step 0.01
Setting for the time multiplier setting to adjust the operating time of the IEEE/US IDMT curves.				
IN2>2 k (RI)	39	40	1	From 0.1 to 10 step 0.05
Setting for the time multiplier setting to adjust the operating time of the RI curve.				
IN2>2 IDG Time	39	41	1.2	From 1s to 2s step 0.01s
Setting for the IDG curve used to set the minimum operating time at high levels of fault current.				
IN2>2 Reset Char	39	43	DT	0 = DT or 1 = Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
IN2>2 tRESET	39	44	0	From 0s to 100s step 0.01s
Setting that determines the reset/release time for definite time reset characteristic.				
IN2>2 Usr Rst Char	39	45	DT	0 = DT 1=User Curve 1 2=User Curve 2 3=User Curve 3 4=User Curve 4

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Setting to determine the type of reset/release characteristic of the User defined curves.				
IN2>3 Status	39	46	Disabled	0 = Disabled, 1 = Enabled
Setting to enable or disable the third stage definite time element. If the function is disabled, then all associated settings with the exception of this setting, are hidden.				
IN2>3 Direction	39	47	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for the derived earth fault overcurrent element.				
IN2>3 Current	39	4A	0.2	0.08*In to 32*In step 0.01In
Pick-up setting for third stage derived earth fault overcurrent element.				
IN2>3 Time Delay	39	4B	1	From 0s to 200s step 0.01s
Setting for the operating time-delay for third stage derived earth fault overcurrent element.				
IN2>4 Status	39	4D	Disabled	0 = Disabled, 1 = Enabled
Setting to enable or disable the fourth stage definite time element. If the function is disabled, then all associated settings with the exception of this setting, are hidden.				
IN2>4 Direction	39	4E	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for the derived earth fault overcurrent element.				
IN2>4 Current	39	51	0.2	0.08*In to 32*In step 0.01In
Pick-up setting for fourth stage derived earth fault overcurrent element.				
IN2>4 Time Delay	39	52	1	From 0s to 200s step 0.01s
Setting for the operating time-delay for fourth stage derived earth fault overcurrent element.				
IN2> Blocking	39	54	0x00F	Bit 0=VTS Blocks IN>1 Bit 1=VTS Blocks IN>2 Bit 2=VTS Blocks IN>3 Bit 3=VTS Blocks IN>4 Bit 4=2H Blocks IN>1 Bit 5=2H Blocks IN>2 Bit 6=2H Blocks IN>3 Bit 7=2H Blocks IN>4 Bit 8=Not Used Bit 9=Not Used Bit 10=Not Used Bit 0=VTS Blocks IN>1 Bit 1=VTS Blocks IN>2 Bit 2=VTS Blocks IN>3 Bit 3=VTS Blocks IN>4 Bit 4=AR Blocks IN>3 Bit 5=AR Blocks IN>4 Bit 6=2H Blocks IN>1 Bit 7=2H Blocks IN>2 Bit 8=2H Blocks IN>3 Bit 9=2H Blocks IN>4 Bit 10=Not Used
Logic Settings that determine whether blocking signals from VT supervision, auto-reclose and 2nd Harmonic blocks derived earth fault overcurrent stages. 2nd Harmonic block - 2nd Harmonic Block logic can be set to selectively block derived earth fault overcurrent elements. This is set in the System Config column. When a block signal is generated then only those derived earth fault overcurrent stages selected to '1' in the I> Function link will be blocked.				
IN2> POL	39	55		Not Settable
IN2> Char Angle	39	56	-45	-95 to 95 step 1
Setting for the IED characteristic angle used for the directional decision.				
IN2> Pol	39	57	Zero Sequence	0=Zero Sequence 1=Neg Sequence
Setting that determines whether the directional function uses zero sequence or negative sequence voltage polarizing.				
IN2> VNpol Set	39	59	5 20	0.5V to 80V step 0.5V 2.0V to 200V step 2.0V
Setting for the minimum zero sequence voltage polarizing quantity for directional decision.				
IN2> V2pol Set	39	5A	5	0.5V to 25V step 0.5V 2.0V to 100V step 2.0V
Setting for the minimum negative sequence voltage polarizing quantity for directional decision.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
IN2> I2pol Set	39	5B	0.08	0.08*In to 1*In step 0.01In
Setting for the minimum negative sequence current polarizing quantity for directional decision.				

Table 7 – Derived Earth Fault

4.7 Sensitive Earth Fault/Restricted Earth Fault

If a system is earthed through high impedance, or is subject to high ground fault resistance, the Earth Fault (EF) level will be severely limited. Consequently, the applied earth fault protection requires both an appropriate characteristic and a suitably sensitive setting range in order to be effective. A separate four-stage Sensitive Earth Fault (SEF) element is provided within the relay for this purpose, which has a dedicated input. This input may be configured to be used as a Restricted Earth Fault (REF) input. The REF protection in the relay may be configured to operate as either a high impedance or biased element.

> *Note* *The high impedance REF element of the relay shares the same CT input as the SEF protection. Hence, only one of these elements may be selected. However, the low impedance REF element does not use the SEF input and so may be selected at the same time.*

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 SEF/REF PROT'N	3A	00		
This column contains settings for SEF/REF				
SEF/REF Options SEF Options	3A	01	SEF	0=SEF, 1=SEF cos(PHI), 2=SEF sin(PHI), 3=Wattmetric, 4=Hi Z REF, 5=Lo Z REF, 6=Lo Z REF+SEF, 7=Lo Z REF+Wattmet 0=SEF, 1=SEF cos(PHI), 2=SEF sin(PHI), 3=Wattmetric, 4=Not Used, 5=Not Used, 6=Not Used, 7=Not Used
Setting to select the type of sensitive earth fault protection function and the type of high-impedance function to be used.				
ISEF>1 Function	3A	2A	DT	0=Disabled 1=DT 2=IEC S Inverse 3=IEC V Inverse 4=IEC E Inverse 5=UK LT Inverse 6=IEEE M Inverse 7=IEEE V Inverse 8=IEEE E Inverse 9=US Inverse 10=US ST Inverse 11=IDG 12=EPATR B 13=User curve 1 14=User curve 2 15=User curve 3 16=User curve 4
Setting for the tripping characteristic for the first stage sensitive earth fault element.				
ISEF>1 Direction	3A	2B	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for the first stage sensitive earth fault element.				
ISEF>1 Current	3A	2E	0.05	0.005*In to 0.1*In step 0.00025In
Pick-up setting for the first stage sensitive earth fault element.				
ISEF>1 IDG Is	3A	2F	1.5	1 to 4 step 0.1
This setting is set as a multiple of ISEF> setting for the IDG curve (Scandinavian) and determines the actual IED current threshold at which the element starts.				
ISEF>1 Delay	3A	31	1	From 0s to 200s step 0.01s
Setting for the time delay for the first stage definite time element.				
ISEF>1 TMS	3A	32	1	0.025 to 1.2 step 0.005
Setting for the time multiplier to adjust the operating time of the IEC IDMT characteristic.				
ISEF>1 Time Dial	3A	33	1	0.01 to 100 step 0.01
Setting for the time multiplier to adjust the operating time of the IEEE/US IDMT curves.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
ISEF>1 IDG Time	3A	34	1.2	From 1s to 2s step 0.01s
Setting for the IDG curve used to set the minimum operating time at high levels of fault current.				
ISEF>1 Reset Chr	3A	36	DT	0 = DT or 1 = Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
ISEF>1 tRESET	3A	37	0	From 0s to 100s step 0.01s
Setting to determine the reset/release time for definite time reset characteristic.				
ISEF>1 Usr Rst Char	3A	38	DT	0 = DT 1=User Curve 1 2=User Curve 2 3=User Curve 3 4=User Curve 4
Setting to determine the type of reset/release characteristic of the User defined curves.				
ISEF>2 Function	3A	3A	Disabled	0=Disabled 1=DT 2=IEC S Inverse 3=IEC V Inverse 4=IEC E Inverse 5=UK LT Inverse 6=IEEE M Inverse 7=IEEE V Inverse 8=IEEE E Inverse 9=US Inverse 10=US ST Inverse 11=IDG 12=EPATR B 13=User curve 1 14=User curve 2 15=User curve 3 16=User curve 4
Setting for the tripping characteristic for the second stage sensitive earth fault element.				
ISEF>2 Direction	3A	3B	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for the second stage sensitive earth fault element.				
ISEF>2 Current	3A	3E	0.05	0.005*In to 0.1*In step 0.00025In
Pick-up setting for the second stage sensitive earth fault element.				
ISEF>2 IDG Is	3A	3F	1.5	1 to 4 step 0.1
This setting is set as a multiple of ISEF> setting for the IDG curve (Scandinavian) and determines the actual IED current threshold at which the element starts.				
ISEF>2 Delay	3A	41	1	From 0s to 200s step 0.01s
Setting for the time delay for the second stage definite time element.				
ISEF>2 TMS	3A	42	1	0.025 to 1.2 step 0.005
Setting for the time multiplier to adjust the operating time of the IEC IDMT characteristic.				
ISEF>2 Time Dial	3A	43	1	0.01 to 100 step 0.01
Setting for the time multiplier to adjust the operating time of the IEEE/US IDMT curves.				
ISEF>2 IDG Time	3A	44	1.2	From 1s to 2s step 0.01s
Setting for the IDG curve used to set the minimum operating time at high levels of fault current.				
ISEF>2 Reset Chr	3A	46	DT	0 = DT or 1 = Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
ISEF>2 tRESET	3A	47	0	From 0s to 100s step 0.01s
Setting to determine the reset/release time for definite time reset characteristic.				
ISEF>2 Usr Rst Char	3A	48	DT	0 = DT 1=User Curve 1 2=User Curve 2 3=User Curve 3 4=User Curve 4
Setting to determine the type of reset/release characteristic of the User defined curves.				
ISEF>3 Status	3A	49	Disabled	0 = Disabled, 1 = Enabled
Setting to enable or disable the third stage definite time sensitive earth fault element.				
ISEF>3 Direction	3A	4A	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for the third stage element.				
ISEF>3 Current	3A	4D	0.4	0.08*In to 32*In step 0.01In
Pick-up setting for the third stage sensitive earth fault element.				
ISEF>3 Delay	3A	4E	0.5	From 0s to 200s step 0.01s
Setting for the operating time delay for third stage sensitive earth fault element.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
ISEF>4 Status	3A	50	Disabled	0 = Disabled, 1 = Enabled
Setting to enable or disable the fourth stage definite time sensitive earth fault element.				
ISEF>4 Direction	3A	51	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for the fourth stage element.				
ISEF>4 Current	3A	54	0.6	0.08*In to 32*In step 0.01In
Pick-up setting for the fourth stage sensitive earth fault element.				
ISEF>4 Delay	3A	55	0.25	From 0s to 200s step 0.01s
Setting for the operating time delay for fourth stage sensitive earth fault element.				
ISEF> Blocking	3A	57	0x00F	Bit 0=VTS Blks ISEF>1, Bit 1=VTS Blks ISEF>2, Bit 2=VTS Blks ISEF>3 ,Bit 3=VTS Blks ISEF>4, Bit 4=2H Blocks ISEF>1, Bit 5=2H Blocks ISEF>2, Bit 6=2H Blocks ISEF>3, Bit 7=2H Blocks ISEF>4, Bit 8=Not Used, Bit 9=Not Used, Bit 10=Not UsedBit 11=Not Used Bit 0=VTS Blks ISEF>1, Bit 1=VTS Blks ISEF>2, Bit 2=VTS Blks ISEF>3, Bit 3=VTS Blks ISEF>4, Bit 4=AR Blks ISEF>3, Bit 5=AR Blks ISEF>4, Bit 6=2H Blocks ISEF>1, Bit 7=2H Blocks ISEF>2, Bit 8=2H Blocks ISEF>3, Bit 9=2H Blocks ISEF>4, Bit 10=Not UsedBit 11=Not Used
Logic Settings that determine whether blocking signals from VT supervision, auto-reclose and 2nd Harmonic blocks sensitive earth fault overcurrent stages. 2nd Harmonic block - 2nd Harmonic Block logic can be set to selectively block sensitive earth fault overcurrent elements. This is set in the System Config column. When a block signal is generated then only those sensitive earth fault overcurrent stages selected to '1' in the I> Function link will be blocked.				
ISEF POL	3A	58		
ISEF> Char Angle	3A	59	90	From -95 to 95 step 1
Setting for the IED characteristic angle used for the directional decision.				
ISEF> VNpol Set	3A	5B	5 20	0.5V to 80V step 0.5V 2.0V to 320V step 2.0V
Setting for the minimum zero sequence voltage polarizing quantity required for directional decision.				
WATTMETRIC SEF	3A	5D		
PN> Setting	3A	5E	9 36	0.0 to 20 step 0.05 0.0 to 80 step 0.20
Setting for the threshold for the wattmetric component of zero sequence power. The power calculation is as follows: The PN> setting corresponds to: Vres x Ires x Cos (φ – φc) = 9 x Vo x Io x Cos (φ– φc) Where; φ = Angle between the Polarizing Voltage (-Vres) and the Residual Current φc = IED Characteristic Angle (RCA) Setting (ISEF> Char Angle) Vres = Residual Voltage Ires = Residual Current Vo = Zero Sequence Voltage Io = Zero Sequence Current				
RESTRICTED E/F	3A	60		
IREF> k1	3A	61	20	From 0 to 20 step 1
Slope angle setting for the first slope of the low impedance biased characteristic.				
IREF> k2	3A	62	150	From 0 to 150 step 1
Slope angle setting for the second slope of the low impedance biased characteristic.				
IREF> Is1	3A	63	0.2	From 0.08 to 1 step 0.01
Setting that determines the miimum differential operating current for the low impedance characteristic.				
IREF> Is2	3A	64	1	From 0.1 to 1.5 step 0.01
Setting that determines the bias current operating threshold for the second slope low impedance characteristic.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
IREF> Is	3A	65	0.2	From 0.05 to 1 step 0.01
Setting that determines the minimum differential operating current for the hi-impedance element.				

Table 8 - Sensitive Earth Fault/Restricted Earth Fault (including (Hi Z Ref options)

4.8 Residual Overvoltage (Neutral Voltage Displacement)

The Neutral Voltage Displacement (NVD) element within the relay is of two-stage design, each stage having separate voltage and time delay settings. Stage 1 may be set to operate on either an IDMT or DT characteristic, whilst stage 2 may be set to DT only.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 RESIDUAL O/V NVD	3B	00		
This column contains settings for Residual Overcurrent				
VN Input	3B	01	Derived Measured	Not Settable
Data cell indicating the VN Input is always derived from the 3 phase voltages				
VN>1 Function	3B	02	DT	0 = Disabled, 1 = DT or 2 = IDMT
Setting for the tripping characteristic of the first stage residual overvoltage element.				
VN>1 Voltage Set	3B	03	5 20	1V to 80V step 1V 4V to 320V step 4V
Pick-up setting for the first stage residual overvoltage characteristic.				
VN>1 Time Delay	3B	04	5	From 0s to 100s step 0.01s
Operating time delay setting for the first stage definite time residual overvoltage element.				
VN>1 TMS	3B	05	1	0.5 to 100 step 0.5
Setting for the time multiplier setting to adjust the operating time of the IDMT characteristic.				
VN>1 tReset	3B	06	0	From 0s to 100s step 0.01s
Setting to determine the reset/release definite time for the first stage characteristic				
VN>2 Status	3B	07	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the second stage definite time residual overvoltage element.				
VN>2 Voltage Set	3B	08	10 40	1V to 80V step 1V 4V to 320V step 4V
Pick-up setting for the second stage residual overvoltage element.				
VN>2 Time Delay	3B	09	10	From 0s to 100s step 0.01s
Operating time delay for the second stage residual overvoltage element.				

Note *VN>1 TMS*

The characteristic is defined as follows:

$t = K / (M - 1)$

Where:

K = Time multiplier setting

t = Operating time in seconds

M = Derived residual voltage/relay setting voltage (VN> Voltage Set)

Table 9 - Residual Overvoltage (Neutral Voltage Displacement)

4.9 Thermal Overload

The thermal overload function within the relay can be selected as a single time constant or dual time constant characteristic, dependent on the type of plant to be protected.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 THERMAL OVERLOAD	3C	00		
This column contains settings for Thermal Overload				
Characteristic	3C	01	Single	0 = Disabled, 1 = Single, 2 = Dual
Setting for the operating characteristic of the thermal overload element.				
Thermal Trip	3C	02	1	0.08*In to 4*In step 0.01In
Sets the maximum full load current allowed and the pick-up threshold of the thermal characteristic.				
Thermal Alarm	3C	03	70	50 to 100 step 1
Setting for the thermal state threshold corresponding to a percentage of the trip threshold at which an alarm will be generated.				
Time Constant 1	3C	04	10	1 to 200 step 1
Setting for the thermal time constant for a single time constant characteristic or the first time constant for the dual time constant characteristic.				
Time Constant 2	3C	05	5	1 to 200 step 1
Setting for the second thermal time constant for the dual time constant characteristic.				

Table 10 - Thermal Overload

4.10 Negative Sequence Overvoltage

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 NEG SEQUENCE O/V	3D	00		
This column contains settings for Negative Sequence Over Voltage protection				
V2> Status	3D	01	Enabled	0 = Disabled, 1 = Enabled
Setting to enable or disable the Negative Sequence Over Voltage protection element.				
V2> Voltage Set	3D	02	15	From 1*V1 to 110*V1 step 1*V1
Pick-up setting for the Negative Sequence Over Voltage protection element.				
V2> Time Delay	3D	03	5	From 0s to 100s step 0.01s
Setting for the operating time-delay for the Negative Sequence Over Voltage protection element.				

Table 11 - Negative Sequence Overvoltage

4.11 Cold Load Pick-Up

The Cold Load Pick-Up (CLP) logic is included for each of the six overcurrent stages and the first stages of the measured (EF1) and derived (EF2) Earth Fault protection.

Note *The CLP logic is enabled/disabled within the configuration column.*

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 COLD LOAD PICKUP	3E	00		

Menu Text	Col	Row	Default Setting	Available Settings
Description				
This column contains settings for Cold Load Pickup				
tcold Time Delay	3E	01	7200	From 0s to 14400s step 1s
This setting determines the time the load needs to be de-energized (dead time) before the new settings are applied.				
tclp Time Delay	3E	02	7200	From 0s to 14400s step 1s
This setting controls the period of time for which the relevant overcurrent and earth fault settings are altered or inhibited following circuit breaker closure.				
OVERCURRENT	3E	20		
I>1 Status	3E	21	Enable	0=Block 1=Enable
As shown in the menu, the I>1 status cells have two setting options, "Enable" and "Block". Selection of "Enable" for a particular stage means that the current and time settings programmed in the following cells will be those that are adopted during the "tclp" time. Selection of "Block" simply blocks the relevant protection stage during the "tclp" time. It also removes the following current and time settings for that stage from the menu.				
I>1 Current Set	3E	22	1.5	0.08*In to 4*In step 0.01In
This setting determines the new pick-up setting for first stage overcurrent element during the tclp time delay.				
I>1 Time Delay	3E	24	1	From 0s to 100s step 0.01s
Setting for the new operating time delay for the first stage definite time overcurrent element during the tclp time.				
I>1 TMS	3E	25	1	From 0.025 to 1.2 step 0.005
Setting for the new time multiplier setting for the first stage element to adjust the operating time of the IEC IDMT characteristic during the tclp time.				
I>1 Time Dial	3E	26	1	From 0.01 to 100 step 0.01
Setting for the new time multiplier setting to adjust the operating time of the IEEE/US IDMT curves during the tclp time.				
I>1 k (RI)	3E	27	1	From 0.1 to 10 step 0.05
Setting for the new time multiplier setting to adjust the operating time of the RI curve during the tclp time.				
I>2 Status	3E	29	Enable	0=Block 1=Enable
As shown in the menu, the I>2 status cells have two setting options, "Enable" and "Block". Selection of "Enable" for a particular stage means that the current and time settings programmed in the following cells will be those that are adopted during the "tclp" time. Selection of "Block" simply blocks the relevant protection stage during the "tclp" time. It also removes the following current and time settings for that stage from the menu.				
I>2 Current Set	3E	2A	1.5	0.08*In to 4*In step 0.01In
This setting determines the new pick-up setting for second stage overcurrent element during the tclp time delay.				
I>2 Time Delay	3E	2C	1	From 0s to 100s step 0.01s
Setting for the new operating time delay for the second stage definite time overcurrent element during the tclp time.				
I>2 TMS	3E	2D	1	From 0.025 to 1.2 step 0.005
Setting for the new time multiplier setting for the second stage element to adjust the operating time of the IEC IDMT characteristic during the tclp time.				
I>2 Time Dial	3E	2E	1	From 0.01 to 100 step 0.01
Setting for the new time multiplier setting to adjust the operating time of the IEEE/US IDMT curves during the tclp time.				
I>2 k (RI)	3E	2F	1	From 0.1 to 10 step 0.05
Setting for the new time multiplier setting to adjust the operating time of the RI curve during the tclp time.				
I>3 Status	3E	31	Block	0=Block 1=Enable
As shown in the menu the I>3 status cells have two setting options, "Enable" and "Block". Selection of "Enable" for a particular stage means that the current and time settings programmed in the following cells will be those that are adopted during the "tclp" time. Selection of "Block" simply blocks the relevant protection stage during the "tclp" time. It also removes the following current and time settings for that stage from the menu.				
I>3 Current Set	3E	32	25	0.08*In to 32*In step 0.01In
This setting determines the new pick-up setting for the third stage overcurrent function during the tclp time delay.				
I>3 Time Delay	3E	33	0	From 0s to 100s step 0.01s
Setting for the new operating time delay for the third stage definite time element during the tclp time.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
I>4 Status	3E	35	Block	From 0 to 1 step 1
As shown in the menu the I>4 status cells have two setting options, "Enable" and "Block". Selection of "Enable" for a particular stage means that the current and time settings programmed in the following cells will be those that are adopted during the "tclp" time. Selection of "Block" simply blocks the relevant protection stage during the "tclp" time. It also removes the following current and time settings for that stage from the menu.				
I>4 Current Set	3E	36	25	From 0.08 to 32 step 0.01
This setting determines the new pick-up setting for the fourth stage overcurrent function during the tclp time delay.				
I>4 Time Delay	3E	37	0	From 0s to 100s step 0.01s
Setting for the new operating time delay for the fourth stage definite time element during the tclp time.				
STAGE 1 E/F 1	3E	39		
IN1>1 Status	3E	3A	Enable	0=Block 1=Enable
As shown in the menu the IN1>1 status cells have two setting options, "Enable" and "Block". Selection of "Enable" for a particular stage means that the current and time settings programmed in the following cells will be those that are adopted during the "tclp" time. Selection of "Block" simply blocks the relevant protection stage during the "tclp" time. It also removes the following current and time settings for that stage from the menu.				
IN1>1 Current	3E	3B	0.2	0.08*In to 4*In step 0.01In
This setting determines the new pick-up setting for first stage earth fault element during the tclp time delay.				
IN1>1 IDG Is	3E	3C	1.5	From 1 to 4 step 0.1
Setting for the new time multiplier setting to adjust the operating time of the IDG curve (Scandinavian) during the tclp time.				
IN1>1 Time Delay	3E	3E	1	From 0s to 200s step 0.01s
Setting for the new operating time delay for the first stage definite time element during the tclp time.				
IN1>1 TMS	3E	3F	1	From 0.025 to 1.2 step 0.005
Setting for the new time multiplier setting to adjust the operating time of the IEC IDMT characteristic during the tclp time.				
IN1>1 Time Dial	3E	40	1	From 0.01 to 100 step 0.01
Setting for the new time multiplier setting to adjust the operating time of the IEEE/US IDMT curves during the tclp time.				
IN1>1 k (RI)	3E	41	1	From 0.1 to 10 step 0.05
Setting for the new time multiplier setting to adjust the operating time of the RI curve during the tclp time.				
STAGE 1 E/F 2	3E	43		
IN2>1 Status	3E	44	Enable	0=Block 1=Enable
As shown in the menu the IN2>1 status cells have two setting options, "Enable" and "Block". Selection of "Enable" for a particular stage means that the current and time settings programmed in the following cells will be those that are adopted during the "tclp" time. Selection of "Block" simply blocks the relevant protection stage during the "tclp" time. It also removes the following current and time settings for that stage from the menu.				
IN2>1 Current	3E	45	0.2	0.08*In to 4*In step 0.01In
This setting determines the new pick-up setting for second stage earth fault element during the tclp time delay.				
IN2>1 IDG Is	3E	46	1.5	From 1 to 4 step 0.1
Setting for the new time multiplier setting to adjust the operating time of the IDG curve (Scandinavian) during the tclp time.				
IN2>1 Time Delay	3E	48	1	From 0s to 200s step 0.01s
Setting for the new operating time delay for the second stage definite time element during the tclp time.				
IN2>1 TMS	3E	49	1	From 0.025 to 1.2 step 0.005
Setting for the new time multiplier setting to adjust the operating time of the IEC IDMT characteristic during the tclp time.				
IN2>1 Time Dial	3E	4A	1	From 0.01 to 100 step 0.01
Setting for the new time multiplier setting to adjust the operating time of the IEEE/US IDMT curves during the tclp time.				
IN2>1 k (RI)	3E	4B	1	From 0.1 to 10 step 0.05
Setting for the new time multiplier setting to adjust the operating time of the RI curve during the tclp time.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
I>5 Status	3E	50	Enable	0=Block 1=Enable
As shown in the menu, the I>5 status cells have two setting options, "Enable" and "Block". Selection of "Enable" for a particular stage means that the current and time settings programmed in the following cells will be those that are adopted during the "tclp" time. Selection of "Block" simply blocks the relevant protection stage during the "tclp" time. It also removes the following current and time settings for that stage from the menu.				
I>5 Current Set	3E	51	1.5	0.08*In to 4*In step 0.01In
This setting determines the new pick-up setting for fifth stage overcurrent element during the tclp time delay.				
I>5 Time Delay	3E	53	1	From 0s to 100s step 0.01s
Setting for the new operating time delay for the fifth stage definite time overcurrent element during the tclp time.				
I>5 TMS	3E	54	1	From 0.025 to 1.2 step 0.005
Setting for the new time multiplier setting for the fifth stage element to adjust the operating time of the IEC IDMT characteristic during the tclp time.				
I>5 Time Dial	3E	55	1	From 0.01 to 100 step 0.01
Setting for the new time multiplier setting to adjust the operating time of the IEEE/US IDMT curves during the tclp time.				
I>5 k (RI)	3E	56	1	From 0.1 to 10 step 0.05
Setting for the new time multiplier setting to adjust the operating time of the RI curve during the tclp time.				
I>6 Status	3E	58	Block	From 0 to 1 step 1
As shown in the menu the I>6 status cells have two setting options, "Enable" and "Block". Selection of "Enable" for a particular stage means that the current and time settings programmed in the following cells will be those that are adopted during the "tclp" time. Selection of "Block" simply blocks the relevant protection stage during the "tclp" time. It also removes the following current and time settings for that stage from the menu.				
I>6 Current Set	3E	59	25	From 0.08 to 32 step 0.01
This setting determines the new pick-up setting for the sixth stage overcurrent function during the tclp time delay.				
I>6 Time Delay	3E	5A	0	From 0s to 100s step 0.01s
Setting for the new operating time delay for the sixth stage definite time element during the tclp time.				

Table 12 - Cold Load Pick-Up

4.12 Selective Overcurrent Logic (SOL)

The Selective Overcurrent Logic (SOL) function provides the ability to temporarily increase the time delay settings of the third, fourth and the sixth stages of phase overcurrent, derived and measured earth fault and sensitive earth fault protection elements. This logic modifies the normal trip timer block functionality, to replace it with a second definite timer and is initiated by energization of the appropriate trip time opto-isolated input.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 SELECTIVE LOGIC	3F	00		
This column contains settings for selective logic				
OVERCURRENT	3F	01		
I>3 Time Delay	3F	02	1	From 0s to 100s step 0.01s
Setting for the third stage definite time overcurrent element operating time when the selective logic is active.				
I>4 Time Delay	3F	03	1	From 0s to 100s step 0.01s
Setting for the fourth stage definite time overcurrent element operating time when the selective logic is active.				
EARTH FAULT 1	3F	04		

Menu Text	Col	Row	Default Setting	Available Settings
Description				
IN1>3 Time Delay	3F	05	2	From 0s to 200s step 0.01s
Setting for the third stage definite time earth fault (measured) element operating time when the selective logic is active.				
IN1>4 Time Delay	3F	06	2	From 0s to 200s step 0.01s
Setting for the fourth stage definite time earth fault (measured) element operating time when the selective logic is active.				
EARTH FAULT 2	3F	07		
IN2>3 Time Delay	3F	08	2	From 0s to 200s step 0.01s
Setting for the third stage definite time earth fault (derived) element operating time when the selective logic is active.				
IN2>4 Time Delay	3F	09	2	From 0s to 200s step 0.01s
Setting for the fourth stage definite time earth fault (derived) element operating time when the selective logic is active.				
SENSITIVE E/F	3F	0A		
ISEF>3 Delay	3F	0B	1	From 0s to 200s step 0.01s
Setting for the third stage definite time sensitive earth fault element operating time when the selective logic is active.				
ISEF>4 Delay	3F	0C	0.5	From 0s to 200s step 0.01s
Setting for the fourth stage definite time sensitive earth fault element operating time when the selective logic is active.				
I>6 Time Delay	3F	0D	1	From 0s to 100s step 0.01s
Setting for the sixth stage definite time overcurrent element operating time when the selective logic is active.				

Table 13 - Selective Overcurrent Logic

4.13 Neutral Admittance Protection

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 ADMIT PROTECTION	40	00		
This column contains settings for Admittance protection				
VN Threshold	40	01	10 40	1V to 40V step 1V 4V to 160V step 4V
The over admittance elements YN>. GN> and BN> will operate providing the neutral voltage remains above the set level for the set operating time of the element. They are blocked by operation of the fast VTS supervision output.				
CT Input Type	40	02	SEF CT	0=SEF CT 1=E/F CT
Setting determines which CT inputs are used for the admittance element calculations				
Correction Angle	40	03	0	From -30 to 30 step 1
This setting causes rotation of the directional boundary for conductance through the set correction angle.				
YN> Status	40	05	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the overadmittance stage. If the function is disabled, then all associated settings with exception of this setting, are hidden.				
YN> Set	40	06	0.005 0.00125	0.0001S to 0.01S step 0.0001S 0.000025S to 0.0025S step 0.000025S
Sets the magnitude of the over admittance threshold. If the measurement exceeds the set value and the magnitude of neutral voltage exceeds the set value threshold, the relay will operate.				
YN> Set	40	07	0.05 0.0125	0.001S to 0.1S step 0.001S 0.00025S to 0.025S step 0.00025S

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Sets the magnitude of the over admittance threshold. If the measurement exceeds the set value and the magnitude of neutral voltage exceeds the set value threshold, the relay will operate.				
YN> Time Delay	40	08	1	From 0.05s to 100s step 0.01s
Operating time delay setting for the over admittance element.				
YN> tRESET	40	09	0	From 0s to 100s step 0.01s
Sets the reset/release time for the definite time reset characteristic.				
GN> Status	40	0B	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the over conductance stage. If the function is disabled, then all associated settings with exception of this setting, are hidden.				
GN> Direction	40	0C	Non-Directional	0=Non-Directional 1=Directional Fwd 2=Directional Rev
This setting determines the direction of measurement for this element.				
GN> Set	40	0D	0.0008 0.0002	0.0001S to 0.01S step 0.0001S 0.000025S to 0.0025S step 0.000025S
Sets the magnitude of the over conductance threshold. Provided the magnitude and direction criteria are met for conductance and the magnitude of neutral voltage exceeds the set value VN Threshold, the relay will operate.				
GN> Set	40	0E	0.002 0.0005	0.001S to 0.1S step 0.001S 0.00025S to 0.025S step 0.00025S
Sets the magnitude of the over conductance threshold. Provided the magnitude and direction criteria are met for conductance and the magnitude of neutral voltage exceeds the set value VN Threshold, the relay will operate.				
GN> Time Delay	40	0F	1	From 0.05s to 100s step 0.01s
Operating time delay setting for the over conductance element.				
GN> tRESET	40	10	0	From 0s to 100s step 0.01s
Sets the reset/release time for the definite time reset characteristic.				
BN> Status	40	12	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the over susceptance stage. If the function is disabled, then all associated settings with exception of this setting, are hidden.				
BN> Direction	40	13	Non-Directional	0=Non-Directional 1=Directional Fwd 2=Directional Rev
This setting determines the direction of measurement for this element.				
BN> Set	40	14	0.0008 0.0002	0.0001S to 0.01S step 0.0001S 0.000025S to 0.0025S step 0.000025S
Sets the magnitude of the over susceptance threshold. Provided the magnitude and direction criteria are met for suseptance and the magnitude of neutral voltage exceeds the set value VN Threshold, the relay will operate.				
BN> Set	40	15	0.002 0.0005	0.001S to 0.1S step 0.001S 0.00025S to 0.025S step 0.00025S
Sets the magnitude of the over susceptance threshold. Provided the magnitude and direction criteria are met for suseptance and the magnitude of neutral voltage exceeds the set value VN Threshold, the relay will operate.				
BN> Time Delay	40	16	1	From 0.05s to 100s step 0.01s
Operating time delay setting for the over susceptance element.				
BN> tRESET	40	17	0	From 0s to 100s step 0.01s
Sets the reset/release time for the definite time reset characteristic.				

Table 14 - Neutral Admittance Protection

4.14 Power Protection

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 POWER PROTECTION	41	00		
This column contains settings for Power protection				
OVER POWER	41	01		
Power>1 Status	41	02	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the Power>1 stage.				
Power>1 Direction	41	03	Forward	0=Reverse 1=Forward
Setting for the direction of the Power>1 stage.				
Power>1 Mode	41	04	Active	0=Active 1=Reactive
Setting to select Active or Reactive mode.				
Power>1 TimeDelay	41	05	1	From 0s to 100s step 0.01s
Operating time delay setting for the 1 stage over power protection element.				
Power>1 tRESET	41	06	0	From 0s to 100s step 0.01s
Resetting time delay setting for the 1 stage over power protection element.				
Power>1 1Ph Watt	41	07	40	From 1 to 325 step 1
Pickup setting of the 1 Phase 1 stage over power protection element - active mode.				
Power>1 1Ph VAR	41	08	24	From 1 to 325 step 1
Pickup setting of the 1 Phase 1 stage over power protection element - reactive mode.				
Power>1 3Ph Watt	41	09	120	From 1 to 325 step 1
Pickup setting of the 3 Phase 1 stage over power protection element - active mode.				
Power>1 3Ph VAR	41	0A	72	From 1 to 325 step 1
Pickup setting of the 3 Phase 1 stage over power protection element - reactive mode.				
Power>2 Status	41	0B	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the Power>2 stage.				
Power>2 Direction	41	0C	Forward	0=Reverse 1=Forward
Setting for the direction of the Power>2 stage.				
Power>2 Mode	41	0D	Active	0=Active 1=Reactive
Setting to select Active or Reactive mode.				
Power>2 TimeDelay	41	0E	1	From 0s to 100s step 0.01s
Operating time delay setting for the 2 stage over power protection element.				
Power>2 tRESET	41	0F	0	From 0s to 100s step 0.01s
Resetting time delay setting for the 2 stage over power protection element.				
Power>2 1Ph Watt	41	10	40	From 1 to 325 step 1
Pickup setting of the 1 Phase stage 2 over power protection element - active mode.				
Power>2 1Ph VAR	41	11	24	From 1 to 325 step 1
Pickup setting of the 1 Phase 2 stage over power protection element - reactive mode.				
Power>2 3Ph Watt	41	12	120	From 1 to 325 step 1
Pickup setting of the 3 Phase 2 stage over power protection element - active mode.				
Power>2 3Ph VAR	41	13	72	From 1 to 325 step 1
Pickup setting of the 3 Phase 2 stage over power protection element - reactive mode.				
UNDER POWER	41	14		

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Power<1 Status	41	15	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the Power<1 stage.				
Power<1 Direction	41	16	Forward	0=Reverse 1=Forward
Setting for the direction of the Power<1 stage.				
Power<1 Mode	41	17	Active	0=Active 1=Reactive
Setting to select Active or Reactive mode.				
Power<1 TimeDelay	41	18	1	From 0s to 100s step 0.01s
Operating time delay setting for the 1 stage under power protection element.				
Power<1 tRESET	41	19	0	From 0s to 100s step 0.01s
Resetting time delay setting for the 1 stage under power protection element.				
Power<1 1Ph Watt	41	1A	10	From 1 to 325 step 1
Pickup setting of the 1 Phase 1 stage under power protection element - active mode.				
Power<1 1Ph VAR	41	1B	6	From 1 to 325 step 1
Pickup setting of the 1 Phase 1 stage under power protection element - reactive mode.				
Power<1 3Ph Watt	41	1C	30	From 1 to 325 step 1
Pickup setting of the 3 Phase 1 stage under power protection element - active mode.				
Power<1 3Ph VAR	41	1D	18	From 1 to 325 step 1
Pickup setting of the 3 Phase 1 stage under power protection element - reactive mode.				
Power<2 Status	41	1E	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the Power<2 stage.				
Power<2 Direction	41	1F	Forward	0=Reverse 1=Forward
Setting for the direction of the Power<2 stage.				
Power<2 Mode	41	20	Active	0=Active 1=Reactive
Setting to select Active or Reactive mode.				
Power<2 TimeDelay	41	21	1	From 0s to 100s step 0.01s
Operating time delay setting for the 2 stage under power protection element.				
Power<2 tRESET	41	22	0	From 0s to 100s step 0.01s
Resetting time delay setting for the 2 stage under power protection element.				
Power<2 1Ph Watt	41	23	10	From 1 to 325 step 1
Pickup setting of the 1 Phase stage 2 under power protection element - active mode.				
Power<2 1Ph VAR	41	24	6	From 1 to 325 step 1
Pickup setting of the 1 Phase 2 stage under power protection element - reactive mode.				
Power<2 3Ph Watt	41	25	30	From 1 to 325 step 1
Pickup setting of the 3 Phase 2 stage under power protection element - active mode.				
Power<2 3Ph VAR	41	26	18	From 1 to 325 step 1
Pickup setting of the 3 Phase 2 stage under power protection element - reactive mode.				
Power Blocking	41	27	0x3	Bit 0=Poledead Blocks Power<1 Bit 1=Poledead Blocks Power<2
Setting to enable or disable the Under Power Pole dead blocking.				
SENSITIVE POWER	41	28		
Aph Sens Power	41	29	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the Sensitive Power.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Comp Angle	41	2A	0	From -5 to 5 step 0.1
This setting for CT compensating angle.				
Sens P1 Function	41	2B	Reverse	0=Disabled 1=Reverse 2=Low Forward 3=Over
First stage sensitive power function operating mode.				
Sens -P>1 Setting	41	2C	0.5*V1*I3	From 0.3*V1*I3 to 100*V1*I3 step 0.1*V1*I3
Pickup setting of the first stage sensitive reverse power protection element.				
Sens P<1 Setting	41	2D	0.5*V1*I3	From 0.3*V1*I3 to 100*V1*I3 step 0.1*V1*I3
Pickup setting of the first stage sensitive low forward power protection element.				
Sens P>1 Setting	41	2E	50*V1*I3	From 0.3*V1*I3 to 100*V1*I3 step 0.1*V1*I3
Pickup setting of the first stage sensitive over power protection element.				
Sens P1 Delay	41	2F	5	From 0s to 100s step 0.01s
Operating time delay setting of the first stage sensitive power protection element.				
Sens P1 tRESET	41	30	0	From 0s to 100s step 0.01s
Drop off time delay setting of the first stage sensitive power protection element.				
P1 PoleDead Inh	41	31	Enabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the Sensitive Power Stage 1 Pole dead inhibit.				
Sens P2 Function	41	32	Low Forward	0=Disabled 1=Reverse 2=Low Forward 3=Over
Second stage sensitive power function operating mode.				
Sens -P>2 Setting	41	33	0.5*V1*I3	From 0.3*V1*I3 to 100*V1*I3 step 0.1*V1*I3
Pickup setting of the second stage sensitive reverse power protection element.				
Sens P<2 Setting	41	34	0.5*V1*I3	From 0.3*V1*I3 to 100*V1*I3 step 0.1*V1*I3
Pickup setting of the second stage sensitive low forward power protection element.				
Sens P>2 Setting	41	35	50*V1*I3	From 0.3*V1*I3 to 100*V1*I3 step 0.1*V1*I3
Pickup setting of the second stage sensitive over power protection element.				
Sens P2 Delay	41	36	2	From 0s to 100s step 0.01s
Operating time delay setting of the second stage sensitive power protection element.				
Sens P2 tRESET	41	37	0	From 0s to 100s step 0.01s
Drop off time delay setting of the second stage sensitive power protection element.				
P2 PoleDead Inh	41	38	Enabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the Sensitive Power Stage 2 Pole dead inhibit.				

Table 15 - Power Protection

4.15 Voltage Protection

The undervoltage protection included within the relay consists of two independent stages. These are configurable as either phase to phase or phase to neutral measuring by means of the "V<Measur't mode" cell.

Stage 1 may be selected as IDMT, DT or Disabled, within the "V<1 function" cell.

Stage 2 is DT only and is enabled/disabled in the "V<2 status" cell.

Two stages are included to provide both alarm and trip stages, where required.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 VOLT PROTECTION	42	00		
This column contains settings for Voltage protection				
UNDER VOLTAGE	42	01		
V< Measur't Mode	42	02	Phase-Phase	0=Phase-Phase 1=Phase-Neutral
Sets the combination of measured input voltage that will be used for the undervoltage elements. Note: If any stage is disabled, the associated text in the setting menu cell setting will remain visible but will not affect the operation of the stage that is enabled.				
V< Operate Mode	42	03	Any Phase	0=Any Phase 1=Three Phase
Setting that determines whether any phase or all three phases has to satisfy the undervoltage criteria before a decision is made. Note: If any stage is disabled, the associated text in the setting menu cell setting will remain visible but will not affect the operation of the stage that is enabled.				
V<1 Function	42	04	DT	0=Disabled 1=DT 2=IDMT
Setting for the tripping characteristic of the first stage undervoltage element.				
V<1 Voltage Set	42	05	80	From 10*V1 to 120*V1 step 1*V1
Sets the pick-up setting for first stage undervoltage element.				
V<1 Time Delay	42	06	10	From 0s to 100s step 0.01s
Setting for the operating time-delay for the first stage definite time undervoltage element.				
V<1 TMS	42	07	1	From 0.5 to 100 step 0.5
Setting for the time multiplier setting to adjust the operating time of the IDMT characteristic.				
V<1 Poledead Inh	42	08	Enabled	0 = Disabled or 1 = Enabled
If the cell is enabled, the relevant stage will become inhibited by the pole dead logic. This logic produces an output when it detects either an open circuit breaker via auxiliary contacts feeding the IED opto inputs or it detects a combination of both undercurrent and undervoltage on any one phase. It allows the undervoltage protection to reset when the circuit breaker opens to cater for line or bus side VT applications.				
V<2 Status	42	09	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the second stage undervoltage element.				
V<2 Voltage Set	42	0A	60	From 10*V1 to 120*V1 step 1*V1
This setting determines the pick-up setting for second stage undervoltage element.				
V<2 Time Delay	42	0B	5	From 0s to 100s step 0.01s
Setting for the operating time-delay for the second stage definite time undervoltage element.				
V<2 Poledead Inh	42	0C	Enabled	0 = Disabled or 1 = Enabled
If the cell is enabled, the relevant stage will become inhibited by the pole dead logic. This logic produces an output when it detects either an open circuit breaker via auxiliary contacts feeding the IED opto inputs or it detects a combination of both undercurrent and undervoltage on any one phase. It allows the undervoltage protection to reset when the circuit breaker opens to cater for line or bus side VT applications.				
OVERVOLTAGE	42	0D		
V> Measur't Mode	42	0E	Phase-Phase	0=Phase-Phase 1=Phase-Neutral
Sets the combination of measured input voltage that will be used for the overvoltage elements. Note: If any stage is disabled, the associated text in the setting menu cell setting will remain visible but will not affect the operation of the stage that is enabled.				
V> Operate Mode	42	0F	Any Phase	0=Any Phase 1=Three Phase
Setting that determines whether any phase or all three phases has to satisfy the overvoltage criteria before a decision is made. Note: If any stage is disabled, the associated text in the setting menu cell setting will remain visible but will not affect the operation of the stage that is enabled.				
V>1 Function	42	10	DT	0=Disabled 1=DT 2=IDMT
Setting for the tripping characteristic of the first stage overvoltage element.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
V>1 Voltage Set	42	11	130	From 40*V1 to 185*V1 step 1*V1
Sets the pick-up setting for first stage overvoltage element.				
V>1 Time Delay	42	12	10	From 0s to 100s step 0.01s
Setting for the operating time-delay for the first stage definite time overvoltage element.				
V>1 TMS	42	13	1	From 0.5 to 100 step 0.5
Setting for the time multiplier setting to adjust the operating time of the IDMT characteristic.				
V>2 Status	42	14	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the second stage overvoltage element.				
V>2 Voltage Set	42	15	150	From 40*V1 to 185*V1 step 1*V1
This setting determines the pick-up setting for the second stage overvoltage element.				
V>2 Time Delay	42	16	0.5	From 0s to 100s step 0.01s
Setting for the operating time-delay for the second stage definite time overvoltage element.				
dv/dt PROTECTION	42	17		
dv/dt Meas Mode	42	18	Phase-Phase	0=Phase-Phase 1=Phase-Neutral
Sets the combination of measured input voltage that will be used for the dv/dt elements. Note: If any stage is disabled, the associated text in the setting menu cell setting will remain visible but will not affect the operation of the stage that is enabled.				
dv/dt1 Function	42	19	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting for the tripping direction for the first stage of dv/dt element.				
dv/dt1 Oper Mode	42	1A	Any Phase	0=Any Phase 1=Three Phase
Setting that determines whether any phase or all three phases has to satisfy the first stage of dv/dt criteria before a decision is made.				
dv/dt1 AvgCycles	42	1B	10	From 5 to 50 step 1
This setting determines the averaging cycles for the first stage dv/dt element.				
dv/dt1 Threshold	42	1C	10	From 0.5*V1 to 200*V1 step 0.5*V1
This setting determines the voltage threshold for the first stage dv/dt element.				
dv/dt1 TimeDelay	42	1D	0.5	From 0s to 100s step 0.01s
Setting for the operating time-delay for the first stage definite time dv/dt element.				
dv/dt1 tRESET	42	1E	0.03	From 0s to 100s step 0.01s
Setting for the resetting time-delay for the first stage definite time dv/dt element.				
dv/dt2 Function	42	1F	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting for the tripping direction for the second stage of dv/dt element.				
dv/dt2 Oper Mode	42	20	Any Phase	0=Any Phase 1=Three Phase
Setting that determines whether any phase or all three phases has to satisfy the second stage of dv/dt criteria before a decision is made.				
dv/dt2 AvgCycles	42	21	5	From 5 to 50 step 1
This setting determines the averaging cycles for the second stage dv/dt element.				
dv/dt2 Threshold	42	22	50	From 0.5*V1 to 200*V1 step 0.5*V1
This setting determines the voltage threshold for the second stage dv/dt element.				
dv/dt2 TimeDelay	42	23	0.3	From 0s to 100s step 0.01s
Setting for the operating time-delay for the second stage definite time dv/dt element.				
dv/dt2 tRESET	42	24	0.03	From 0s to 100s step 0.01s
Setting for the resetting time-delay for the second stage definite time dv/dt element.				

Table 16 - Voltage Protection

4.16 Frequency Protection

The relay includes four stages of underfrequency and two stages of overfrequency protection to facilitate load shedding and subsequent restoration. The underfrequency stages may be optionally blocked by a pole dead (CB Open) condition.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 FREQ PROTECTION	43	00		
This column contains settings for Frequency				
UNDER FREQUENCY	43	01		
F<1 Status	43	02	Enabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the first stage underfrequency element.				
F<1 Setting	43	03	49.5	From 45Hz to 65Hz step 0.01Hz
Setting that determines the pick-up threshold for the first stage underfrequency element.				
F<1 Time Delay	43	04	4	From 0s to 100s step 0.01s
Setting that determines the minimum operating time-delay for the first stage underfrequency element.				
F<2 Status	43	05	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the second stage underfrequency element.				
F<2 Setting	43	06	49	From 45Hz to 65Hz step 0.01Hz
Setting that determines the pick-up threshold for the second stage underfrequency element.				
F<2 Time Delay	43	07	3	From 0s to 100s step 0.01s
Setting that determines the minimum operating time-delay for the second stage underfrequency element.				
F<3 Status	43	08	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the third stage underfrequency element.				
F<3 Setting	43	09	48.5	From 45Hz to 65Hz step 0.01Hz
Setting that determines the pick-up threshold for the third stage underfrequency element.				
F<3 Time Delay	43	0A	2	From 0s to 100s step 0.01s
Setting that determines the minimum operating time-delay for the third stage underfrequency element.				
F<4 Status	43	0B	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the fourth stage underfrequency element.				
F<4 Setting	43	0C	48	From 45Hz to 65Hz step 0.01Hz
Setting that determines the pick-up threshold for the fourth stage underfrequency element.				
F<4 Time Delay	43	0D	1	From 0s to 100s step 0.01s
Setting that determines the minimum operating time-delay for the fourth stage underfrequency element.				
F< Function Link	43	0E	0x0	Bit 0=F<1 Poledead Blk Bit 1=F<2 Poledead Blk Bit 2=F<3 Poledead Blk Bit 3=F<4 Poledead Blk Bit 4=Not Used Bit 5=Not Used Bit 6=Not Used Bit 7=Not Used
Setting function link string, selecting which under frequency elements (1 to 4) will be blocked by the pole dead logic.				
OVER FREQUENCY	43	0F		
F>1 Status	43	10	Enabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the first stage overfrequency element.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
F>1 Setting	43	11	50.5	From 45Hz to 65Hz step 0.01Hz
Setting that determines the pick-up threshold for the first stage overfrequency element.				
F>1 Time Delay	43	12	2	From 0s to 100s step 0.01s
Setting that determines the minimum operating time-delay for the first stage overfrequency element.				
F>2 Status	43	13	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the second stage overfrequency element.				
F>2 Setting	43	14	51	From 45Hz to 65Hz step 0.01Hz
Setting that determines the pick-up threshold for the second stage overfrequency element.				
F>2 Time Delay	43	15	1	From 0s to 100s step 0.01s
Setting that determines the minimum operating time-delay for the second stage overfrequency element.				

Table 17 - Frequency Protection

4.17 Circuit Breaker Fail and Undercurrent Function

This function consists of a two-stage Circuit Breaker (CB) fail function initiated by:

- Current-based or Voltage-based protection elements
- External protection elements.

For current-based protection, the reset condition is based on undercurrent operation to determine that the CB has opened. For the non-current based protection, the reset criteria may be selected by means of a setting for determining a CB Failure condition.

It is common practice to use low set undercurrent elements in protection relays to indicate that circuit breaker poles have interrupted the fault or load current, as required.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 CB FAIL & I<	45	00		
This column contains settings for Circuit Fail and Under Current				
BREAKER FAIL	45	01		
CB Fail 1 Status	45	02	Enabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the first stage of the circuit breaker function.				
CB Fail 1 Timer	45	03	0.2	From 0s to 50s step 0.01s
Setting for the circuit breaker fail timer stage 1, during which breaker opening must be detected. There are timers per phase to cope with evolving faults, but the timer setting is common.				
CB Fail 2 Status	45	04	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the second stage of the circuit breaker function.				
CB Fail 2 Timer	45	05	0.4	From 0s to 50s step 0.01s
Setting for the circuit breaker fail timer stage 2, during which breaker opening must be detected.				
Volt Prot Reset	45	06	CB Open & I<	0=I< Only 1=CB Open & I< 2=Prot Reset & I<
Setting which determines the elements that will reset the circuit breaker fail time for voltage protection function initiated circuit breaker fail conditions.				
Ext Prot Reset	45	07	CB Open & I<	0=I< Only 1=CB Open & I< 2=Prot Reset & I<
Setting which determines the elements that will reset the circuit breaker fail time for external protection function initiated circuit breaker fail conditions.				
UNDER CURRENT	45	08		

Menu Text	Col	Row	Default Setting	Available Settings
Description				
I< Current Set	45	09	0.1	From 0.02*I1 to 3.2*I1 step 0.01*I1
Setting that determines the circuit breaker fail timer reset current for overcurrent based protection circuit breaker fail initiation. This setting is also used in the pole dead logic to determine the status of the pole (dead or live).				
IN< Current Set	45	0A	0.1	From 0.02*I2 to 3.2*I2 step 0.01*I2
Setting that determines the circuit breaker fail timer reset current for eart fault based protection circuit breaker fail initiation.				
ISEF< Current	45	0B	0.02	From 0.001*I3 to 0.8*I3 step 0.0005*I3
Setting that determines the circuit breaker fail timer reset current for sensetive eart fault based protection circuit breaker fail initiation.				
BLOCKED O/C	45	0C		
Remove I> Start	45	0D	Disabled	0 = Disabled or 1 = Enabled
Remove IN> Start	45	0E	Disabled	0 = Disabled or 1 = Enabled

Table 18 - Circuit Breaker Fail and Undercurrent Function

4.18 Supervision (VTS and CTS)

The VTS feature within the relay operates on detection of Negative Phase Sequence (NPS) voltage without the presence of NPS current.

The CT Supervision (CTS) feature operates on detection of derived zero sequence current, in the absence of corresponding derived zero sequence voltage that would normally accompany it.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 SUPERVISION	46	00		
This column contains settings for Supervision				
VT SUPERVISION	46	01		
VTS Status	46	02	Blocking	0=Blocking 1=Indication
This setting determines whether the following operations will occur upon detection of VTS. • VTS set to provide alarm indication only. • Optional blocking of voltage dependent protection elements. • Optional conversion of directional overcurrent elements to non-directional protection (available when set to blocking mode only). These settings are found in the function links cell of the relevant protection element columns in the menu.				
VTS Reset Mode	46	03	Manual	0=Manual 1=Auto
The VTS block will be latched after a user settable time delay 'VTS Time Delay'. Once the signal has latched then two methods of resetting are available. The first is manually via the front panel interface (or remote communications) and secondly, when in 'Auto' mode, provided the VTS condition has been removed and the 3 phase voltages have been restored above the phase level detector settings for more than 240 ms.				
VTS Time Delay	46	04	5	From 1s to 10s step 0.1s
Setting that determines the operating time-delay of the element upon detection of a voltage supervision condition.				
VTS I> Inhibit	46	05	10	From 0.08*I1 to 32*I1 step 0.01*I1
The setting is used to override a voltage supervision block in the event of a phase fault occurring on the system that could trigger the voltage supervision logic.				
VTS I2> Inhibit	46	06	0.05	From 0.05*I1 to 0.5*I1 step 0.01*I1

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The setting is used to override a voltage supervision block in the event of a fault occurring on the system with negative sequence current above this setting which could trigger the voltage supervision logic.				
CT SUPERVISION	46	07		
CTS Status	46	08	Disabled	0 = Disabled or 1 = Enabled
Setting to disable/enable the standard CT Supervision				
CTS VN< Inhibit	46	09	5 20	0.5V to 22V step 0.5V 2.0V to 88V step 2.0V
This setting is used to inhibit the current transformer supervision element should the zero sequence voltage exceed this setting. The setting is visible if CTS Mode is not disabled				
CTS IN> Set	46	0A	0.1	From 0.08*I1 to 4*I1 step 0.01*I1
This setting determines the level of zero sequence current that must be present for a valid current transformer supervision condition. The setting is visible if CTS Mode is not disabled				
CTS Time Delay	46	0B	5	From 0s to 10s step 1s
Setting for the operating time-delay for the CT Supervision element.				
VTS Pickup Threshold	46	0C	30	From 20*V1 to 120*V1 step 1*V1
Setting for the threshold for the VT Supervision element.				

Table 19 - Supervision (VTS and CTS)

4.19 Fault Locator

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 FAULT LOCATOR	47	00		
This column contains settings for Fault locator				
Line Length	47	01	16000	From 10 to 1000000 step 1
Setting for the line length. Distance to fault is available in metres.				
Line Length	47	02	10	From 0.005 to 621 step 0.005
Setting for the line length. Distance to fault is available in miles.				
Line Impedance	47	03	6	From 0.1*V1/I1 to 250*V1/I1 step 0.01*V1/I1
Setting for the positive sequence line impedance.				
Line Angle	47	04	70	From 20 to 85 step 1
Setting for the positive sequence line impedance angle.				
KZN Residual	47	05	1	From 0 to 7 step 0.01
Setting for the residual compensating factor.				
KZN Res Angle	47	06	0	From -90 to 90 step 1
Setting for the residual compensating factor angle.				

Table 20 - Fault Locator

4.20 System Checks (Check Sync. Function)

The P14x has a two stage Check Synchronization function that can be set independently.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 SYSTEM CHECKS	48	00		
This column contains settings for System checks.				
VOLTAGE MONITORS	48	14		
Live Voltage	48	15	32	From 1*V1 to 132*V1 step 0.5*V1
Sets the minimum voltage threshold above which a line or bus is to be recognized as being ‘Live’.				
Dead Voltage	48	16	13	From 1*V1 to 132*V1 step 0.5*V1
Sets the voltage threshold below which a line or bus to be recognized as being ‘Dead’.				
CHECK SYNC.	48	17		
CS1 Status	48	18	Enabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the first stage check sync. element.				
CS1 Phase Angle	48	19	20	From 5 to 90 step 1
Sets the maximum phase angle difference between the line and bus voltage for the first stage check sync. element phase angle criteria to be satisfied.				
CS1 Slip Control	48	1A	Frequency	0=None 1=Timer 2=Frequency 3=Both
Setting that determines whether slip control is by slip frequency only, frequency + timer or timer only criteria to satisfy the first stage check sync. conditions.				
CS1 Slip Freq	48	1B	0.05	From 0.01Hz to 1Hz step 0.01Hz
Sets the maximum frequency difference between the line and bus voltage for the first stage check sync. element slip frequency to be satisfied.				
CS1 Slip Timer	48	1C	1	From 0s to 99s step 0.01s
Minimum operating time-delay setting for the first stage check sync. element.				
CS2 Status	48	1D	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the second stage check sync. element.				
CS2 Phase Angle	48	1E	20	From 5 to 90 step 1
Sets the maximum phase angle difference between the line and bus voltage for the second stage check sync. element phase angle criteria to be satisfied.				
CS2 Slip Control	48	1F	Frequency	0=None 1=Timer 2=Frequency 3=Timer + Freq 4=Freq + CB Comp
Setting that determines whether slip control is by slip frequency only, frequency + timer or timer only criteria to satisfy the CS1 conditions.				
CS2 Slip Freq	48	20	0.05	From 0.01Hz to 1Hz step 0.01Hz
Slip frequency setting for the second stage check sync. element.				
CS2 Slip Timer	48	21	1	From 0s to 99s step 0.01s
Setting for the second stage Check Sync. slip timer.				
CS Undervoltage	48	22	54	From 10 to 132 step 0.5
Sets an undervoltage threshold above which the line and bus voltage must be to satisfy the Check Sync. condition if selected in the ‘CS Voltage Block’ cell.				
CS Overvoltage	48	23	130	From 40 to 185 step 0.5
Sets an overvoltage threshold above below which the line and bus voltage must be to satisfy the Check Sync. condition if selected in the ‘CS Voltage Block’ cell.				
CS Diff Voltage	48	24	6.5	From 1 to 132 step 0.5
Sets the voltage magnitude threshold between the line and bus volts below that the line and bus voltage difference must be to satisfy the Check Sync. condition if selected in the ‘CS Voltage Block’ cell.				
CS Voltage Block	48	25	V<	0=None 1=V< 2=V> 3=Vdiff> 4=V< and V> 5=V< and Vdiff> 6=V> and Vdiff> 7=V< V> and Vdiff

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Selects whether an undervoltage, overvoltage and voltage difference thresholds for the line and bus voltages must be satisfied in order for the Check Sync. conditions to be satisfied.				
SYSTEM SPLIT	48	26		
SS Status	48	27	Enabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the system split function - to detect a line and bus which are not possible to synchronize.				
SS Phase Angle	48	28	120	From 90 to 175 step 1
Sets the maximum phase angle difference between the line and bus voltage, which must be exceeded, for the System Split condition to be satisfied.				
SS Under V Block	48	29	Enabled	0 = Disabled or 1 = Enabled
Activates and undervoltage block criteria.				
SS Undervoltage	48	2A	54	From 10 to 132 step 0.5
Sets an undervoltage threshold above which the line and bus voltage must be to satisfy the System Split condition.				
SS Timer	48	2B	1	From 0s to 99s step 0.01s
The System Split output remains set for as long as the System Split criteria are true, or for a minimum period equal to the System Split Timer setting, whichever is longer.				
CB Close Time	48	2F	0.05	From 0s to 0.5s step 0.001s
This sets CB closing time, from receipt of CB close command until main contacts touch.				

Additional Description for CS1 Slip Control

Setting that determines whether slip control is by slip frequency only, frequency + timer or timer only criteria to satisfy the first stage check sync. conditions.

If slip control by timer or frequency + timer is selected, the combination of phase angle and timer settings determines an effective maximum slip frequency, calculated as:

(2 x A)/(T x 360) Hz. for Check Sync. 1

Where A = Phase angle setting (deg) and T = Slip timer setting (seconds)

For example, with Check Sync. 1 Phase Angle setting 30 degrees and Timer setting 3.3 sec, the “slipping” vector has to remain within + or - 30deg of the reference vector for at least 3.3 seconds. Therefore a synchro check output will not be given if the slip is greater than 2 x 30deg in 3.3 seconds. Using the formula: 2 x 30deg (3.3 x 360) = 0.0505 Hz (50.5 mHz).

If Slip Control by Frequency + Timer is selected, for an output to be given, the slip frequency must be less than BOTH the set Slip Freq. value and the value determined by the Phase Angle and Timer settings.

If Slip Control by Frequency, for an output to be given, the slip frequency must be less than the set Slip Freq. value setting only.

Additional Description for CS2 Slip Control

Setting that determines whether slip control is by slip frequency only, frequency + timer or timer only criteria to satisfy the CS1 conditions.

If Slip Control by Timer or Frequency + Timer is selected, the combination of Phase Angle and Timer settings determines an effective maximum slip frequency, calculated as:

(A)/(T x 360) Hz. for Check Sync. 2

Where A = Phase angle setting (deg) and T = Slip timer setting (seconds)

For Check Sync. 2, with Phase Angle setting 10 deg and Timer setting 0.1 sec, the slipping vector has to remain within 10 deg of the reference vector, with the angle decreasing, for 0.1 sec. When the angle passes through zero and starts to increase, the synchro check output is blocked. Therefore an output will not be given if slip is greater than 10 deg in 0.1 second. Using the formula: 10 □ (0.1 x 360) = 0.278 Hz (278 mHz).

If Slip Control by Frequency + Timer is selected, for an output to be given, the slip frequency must be less than BOTH the set Slip Freq. value and the value determined by the Phase Angle and Timer settings.

If Slip Control by Frequency, for an output to be given, the slip frequency must be less than the set Slip Freq. value setting only.

The “Freq. + Comp.” (Frequency + CB Time Compensation) setting modifies the Check Sync. 2 function to take account of the circuit breaker closing time. By measuring the slip frequency, and using the “CB Close Time” setting as a reference, the relay will issue the close command so that the circuit breaker closes at the instant the slip angle is equal to zero. Unlike Check Sync. 1, Check Sync. 2 only permits closure for decreasing angles of slip, therefore the circuit breaker should always close within the limits defined by Check Sync. 2.

Table 21 - System Checks

4.21 Auto-Reclose (AR) Function (P142/P143/P145 Only)

The relay will initiate Auto-Reclose (AR) for fault clearances by the phase overcurrent, earth fault and SEF protections. It will block auto-reclose for fault clearances by other protections (voltage, frequency, thermal, etc.).

The following shows the relay settings for the auto-reclose function, which must be set in conjunction with the Circuit Breaker Control settings. The available setting ranges and factory defaults are shown below:

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 AUTORECLOSE	49	00		
This column contains settings for Autoreclose				
AR Mode Select	49	01	Command Mode	0=Command Mode 1=Opto Set Mode 2=User Set Mode 3=Pulse Set Mode
If the Live Line logic input is high, then auto-reclose is taken out of service and certain live-line specific settings applied as appropriate. Provided Live Line is low: COMMAND MODE: Auto/Non-auto is selected by command cell "Auto-reclose Mode". OPTO SET MODE: Selects the Auto-reclose in service or out of service via an opto input linked to the appropriate Auto Mode input signal. USER SET MODE: Selects the mode of the AR via the telecontrol input signal. If Telecontrol input is high, the CB Control Auto-reclose Mode command cell is used to select Auto or Non-auto operating mode. If Telecontrol input is low, behaves as OPTO SET setting (follows the status of the Auto Input signal). PULSE SET MODE: Selects the mode of the AR via the telecontrol input signals. If Telecontrol input is high, the operating mode is toggled between Auto and Non-auto Mode on the falling edge of Auto Mode input pulses. The pulses are produced by SCADA system. If the Telecontrol input is low, behaves as OPTO SET setting setting (follows the status of the Auto Input signal). Note: Auto Mode = AR in service and Non-auto = AR is out of service and instantaneous protection is blocked.				
Number of Shots	49	02	1	From 1 to 4 step 1
Sets the number of auto-reclose shots/cycles for overcurrent fault trips.				
Number SEF Shots	49	03	0	From 0 to 4 step 1
Sets the number of auto-reclose shots/cycles for overcurrent sensitive earth fault trips.				
Sequence Co-ord	49	04	Disabled	0 = Disabled or 1 = Enabled
Enables the sequence co-ordination function to ensure the correct protection grading between an upstream and downstream re-closing device. The main protection start or sensitive earth fault protection start signals indicate to the relay when fault current is present, advance the sequence count by one and start the dead time whether the breaker is open or closed. When the dead time is complete and the protection start inputs are off the reclaim timer will be initiated.				
CS AR Immediate	49	05	Disabled	0 = Disabled or 1 = Enabled
Setting "CS AR Immediate" Enabled allows immediate re-closure of the circuit breaker provided both sides of the circuit breaker are live and in synchronism at any time after the dead time has started. This allows for quicker load restoration, as it is not necessary to wait for the full dead time. If "CS AR Immediate" is disabled, or Line and Bus volts are not both live, the dead timer will continue to run, assuming the "DDB#457: Dead Time Enabled" (mapped in Programmable Scheme Logic) is asserted high. The "Dead Time Enabled" function could be mapped to an opto input to indicate that the circuit breaker is healthy i.e. spring charged etc. Mapping the "Dead Time Enabled" function in PSL increases the flexibility by allowing it, if necessary, to be triggered by other conditions such as "Live Line/Dead Bus" for example. If "Dead Time Enabled" is not mapped in PSL, it defaults to high, so the dead time can run.				
Dead Time 1	49	06	10	From 0.01s to 300s step 0.01s
Sets the dead time for the first auto-reclose cycle.				
Dead Time 2	49	07	60	From 0.01s to 300s step 0.01s
Sets the dead time for the second auto-reclose cycle.				
Dead Time 3	49	08	180	From 0.01s to 9999s step 0.01s
Sets the dead time for the third auto-reclose cycle.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Dead Time 4	49	09	180	From 0.01s to 9999s step 0.01s
Sets the dead time for the fourth auto-reclose cycle.				
CB Healthy Time	49	0A	5	From 0.01s to 9999s step 0.01s
If on completion of the dead time, the “CB Healthy" input is low, and remains low for a period given by the "CB Healthy Time" timer, lockout will result and the circuit breaker will remain open.				
Start Dead t On	49	0B	Protection Reset	0=Protection Reset 1=CB Trips
Setting that determines whether the dead time is started when the circuit breaker trips or when the protection trip resets.				
tReclaim Extend	49	0C	No Operation	0=On Prot Start 1=No Operation
The setting allows the user to control whether the reclaim timer is suspended by the protection start contacts or not (i.e. whether the relay is permitted to reclaim if a fault condition is present and will be cleared in a long time-scale). When a setting of “No Operation” is used the Reclaim Timer will operate from the instant that the circuit breaker is closed and will continue until the timer expires. For certain applications it is advantageous to set “tReclaim Extend” to “On Prot. Start”. This facility allows the operation of the reclaim timer to be suspended after circuit breaker re-closure by a signal from the main protection start or sensitive earth fault protection start signals. The main protection start signal is initiated from the start of any protection which has been selected to "Initiate Main AR" (initiate auto-reclose) in the "AR Initiation" settings.				
Reclaim Time 1	49	0D	180	From 1s to 600s step 0.01s
Sets the auto-reclose reclaim time for the first auto-reclose cycle.				
Reclaim Time 2	49	0E	180	From 1s to 600s step 0.01s
Sets the auto-reclose reclaim time for the second auto-reclose cycle.				
Reclaim Time 3	49	0F	180	From 1s to 600s step 0.01s
Sets the auto-reclose reclaim time for the third auto-reclose cycle.				
Reclaim Time 4	49	10	180	From 1s to 600s step 0.01s
Sets the auto-reclose reclaim time for the fourth auto-reclose cycle.				
AR Inhibit Time	49	11	5	From 0.01s to 600s step 0.01s
With this setting, auto-reclose initiation is inhibited for a period equal to setting “A/R Inhibit Time” following a manual circuit breaker closure.				
AR Lockout	49	12	No Block	0=No Block 1=Block Inst Prot
Instantaneous protection can be blocked when the relay is locked out, using this setting.				
EFF Maint Lock	49	13	No Block	0=No Block 1=Block Inst Prot
If this is set to "Block Inst. Prot." the instantaneous protection will be blocked for the last circuit breaker trip before lockout occurs. The instantaneous protection can be blocked to ensure that the last circuit breaker trip before lockout will be due to discriminative protection operation when the circuit breaker maintenance lockout counter or excessive fault frequency lockout has reached its penultimate value.				
AR Deselected	49	14	No Block	0=No Block 1=Block Inst Prot
This setting allows the instantaneous protection to be blocked when auto-reclose is in non-auto mode of operation.				
Manual Close	49	15	No Block	0=No Block 1=Block Inst Prot
This setting allows the instantaneous protection to be blocked when the circuit breaker is closed manually whilst there is no auto-reclose sequence in progress or auto-reclose is inhibited.				
Trip 1 Main	49	16	No Block	0=No Block 1=Block Inst Prot
These allow the instantaneous elements of phase, earth fault protection to be selectively blocked for a circuit breaker trip sequence. For example, if "Trip 1 Main" is set to "No Block" and "Trip 2 Main" is set to "Block Inst. Prot.", the instantaneous elements of the phase and earth fault protection will be available for the first trip but blocked afterwards for the second trip during the auto-reclose cycle.				
Trip 2 Main	49	17	Block Inst Prot	0=No Block 1=Block Inst Prot
These allow the instantaneous elements of phase, earth fault protection to be selectively blocked for a circuit breaker trip sequence. For example, if "Trip 1 Main" is set to "No Block" and "Trip 2 Main" is set to "Block Inst. Prot.", the instantaneous elements of the phase and earth fault protection will be available for the first trip but blocked afterwards for the second trip during the auto-reclose cycle.				
Trip 3 Main	49	18	Block Inst Prot	0=No Block 1=Block Inst Prot
These allow the instantaneous elements of phase, earth fault protection to be selectively blocked for a circuit breaker trip sequence. For example, if "Trip 1 Main" is set to "No Block" and "Trip 2 Main" is set to "Block Inst. Prot.", the instantaneous elements of the phase and earth fault protection will be available for the first trip but blocked afterwards for the second trip during the auto-reclose cycle.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Trip 4 Main	49	19	Block Inst Prot	0=No Block 1=Block Inst Prot
These allow the instantaneous elements of phase, earth fault protection to be selectively blocked for a circuit breaker trip sequence. For example, if "Trip 1 Main" is set to "No Block" and "Trip 2 Main" is set to "Block Inst. Prot.", the instantaneous elements of the phase and earth fault protection will be available for the first trip but blocked afterwards for the second trip during the auto-reclose cycle.				
Trip 5 Main	49	1A	Block Inst Prot	0=No Block 1=Block Inst Prot
These allow the instantaneous elements of phase, earth fault protection to be selectively blocked for a circuit breaker trip sequence. For example, if "Trip 1 Main" is set to "No Block" and "Trip 2 Main" is set to "Block Inst. Prot.", the instantaneous elements of the phase and earth fault protection will be available for the first trip but blocked afterwards for the second trip during the auto-reclose cycle.				
Trip 1 SEF	49	1B	Block Inst Prot	0=No Block 1=Block Inst Prot
These allow the instantaneous elements of sensitive earth fault protection to be selectively blocked for a circuit breaker trip sequence. For example, if "Trip 1 SEF" is set to "No Block" and "Trip 2 SEF" is set to "Block Inst. Prot.", the instantaneous elements of the sensitive protection will be available for the first trip but blocked afterwards for the second trip during the auto-reclose cycle.				
Trip 2 SEF	49	1C	Block Inst Prot	0=No Block 1=Block Inst Prot
These allow the instantaneous elements of sensitive earth fault protection to be selectively blocked for a circuit breaker trip sequence. For example, if "Trip 1 SEF" is set to "No Block" and "Trip 2 SEF" is set to "Block Inst. Prot.", the instantaneous elements of the sensitive protection will be available for the first trip but blocked afterwards for the second trip during the auto-reclose cycle.				
Trip 3 SEF	49	1D	Block Inst Prot	0=No Block 1=Block Inst Prot
These allow the instantaneous elements of sensitive earth fault protection to be selectively blocked for a circuit breaker trip sequence. For example, if "Trip 1 SEF" is set to "No Block" and "Trip 2 SEF" is set to "Block Inst. Prot.", the instantaneous elements of the sensitive protection will be available for the first trip but blocked afterwards for the second trip during the auto-reclose cycle.				
Trip 4 SEF	49	1E	Block Inst Prot	0=No Block 1=Block Inst Prot
These allow the instantaneous elements of sensitive earth fault protection to be selectively blocked for a circuit breaker trip sequence. For example, if "Trip 1 SEF" is set to "No Block" and "Trip 2 SEF" is set to "Block Inst. Prot.", the instantaneous elements of the sensitive protection will be available for the first trip but blocked afterwards for the second trip during the auto-reclose cycle.				
Trip 5 SEF	49	1F	Block Inst Prot	0=No Block 1=Block Inst Prot
These allow the instantaneous elements of sensitive earth fault protection to be selectively blocked for a circuit breaker trip sequence. For example, if "Trip 1 SEF" is set to "No Block" and "Trip 2 SEF" is set to "Block Inst. Prot.", the instantaneous elements of the sensitive protection will be available for the first trip but blocked afterwards for the second trip during the auto-reclose cycle.				
Man Close on Flt	49	20	Lockout	0=No Lockout 1=Lockout
An auto-reclose lockout is caused by a protection operation after manual closing during the "AR Inhibit Time" when the "Manual Close on Flt" setting is set to “Lockout”.				
Trip AR Inactive	49	21	No Lockout	0=No Lockout 1=Lockout
An auto-reclose lockout is caused by a protection operation when the relay is in the Live Line or Non-auto modes when "Trip AR Inactive" is set to "Lockout".				
Reset Lockout by	49	22	User Interface	0=User Interface 1=Select NonAuto
The setting is used to enable/disable the resetting of lockout when the relay is in the Non-auto operating mode.				
AR on Man Close	49	24	Inhibited	0=Enabled 1=Inhibited
If this is set to “Enabled”, auto-reclosing can be initiated immediately on circuit breaker closure, and settings “A/R Inhibit Time”, “Man Close on Flt” and “Manual Close” are irrelevant.				
Sys Check Time	49	25	5	From 0.01s to 9999s step 0.01s
AR Skip Shot 1	49	26	Disabled	0 = Disabled or 1 = Enabled
When enabled this setting will allow the auto-reclose sequence counter to be incremented by one via a DDB input signal. This will therefore decrease the available re-close shots.				
AR INITIATION	49	28		
I>1 AR	49	29	Initiate Main AR	0=No Action 1=Initiate Main AR
Setting that determines impact of the first stage overcurrent protection on AR operation.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
I>2 AR	49	2A	Initiate Main AR	0=No Action 1=Initiate Main AR
Setting that determines impact of the second stage overcurrent protection on AR operation.				
I>3 AR	49	2B	Initiate Main AR	0=No Action 1=Initiate Main AR 2=Block AR
Setting that determines impact of the third stage overcurrent protection on AR operation.				
I>4 AR	49	2C	Initiate Main AR	0=No Action 1=Initiate Main AR 2=Block AR
Setting that determines impact of the fourth stage overcurrent protection on AR operation.				
IN1>1 AR	49	2D	Initiate Main AR	0=No Action 1=Initiate Main AR
Setting that determines impact of the first stage measured earth fault overcurrent protection on AR operation.				
IN1>2 AR	49	2E	Initiate Main AR	0=No Action 1=Initiate Main AR
Setting that determines impact of the second stage measured earth fault overcurrent protection on AR operation.				
IN1>3 AR	49	2F	Initiate Main AR	0=No Action 1=Initiate Main AR 2=Block AR
Setting that determines impact of the third stage measured earth fault overcurrent protection on AR operation.				
IN1>4 AR	49	30	Initiate Main AR	0=No Action 1=Initiate Main AR 2=Block AR
Setting that determines impact of the fourth stage measured earth fault overcurrent protection on AR operation.				
IN2>1 AR	49	31	No Action	0=No Action 1=Initiate Main AR
Setting that determines impact of the first stage derived earth fault overcurrent protection on AR operation.				
IN2>2 AR	49	32	No Action	0=No Action 1=Initiate Main AR
Setting that determines impact of the second stage derived earth fault overcurrent protection on AR operation.				
IN2>3 AR	49	33	No Action	0=No Action 1=Initiate Main AR 2=Block AR
Setting that determines impact of the third stage derived earth fault overcurrent protection on AR operation.				
IN2>4 AR	49	34	No Action	0=No Action 1=Initiate Main AR 2=Block AR
Setting that determines impact of the fourth stage derived earth fault overcurrent protection on AR operation.				
ISEF>1 AR	49	35	No Action	0=No Action 1=Initiate Main AR 2=Initiate SEF AR 3=Block AR
Setting that determines impact of the first stage sensitive earth fault overcurrent protection on AR operation.				
ISEF>2 AR	49	36	No Action	0=No Action 1=Initiate Main AR 2=Initiate SEF AR 3=Block AR
Setting that determines impact of the second stage sensitive earth fault overcurrent protection on AR operation.				
ISEF>3 AR	49	37	No Action	0=No Action 1=Initiate Main AR 2=Initiate SEF AR 3=Block AR
Setting that determines impact of the third stage sensitive earth fault overcurrent protection on AR operation.				
ISEF>4 AR	49	38	No Action	0=No Action 1=Initiate Main AR 2=Initiate SEF AR 3=Block AR
Setting that determines impact of the fourth stage sensitive earth fault overcurrent protection on AR operation.				
YN> AR	49	39	No Action	0=No Action 1=Initiate Main AR
Setting that determines impact of the overadmittance protection on AR operation.				
GN> AR	49	3A	No Action	0=No Action 1=Initiate Main AR
Setting that determines impact of the overc onductance protection on AR operation.				
BN> AR	49	3B	No Action	0=No Action 1=Initiate Main AR
Setting that determines impact of the over susceptance protection on AR operation.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Ext Prot	49	3C	No Action	0=No Action 1=Initiate Main AR
Setting that determines if external protection inputs initiates auto-reclose. This must be mapped in programmable scheme logic.				
SYSTEM CHECKS	49	40		
AR with ChkSyn	49	41	Disabled	0 = Disabled or 1 = Enabled
Enables auto-reclose with check synchronization. Only allows auto-reclose when the system satisfies the “Check Sync. Stage 1” settings.				
AR with SysSyn	49	42	Disabled	0 = Disabled or 1 = Enabled
Enables auto-reclose with check synchronization. Only allows auto-reclose when the system satisfies the “Check Sync. Stage 2” settings				
Live/Dead Ccts	49	43	Disabled	0 = Disabled or 1 = Enabled
When enabled, this setting will give an “AR Check Ok” signal when the “DDB#461 Circuits OK” is asserted high. This logic input DDB would normally be mapped in programmable scheme logic to appropriate combinations of Line Live, Line Dead, Bus Live and Bus Dead DDB signals. Auto-reclose can be initiated once DDB#461 is asserted high				
No System Checks	49	44	Enabled	0 = Disabled or 1 = Enabled
When enabled this setting completely disables system checks thus allowing auto-reclose initiation.				
SysChk on Shot 1	49	45	Enabled	0 = Disabled or 1 = Enabled
Can be used to disable system checks on the first auto-reclose shot.				
I>5 AR	49	46	Initiate Main AR	0=No Action 1=Initiate Main AR
Setting that determines impact of the fifth stage overcurrent protection on AR operation.				
I>6 AR	49	47	Initiate Main AR	0=No Action 1=Initiate Main AR 2=Block AR
Setting that determines impact of the sixth stage overcurrent protection on AR operation.				

Table 22 - Auto-Reclose Function (P142/P143/P145 Only)

4.22 Input Labels

The column **GROUP x INPUT LABELS** is used to individually label each opto input that is available in the relay. The text is restricted to 16 characters and is available if ‘Input Labels’ are set visible under CONFIGURATION column.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 INPUT LABELS	4A	00		
This column contains settings for Input Labels				
Opto Input 1	4A	01	Input L1	From 32 to 234 step 1
Label for Opto Input 1				
Opto Input 2	4A	02	Input L2	From 32 to 234 step 1
Label for Opto Input 2				
Opto Input 3	4A	03	Input L3	From 32 to 234 step 1
Label for Opto Input 3				
Opto Input 4	4A	04	Input L4	From 32 to 234 step 1
Label for Opto Input 4				
Opto Input 5	4A	05	Input L5	From 32 to 234 step 1
Label for Opto Input 5				
Opto Input 6	4A	06	Input L6	From 32 to 234 step 1

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Label for Opto Input 6				
Opto Input 7	4A	07	Input L7	From 32 to 234 step 1
Label for Opto Input 7				
Opto Input 8	4A	08	Input L8	From 32 to 234 step 1
Label for Opto Input 8				
Opto Input 9	4A	09	Input L9	From 32 to 234 step 1
Label for Opto Input 9				
Opto Input 10	4A	0A	Input L10	From 32 to 234 step 1
Label for Opto Input 10				
Opto Input 11	4A	0B	Input L11	From 32 to 234 step 1
Label for Opto Input 11				
Opto Input 12	4A	0C	Input L12	From 32 to 234 step 1
Label for Opto Input 12				
Opto Input 13	4A	0D	Input L13	From 32 to 234 step 1
Label for Opto Input 13				
Opto Input 14	4A	0E	Input L14	From 32 to 234 step 1
Label for Opto Input 14				
Opto Input 15	4A	0F	Input L15	From 32 to 234 step 1
Label for Opto Input 15				
Opto Input 16	4A	10	Input L16	From 32 to 234 step 1
Label for Opto Input 16				
Opto Input 17	4A	11	Input L17	From 32 to 234 step 1
Label for Opto Input 17				
Opto Input 18	4A	12	Input L18	From 32 to 234 step 1
Label for Opto Input 18				
Opto Input 19	4A	13	Input L19	From 32 to 234 step 1
Label for Opto Input 19				
Opto Input 20	4A	14	Input L20	From 32 to 234 step 1
Label for Opto Input 20				
Opto Input 21	4A	15	Input L21	From 32 to 234 step 1
Label for Opto Input 21				
Opto Input 22	4A	16	Input L22	From 32 to 234 step 1
Label for Opto Input 22				
Opto Input 23	4A	17	Input L23	From 32 to 234 step 1
Label for Opto Input 23				
Opto Input 24	4A	18	Input L24	From 32 to 234 step 1
Label for Opto Input 24				
Opto Input 25	4A	19	Input L25	From 32 to 234 step 1
Label for Opto Input 25				
Opto Input 26	4A	1A	Input L26	From 32 to 234 step 1
Label for Opto Input 26				
Opto Input 27	4A	1B	Input L27	From 32 to 234 step 1
Label for Opto Input 27				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Opto Input 28	4A	1C	Input L28	From 32 to 234 step 1
Label for Opto Input 28				
Opto Input 29	4A	1D	Input L29	From 32 to 234 step 1
Label for Opto Input 29				
Opto Input 30	4A	1E	Input L30	From 32 to 234 step 1
Label for Opto Input 30				
Opto Input 31	4A	1F	Input L31	From 32 to 234 step 1
Label for Opto Input 31				
Opto Input 32	4A	20	Input L32	From 32 to 234 step 1
Label for Opto Input 32				

Table 23 – Input labels

4.23 Output Labels

The column **GROUP x OUTPUT LABELS** is used to individually label each output relay that is available in the relay. The text is restricted to 16 characters and is available if 'Output Labels' are set visible under CONFIGURATION column.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 OUTPUT LABELS	4B	00		
This column contains settings for Output Relay Labels				
Relay 1	4B	01	Output R1	From 32 to 234 step 1
Label for output relay 1				
Relay 2	4B	02	Output R2	From 32 to 234 step 1
Label for output relay 2				
Relay 3	4B	03	Output R3	From 32 to 234 step 1
Label for output relay 3				
Relay 4	4B	04	Output R4	From 32 to 234 step 1
Label for output relay 4				
Relay 5	4B	05	Output R5	From 32 to 234 step 1
Label for output relay 5				
Relay 6	4B	06	Output R6	From 32 to 234 step 1
Label for output relay 6				
Relay 7	4B	07	Output R7	From 32 to 234 step 1
Label for output relay 7				
Relay 8	4B	08	Output R8	From 32 to 234 step 1
Label for output relay 8				
Relay 9	4B	09	Output R9	From 32 to 234 step 1
Label for output relay 9				
Relay 10	4B	0A	Output R10	From 32 to 234 step 1
Label for output relay 10				
Relay 11	4B	0B	Output R11	From 32 to 234 step 1

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Label for output relay 11				
Relay 12	4B	0C	Output R12	From 32 to 234 step 1
Label for output relay 12				
Relay 13	4B	0D	Output R13	From 32 to 234 step 1
Label for output relay 13				
Relay 14	4B	0E	Output R14	From 32 to 234 step 1
Label for output relay 14				
Relay 15	4B	0F	Output R15	From 32 to 234 step 1
Label for output relay 15				
Relay 16	4B	10	Output R16	From 32 to 234 step 1
Label for output relay 16				
Relay 17	4B	11	Output R17	From 32 to 234 step 1
Label for output relay 17				
Relay 18	4B	12	Output R18	From 32 to 234 step 1
Label for output relay 18				
Relay 19	4B	13	Output R19	From 32 to 234 step 1
Label for output relay 19				
Relay 20	4B	14	Output R20	From 32 to 234 step 1
Label for output relay 20				
Relay 21	4B	15	Output R21	From 32 to 234 step 1
Label for output relay 21				
Relay 22	4B	16	Output R22	From 32 to 234 step 1
Label for output relay 22				
Relay 23	4B	17	Output R23	From 32 to 234 step 1
Label for output relay 23				
Relay 24	4B	18	Output R24	From 32 to 234 step 1
Label for output relay 24				
Relay 25	4B	19	Output R25	From 32 to 234 step 1
Label for output relay 25				
Relay 26	4B	1A	Output R26	From 32 to 234 step 1
Label for output relay 26				
Relay 27	4B	1B	Output R27	From 32 to 234 step 1
Label for output relay 27				
Relay 28	4B	1C	Output R28	From 32 to 234 step 1
Label for output relay 28				
Relay 29	4B	1D	Output R29	From 32 to 234 step 1
Label for output relay 29				
Relay 30	4B	1E	Output R30	From 32 to 234 step 1
Label for output relay 30				
Relay 31	4B	1F	Output R31	From 32 to 234 step 1
Label for output relay 31				
Relay 32	4B	20	Output R32	From 32 to 234 step 1
Label for output relay 32				

Table 24 – Output labels

4.24 Advanced Frequency Protection

Menu Text	Col	Row	Default Setting	Available Settings
Description				
GROUP 1 ADV. FREQ PROT'N	4D	00		
This column contains settings for Advanced frequency protection.				
Freq Avg.Cycles	4D	01	5	From 0 to 48 step 1
Sets the number of power system cycles that are used to average the frequency measurement.				
df/dt Avg.Cycles	4D	02	5	From 0 to 48 step 1
Sets the number of power system cycles that are used to average the rate of change of frequency measurement.				
V<B Status	4D	03	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the under voltage blocking of the frequency protection elements.				
V<B Voltage Set	4D	04	25*V1	From 10*V1 to 120*V1 step 1*V1
Pick up setting for the under voltage blocking element. When operated, this will prevent any frequency based protection from operating.				
V<B Measur Mode	4D	05	Phase-Phase	0=Phase-Phase 1=Phase-Neutral
Sets the measured input voltage that will be used for the under voltage blocking.				
V<B Operate Mode	4D	06	Three Phase	0=Any Phase 1=Three Phase
Setting that determines whether any phase or all three phases has to satisfy the under voltage criteria before a decision is made.				
Stage 1	4D	07	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or enable first stage frequency protection.				
Stg 1 f+t Status	4D	08	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over frequency of the first stage frequency protection.				
Stg 1 f+t Freq	4D	09	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the first stage frequency protection element.				
Stg 1 f+t Time	4D	0A	2	From 0s to 100s step 0.01s
Setting for the operating time delay for the first stage frequency protection element.				
df/dt+t 1 Status	4D	0B	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the first stage df/dt protection.				
df/dt+t 1 Set	4D	0C	2	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Rate of change of frequency threshold for the first stage.				
df/dt+t 1 Time	4D	0D	0.5	From 0s to 100s step 0.01s
Setting for the operating time delay for the first stage rate of change of frequency protection element.				
f+df/dt 1 Status	4D	0E	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the first stage frequency supervised rate of change of frequency protection.				
f+df/dt 1 freq	4D	0F	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the first stage frequency supervised rate of change of frequency protection element.				
f+df/dt 1 df/dt	4D	10	1	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Frequency supervised rate of change of frequency threshold for the first stage.				
f+Df/Dt 1 Status	4D	11	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over average rate of change of frequency of the first stage.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
f+Df/Dt 1 freq	4D	12	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the first stage average rate of change of frequency protection element.				
f+Df/Dt 1 Dfreq	4D	13	1	From 0.1Hz to 10Hz step 0.01Hz
Change in frequency that must be measured in the set time for the first stage average rate of change of frequency protection element.				
f+Df/Dt 1 Dtime	4D	14	0.5	From 0.02s to 100s step 0.01s
The time period over which a change in frequency that in excess of the setting f+Df/Dt 1 Dfreq that must be measured for the first stage average rate of change of frequency protection element.				
Restore1 Status	4D	15	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or Enable the first stage of load restoration.				
Restore1 Freq	4D	16	49.5	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the first stage of load restoration, above which the associated load restoration time can start.				
Restore1 Time	4D	17	240	From 0s to 7200s step 0.25s
Time period for which the measured frequency must be higher than first stage restoration frequency setting to permit load restoration.				
Holding Timer 1	4D	18	5	From 1s to 7200s step 1s
Sets the holding time of the first stage load restoration function.				
Stg 1 UV Block	4D	19	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the under voltage blocking of the stage 1 load restoration element.				
Stage 2	4D	1A	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or enable second stage frequency protection.				
Stg 2 f+t Status	4D	1B	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over frequency of the second stage frequency protection.				
Stg 2 f+t Freq	4D	1C	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the second stage frequency protection element.				
Stg 2 f+t Time	4D	1D	2	From 0s to 100s step 0.01s
Setting for the operating time delay for the second stage frequency protection element.				
df/dt+t 2 Status	4D	1E	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the second stage df/dt protection.				
df/dt+t 2 Set	4D	1F	2	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Rate of change of frequency threshold for the second stage.				
df/dt+t 2 Time	4D	20	0.5	From 0s to 100s step 0.01s
Setting for the operating time delay for the second stage rate of change of frequency protection element.				
f+df/dt 2 Status	4D	21	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the second stage frequency supervised rate of change of frequency protection.				
f+df/dt 2 freq	4D	22	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the second stage frequency supervised rate of change of frequency protection element.				
f+df/dt 2 df/dt	4D	23	1	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Frequency supervised rate of change of frequency threshold for the second stage.				
f+Df/Dt 2 Status	4D	24	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over average rate of change of frequency of the second stage.				
f+Df/Dt 2 freq	4D	25	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the second stage average rate of change of frequency protection element.				
f+Df/Dt 2 Dfreq	4D	26	1	From 0.1Hz to 10Hz step 0.01Hz

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Change in frequency that must be measured in the set time for the second stage average rate of change of frequency protection element.				
f+Df/Dt 2 Dtime	4D	27	0.5	From 0.02s to 100s step 0.01s
The time period over which a change in frequency that in excess of the setting f+Df/Dt 2 Dfreq that must be measured for the second stage average rate of change of frequency protection element.				
Restore2 Status	4D	28	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or Enable the second stage of load restoration.				
Restore2 Freq	4D	29	49.5	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the second stage of load restoration, above which the associated load restoration time can start.				
Restore2 Time	4D	2A	240	From 0s to 7200s step 0.25s
Time period for which the measured frequency must be higher than second stage restoration frequency setting to permit load restoration.				
Holding Timer 2	4D	2B	5	From 1s to 7200s step 1s
Sets the holding time of the second stage load restoration function.				
Stg 2 UV Block	4D	2C	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the under voltage blocking of the stage 2 load restoration element.				
Stage 3	4D	2D	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or enable third stage frequency protection.				
Stg 3 f+t Status	4D	2E	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over frequency of the third stage frequency protection.				
Stg 3 f+t Freq	4D	2F	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the third stage frequency protection element.				
Stg 3 f+t Time	4D	30	2	From 0s to 100s step 0.01s
Setting for the operating time delay for the third stage frequency protection element.				
df/dt+t 3 Status	4D	31	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the third stage df/dt protection.				
df/dt+t 3 Set	4D	32	2	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Rate of change of frequency threshold for the third stage.				
df/dt+t 3 Time	4D	33	0.5	From 0s to 100s step 0.01s
Setting for the operating time delay for the third stage rate of change of frequency protection element.				
f+df/dt 3 Status	4D	34	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the third stage frequency supervised rate of change of frequency protection.				
f+df/dt 3 freq	4D	35	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the third stage frequency supervised rate of change of frequency protection element.				
f+df/dt 3 df/dt	4D	36	1	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Frequency supervised rate of change of frequency threshold for the third stage.				
f+Df/Dt 3 Status	4D	37	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over average rate of change of frequency of the third stage.				
f+Df/Dt 3 freq	4D	38	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the third stage average rate of change of frequency protection element.				
f+Df/Dt 3 Dfreq	4D	39	1	From 0.1Hz to 10Hz step 0.01Hz
Change in frequency that must be measured in the set time for the third stage average rate of change of frequency protection element.				
f+Df/Dt 3 Dtime	4D	3A	0.5	From 0.02s to 100s step 0.01s
The time period over which a change in frequency that in excess of the setting f+Df/Dt 3 Dfreq that must be measured for the third stage average rate of change of frequency protection element.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Restore3 Status	4D	3B	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or Enable the third stage of load restoration.				
Restore3 Freq	4D	3C	49.5	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the third stage of load restoration, above which the associated load restoration time can start.				
Restore3 Time	4D	3D	240	From 0s to 7200s step 0.25s
Time period for which the measured frequency must be higher than third stage restoration frequency setting to permit load restoration.				
Holding Timer 3	4D	3E	5	From 1s to 7200s step 1s
Sets the holding time of the third stage load restoration function.				
Stg 3 UV Block	4D	3F	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the under voltage blocking of the stage 3 load restoration element.				
Stage 4	4D	40	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or enable fourth stage frequency protection.				
Stg 4 f+t Status	4D	41	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over frequency of the fourth stage frequency protection.				
Stg 4 f+t Freq	4D	42	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the fourth stage frequency protection element.				
Stg 4 f+t Time	4D	43	2	From 0s to 100s step 0.01s
Setting for the operating time delay for the fourth stage frequency protection element.				
df/dt+t 4 Status	4D	44	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the fourth stage df/dt protection.				
df/dt+t 4 Set	4D	45	2	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Rate of change of frequency threshold for the fourth stage.				
df/dt+t 4 Time	4D	46	0.5	From 0s to 100s step 0.01s
Setting for the operating time delay for the fourth stage rate of change of frequency protection element.				
f+df/dt 4 Status	4D	47	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the fourth stage frequency supervised rate of change of frequency protection.				
f+df/dt 4 freq	4D	48	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the fourth stage frequency supervised rate of change of frequency protection element.				
f+df/dt 4 df/dt	4D	49	1	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Frequency supervised rate of change of frequency threshold for the fourth stage.				
f+Df/Dt 4 Status	4D	4A	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over average rate of change of frequency of the fourth stage.				
f+Df/Dt 4 freq	4D	4B	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the fourth stage average rate of change of frequency protection element.				
f+Df/Dt 4 Dfreq	4D	4C	1	From 0.1Hz to 10Hz step 0.01Hz
Change in frequency that must be measured in the set time for the fourth stage average rate of change of frequency protection element.				
f+Df/Dt 4 Dtime	4D	4D	0.5	From 0.02s to 100s step 0.01s
The time period over which a change in frequency that in excess of the setting f+Df/Dt 4 Dfreq that must be measured for the fourth stage average rate of change of frequency protection element.				
Restore4 Status	4D	4E	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or Enable the fourth stage of load restoration.				
Restore4 Freq	4D	4F	49.5	From 40.1Hz to 69.9Hz step 0.01Hz

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Pick up setting for the fourth stage of load restoration, above which the associated load restoration time can start.				
Restore4 Time	4D	50	240	From 0s to 7200s step 0.25s
Time period for which the measured frequency must be higher than fourth stage restoration frequency setting to permit load restoration.				
Holding Timer 4	4D	51	5	From 1s to 7200s step 1s
Sets the holding time of the fourth stage load restoration function.				
Stg 4 UV Block	4D	52	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the under voltage blocking of the stage 4 load restoration element.				
Stage 5	4D	53	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or enable fifth stage frequency protection.				
Stg 5 f+t Status	4D	54	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over frequency of the fifth stage frequency protection.				
Stg 5 f+t Freq	4D	55	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the fifth stage frequency protection element.				
Stg 5 f+t Time	4D	56	2	From 0s to 100s step 0.01s
Setting for the operating time delay for the fifth stage frequency protection element.				
df/dt+t 5 Status	4D	57	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the fifth stage df/dt protection.				
df/dt+t 5 Set	4D	58	2	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Rate of change of frequency threshold for the fifth stage.				
df/dt+t 5 Time	4D	59	0.5	From 0s to 100s step 0.01s
Setting for the operating time delay for the fifth stage rate of change of frequency protection element.				
f+df/dt 5 Status	4D	5A	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the fifth stage frequency supervised rate of change of frequency protection.				
f+df/dt 5 freq	4D	5B	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the fifth stage frequency supervised rate of change of frequency protection element.				
f+df/dt 5 df/dt	4D	5C	1	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Frequency supervised rate of change of frequency threshold for the fifth stage.				
f+Df/Dt 5 Status	4D	5D	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over average rate of change of frequency of the fifth stage.				
f+Df/Dt 5 freq	4D	5E	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the fifth stage average rate of change of frequency protection element.				
f+Df/Dt 5 Dfreq	4D	5F	1	From 0.1Hz to 10Hz step 0.01Hz
Change in frequency that must be measured in the set time for the fifth stage average rate of change of frequency protection element.				
f+Df/Dt 5 Dtime	4D	60	0.5	From 0.02s to 100s step 0.01s
The time period over which a change in frequency that in excess of the setting f+Df/Dt 5 Dfreq that must be measured for the fifth stage average rate of change of frequency protection element.				
Restore5 Status	4D	61	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or Enable the fifth stage of load restoration.				
Restore5 Freq	4D	62	49.5	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the fifth stage of load restoration, above which the associated load restoration time can start.				
Restore5 Time	4D	63	240	From 0s to 7200s step 0.25s
Time period for which the measured frequency must be higher than fifth stage restoration frequency setting to permit load restoration.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Holding Timer 5	4D	64	5	From 1s to 7200s step 1s
Sets the holding time of the fifth stage load restoration function.				
Stg 5 UV Block	4D	65	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the under voltage blocking of the stage 5 load restoration element.				
Stage 6	4D	66	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or enable sixth stage frequency protection.				
Stg 6 f+t Status	4D	67	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over frequency of the sixth stage frequency protection.				
Stg 6 f+t Freq	4D	68	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the sixth stage frequency protection element.				
Stg 6 f+t Time	4D	69	2	From 0s to 100s step 0.01s
Setting for the operating time delay for the sixth stage frequency protection element.				
df/dt+t 6 Status	4D	6A	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the sixth stage df/dt protection.				
df/dt+t 6 Set	4D	6B	2	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Rate of change of frequency threshold for the sixth stage.				
df/dt+t 6 Time	4D	6C	0.5	From 0s to 100s step 0.01s
Setting for the operating time delay for the sixth stage rate of change of frequency protection element.				
f+df/dt 6 Status	4D	6D	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the sixth stage frequency supervised rate of change of frequency protection.				
f+df/dt 6 freq	4D	6E	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the sixth stage frequency supervised rate of change of frequency protection element.				
f+df/dt 6 df/dt	4D	6F	1	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Frequency supervised rate of change of frequency threshold for the sixth stage.				
f+Df/Dt 6 Status	4D	70	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over average rate of change of frequency of the sixth stage.				
f+Df/Dt 6 freq	4D	71	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the sixth stage average rate of change of frequency protection element.				
f+Df/Dt 6 Dfreq	4D	72	1	From 0.1Hz to 10Hz step 0.01Hz
Change in frequency that must be measured in the set time for the sixth stage average rate of change of frequency protection element.				
f+Df/Dt 6 Dtime	4D	73	0.5	From 0.02s to 100s step 0.01s
The time period over which a change in frequency that in excess of the setting f+Df/Dt 6 Dfreq that must be measured for the sixth stage average rate of change of frequency protection element.				
Restore6 Status	4D	74	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or Enable the sixth stage of load restoration.				
Restore6 Freq	4D	75	49.5	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the sixth stage of load restoration, above which the associated load restoration time can start.				
Restore6 Time	4D	76	240	From 0s to 7200s step 0.25s
Time period for which the measured frequency must be higher than sixth stage restoration frequency setting to permit load restoration.				
Holding Timer 6	4D	77	5	From 1s to 7200s step 1s
Sets the holding time of the sixth stage load restoration function.				
Stg 6 UV Block	4D	78	Disabled	0 = Disabled or 1 = Enabled

Menu Text	Col	Row	Default Setting	Available Settings
Description				
To enable (activate) or disable (turn off) the under voltage blocking of the stage 6 load restoration element.				
Stage 7	4D	79	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or enable seventh stage frequency protection.				
Stg 7 f+t Status	4D	7A	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over frequency of the seventh stage frequency protection.				
Stg 7 f+t Freq	4D	7B	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the seventh stage frequency protection element.				
Stg 7 f+t Time	4D	7C	2	From 0s to 100s step 0.01s
Setting for the operating time delay for the seventh stage frequency protection element.				
df/dt+t 7 Status	4D	7D	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the seventh stage df/dt protection.				
df/dt+t 7 Set	4D	7E	2	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Rate of change of frequency threshold for the seventh stage.				
df/dt+t 7 Time	4D	7F	0.5	From 0s to 100s step 0.01s
Setting for the operating time delay for the seventh stage rate of change of frequency protection element.				
f+df/dt 7 Status	4D	80	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the seventh stage frequency supervised rate of change of frequency protection.				
f+df/dt 7 freq	4D	81	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the seventh stage frequency supervised rate of change of frequency protection element.				
f+df/dt 7 df/dt	4D	82	1	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Frequency supervised rate of change of frequency threshold for the seventh stage.				
f+Df/Dt 7 Status	4D	83	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over average rate of change of frequency of the seventh stage.				
f+Df/Dt 7 freq	4D	84	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the seventh stage average rate of change of frequency protection element.				
f+Df/Dt 7 Dfreq	4D	85	1	From 0.1Hz to 10Hz step 0.01Hz
Change in frequency that must be measured in the set time for the seventh stage average rate of change of frequency protection element.				
f+Df/Dt 7 Dtime	4D	86	0.5	From 0.02s to 100s step 0.01s
The time period over which a change in frequency that in excess of the setting f+Df/Dt 7 Dfreq that must be measured for the seventh stage average rate of change of frequency protection element.				
Restore7 Status	4D	87	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or Enable the seventh stage of load restoration.				
Restore7 Freq	4D	88	49.5	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the seventh stage of load restoration, above which the associated load restoration time can start.				
Restore7 Time	4D	89	240	From 0s to 7200s step 0.25s
Time period for which the measured frequency must be higher than seventh stage restoration frequency setting to permit load restoration.				
Holding Timer 7	4D	8A	5	From 1s to 7200s step 1s
Sets the holding time of the seventh stage load restoration function.				
Stg 7 UV Block	4D	8B	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the under voltage blocking of the stage 7 load restoration element.				
Stage 8	4D	8C	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or enable eighth stage frequency protection.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Stg 8 f+t Status	4D	8D	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over frequency of the eighth stage frequency protection.				
Stg 8 f+t Freq	4D	8E	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the eighth stage frequency protection element.				
Stg 8 f+t Time	4D	8F	2	From 0s to 100s step 0.01s
Setting for the operating time delay for the eighth stage frequency protection element.				
df/dt+t 8 Status	4D	90	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the eighth stage df/dt protection.				
df/dt+t 8 Set	4D	91	2	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Rate of change of frequency threshold for the eighth stage.				
df/dt+t 8 Time	4D	92	0.5	From 0s to 100s step 0.01s
Setting for the operating time delay for the eighth stage rate of change of frequency protection element.				
f+df/dt 8 Status	4D	93	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the eighth stage frequency supervised rate of change of frequency protection.				
f+df/dt 8 freq	4D	94	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the eighth stage frequency supervised rate of change of frequency protection element.				
f+df/dt 8 df/dt	4D	95	1	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Frequency supervised rate of change of frequency threshold for the eighth stage.				
f+Df/Dt 8 Status	4D	96	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over average rate of change of frequency of the eighth stage.				
f+Df/Dt 8 freq	4D	97	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the eighth stage average rate of change of frequency protection element.				
f+Df/Dt 8 Dfreq	4D	98	1	From 0.1Hz to 10Hz step 0.01Hz
Change in frequency that must be measured in the set time for the eighth stage average rate of change of frequency protection element.				
f+Df/Dt 8 Dtime	4D	99	0.5	From 0.02s to 100s step 0.01s
The time period over which a change in frequency that in excess of the setting f+Df/Dt 8 Dfreq that must be measured for the eighth stage average rate of change of frequency protection element.				
Restore8 Status	4D	9A	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or Enable the eighth stage of load restoration.				
Restore8 Freq	4D	9B	49.5	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the eighth stage of load restoration, above which the associated load restoration time can start.				
Restore8 Time	4D	9C	240	From 0s to 7200s step 0.25s
Time period for which the measured frequency must be higher than eighth stage restoration frequency setting to permit load restoration.				
Holding Timer 8	4D	9D	5	From 1s to 7200s step 1s
Sets the holding time of the eighth stage load restoration function.				
Stg 8 UV Block	4D	9E	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the under voltage blocking of the stage 8 load restoration element.				
Stage 9	4D	9F	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or enable ninth stage frequency protection.				
Stg 9 f+t Status	4D	A0	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over frequency of the ninth stage frequency protection.				
Stg 9 f+t Freq	4D	A1	49	From 40.1Hz to 69.9Hz step 0.01Hz

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Pick up setting for the ninth stage frequency protection element.				
Stg 9 f+t Time	4D	A2	2	From 0s to 100s step 0.01s
Setting for the operating time delay for the ninth stage frequency protection element.				
df/dt+t 9 Status	4D	A3	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the ninth stage df/dt protection.				
df/dt+t 9 Set	4D	A4	2	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Rate of change of frequency threshold for the ninth stage.				
df/dt+t 9 Time	4D	A5	0.5	From 0s to 100s step 0.01s
Setting for the operating time delay for the ninth stage rate of change of frequency protection element.				
f+df/dt 9 Status	4D	A6	Disabled	0=Disabled 1=Negative 2=Positive 3=Both
Setting to disable or set the ramp direction of the ninth stage frequency supervised rate of change of frequency protection.				
f+df/dt 9 freq	4D	A7	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the ninth stage frequency supervised rate of change of frequency protection element.				
f+df/dt 9 df/dt	4D	A8	1	From 0.01Hz/s to 10Hz/s step 0.01Hz/s
Frequency supervised rate of change of frequency threshold for the ninth stage.				
f+Df/Dt 9 Status	4D	A9	Disabled	0=Disabled 1=Under 2=Over
Setting to disable or to set as Under or Over average rate of change of frequency of the ninth stage.				
f+Df/Dt 9 freq	4D	AA	49	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the ninth stage average rate of change of frequency protection element.				
f+Df/Dt 9 Dfreq	4D	AB	1	From 0.1Hz to 10Hz step 0.01Hz
Change in frequency that must be measured in the set time for the ninth stage average rate of change of frequency protection element.				
f+Df/Dt 9 Dtime	4D	AC	0.5	From 0.02s to 100s step 0.01s
The time period over which a change in frequency that in excess of the setting f+Df/Dt 9 Dfreq that must be measured for the ninth stage average rate of change of frequency protection element.				
Restore9 Status	4D	AD	Disabled	0 = Disabled or 1 = Enabled
Setting to disable or Enable the ninth stage of load restoration.				
Restore9 Freq	4D	AE	49.5	From 40.1Hz to 69.9Hz step 0.01Hz
Pick up setting for the ninth stage of load restoration, above which the associated load restoration time can start.				
Restore9 Time	4D	AF	240	From 0s to 7200s step 0.25s
Time period for which the measured frequency must be higher than ninth stage restoration frequency setting to permit load restoration.				
Holding Timer 9	4D	B0	5	From 1s to 7200s step 1s
Sets the holding time of the ninth stage load restoration function.				
Stg 9 UV Block	4D	B1	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the under voltage blocking of the stage 9 load restoration element.				

Table 25 - Advanced Frequency Protection

5 INTEGRAL TELEPROTECTION SETTINGS

5.1 EIA(RS)232 InterMiCOM

'**InterMiCOM**' operates via an EIA(RS)232 physical output on the back of the 2nd rear communication board. It provides 8 independently settable digital signals that can be conveyed between line ends. The InterMiCOM teleprotection is restricted to 2 ends. InterMiCOM input and output mapping has to be done in the Programmable Scheme Logic (PSL).

Menu Text	Col	Row	Default Setting	Available Settings
Description				
INTERMICOM COMMS	15	00		
This column is only visible if the model number supports InterMiCOM and second rear comms board is fitted.				
IM Input Status	15	01	00000000	Not Settable
Displays the status of each InterMiCOM input signal, with IM1 signal starting from the right. When loop back mode is set, all bits will display zero.				
IM Output Status	15	02	00000000	Not Settable
Displays the status of each InterMiCOM output signal.				
Source Address	15	10	1	From 1 to 10 step 1
Setting for the unique IED address that is encoded in the InterMiCOM sent message.				
Received Address	15	11	2	From 1 to 10 step 1
The aim of setting addresses is to establish pairs of IED's which will only communicate with each other. Should an inadvertent channel misrouting or spurious loopback occur, an error will be logged, and the erroneous received data will be rejected. As an example, in a 2 ended scheme the following address setting would be correct: Local IED: Source Address = 1, Receive Address = 2 Remote IED: Source Address = 2, Receive Address = 1				
Data Rate	15	12	9600	0 = 600, 1 = 1200, 2 = 2400, 3 = 4800, 4 = 9600 or 5 = 19200
Setting of the signalling speed in terms of number of bits per second. The speed will match the capability of the MODEM or other characteristics of the channel provided.				
Px30 Comms	15	13	Disable	0 to 1 step 1
Ch Statistics	15	20	Invisible	0 = Invisible, 1 = Visible
Settings that makes visible or invisible Channel Statistics on the LCD. The statistic is reset by either IED's powering down or using the 'Reset Statistics' cell.				
Rx Direct Count	15	21		Not Settable
Displays the number of valid Direct Tripping messages since last counter reset.				
Rx Perm Count	15	22		Not Settable
Displays the number of valid Permissive Tripping messages since last counter reset.				
Rx Block Count	15	23		Not Settable
Displays the number of valid Blocking messages since last counter reset.				
Rx NewDataCount	15	24		Not Settable
Displays the number of different messages (change events) since last counter reset.				
Rx ErroredCount	15	25		Not Settable
Displays the number of invalid received messages since last counter reset.				
Lost Messages	15	26		Not Settable
Displays the difference between the number of messages that were supposed to be received (based on set Baud Rate) and actual valid received messages since last reset.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Elapsed Time	15	30		Not Settable
Displays the time in seconds since last counter reset.				
Reset Statistics	15	31	No	0 = No, 1 = Yes
Command that allows all Statistics and Channel Diagnostics to be reset.				
Ch Diagnostics	15	40	Invisible	0 = Invisible, 1 = Visible
Setting that makes visible or invisible Channel Diagnostics on the LCD. The diagnostic is reset by either IED's powering down or using the 'Reset Statistics' cell.				
Data CD Status	15	41		0 = OK, 1 = Fail, 2 = SCC Absent
Indicates when the DCD line (pin 1 on EIA232 Connector) is energized. OK = DCD is energized FAIL = DCD is de-energized Absent = 2nd Rear port board is not fitted				
FrameSync Status	15	42		0 = OK, 1 = Fail, 2 = SCC Absent
Indicates when the message structure and synchronization is valid. OK = Valid message structure and synchronization FAIL = Synchronization has been lost Absent = 2nd Rear port board is not fitted Unavailable = Hardware error present				
Message Status	15	43		0 = OK, 1 = Fail, 2 = SCC Absent
Indicates when the percentage of received valid messages has fallen below the 'IM Msg Alarm Lvl' setting within the alarm time period. OK = Acceptable ratio of lost messages FAIL = Unacceptable ratio of lost messages Absent = 2nd Rear port board is not fitted Unavailable = Hardware error present				
Channel Status	15	44		0 = OK, 1 = Fail, 2 = SCC Absent
Indicates the state of the InterMiCOM communication channel. OK = Channel healthy FAIL = Channel failure Absent = 2nd Rear port board is not fitted Unavailable = Hardware error present				
IM H/W Status	15	45		0 = OK, 1 = Fail, 2 = SCC Absent, 3 = SCC Read Error, 4 = SCC Write Error
Indicates the state of InterMiCOM hardware OK = InterMiCOM hardware healthy Read or Write Error = InterMiCOM failure Absent = 2nd Rear port is not fitted or failed to initialize.				
Loopback Mode	15	50	Disabled	0 = Disabled, 1 = Internal or 2 = External
Setting to allow testing of the InterMiCOM channel. When 'Internal' is selected, only the local InterMiCOM software functionality is tested, whereby the IED will receive its own sent data. 'External' setting allows a hardware and software check, with an external link required to jumper the sent data onto the receive channel. During normal service condition Loopback mode must be disabled.				
Test Pattern	15	51	0xFF	8 bits
Allows specific bit statuses to be inserted directly into the InterMiCOM message, to substitute real data. This is used for testing purposes.				
Loopback Status	15	52		0 = OK, 1 = Fail, 2 = SCC Absent
Indicates the status of the InterMiCOM loopback mode OK = Loopback software (and hardware) is working correctly FAIL = Loopback mode failure Unavailable = Hardware error present.				

Table 26 - EIA(RS)232 InterMiCOM

6 CONTROL AND SUPPORT SETTINGS

The control and support settings are part of the main menu and are used to configure the global configuration for the relay. It includes submenu settings as shown here.

- Relay function configuration settings
- Open/close circuit breaker
- CT & VT ratio settings
- Reset LEDs
- Active protection setting group
- Password & language settings
- Circuit breaker control & monitoring settings
- Communications settings
- Measurement settings
- Event & fault record settings
- User interface settings
- Commissioning settings

6.1 System Data

This menu provides information for the device and general status of the relay.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
SYSTEM DATA	00	00		
This column contains general system settings				
Language	00	01	English	0 = English, 1 = Francais, 2 = Deutsch, 3 = Espanol 0 = English, 1 = Francais, 2 = Deutsch, 3 = Russian 0 = English, 1 = Francais, 2 = Chinese
The default language used by the device. Selectable as English, French, German, Spanish. The default language used by the device. Selectable as English, French, German, Russian. The default language used by the device. Selectable as English, French, Chinese.				
Sys Fn Links	00	03	0	Bit 0 = Trip led self reset (1 = enable self reset), Bit 1 = Not Used, Bit 2 = Not Used, Bit 3 = Not Used, Bit 4 = Not Used, Bit 5 = Not Used, Bit 6 = Not Used or Bit 7 = Not Used
Setting to allow the fixed function trip LED to be self resetting (set to 1 to extinguish the LED after a period of healthy restoration of load current).				
Description	00	04	MiCOM P141 MiCOM P142 MiCOM P143 MiCOM P144 MiCOM P145	32 to 163 step 1
16 character relay description. Can be edited.				
Plant Reference	00	05	MiCOM	32 to 234 step 1
Associated plant description and can be edited.				
Model Number	00	06	Model Number	<Model number>
Relay model number. This display cannot be altered.				
Serial Number	00	08	Serial Number	<Serial number>
Relay serial number. This display cannot be altered.				
Frequency	00	09	50	50 to 60 step 10

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Relay set frequency. Settable either 50 or 60 Hz				
Comms Level	00	0A	2	<conformance level displayed>
Displays the conformance of the relay to the Courier Level 2 comms.				
Relay Address	00	0B	255	0 to 255 step 1 0 to 247 step 1 0 to 65534 step 1
Sets the first rear port relay address.				
Plant Status	00	0C		16-bit binary flag
Displays the circuit breaker plant status.				
Control Status	00	0D		Not used
Not used				
Active Group	00	0E	1	1 to 4 step 1
Displays the active settings group				
CB Trip/Close	00	10	No Operation	0 = No Operation, 1 = Trip, 2 = Close
Supports trip and close commands if enabled in the Circuit Breaker Control menu.				
CB Trip/Close	00	10	No Operation	0 = No Operation, 1 = Trip, 2 = Close
Supports trip and close commands if enabled in the Circuit Breaker Control menu.				
Software Ref. 1	00	11		<Software Ref. 1>
Displays the relay software version including protocol and relay model.				
Software Ref. 2	00	12		<Software Ref. 2>
Software Ref. 2 is displayed for relay with IEC 61850 protocol only and this will display the software version of the Ethernet card.				
Software Ref. 3	00	13		<Software Ref. 3>
Relay Process Bus card software reference. Visible when Process Bus card fitted.				
NIC Platform Ref	00	14		<NIC platform reference>
UNUSED				
IEC61850 Edition	00	15	2	Edition 1, Edition 2
Set the IEC61850 version (edition 1 or edition 2)				
ETH COMM Mode	00	16	Dual IP	Dual IP, PRP, HSR, RSTP
Sets the redundancy protocol. This setting can only be changed via the UI and the changes will cause the Ethernet board to reboot.				
PB COMM Mode	00	17	Dual IP	Dual IP, PRP
Sets the redundancy protocol. This setting can only be changed via the UI and the changes will cause the Process Bus board to reboot.				
Opto I/P Status	00	20		32-bit binary flag: 0 = energized, 1 = de-energized
Display the status of the available opto inputs fitted.				
Relay O/P Status	00	21		32-bit binary flag: 0 = operated state 1 = non-operated state
Displays the status of all available output relays fitted.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Alarm Status 1	00	22		0=Unused 1=Unused 2=SG-optoInvalid 3=Prot'nDisabled 4=FoutofRange 5=VTFailAlarm 6=CTFailAlarm 7=CBFailAlarm 8=I^MaintAlarm 9=I^LockoutAlarm 10=CBOpsMaint 11=CBOpsLockout 12=CBOpTimeMaint 13=CBOpTimeLock 14=FaultFreqLock 15=CBStatusAlarm 16=ManCBTripFail 17=CBClsFail 18=ManCBUnhealthy 19=ManNoChecksync 20=ARLockout 21=ARCBUnhealthy 22=ARNoSysCheck 23=SystemSplit 24=UVBlock 25=SRUserAlarm1 26=SRUserAlarm2 27=SRUserAlarm3 28=SRUserAlarm4 29=SRUserAlarm5 30=SRUserAlarm6 31=SRUserAlarm7
Displays the status of the first 32 alarms as a binary string. Includes fixed and user settable alarms. Data type G96				
Opto I/P Status	00	30		32-bit binary flag: 0 = energized, 1 = de-energized
Display the status of the available opto inputs fitted.				
Relay O/P Status	00	40		32-bit binary flag: 0 = operated state 1 = non-operated state
Displays the status of all available output relays fitted.				
Alarm Status 1	00	50		0=Unused 1=Unused 2=SG-optoInvalid 3=Prot'nDisabled 4=FoutofRange 5=VTFailAlarm 6=CTFailAlarm 7=CBFailAlarm 8=I^MaintAlarm 9=I^LockoutAlarm 10=CBOpsMaint 11=CBOpsLockout 12=CBOpTimeMaint 13=CBOpTimeLock 14=FaultFreqLock 15=CBStatusAlarm 16=ManCBTripFail 17=CBClsFail 18=ManCBUnhealthy 19=ManNoChecksync 20=ARLockout 21=ARCBUnhealthy 22=ARNoSysCheck 23=SystemSplit 24=UVBlock 25=SRUserAlarm1 26=SRUserAlarm2 27=SRUserAlarm3 28=SRUserAlarm4 29=SRUserAlarm5 30=SRUserAlarm6 31=SRUserAlarm7
Displays the status of the first 32 alarms as a binary string. Includes fixed and user settable alarms. Data type G96				
Alarm Status 2	00	51		0=Unused 1=Unused 2=Unused 3=Unused 4=SR User Alarm 8 5=SR User Alarm 9 6=SR User Alarm 10 7=SR User Alarm 11 8=SR User Alarm 12 9=SR User Alarm 13 10=SR User Alarm 14 11=SR User Alarm 15 12=SR User Alarm 16 13=SR User Alarm 17 14=MR User Alarm 18 15=MR User Alarm 19 16=MR User Alarm 20 17=MR User Alarm 21 18=MR User Alarm 22 19=MR User Alarm 23 20=MR User Alarm 24 21=MR User Alarm 25 22=MR User Alarm 26 23=MR User Alarm 27 24=MR User Alarm 28 25=MR User Alarm 29 26=MR User Alarm 30 27=MR User Alarm 31 28=MR User Alarm 32 29=MR User Alarm 33 30=MR User Alarm 34 31=MR User Alarm 35
Displays the status of the next 32 alarms as a binary string. Includes fixed and user settable alarms. Data type G96				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Alarm Status 3	00	52		0=Battery Fail 1=Field Volt Fail 2=Unused 3=GOOSE IED Absent 4=NIC Not Fitted 5=NIC No Response 6=NIC Fatal Error 7=Unused 8=Unused 9=Unused 10=NIC Link Fail 11=NIC SW Mis-Match 12=IP Addr Conflist 13=Unused 14=Unused 15=Unused 16=Unused 17=Backup Setting 18=Unused 19=Unused 20=Unused 21=Unused 22=Unused 23=Unused 24=Unused 25=Unused 26=Unused 27=Unused 28=Unused 29=Unused 30=Unused 31=Unused
Displays the status of the next 32 alarms as a binary string. Includes fixed and user settable alarms.				
Access Level	00	D0		
Access Level, Read only				
New Eng.Level PW	00	D3		ASCII 33 to 122
Allows user to change password for EngineerLevel.				
New Op.Level PW	00	D4		ASCII 33 to 122
Allows user to change password for OperatorLevel.				
Security Feature	00	DF		Not Settable
Displays the level of cyber security implemented, 1 = phase 1.				
Password	00	E1		ASCII 33 to 122
Encrypted password entry cell. Not visbile via UI				
Encryption Salt	00	E5		
Enter username	00	F1		
Accept username writing				
Number of users	00	F2		
New UI pwd	00	F3		
New password	00	F4		
Allow password change if engineer or operator logged in and model number indicates no CS				

Table 27 - System Data

6.2 View Records

This menu provides information on fault and maintenance records. The relay records the last five fault records and the last ten maintenance records.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
VIEW RECORDS	01	00		
This column contains record configuration				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Select Event [0...n]	01	01	0	From 0 to 512 step 1
This selects the required event record. A value of 0 corresponds to the latest event and so on.				
Menu Cell Ref	01	02	(From Record)	Not Settable
Indicates the type of event				
Time & Date	01	03	(From Record)	Not Settable
Time & Date Stamp for the event given by the internal Real Time Clock.				
Record Text	01	04		Not Settable
Up to 32 Character description of the Event (refer to following sections).				
Record Value	01	05		Not Settable
Up to 32 Bit Binary Flag or integer representative of the Event (refer to following sections).				
Select Fault [0...n]	01	06	0	From 0 to 4 step 1
Setting range from 0 to 4. This selects the required fault record from the possible 5 that may be stored. A value of 0 corresponds to the latest fault and so on.				
Faulted Phase	01	07		Not Settable
Displays the faulted phase. Started phases + tripped phases				
Start Elements 1	01	08		Not Settable
Displays the status of the first 32 start signals.				
Start Elements 2	01	09		Not Settable
Displays the status of the next 32 start signals.				
Start Elements 3	01	0A		Not Settable
Displays the status of the next 32 start signals.				
Trip Elements 1	01	0C		Not Settable
Displays the status of the first 32 trip signals.				
Trip Elements 2	01	0D		Not Settable
Displays the status of the next 32 trip signals.				
Trip Elements 3	01	0E		Not Settable
Displays the status of the next 32 trip signals.				
Trip Elements 4	01	0F		Not Settable
Displays the status of the next 32 trip signals.				
Fault Alarms	01	10		Not Settable
Displays the status of the fault alarm signals.				
Fault Time	01	11		Not Settable
Displays fault time and date.				
Active Group	01	12		Not Settable
Displays active setting group				
System Frequency	01	13		Not Settable
Displays the system frequency				
Fault Duration	01	14		Not Settable
Displays time from the start or trip until the undercurrent elements indicate the CB is open				
CB Operate Time	01	15		Not Settable
Displays time from protection trip to undercurrent elements indicating the CB is open				
Relay Trip Time	01	16		Not Settable

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Displays time from protection start to protection trip				
Fault Location	01	17		Not Settable
Displays fault location in metres.				
Fault Location	01	18		Not Settable
Displays fault location in miles.				
Fault Location	01	19		Not Settable
Displays fault location in ohms.				
Fault Location	01	1A		Not Settable
Displays fault location in percentage.				
IA	01	1B		Not Settable
Measured parameter				
IB	01	1C		Not Settable
Measured parameter				
IC	01	1D		Not Settable
Measured parameter				
VAB	01	1E		Not Settable
Measured parameter				
VBC	01	1F		Not Settable
Measured parameter				
VCA	01	20		Not Settable
Measured parameter				
IN Measured	01	21		Not Settable
Measured parameter				
IN Derived	01	22		Not Settable
Measured parameter				
IN Sensitive	01	23		Not Settable
Measured parameter				
IREF Diff	01	24		Not Settable
Measured parameter				
IREF Bias	01	25		Not Settable
Measured parameter				
VAN	01	26		Not Settable
Measured parameter				
VBN	01	27		Not Settable
Measured parameter				
VCN	01	28		Not Settable
Measured parameter				
VN Derived VN Measured	01	29		Not Settable
Measured parameter				
SEF Admittance	01	2A		Not Settable
Measured parameter				
SEF Conductance	01	2B		Not Settable
Measured parameter				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
SEF Susceptance	01	2C		Not Settable
Measured parameter				
EF Admittance	01	2D		Not Settable
Measured parameter				
EF Conductance	01	2E		Not Settable
Measured parameter				
EF Susceptance	01	2F		Not Settable
Measured parameter				
Select Maint [0...n]	01	F0	Manual override to select a fault record.	From 0 to 4 step 1
This selects the required maintenance report from those stored. A value of 0 corresponds to the latest report and so on.				
Maint Text	01	F1		Not Settable
Up to 16 Character description of the occurrence (refer to following sections).				
Maint Type	01	F2		Not Settable
These cells are numbers representative of the occurrence. They form a specific error code which should be quoted in any related correspondence to Report Data.				
Maint Data	01	F3		Not Settable
These cells are numbers representative of the occurrence. They form a specific error code which should be quoted in any related correspondence to Report Data.				
Evt Iface Source	01	FA		Not Settable
Interface on which the event was logged				
Evt Access Level	01	FB		Not Settable
Any security event that indicates that it came from an interface action, such as disabling a port, will also record the access level of the interface that initiated the event. This will be recorded in the ‘Event State’ field of the event.				
Evt Extra Info	01	FC		Not Settable
This cell provides supporting information for the event and can vary between the different event types.				
Evt Unique Id	01	FE		Not Settable
Each event will have a unique event id. The event id is a 32 bit unsigned integer that is incremented for each new event record and is stored in the record in battery-backed memory (BBRAM). The current event id must be non-volatile so as to preserve it du				
Reset Indication	01	FF	No	0=No 1=Yes
This serves to reset the trip LED indications provided that the relevant protection element has reset.				

Table 28 – View Records

6.3 Measurements 1

This menu provides measurement information.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
MEASUREMENTS 1	02	00		
This column contains measurement parameters				
IA Magnitude	02	01		Not Settable
IA Magnitude				
IA Phase Angle	02	02		Not Settable

Menu Text	Col	Row	Default Setting	Available Settings
Description				
IA Phase Angle				
IB Magnitude	02	03		Not Settable
IB Magnitude				
IB Phase Angle	02	04		Not Settable
IB Phase Angle				
IC Magnitude	02	05		Not Settable
IC Magnitude				
IC Phase Angle	02	06		Not Settable
IC Phase Angle				
IN Measured Mag	02	07		Not Settable
IN Measured Mag				
IN Measured Ang	02	08		Not Settable
IN Measured Ang				
IN Derived Mag	02	09		Not Settable
IN Derived Mag				
IN Derived Angle	02	0A		Not Settable
IN Derived Angle				
ISEF Magnitude	02	0B		Not Settable
ISEF Magnitude				
ISEF Angle	02	0C		Not Settable
ISEF Angle				
I1 Magnitude	02	0D		Not Settable
I1 Magnitude				
I2 Magnitude	02	0E		Not Settable
I2 Magnitude				
I0 Magnitude	02	0F		Not Settable
I0 Magnitude				
IA RMS	02	10		Not Settable
IA RMS				
IB RMS	02	11		Not Settable
IB RMS				
IC RMS	02	12		Not Settable
IC RMS				
VAB Magnitude	02	14		Not Settable
VAB Magnitude				
VAB Phase Angle	02	15		Not Settable
VAB Phase Angle				
VBC Magnitude	02	16		Not Settable
VBC Magnitude				
VBC Phase Angle	02	17		Not Settable
VBC Phase Angle				
VCA Magnitude	02	18		Not Settable
VCA Magnitude				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
VCA Phase Angle	02	19		Not Settable
VCA Phase Angle				
VAN Magnitude	02	1A		Not Settable
VAN Magnitude				
VAN Phase Angle	02	1B		Not Settable
VAN Phase Angle				
VBN Magnitude	02	1C		Not Settable
VBN Magnitude				
VBN Phase Angle	02	1D		Not Settable
VBN Phase Angle				
VCN Magnitude	02	1E		Not Settable
VCN Magnitude				
VCN Phase Angle	02	1F		Not Settable
VCN Phase Angle				
VN Derived Mag VN Measured Mag	02	22		Not Settable
VN Derived Mag VN Measured Mag				
VN Derived Ang VN Measured Ang	02	23		Not Settable
VN Derived Ang VN Measured Ang				
V1 Magnitude	02	24		Not Settable
V1 Magnitude				
V2 Magnitude	02	25		Not Settable
V2 Magnitude				
V0 Magnitude	02	26		Not Settable
V0 Magnitude				
VAN RMS	02	27		Not Settable
VAN RMS				
VBN RMS	02	28		Not Settable
VBN RMS				
VCN RMS	02	29		Not Settable
VCN RMS				
Frequency	02	2D		Not Settable
Frequency				
C/S Voltage Mag	02	2E		Not Settable
C/S Voltage Mag				
C/S Voltage Ang	02	2F		Not Settable
C/S Voltage Ang				
C/S Bus-Line Ang	02	30		Not Settable
C/S Bus-Line Ang				
Slip Frequency	02	31		Not Settable
Slip Frequency				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
C/S Bus-Line Mag	02	3A		Not Settable
Bus Line Magnitude				
I1 Magnitude	02	40		Not Settable
I1 Magnitude				
I1 Phase Angle	02	41		Not Settable
I1 Phase Angle				
I2 Magnitude	02	42		Not Settable
I2 Magnitude				
I2 Phase Angle	02	43		Not Settable
I2 Phase Angle				
I0 Magnitude	02	44		Not Settable
I0 Magnitude				
I0 Phase Angle	02	45		Not Settable
I0 Phase Angle				
V1 Magnitude	02	46		Not Settable
V1 Magnitude				
V1 Phase Angle	02	47		Not Settable
V1 Phase Angle				
V2 Magnitude	02	48		Not Settable
V2 Magnitude				
V2 Phase Angle	02	49		Not Settable
V2 Phase Angle				
V0 Magnitude	02	4A		Not Settable
V0 Magnitude				
V0 Phase Angle	02	4B		Not Settable
V0 Phase Angle				

Table 29 – Measurements 1

6.4 Measurements 2

This menu provides measurement information.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
MEASUREMENTS 2	03	00		
This column contains measurement parameters				
A Phase Watts	03	01		Not Settable
A Phase Watts				
B Phase Watts	03	02		Not Settable
B Phase Watts				
C Phase Watts	03	03		Not Settable
C Phase Watts				
A Phase VArs	03	04		Not Settable
A Phase VArs				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
B Phase VArs	03	05		Not Settable
B Phase VArs				
C Phase VArs	03	06		Not Settable
C Phase VArs				
A Phase VA	03	07		Not Settable
A Phase VA				
B Phase VA	03	08		Not Settable
B Phase VA				
C Phase VA	03	09		Not Settable
C Phase VA				
3 Phase Watts	03	0A		Not Settable
3 Phase Watts				
3 Phase VArs	03	0B		Not Settable
3 Phase VArs				
3 Phase VA	03	0C		Not Settable
3 Phase VA				
3Ph Power Factor	03	0E		Not Settable
3Ph Power Factor				
APh Power Factor	03	0F		Not Settable
APh Power Factor				
BPh Power Factor	03	10		Not Settable
BPh Power Factor				
CPh Power Factor	03	11		Not Settable
CPh Power Factor				
3Ph WHours Fwd	03	12		Not Settable
3Ph WHours Fwd				
3Ph WHours Rev	03	13		Not Settable
3Ph WHours Rev				
3Ph VArHours Fwd	03	14		Not Settable
3Ph VArHours Fwd				
3Ph VArHours Rev	03	15		Not Settable
3Ph VArHours Rev				
3Ph W Fix Demand	03	16		Not Settable
3Ph W Fix Demand				
3Ph VArs Fix Dem	03	17		Not Settable
3Ph VArs Fix Dem				
IA Fixed Demand	03	18		Not Settable
IA Fixed Demand				
IB Fixed Demand	03	19		Not Settable
IB Fixed Demand				
IC Fixed Demand	03	1A		Not Settable
IC Fixed Demand				
3 Ph W Roll Dem	03	1B		Not Settable

Menu Text	Col	Row	Default Setting	Available Settings
Description				
3 Ph W Roll Dem				
3Ph VArs RollDem	03	1C		Not Settable
3Ph VArs RollDem				
IA Roll Demand	03	1D		Not Settable
IA Roll Demand				
IB Roll Demand	03	1E		Not Settable
IB Roll Demand				
IC Roll Demand	03	1F		Not Settable
IC Roll Demand				
3Ph W Peak Dem	03	20		Not Settable
3Ph W Peak Dem				
3Ph VAr Peak Dem	03	21		Not Settable
3Ph VAr Peak Dem				
IA Peak Demand	03	22		Not Settable
IA Peak Demand				
IB Peak Demand	03	23		Not Settable
IB Peak Demand				
IC Peak Demand	03	24		Not Settable
IC Peak Demand				
Reset Demand	03	25	No	0 = No or 1 = Yes
Reset Demand				

Table 30 – Measurements 2

6.5 Measurements 3

This menu provides measurement information.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
MEASUREMENTS 3	04	00		
This column contains measurement parameters				
Highest Phase I	04	01		Not Settable
Highest Phase I				
Thermal State	04	02		Not Settable
Thermal State				
Reset Thermal	04	03	No	0 = No or 1 = Yes
Reset Thermal				
IREF Diff	04	04		Not Settable
IREF Diff				
IREF Bias	04	05		Not Settable
IREF Bias				
Admittance SEF	04	06		Not Settable
Admittance SEF				
Conductance SEF	04	07		Not Settable

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Conductance SEF				
Susceptance SEF	04	08		Not Settable
Susceptance SEF				
Admittance E/F	04	09		Not Settable
Admittance E/F				
Conductance E/F	04	0A		Not Settable
Conductance E/F				
Susceptance E/F	04	0B		Not Settable
Susceptance E/F				
I2/I1 Ratio	04	0C		Not Settable
I2/I1 Ratio				
SEF Power	04	0D		Not Settable
SEF Power				
df/dt	04	0E		Not Settable
df/dt				
IA 2ndHarm	04	0F		Not Settable
IA 2ndHarm				
IB 2ndHarm	04	10		Not Settable
IB 2ndHarm				
IC 2ndHarm	04	11		Not Settable
IC 2ndHarm				
APh Sen Watts	04	12		Not Settable
APh Sen Watts				
APh Sen Vars	04	13		Not Settable
APh Sen Vars				
APh Power Angle	04	14		Not Settable
APh Power Angle				
Z0 Imp Mag	04	15		Not Settable
Z0 Imp Mag				
Z0 Seq Imp Ang	04	16		Not Settable
Z0 Seq Imp Ang				
Phase A Imp Mag	04	17		Not Settable
Phase A Imp Mag				
Phase A Imp Ang	04	18		Not Settable
Phase A Imp Ang				
Phase B Imp Mag	04	19		Not Settable
Phase B Imp Mag				
Phase B Imp Ang	04	1A		Not Settable
Phase B Imp Ang				
Phase C Imp Mag	04	1B		Not Settable
Phase C Imp Mag				
Phase C Imp Ang	04	1C		Not Settable
Phase C Imp Ang				

Table 31 – Measurements 3

6.6 Adv.Freq.Stat

Menu Text	Col	Row	Default Setting	Available Settings
Description				
ADV.FREQ.STAT.	05	00		
This column contains statistical parameters				
Stg1 f+t Sta	05	01		Not Settable
Number of f+t starts for Stage 1				
Stg1 f+t Trp	05	02		Not Settable
Number of f+t trips for Stage 1				
Stg1 f+df/dt Trp	05	03		Not Settable
Number of f+df/dt trips for Stage 1				
Stg1 df/dt+t Sta	05	04		Not Settable
Number of df/dt+t starts for Stage 1				
Stg1 df/dt+t Trp	05	05		Not Settable
Number of df/dt trips for Stage 1				
Stg1 f+Df/Dt Sta	05	06		Not Settable
Number of f+DF/DT starts for Stage 1				
Stg1 f+Df/Dt Trp	05	07		Not Settable
Number of f+DF/DT trips for Stage 1				
Stg1 Revn Date	05	08		Not Settable
Stage 1 Revision Date				
Stg2 f+t Sta	05	0A		Not Settable
Number of f+t starts for Stage 2				
Stg2 f+t Trp	05	0B		Not Settable
Number of f+t trips for Stage 2				
Stg2 f+df/dt Trp	05	0C		Not Settable
Number of f+df/dt trips for Stage 2				
Stg2 df/dt+t Sta	05	0D		Not Settable
Number of df/dt+t starts for Stage 2				
Stg2 df/dt+t Trp	05	0E		Not Settable
Number of df/dt trips for Stage 2				
Stg2 f+Df/Dt Sta	05	0F		Not Settable
Number of f+DF/DT starts for Stage 2				
Stg2 f+Df/Dt Trp	05	10		Not Settable
Number of f+DF/DT trips for Stage 2				
Stg2 Revn Date	05	11		Not Settable
Stage 2 Revision Date				
Stg3 f+t Sta	05	13		Not Settable
Number of f+t starts for Stage 3				
Stg3 f+t Trp	05	14		Not Settable
Number of f+t trips for Stage 3				
Stg3 f+df/dt Trp	05	15		Not Settable

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Number of f+df/dt trips for Stage 3				
Stg3 df/dt+t Sta	05	16		Not Settable
Number of df/dt+t starts for Stage 3				
Stg3 df/dt+t Trp	05	17		Not Settable
Number of df/dt trips for Stage 3				
Stg3 f+Df/Dt Sta	05	18		Not Settable
Number of f+DF/DT starts for Stage 3				
Stg3 f+Df/Dt Trp	05	19		Not Settable
Number of f+DF/DT trips for Stage 3				
Stg3 Revn Date	05	1A		Not Settable
Stage 3 Revision Date				
Stg4 f+t Sta	05	1C		Not Settable
Number of f+t starts for Stage 4				
Stg4 f+t Trp	05	1D		Not Settable
Number of f+t trips for Stage 4				
Stg4 f+df/dt Trp	05	1E		Not Settable
Number of f+df/dt trips for Stage 4				
Stg4 df/dt+t Sta	05	1F		Not Settable
Number of df/dt+t starts for Stage 4				
Stg4 df/dt+t Trp	05	20		Not Settable
Number of df/dt trips for Stage 4				
Stg4 f+Df/Dt Sta	05	21		Not Settable
Number of f+DF/DT starts for Stage 4				
Stg4 f+Df/Dt Trp	05	22		Not Settable
Number of f+DF/DT trips for Stage 4				
Stg4 Revn Date	05	23		Not Settable
Stage 4 Revision Date				
Stg5 f+t Sta	05	25		Not Settable
Number of f+t starts for Stage 5				
Stg5 f+t Trp	05	26		Not Settable
Number of f+t trips for Stage 5				
Stg5 f+df/dt Trp	05	27		Not Settable
Number of f+df/dt trips for Stage 5				
Stg5 df/dt+t Sta	05	28		Not Settable
Number of df/dt+t starts for Stage 5				
Stg5 df/dt+t Trp	05	29		Not Settable
Number of df/dt trips for Stage 5				
Stg5 f+Df/Dt Sta	05	2A		Not Settable
Number of f+DF/DT starts for Stage 5				
Stg5 f+Df/Dt Trp	05	2B		Not Settable
Number of f+DF/DT trips for Stage 5				
Stg5 Revn Date	05	2C		Not Settable
Stage 5 Revision Date				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Stg6 f+t Sta	05	2E		Not Settable
Number of f+t starts for Stage 6				
Stg6 f+t Trp	05	2F		Not Settable
Number of f+t trips for Stage 6				
Stg6 f+df/dt Trp	05	30		Not Settable
Number of f+df/dt trips for Stage 6				
Stg6 df/dt+t Sta	05	31		Not Settable
Number of df/dt+t starts for Stage 6				
Stg6 df/dt+t Trp	05	32		Not Settable
Number of df/dt trips for Stage 6				
Stg6 f+Df/Dt Sta	05	33		Not Settable
Number of f+DF/DT starts for Stage 6				
Stg6 f+Df/Dt Trp	05	34		Not Settable
Number of f+DF/DT trips for Stage 6				
Stg6 Revn Date	05	35		Not Settable
Stage 6 Revision Date				
Stg7 f+t Sta	05	37		Not Settable
Number of f+t starts for Stage 7				
Stg7 f+t Trp	05	38		Not Settable
Number of f+t trips for Stage 7				
Stg7 f+df/dt Trp	05	39		Not Settable
Number of f+df/dt trips for Stage 7				
Stg7 df/dt+t Sta	05	3A		Not Settable
Number of df/dt+t starts for Stage 7				
Stg7 df/dt+t Trp	05	3B		Not Settable
Number of df/dt trips for Stage 7				
Stg7 f+Df/Dt Sta	05	3C		Not Settable
Number of f+DF/DT starts for Stage 7				
Stg7 f+Df/Dt Trp	05	3D		Not Settable
Number of f+DF/DT trips for Stage 7				
Stg7 Revn Date	05	3E		Not Settable
Stage 7 Revision Date				
Stg8 f+t Sta	05	40		Not Settable
Number of f+t starts for Stage 8				
Stg8 f+t Trp	05	41		Not Settable
Number of f+t trips for Stage 8				
Stg8 f+df/dt Trp	05	42		Not Settable
Number of f+df/dt trips for Stage 8				
Stg8 df/dt+t Sta	05	43		Not Settable
Number of df/dt+t starts for Stage 8				
Stg8 df/dt+t Trp	05	44		Not Settable
Number of df/dt trips for Stage 8				
Stg8 f+Df/Dt Sta	05	45		Not Settable

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Number of f+DF/DT starts for Stage 8				
Stg8 f+Df/Dt Trp	05	46		Not Settable
Number of f+DF/DT trips for Stage 8				
Stg8 Revn Date	05	47		Not Settable
Stage 8 Revision Date				
Stg9 f+t Sta	05	49		Not Settable
Number of f+t starts for Stage 9				
Stg9 f+t Trp	05	4A		Not Settable
Number of f+t trips for Stage 9				
Stg9 f+df/dt Trp	05	4B		Not Settable
Number of f+df/dt trips for Stage 9				
Stg9 df/dt+t Sta	05	4C		Not Settable
Number of df/dt+t starts for Stage 9				
Stg9 df/dt+t Trp	05	4D		Not Settable
Number of df/dt trips for Stage 9				
Stg9 f+Df/Dt Sta	05	4E		Not Settable
Number of f+DF/DT starts for Stage 9				
Stg9 f+Df/Dt Trp	05	4F		Not Settable
Number of f+DF/DT trips for Stage 9				
Stg9 Revn Date	05	50		Not Settable
Stage 9 Revision Date				
Reset Statistics	05	52	No Operation	0=No Operation 1=All 2=Stage 1 3=Stage 2 4=Stage 3 5=Stage 4 6=Stage 5 7=Stage 6 8=Stage 7 9=Stage 8 10=Stage 9
Reset Stage statistics				

Table 32 – Advanced Statistical Parameters

6.7 Circuit Breaker (CB) Condition Monitoring

The following table, detailing the options available for the Circuit Breaker condition monitoring, is taken from the relay menu. It includes the setup of the current broken facility and those features that can be set to raise an alarm or Circuit Breaker lockout.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
CB CONDITION	06	00		
This column contains CB Condition Monitoring Measured Parameters				
CB Operations	06	01		Not Settable
CB Operations				
Total IA Broken	06	02		Not Settable
Total IA Broken				
Total IB Broken	06	03		Not Settable
Total IB Broken				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Total IC Broken	06	04		Not Settable
Total IC Broken				
CB Operate Time	06	05		Not Settable
CB Operate Time				
Reset CB Data	06	06	No	0 = No or 1 = Yes
Reset CB Data				

Table 33 – Circuit Breaker (CB) Condition Monitoring

6.8 Circuit Breaker (CB) Control

The IED/relay includes the following options for control of a single circuit breaker:

- Local tripping and closing, via the relay menu or hotkeys
- Local tripping and closing, via relay opto-isolated inputs
- Remote tripping and closing, using the relay communications

Menu Text	Col	Row	Default Setting	Available Settings
Description				
CB CONTROL	07	00		
This column controls the circuit Breaker Control configuration				
CB Control by	07	01	Disabled	0=Disabled 1=Local 2=Remote 3=Local+Remote 4=Opto 5=Opto+local 6=Opto+Remote 7=Opto+Rem+local
Selects the type of circuit breaker control to be used				
Close Pulse Time	07	02	0.5	From 0.1s to 50s step 0.01s
Defines the duration of the close pulse within which CB should close when close command is issued. If CB fails to close after elapse of this time, CB close fail alarm is set.				
Trip Pulse Time	07	03	0.5	From 0.1s to 5s step 0.01s
Defines the duration of the trip pulse within which CB should trip when manual or protection trip command is issued. If CB does not trip within set Trip Pulse Time, CB failed to trip alarm is set.				
Man Close Delay	07	05	10	From 0.01s to 600s step 0.01s
This defines the delay time before the close pulse is executed.				
CB Healthy Time	07	06	5	From 0.01s to 9999s step 0.01s
Settable time delay for manual closure with this circuit breaker check. If the circuit breaker does not indicate a healthy condition in this time period following a close command then the IED will lockout and alarm. CB Healthy is required for manual and auto reclosure.				
Sys Check Time	07	07	5	From 0.01s to 9999s step 0.01s
Lockout Reset	07	08	No	0 = No or 1 = Yes
This resets the AutoReclose Lockout				
Reset Lockout by	07	09	CB Close	0=User Interface 1=CB Close
Allows the AutoReclose Lockout signal to be reset by UI or CB Closed signal				
Man Close RstDly	07	0A	5	From 0.1s to 600s step 0.01s
If Reset Lockout by is set to CB close then Man Close RstDly timer allows reset of Lockout state after set time delay				
Autoreclose Mode	07	0B	No Operation	0=No Operation 1=Auto 2=Non Auto
Command to changes state of Auto-Reclose, In Service or Out of Service				
AR Status	07	0E		Not Settable

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Status of the Auto Reclose - In Service / Out of service				
Total Reclosures	07	0F		Not Settable
Displays the number of successful re-closures.				
Reset Total AR	07	10	No	0 = No or 1 = Yes
Allows user to reset the auto-reclose counters.				
CB Status Input	07	11	None	0=None 1=52A 2=52B 3=Both 52A and 52B
Setting to define the type of circuit breaker contacts that will be used for the circuit breaker control logic. Form A contacts match the status of the circuit breaker primary contacts, form B are opposite to the breaker status.				
1 Shot Clearance	07	12		Not Settable
Total number of successful clearances after 1 shot				
2 Shot Clearance	07	13		Not Settable
Total number of successful clearances after 2 shots				
3 Shot Clearance	07	14		Not Settable
Total number of successful clearances after 3 shots				
4 Shot Clearance	07	15		Not Settable
Total number of successful clearances after 4 shots				
Persistent Fault	07	16		Not Settable
Total number of unsuccessful clearances with AR going to lockout				
Shot1 Recloses	07	20		Not Settable
Total number of 1 shot reclose attempts				
Shot234 Recloses	07	21		Not Settable
Total number of 2,3,4 shot reclose attempts				

Table 34 - Circuit Breaker Control

6.9 Date and Time

Displays the date and time as well as the battery condition.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DATE AND TIME	08	00		
This column contains Date and Time stamp settings				
Date/Time	08	01		
Displays the IED’s current date and time.				
IRIG-B Sync	08	04	Disabled	0 = Disabled or 1 = Enabled
Enable IRIG-B time synchronization.				
IRIG-B Status	08	05		Not Settable
Displays the status of IRIG-B				
Battery Status	08	06		Not Settable
Displays whether the battery is healthy or not				
Battery Alarm	08	07	Enabled	0 = Disabled or 1 = Enabled
Enables or disables battery alarm. The battery alarm needs to be disabled when a battery is removed or not used				
SNTP Status	08	13		Not Settable
IEC61850 or DNP3.0 over Ethernet versions only. Displays information about the SNTP time synchronization status				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
LocalTime Enable	08	20	Fixed	0 = Disabled, 1 = Fixed or 2 = Flexible
Setting to turn on/off local time adjustments. Disabled - No local time zone will be maintained. Time synchronization from any interface will be used to directly set the master clock and all displayed (or read) times on all interfaces will be based on the master clock with no adjustment. Fixed - A local time zone adjustment can be defined using the LocalTime offset setting and all interfaces will use local time except SNTP time synchronization and IEC 61850 timestamps. Flexible - A local time zone adjustment can be defined using the LocalTime offset setting and each interface can be assigned to the UTC zone or local time zone with the exception of the local interfaces which will always be in the local time zone and IEC 61850/SNTP which will always be in the UTC zone.				
LocalTime Offset	08	21	0	From -720m to 720m step 15m
Setting to specify an offset of -12 to +12 hrs in 15 minute intervals for local time zone. This adjustment is applied to the time based on the master clock which is UTC/GMT				
DST Enable	08	22	Enabled	0 = Disabled or 1 = Enabled
Setting to turn on/off daylight saving time adjustment to local time.				
DST Offset	08	23	60	From 30m to 60m step 30m
Setting to specify daylight saving offset which will be used for the time adjustment to local time.				
DST Start	08	24	Last	0 = First, 1 = Second, 2 = Third, 3 = Fourth or 4 = Last
Setting to specify the week of the month in which daylight saving time adjustment starts				
DST Start Day	08	25	Sunday	0 = Sunday, 1 = Monday, 2 = Tuesday, 3 = Wednesday, 4 = Thursday, 5 = Friday or 6 = Saturday
Setting to specify the day of the week in which daylight saving time adjustment starts				
DST Start Month	08	26	March	0 = January, 1 = February, 2 = March, 3 = April, 4 = May, 5 = June, 6 = July, 7 = August, 8 = September, 9 = October, 10 = November or 11 = December
Setting to specify the month in which daylight saving time adjustment starts				
DST Start Mins	08	27	60	From 0m to 1425m step 15m
Setting to specify the time of day in which daylight saving time adjustment starts. This is set relative to 00:00 hrs on the selected day when time adjustment is to start				
DST End	08	28	Last	0 = First, 1 = Second, 2 = Third, 3 = Fourth or 4 = Last
Setting to specify the week of the month in which daylight saving time adjustment ends				
DST End Day	08	29	Sunday	0 = Sunday, 1 = Monday, 2 = Tuesday, 3 = Wednesday, 4 = Thursday, 5 = Friday or 6 = Saturday
Setting to specify the day of the week in which daylight saving time adjustment ends				
DST End Month	08	2A	October	0 = January, 1 = February, 2 = March, 3 = April, 4 = May, 5 = June, 6 = July, 7 = August, 8 = September, 9 = October, 10 = November or 11 = December
Setting to specify the month in which daylight saving time adjustment ends				
DST End Mins	08	2B	60	From 0m to 1425m step 15m
Setting to specify the time of day in which daylight saving time adjustment ends. This is set relative to 00:00 hrs on the selected day when time adjustment is to end				
RP1 Time Zone	08	30	Local	0 = UTC or 1 = Local
Setting for the rear port 1 interface to specify if time synchronization received will be local or universal time co-ordinated				
RP2 Time Zone	08	31	Local	0 = UTC or 1 = Local
Setting for the rear port 2 interface to specify if time synchronization received will be local or universal time co-ordinated				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DNPOE Time Zone	08	32	Local	0 = UTC or 1 = Local
DNP3.0 over Ethernet versions only. Setting to specify if time synchronisation received will be local or universal time co-ordinated.				
Tunnel Time Zone	08	33	Local	0 = UTC or 1 = Local
Ethernet versions only for tunnelled courier. Setting to specify if time synchronization received will be local or universal time co-ordinated				
1588 Sync	08	40	DISABLE	0 = Disabled or 1 = Intfc 1 Enabled or 2 = Intfc 2 Enabled or 3 = Intfc 1 & 2 Enabled
The setting that indicate the 1588 enable or the Intfc 1,Intfc 2 OR Both.				
1588 DomainNum	08	41	0	0 to 255 step 1
The domian number of 1588 which define the scope of PTP message communication, state, operations, data sets, and timescale.				
1588 PdelInterv	08	42	0	From 0 to 5 step 1
The initialization value is implementation-specific consistent				
1588 Status	08	50		Not Settable
Indication the status of 1588				
InterfaceNum	08	51		Not Settable
The value of the port number				
OffsetFromMaster	08	52		Not Settable
An implementation-specific representation of the current value of the time difference between a master and a slave as computed by the slave				
PeerMeanPDelay	08	53		Not Settable
An estimate of the current one-way propagation delay on the link				
StepsRemoved	08	54		Not Settable
The number of communication paths traversed between the local clock and the grandmaster clock.				
ParentClockId	08	55		Not Settable
The clock clockIdentity of the parent clock.				
ParentPortNum	08	56		Not Settable
The value of parent port number				
ParentClockClass	08	57		Not Settable
The parent clock class which is the attribute defining a clock's TAI traceability				
ParentClockAcc	08	58		Not Settable
The parent clock accuracy which is the attribute defining the accuracy of a clock				
ParentClockVar	08	59		Not Settable
The parent clock variance which is the attribute defining the stability of a clock				
ParentPriority1	08	5A		Not Settable
A user configurable designation that a clock belongs to an ordered set of clocks from which a master is selected				
ParentPriority2	08	5B		Not Settable
A user configurable designation that provides finer grained ordering among otherwise equivalent clocks				

Table 35 - Date and Time

6.10 CT/VT Ratios

Menu Text	Col	Row	Default Setting	Available Settings
Description				
CT AND VT RATIOS	0A	00		
This column contains settings for Current and Voltage Transformer ratios				
Main VT Primary	0A	01	110	100 V to 1 MV step 1 V
Sets the main voltage transformer input primary voltage.				
Main VT Sec'y	0A	02	110	80 V to 140 V step 0.2 V 196V to 560V step 0.8 V @440V
Sets the main voltage transformer input secondary voltage.				
C/S VT Primary	0A	03	110	100 V to 1 MV step 1 V
Sets the System Check Synchronism voltage transformer input primary voltage.				
C/S VT Secondary	0A	04	110	80 V to 140 V step 0.2 V 196V to 560V step 0.8 V @440V
Sets the System Check Synchronism voltage transformer input secondary voltage.				
NVD VT Primary	0A	05	440	100 V to 1 MV step 1 V
Sets the NVD transformer input primary voltage.				
NVD VT Secondary	0A	06	440	From 196V to 560V step 0.8V
Sets the NVD transformer input secondary voltage.				
Phase CT Primary	0A	07	1	From 1A to 30000A step 1A
Sets the phase current transformer input primary current rating.				
Phase CT Sec'y	0A	08	1	1A or 5A
Sets the phase current transformer input secondary current rating.				
E/F CT Primary	0A	09	1	From 1A to 30000A step 1A
Sets the earth fault current transformer input primary current rating.				
E/F CT Secondary	0A	0A	1	1A or 5A
Sets the earth fault current transformer input secondary current rating.				
SEF CT Primary	0A	0B	1	From 1A to 30000A step 1A
Sets the sensitive earth fault current transformer input primary current rating.				
SEF CT Secondary	0A	0C	1	1A or 5A
Sets the sensitive earth fault current transformer input secondary current rating.				
C/S Input	0A	0F	A-N	0 = AN, 1 = BN, 2 = CN, 3 = AB, 4 = BC, 5 = CA
Selects the System Check Synchronism Input voltage measurement.				
Main VT Location	0A	10	Line	0 = Line or 1 = Bus
Sets the Main VT Location.				
I Derived Phase	0A	11	IB	0=IA 1=IB 2=IC 3=None
Sets the current derived phase.				
C/S V kSM	0A	14	1	From 0.1 to 5 step 0.001
Sets the voltage correction factor in case of different VT ratios.				
C/S Phase kSA	0A	15	0	From -150 to 180 step 30
Sets the phase angle correction factor.				

Table 36 - CT/VT Ratios

6.11 Record Control

It is possible to disable the reporting of events from all interfaces that support setting changes. The settings that control the various types of events are in the Record Control column. The effect of setting each to disabled is as follows:

Menu Text	Col	Row	Default Setting	Available Settings
Description				
RECORD CONTROL	0B	00		
This column contains settings for Record Controls				
Clear Events	0B	01	No	0 = No or 1 = Yes
Clear Event records				
Clear Faults	0B	02	No	1 = No or 1 = Yes
Clear Fault records				
Clear Maint	0B	03	No	2 = No or 1 = Yes
Clear Maintenance records				
Alarm Event	0B	04	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event is generated for alarms				
Relay O/P Event	0B	05	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any change in logic output state.				
Opto Input Event	0B	06	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any change in logic input state.				
General Event	0B	07	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no General Events are generated				
Fault Rec Event	0B	08	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any fault that produces a fault record				
Maint Rec Event	0B	09	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any occurrence that produces a maintenance record.				
Protection Event	0B	0A	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that any operation of protection elements will not be logged as an event				
Clear Dist Recs	0B	30	No	0 = No or 1 = Yes
Clear Disturbance records				
Security Event	0B	31	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that any operation of security elements will not be logged as an event				
DDB 31 - 0	0B	40	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 63 - 32	0B	41	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 95 - 64	0B	42	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 127 - 96	0B	43	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 159 - 128	0B	44	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DDB 191 - 160	0B	45	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 223 - 192	0B	46	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 255 - 224	0B	47	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 287 - 256	0B	48	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 319 - 288	0B	49	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 351 - 320	0B	4A	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 383 - 352	0B	4B	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 415 - 384	0B	4C	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 447 - 416	0B	4D	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 479 - 448	0B	4E	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 511 - 480	0B	4F	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 543 - 512	0B	50	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 575 - 544	0B	51	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 607 - 576	0B	52	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 639 - 608	0B	53	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 671 - 640	0B	54	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DDB 703 - 672	0B	55	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 735 - 704	0B	56	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 767 - 736	0B	57	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 799 - 768	0B	58	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 831 - 800	0B	59	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 863 - 832	0B	5A	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 895 - 864	0B	5B	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 927 - 896	0B	5C	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 959 - 928	0B	5D	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 991 - 960	0B	5E	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1023 - 992	0B	5F	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1055 - 1024	0B	60	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1087 - 1056	0B	61	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1119 - 1088	0B	62	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1151 - 1120	0B	63	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1183 - 1152	0B	64	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DDB 1215 - 1184	0B	65	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1247 - 1216	0B	66	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1279 - 1248	0B	67	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1311 - 1280	0B	68	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1343 - 1312	0B	69	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1375 - 1344	0B	6A	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1407 - 1376	0B	6B	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1439 - 1408	0B	6C	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1471 - 1440	0B	6D	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1503 - 1472	0B	6E	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1535 - 1504	0B	6F	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1567 - 1536	0B	70	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1599 - 1568	0B	71	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1631 - 1600	0B	72	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1663 - 1632	0B	73	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1695 - 1664	0B	74	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DDB 1727 - 1696	0B	75	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1759- 1728	0B	76	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1791- 1760	0B	77	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1823 - 1792	0B	78	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1855 - 1824	0B	79	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1887 - 1856	0B	7A	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1919 - 1888	0B	7B	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1951 - 1920	0B	7C	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1983 - 1952	0B	7D	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 2015 - 1984	0B	7E	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 2047 - 2016	0B	7F	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Table 37 - Record Control

Note	*The DDBs at the end of the above table are stored in blocks of 32. Starting at DDB 31 – 0, their first location is 0B40, There are stored in blocks of 32, up to DDB 2047 – 2016 at location 0B7F.*

6.12 MeasurementSetup

Menu Text	Col	Row	Default Setting	Available Settings
Description				
MEASURE'T SETUP	0D	00		
This column contains settings for the measurement setup				
Default Display	0D	01	Banner	0 = User Banner, 1 = 3Ph + N Current, 2 = 3Ph Voltage, 3 = Power, 4 = Date and Time, 5 = Description, 6 = Plant Reference, 7 = Frequency, 8 = Access Level

Menu Text	Col	Row	Default Setting	Available Settings
Description				
This setting can be used to select the default display from a range of options, note that it is also possible to view the other default displays whilst at the default level using the left and right cursor keys. However once the 15 minute timeout elapses the default display will revert to that selected by this setting.				
Local Values	0D	02	Primary	0 = Primary or 1 = Secondary
This setting controls whether measured values via the front panel user interface and the front courier port are displayed as primary or secondary quantities.				
Remote Values	0D	03	Primary	0 = Primary or 1 = Secondary
This setting controls whether measured values via the rear communication port are displayed as primary or secondary quantities.				
Measurement Ref	0D	04	VA	0 = VA, 1 = VB, 2 = VC, 3 = IA, 4 = IB, 5 = IC
Using this setting the phase reference for all angular measurements by the IED can be selected. This reference is for Measurements 1. Measurements 3 uses always IA local as a reference				
Measurement Mode	0D	05	0	0 to 3 step 1
This setting is used to control the signing of the real and reactive power quantities.				
Fix Dem Period	0D	06	30	From 1m to 99m step 1m
This setting defines the length of the fixed demand window				
Roll Sub Period	0D	07	30	From 1m to 99m step 1m
These two settings are used to set the length of the window used for the calculation of rolling demand quantities				
Num Sub Periods	0D	08	1	1 to 15 step 1
This setting is used to set the resolution of the rolling sub window				
Distance Unit	0D	09	Miles	0 = Kilometres or 1 = Miles
This setting is used to select the unit of distance for fault location purposes, note that the length of the line is preserved when converting from km to miles and vice versa				
Fault Location	0D	0A	Distance	0 = Distance, 1 = Ohms, 2 = % of Line
The calculated fault location can be displayed using one of several options selected using this setting				
Remote 2 Values	0D	0B	Primary	0 = Primary or 1 = Secondary
The setting defines whether the values measured via the Second Rear Communication port are displayed in primary or secondary terms.				

Table 38 - Measurement Setup

6.13 Communications

The communications settings apply to the rear communications ports only and will depend upon the particular protocol being used. Further details are given in the SCADA Communications chapter.

Depending on the values stored, the available settings may change too. The applicability of each setting is given in the description or available setting cell. These settings are available in the menu '**Communications'** column and are displayed.

These settings potentially cover a variety of different protocols and ports, including:

- Courier Protocol
- MODBUS Protocol
- IEC60870-5-103 Protocol
- DNP3.0 Protocol
- Ethernet Port - IEC 61850
- Ethernet Port - DNP3.0
- Rear Port 2 Settings

Menu Text	Col	Row	Default Setting	Available Settings
Description				
COMMUNICATIONS	0E	00		
This column contains general communications settings				
RP1 Protocol	0E	01		0 = Courier, 1 = IEC870-5-103, 3 = DNP3.0
Indicates the communications protocol that will be used on the rear communications port.				
RP1 Address	0E	02	255 1 1 1	0 to 255 step 1 0 to 247 step 1 0 to 254 step 1 0 to 65534 step 1
Sets the address of Rear Port 1				
RP1 InactivTimer	0E	03	15	From 1m to 30m step 1m
Defines the period of inactivity before IED reverts to its default state				
RP1 Baud Rate	0E	04	19200 bits/s	0=9600 bits/s 1=19200 bits/s 2=38400 bits/s 0=9600 bits/s 1=19200 bits/s 0=1200 bits/s 1=2400 bits/s 2=4800 bits/s 3=9600 bits/s 4=19200 bits/s 5=38400 bits/s
This cell controls the communication speed between IED and master station. It is important that both IED and master station are set at the same speed setting.				
RP1 Parity	0E	05	None	0 = Odd, 1 = Even, 2 = None
This cell controls the parity format used in the data frames. It is important that both IED and master station are set with the same parity setting.				
RP1 Meas Period	0E	06	15	From 1s to 60s step 1s
IEC60870-5-103 versions only. This cell controls the time interval that the IED will use between sending measurement data to the master station.				
RP1 PhysicalLink	0E	07	RS485	0 = Copper or 1 = Fibre Optic
This cell defines whether an electrical EIA(RS) 485 or fiber optic connection is being used for communication between the master station and IED. This cell is only visible if a fibre optic board is fitted.				
RP1 Time Sync	0E	08	Disabled	0 = Disabled or 1 = Enabled
DNP3.0 versions only. If set to Enabled the master station can be used to synchronize the time on the IED. If set to Disabled either the internal free running clock or IRIG-B input are used.				
Modbus IEC Time	0E	09	Standard	0=Standard IEC (Existing format) 1=Reverse IEC (Company agreed format)
When ‘Standard IEC’ is selected the time format complies with IEC60870-5-4 requirements such that byte 1 of the information is transmitted first, followed by bytes 2 through to 7. If ‘Reverse’ is selected the transmission of information is reversed.				
RP1 CS103Blcking	0E	0A	Disabled	0 = Disabled, 1 = Monitor Blocking or 2 = Command Blocking
IEC60870-5-103 versions only. There are three settings associated with this cell: Disabled - No blocking selected. Monitor Blocking - When the monitor blocking DDB Signal is active high, either by energizing an opto input or control input, reading of the status information and disturbance records is not permitted. When in this mode the IED returns a “termination of general interrogation” message to the master station. Command Blocking - When the command blocking DDB signal is active high, either by energizing an opto input or control input, all remote commands will be ignored (i.e. CB Trip/Close, change setting group etc.). When in this mode the IED returns a “negative acknowledgement of command” message to the master station.				
RP1 Card Status	0E	0B		0 = K Bus OK, 1 = EIA485 OK or 2 = Fibre Optic OK
Displays the status of the card in RP1				
RP1 Port Config	0E	0C	K-Bus	0 = K Bus or 1 = EIA485 (RS485)
Courier versions only. This cell defines whether an electrical KBus or EIA(RS)485 is being used for communication between the master station and IED.				
RP1 Comms Mode	0E	0D	IEC60870 FT1.2	0 = IEC60870 FT1.2 Frame or 1 = 10-bit no parity

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Courier versions only. The choice is either IEC 60870 FT1.2 for normal operation with 11-bit modems, or 10-bit no parity.				
RP1 Baud Rate	0E	0E	19200 bits/s	0 = 9600 bits/s, 1 = 19200 bits/s, 2 = 38400 bits/s
Courier versions only. This cell controls the communication speed between IED and master station. It is important that both IED and master station are set at the same speed setting.				
Meas Scaling	0E	0F	Primary	0 = Normalised, 1 = Primary, 2 = Secondary
DNP 3.0 versions only. Setting to report analogue values in terms of primary, secondary or normalized (with respect to the CT/VT ratio setting) values.				
Message Gap (ms)	0E	10	0	From 0ms to 50ms step 1ms
DNP 3.0 versions only. This setting allows the master station to have an interframe gap.				
DNP Need Time	0E	11	10	From 1m to 30m step 1m
DNP 3.0 versions only. The duration of time waited before requesting another time sync from the master.				
DNP App Fragment	0E	12	2048	100 to 2048 step 1
DNP 3.0 versions only. The maximum message length (application fragment size) transmitted by the IED.				
DNP App Timeout	0E	13	2	From 1s to 120s step 1s
DNP 3.0 versions only. Duration of time waited, after sending a message fragment and awaiting a confirmation from the master.				
DNP SBO Timeout	0E	14	10	From 1s to 10s step 1s
DNP 3.0 versions only. Duration of time waited, after receiving a select command and awaiting an operate confirmation from the master.				
DNP Link Timeout	0E	15	0	From 0s to 120s step 1s
DNP 3.0 versions only. Duration of time that the IED will wait for a Data Link Confirm from the master. A value of 0 means data link support disabled and 1 to 120 seconds is the timeout setting.				
ETH Protocol	0E	1F		IEC61850 (Ethernet)
IEC61850 versions only. Indicates that IEC 61850 will be used on the rear Ethernet port.				
ETH MAC Addr1	0E	22	Ethernet MAC Addr	Not Settable
Shows the MAC address of the 1st Ethernet port. Visible when Ethernet card fitted.				
ETH MAC Addr2	0E	23	Ethernet MAC Addr	Not Settable
Shows the MAC address of the 2nd Ethernet port. Visible when Ethernet card fitted.				
PB MAC Addr1	0E	24	PB MAC Addr	Not Settable
Shows the MAC address of the 1st Ethernet port. Visible when Process Bus card fitted.				
PB MAC Addr2	0E	25	PB MAC Addr	Not Settable
Shows the MAC address of the 2nd Ethernet port. Visible when Process Bus card fitted.				
NIC Tunl Timeout	0E	64	15.00 min	From 1m to 30m step 1m
DNP 3.0 over Ethernet versions only. Duration of time waited before an inactive tunnel to MiCOM S1 Studio is reset.				
Redundancy Conf	0E	70	Sub-Heading	Sub-Heading
NIOS PARAMETERS				
MAC Address	0E	71	NIOS MAC Addr	MAC address (Ethernet)
MAC address for the NIOS. Build=IEC61850				
IP Address	0E	72	0.0.0.0	<IP address of relay>
IP address for the NIOS. Build=IEC61850				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Subnet Mask	0E	73	0.0.0.0	<Subnet mask of relay>
Sub-network address for the NIOS. Build=IEC61850				
Gateway	0E	74	0.0.0.0	<Gateway address>
Gateway for the NIOS. Build=IEC61850				
RSTPPriority	0E	75	32768	From 0 to 61440 step 4096
The manageable component of the Bridge Identifier, also known as the Bridge Priority				
RSTPMaxAge	0E	76	20	From 6 to 40 step 1
The maximum age of the information transmitted by the Bridge when it is the Root Bridge				
RSTPFwdDelay	0E	77	15	From 4 to 30 step 1
The delay used by STP Bridges to transition Root and Designated Ports to Forwarding				
RSTPHelloTime	0E	78	2	From 1 to 2 step 1
The interval between periodic transmissions of Configuration Messages by Designated Ports				
RSTPPortAStatus	0E	7E		Not Settable
Indication the status of port A.				
RSTPPortBStatus	0E	7F		Not Settable
Indication the status of port B.				
REAR PORT2 (RP2)	0E	80		
RP2 versions only.				
RP2 Protocol	0E	81	Courier	Not Settable
RP2 versions only. Indicates the communications protocol that will be used on the rear communications port.				
RP2 Card Status	0E	84		0 = Unsupported, 1 = Card Not Fitted, 2 = EIA232 OK, 3 = EIA485 OK, 4 = K Bus OK
RP2 versions only. Displays the status of the card in RP2				
RP2 Port Config	0E	88	EIA232 (RS232)	0 = EIA232 (RS232), 1 = EIA485 (RS485), 2 = K-Bus
RP2 versions only. This cell defines whether an electrical EIA(RS)232, EIA(RS)485 or KBus is being used for communication.				
RP2 Comms Mode	0E	8A	IEC60870 FT1.2	0 = IEC60870 FT1.2 Frame or 1 = 10-bit no parity
RP2 versions only. The choice is either IEC 60870 FT1.2 for normal operation with 11-bit modems, or 10-bit no parity.				
RP2 Address	0E	90	255	0 to 255 step 1
RP2 versions only. This cell sets the unique address for the IED such that only one IED is accessed by master station software.				
RP2 InactivTimer	0E	92	15	From 1m to 30m step 1m
RP2 versions only. This cell controls how long the IED will wait without receiving any messages on the rear port before it reverts to its default state, including resetting any password access that was enabled.				
RP2 Baud Rate	0E	94	19200 bits/s	0 = 9600 bits/s, 1 = 19200 bits/s, 2 = 38400 bits/s
RP2 versions only. This cell controls the communication speed between IED and master station. It is important that both IED and master station are set at the same speed setting.				
IP Address	0E	A1	0.0.0.0	Not Settable
DNP 3.0 over Ethernet versions only. Indicates the IP address of the IED				
Subnet Address	0E	A2	0.0.0.0	Not Settable

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DNP 3.0 over Ethernet versions only. Indicates the Subnet address				
Gateway	0E	A4	0.0.0.0	Not Settable
DNP 3.0 over Ethernet versions only. Indicates the Gateway address				
DNP Time Synch	0E	A5	Disabled	0 = Disabled or 1 = Enabled
DNP 3.0 over Ethernet versions only. If set to ‘Enabled’ the DNP3.0 master station can be used to synchronize the time on the IED. If set to ‘Disabled’ either the internal free running clock, or IRIG-B input are used.				
Meas Scaling	0E	A6	Primary	0 = Normalised, 1 = Primary, 2 = Secondary
DNP 3.0 over Ethernet versions only. Setting to report analogue values in terms of primary, secondary or normalized (with respect to the CT/VT ratio setting) values.				
NIC Tunl Timeout	0E	A7	5	From 1m to 30m step 1m
DNP 3.0 over Ethernet versions only. Duration of time waited before an inactive tunnel to MiCOM S1 Studio is reset.				
NIC Link Report	0E	A8	Alarm	0 = Alarm, 1 = Event, 2 = None
DNP 3.0 over Ethernet versions only. Configures how a failed/unfitted network link (copper or fiber) is reported: Alarm - an alarm is raised for a failed link Event - an event is logged for a failed link None - nothing reported for a failed link				
NIC Link Timeout	0E	A9	60s	From 0.1m to 60m step 0.1m
Duration of time waited, after failed network link is detected, before communication by the alternative media interface is attempted.				
SNTP PARAMETERS	0E	AA		
DNP 3.0 over Ethernet versions only				
SNTP Server 1	0E	AB	0.0.0.0	Not Settable
DNP 3.0 over Ethernet versions only. Indicates the SNTP Server 1 address.				
SNTP Server 2	0E	AC	0.0.0.0	Not Settable
DNP 3.0 over Ethernet versions only. Indicates the SNTP Server 2 address.				
SNTP Poll Rate	0E	AD	64s	Not Settable
DNP 3.0 over Ethernet versions only. Duration of SNTP poll rate in seconds.				
DNP Need Time	0E	B1	10	From 1 to 30 step 1
DNP 3.0 versions only. The duration of time waited before requesting another time sync from the master.				
DNP App Fragment	0E	B2	2048	From 100 to 2048 step 1
DNP 3.0 versions only. The maximum message length (application fragment size) transmitted by the IED.				
DNP App Timeout	0E	B3	2	From 1s to 120s step 1s
DNP 3.0 versions only. Duration of time waited, after sending a message fragment and awaiting a confirmation from the master.				
DNP SBO Timeout	0E	B4	10	From 1s to 10s step 1s
DNP 3.0 versions only. Duration of time waited, after receiving a select command and awaiting an operate confirmation from the master.				

Table 39 - Communications Settings

6.14 Commissioning Tests

To help minimising the time required to test MiCOM relays the relay provides several test facilities under the 'COMMISSION TESTS' menu heading.

There are menu cells which allow the status of the opto-isolated inputs, output relay contacts, internal Digital Data Bus (DDB) signals and user-programmable LEDs to be monitored. Additionally there are cells to test the operation of the output contacts, user-programmable LEDs.

This column is visible when the "Commission tests" setting ("Configuration" column) = "visible".

Menu Text	Col	Row	Default Setting	Available Settings
Description				
COMMISSION TESTS	0F	00		
This column contains commissioning test settings				
Opto I/P Status	0F	01		Not Settable
This menu cell displays the status of the available IED's opto-isolated inputs as a binary string, a '1' indicating an energized opto-isolated input and a '0' a de-energized one.				
Relay O/P Status	0F	02		Not Settable
This menu cell displays the status of the digital data bus (DDB) signals that result in energization of the available output relays as a binary string, a '1' indicating an operated state and '0' a non-operated state. When the 'Test Mode' cell is set to 'Enabled' the 'Relay O/P Status' cell does not show the current status of the output relays and hence can not be used to confirm operation of the output relays. Therefore it will be necessary to monitor the state of each contact in turn.				
Test Port Status	0F	03		Not Settable
This menu cell displays the status of the eight digital data bus (DDB) signals that have been allocated in the 'Monitor Bit' cells.				
LED Status	0F	04		Not Settable
8-bit binary string that indicates which of the LEDs are ON				
Monitor Bit 1	0F	05	64 640	From 0 to 1279 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 2	0F	06	65 642	From 0 to 1279 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 3	0F	07	66 644	From 0 to 1279 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 4	0F	08	67 646	From 0 to 1279 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 5	0F	09	68 648	From 0 to 1279 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 6	0F	0A	69 650	From 0 to 1279 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 7	0F	0B	70 652	From 0 to 1279 step 1

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 8	0F	0C	71 654	From 0 to 1279 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Test Mode	0F	0D	Disabled	0 = Disabled, 1 = Test Mode, 2 = Contacts Blocked
The Test Mode menu cell is used to allow secondary injection testing to be performed on the IED without operation of the trip contacts. It also enables a facility to directly test the output contacts by applying menu controlled test signals. To select test mode the Test Mode menu cell should be set to 'Test Mode', which takes the IED out of service . It also causes an alarm condition to be recorded and the yellow 'Out of Service' LED to illuminate and an alarm message 'Prot'n. Disabled' is given. In IEC 60870-5-103 builds changes the Cause of Transmission, COT, to Test Mode. To enable testing of output contacts the Test Mode cell should be set to Contacts Blocked. This blocks the protection from operating the contacts and enables the test pattern and contact test functions which can be used to manually operate the output contacts. This mode also blocks maintenance, counters and freezes any information stored in the Circuit Breaker Condition column. Also in IEC 60870-5-103 builds changes the Cause of Transmission, COT, to Test Mode. Once testing is complete the cell must be set back to 'Disabled' to restore the IED back to service.				
Test Pattern	0F	0E	0x0	0=Not Operated or 1=Operated
This cell is used to select the output relay contacts that will be tested when the 'Contact Test' cell is set to 'Apply Test'.				
Contact Test	0F	0F	No Operation	0 = No Operation, 1 = Apply Test, 2 = Remove Test
When the 'Apply Test' command in this cell is issued the contacts set for operation (set to '1') in the 'Test Pattern' cell change state. After the test has been applied the command text on the LCD will change to 'No Operation' and the contacts will remain in the Test State until reset issuing the 'Remove Test' command. The command text on the LCD will again revert to 'No Operation' after the 'Remove Test' command has been issued. Note: When the 'Test Mode' cell is set to 'Enabled' the 'Relay O/P Status' cell does not show the current status of the output relays and hence can not be used to confirm operation of the output relays. Therefore it will be necessary to monitor the state of each contact in turn.				
Test LEDs	0F	10	No Operation	0 = No Operation or 1 = Apply Test
When the 'Apply Test' command in this cell is issued, the eighteen user-programmable LEDs will illuminate for approximately 2 seconds before they extinguish and the command text on the LCD reverts to 'No Operation'.				
Test Autoreclose	0F	11	No Operation	0=No Operation 1=3 Pole Test
This is a command used to simulate tripping in order to test Auto-reclose cycle.				
Red LED Status	0F	15		Not Settable
This cell is an eighteen bit binary string that indicates which of the user-programmable LEDs on the IED are illuminated with the Red LED input active when accessing the IED from a remote location, a '1' indicating a particular LED is lit and a '0' not lit.				
Green LED Status	0F	16		Not Settable
This cell is an eighteen bit binary string that indicates which of the user-programmable LEDs on the IED are illuminated with the Green LED input active when accessing the IED from a remote location, a '1' indicating a particular LED is lit and a '0' not lit.				
DDB 31 - 0	0F	20		Not Settable
Displays the status of DDB signals				
DDB 63 - 32	0F	21		Not Settable
Displays the status of DDB signals				
DDB 95 - 64	0F	22		Not Settable
Displays the status of DDB signals				
DDB 127 - 96	0F	23		Not Settable
Displays the status of DDB signals				
DDB 159 - 128	0F	24		Not Settable
Displays the status of DDB signals				
DDB 191 - 160	0F	25		Not Settable
Displays the status of DDB signals				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DDB 223 - 192	0F	26		Not Settable
Displays the status of DDB signals				
DDB 255 - 224	0F	27		Not Settable
Displays the status of DDB signals				
DDB 287 - 256	0F	28		Not Settable
Displays the status of DDB signals				
DDB 319 - 288	0F	29		Not Settable
Displays the status of DDB signals				
DDB 351 - 320	0F	2A		Not Settable
Displays the status of DDB signals				
DDB 383 - 352	0F	2B		Not Settable
Displays the status of DDB signals				
DDB 415 - 384	0F	2C		Not Settable
Displays the status of DDB signals				
DDB 447 - 416	0F	2D		Not Settable
Displays the status of DDB signals				
DDB 479 - 448	0F	2E		Not Settable
Displays the status of DDB signals				
DDB 511 - 480	0F	2F		Not Settable
Displays the status of DDB signals				
DDB 543 - 512	0F	30		Not Settable
Displays the status of DDB signals				
DDB 575 - 544	0F	31		Not Settable
Displays the status of DDB signals				
DDB 607 - 576	0F	32		Not Settable
Displays the status of DDB signals				
DDB 639 - 608	0F	33		Not Settable
Displays the status of DDB signals				
DDB 671 - 640	0F	34		Not Settable
Displays the status of DDB signals				
DDB 703 - 672	0F	35		Not Settable
Displays the status of DDB signals				
DDB 735 - 704	0F	36		Not Settable
Displays the status of DDB signals				
DDB 767 - 736	0F	37		Not Settable
Displays the status of DDB signals				
DDB 799 - 768	0F	38		Not Settable
Displays the status of DDB signals				
DDB 831 - 800	0F	39		Not Settable
Displays the status of DDB signals				
DDB 863 - 832	0F	3A		Not Settable
Displays the status of DDB signals				
DDB 895 - 864	0F	3B		Not Settable

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Displays the status of DDB signals				
DDB 927 - 896	0F	3C		Not Settable
Displays the status of DDB signals				
DDB 959 - 928	0F	3D		Not Settable
Displays the status of DDB signals				
DDB 991 - 960	0F	3E		Not Settable
Displays the status of DDB signals				
DDB 1023 - 992	0F	3F		Not Settable
Displays the status of DDB signals				
DDB 1055 - 1024	0F	40		Not Settable
Displays the status of DDB signals				
DDB 1087 - 1056	0F	41		Not Settable
Displays the status of DDB signals				
DDB 1119 - 1088	0F	42		Not Settable
Displays the status of DDB signals				
DDB 1151 - 1120	0F	43		Not Settable
Displays the status of DDB signals				
DDB 1183 - 1152	0F	44		Not Settable
Displays the status of DDB signals				
DDB 1215 - 1184	0F	45		Not Settable
Displays the status of DDB signals				
DDB 1247 - 1216	0F	46		Not Settable
Displays the status of DDB signals				
DDB 1279 - 1248	0F	47		Not Settable
Displays the status of DDB signals				
DDB 1311 - 1280	0F	48		Not Settable
Displays the status of DDB signals				
DDB 1343 - 1312	0F	49		Not Settable
Displays the status of DDB signals				
DDB 1375 - 1344	0F	4A		Not Settable
Displays the status of DDB signals				
DDB 1407 - 1376	0F	4B		Not Settable
Displays the status of DDB signals				
DDB 1439 - 1408	0F	4C		Not Settable
Displays the status of DDB signals				
DDB 1471 - 1440	0F	4D		Not Settable
Displays the status of DDB signals				
DDB 1503 - 1472	0F	4E		Not Settable
Displays the status of DDB signals				
DDB 1535 - 1504	0F	4F		Not Settable
Displays the status of DDB signals				
DDB 1567 - 1536	0F	50		Not Settable
Displays the status of DDB signals				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DDB 1599 - 1568	0F	51		Not Settable
Displays the status of DDB signals				
DDB 1631 - 1600	0F	52		Not Settable
Displays the status of DDB signals				
DDB 1663 - 1632	0F	53		Not Settable
Displays the status of DDB signals				
DDB 1695 - 1664	0F	54		Not Settable
Displays the status of DDB signals				
DDB 1727 - 1696	0F	55		Not Settable
Displays the status of DDB signals				
DDB 1759- 1728	0F	56		Not Settable
Displays the status of DDB signals				
DDB 1791- 1760	0F	57		Not Settable
Displays the status of DDB signals				
DDB 1823 - 1792	0F	58		Not Settable
Displays the status of DDB signals				
DDB 1855 - 1824	0F	59		Not Settable
Displays the status of DDB signals				
DDB 1887 - 1856	0F	5A		Not Settable
Displays the status of DDB signals				
DDB 1919 - 1888	0F	5B		Not Settable
Displays the status of DDB signals				
DDB 1951 - 1920	0F	5C		Not Settable
Displays the status of DDB signals				
DDB 1983 - 1952	0F	5D		Not Settable
Displays the status of DDB signals				
DDB 2015 - 1984	0F	5E		Not Settable
Displays the status of DDB signals				
DDB 2047 - 2016	0F	5F		Not Settable
Displays the status of DDB signals				

Table 40 - Commissioning Tests

Note	*The DDBs at the end of the above table are stored in blocks of 32. Starting at DDB 31 – 0, their first location is 0F20, There are stored in blocks of 32, up to DDB 2047 – 2016 at location 0F5F.*

6.15 Circuit Breaker Condition Monitor Setup

The following table, detailing the options available for the Circuit Breaker condition monitoring, is taken from the relay menu. It includes the setup of the current broken facility and those features that can be set to raise an alarm or Circuit Breaker lockout.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
CB MONITOR SETUP	10	00		
This column contains Circuit Breaker monitoring parameters				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Broken I^	10	01	2	1 to 2 step 0.1
This sets the factor to be used for the cumulative I^ counter calculation that monitors the cumulative severity of the duty placed on the interrupter. This factor is set according to the type of Circuit Breaker used				
I^ Maintenance	10	02	Alarm Disabled	0 = Alarm Disabled or 1 = Alarm Enabled
Setting which determines if an alarm will be raised or not when the cumulative I^ maintenance counter threshold is exceeded.				
I^ Maintenance	10	03	1000	From 1 * NM1 to 25000 * NM1 step 1 * NM1
Setting that determines the threshold for the cumulative I^ maintenance counter monitors.				
I^ Lockout	10	04	Alarm Disabled	0 = Alarm Disabled or 1 = Alarm Enabled
Setting which determines if an alarm will be raised or not when the cumulative I^lockout counter threshold is exceeded.				
I^ Lockout	10	05	2000	From 1 * NM1 to 25000 * NM1 step 1 * NM1
Setting that determines the threshold for the cumulative I^ lockout counter monitor. Set that should maintenance not be carried out, the IED can be set to lockout the auto-reclose function on reaching a second operations threshold.				
No. CB Ops Maint	10	06	Alarm Disabled	0 = Alarm Disabled or 1 = Alarm Enabled
Setting to activate the number of circuit breaker operations maintenance alarm.				
No. CB Ops Maint	10	07	10	1 to 10000 step 1
Sets the threshold for number of circuit breaker operations maintenance alarm, indicating when preventative maintenance is due.				
No. CB Ops Lock	10	08	Alarm Disabled	0 = Alarm Disabled or 1 = Alarm Enabled
Setting to activate the number of circuit breaker operations lockout alarm.				
No. CB Ops Lock	10	09	20	1 to 10000 step 1
Sets the threshold for number of circuit breaker operations lockout. The IED can be set to lockout the auto-reclose function on reaching a second operations threshold.				
CB Time Maint	10	0A	Alarm Disabled	0 = Alarm Disabled or 1 = Alarm Enabled
Setting to activate the circuit breaker operating time maintenance alarm.				
CB Time Maint	10	0B	0.1	From 0.005s to 0.5s step 0.001s
Setting for the circuit operating time threshold which is set in relation to the specified interrupting time of the circuit breaker.				
CB Time Lockout	10	0C	Alarm Disabled	0 = Alarm Disabled or 1 = Alarm Enabled
Setting to activate the circuit breaker operating time lockout alarm.				
CB Time Lockout	10	0D	0.2	From 0.005s to 0.5s step 0.001s
Setting for the circuit breaker operating time threshold which is set in relation to the specified interrupting time of the circuit breaker. The IED can be set to lockout the auto-reclose function on reaching a second operations threshold.				
Fault Freq Lock	10	0E	Alarm Disabled	0 = Alarm Disabled or 1 = Alarm Enabled
Enables the excessive fault frequency alarm.				
Fault Freq Count	10	0F	10	From 1 to 9999 step 1
Sets a circuit breaker frequent operations counter that monitors the number of operations over a set time period				
Fault Freq Time	10	10	3600	From 0s to 9999s step 1s
Sets the time period over which the circuit breaker operations are to be monitored. Should the set number of trip operations be accumulated within this time period, an alarm can be raised. Excessive fault frequency/trips can be used to indicate that the circuit may need maintenance attention (e.g. Tree-felling or insulator cleaning).				

Table 41 - Circuit Breaker Condition Monitor Setup

6.16 Opto Configuration

Menu Text	Col	Row	Default Setting	Available Settings
Description				
OPTO CONFIG	11	00		
This column contains opto-input configuration settings				
Global Nominal V	11	01	48/54V	0 = 24-27V, 1 = 30-34V, 2 = 48-54V, 3 = 110-125V, 4 = 220-250V or 5 = Custom
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 1	11	02	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 2	11	03	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 3	11	04	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 4	11	05	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 5	11	06	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 6	11	07	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 7	11	08	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 8	11	09	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 9	11	0A	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 10	11	0B	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 11	11	0C	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 12	11	0D	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 13	11	0E	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 14	11	0F	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 15	11	10	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 16	11	11	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 17	11	12	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 18	11	13	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 19	11	14	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 20	11	15	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 21	11	16	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 22	11	17	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 23	11	18	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 24	11	19	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 25	11	1A	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 26	11	1B	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 27	11	1C	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 28	11	1D	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 29	11	1E	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 30	11	1F	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 31	11	20	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 32	11	21	48/54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Filter Cntl	11	50	0xFFFFFFFF	32-bit binary setting: 0 = Off, 1= Energized
Selects each input with a pre-set filter of ½ cycle that renders the input immune to induced noise on the wiring. The number of available bits may be 16, 24 or 32, depending on the I/O configuration.				
Characteristic	11	80	Standard 60%-80%	0 = Standard 60% to 80% or 1 = 50% to 70%
Selects the pick-up and drop-off characteristics of the opto's. Selecting the standard setting means they nominally provide a Logic 1 or On value for Voltages ≥80% of the set lower nominal voltage and a Logic 0 or Off value for the voltages ≤60% of the set higher nominal voltage.				

Table 42 - Opto Configuration

6.17 Control Inputs

Each custom input can be set or reset from a Bit Field or separate enable/disable selection.

There are many of these inputs. These are all recorded in blocks of settings within the MiCOM relay. They all have the same Default and Available Settings and the same Description applies to all of them. The following table shows the first and last inputs in the sequence(s).

Menu Text	Col	Row	Default Setting	Available Settings
Description				
CONTROL INPUTS	12	00		
This column contains settings for the type of control input (32 in all)				
Ctrl I/P Status	12	01	0x00000000	Binary Flag (32 bits) Indexed String (0 = Reset, 1 = Set)
Cell that is used to set (1) and reset (0) the selected Control Input by simply scrolling and changing the status of selected bits. This command will be then recognized and executed in the PSL. Alternatively, each of the 32 Control input can also be set and reset using the individual menu setting cells as follows:				
Control Input 1	12	02	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 1 set/ reset.				
Control Input 2	12	03	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 2 set/ reset.				
Control Input 3	12	04	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 3 set/ reset.				
Control Input 4	12	05	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 4 set/ reset.				
Control Input 5	12	06	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 5 set/ reset.				
Control Input 6	12	07	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 6 set/ reset.				
Control Input 7	12	08	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 7 set/ reset.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Control Input 8	12	09	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 8 set/ reset.				
Control Input 9	12	0A	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 9 set/ reset.				
Control Input 10	12	0B	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 10 set/ reset.				
Control Input 11	12	0C	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 11 set/ reset.				
Control Input 12	12	0D	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 12 set/ reset.				
Control Input 13	12	0E	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 13 set/ reset.				
Control Input 14	12	0F	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 14 set/ reset.				
Control Input 15	12	10	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 15 set/ reset.				
Control Input 16	12	11	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 16 set/ reset.				
Control Input 17	12	12	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 17 set/ reset.				
Control Input 18	12	13	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 18 set/ reset.				
Control Input 19	12	14	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 19 set/ reset.				
Control Input 20	12	15	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 20 set/ reset.				
Control Input 21	12	16	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 21 set/ reset.				
Control Input 22	12	17	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 22 set/ reset.				
Control Input 23	12	18	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 23 set/ reset.				
Control Input 24	12	19	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 24 set/ reset.				
Control Input 25	12	1A	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 25 set/ reset.				
Control Input 26	12	1B	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 26 set/ reset.				
Control Input 27	12	1C	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 27 set/ reset.				
Control Input 28	12	1D	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 28 set/ reset.				
Control Input 29	12	1E	No Operation	0 = No Operation, 1 = Set , 2 = Reset

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Setting to allow Control Inputs 29 set/ reset.				
Control Input 30	12	1F	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 30 set/ reset.				
Control Input 31	12	20	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 31 set/ reset.				
Control Input 32	12	21	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 32 set/ reset.				
Setting Input Status	12	22	0x0000	Binary Flag (32 bits) Indexed String (0 = Reset, 1 = Set)
Cell that is used to set (1) and reset (0) the selected Setting Input by simply scrolling and changing the status of selected bits. This command will be then recognized and executed in the PSL. Alternatively, each of the 16 setting input can also be set and reset using the individual menu setting cells as follows:				
Setting Input 33	12	23	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 33				
Setting Input 34	12	24	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 34				
Setting Input 35	12	25	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 35				
Setting Input 36	12	26	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 36				
Setting Input 37	12	27	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 37				
Setting Input 38	12	28	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 38				
Setting Input 39	12	29	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 39				
Setting Input 40	12	2A	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 40				
Setting Input 41	12	2B	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 41				
Setting Input 42	12	2C	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 42				
Setting Input 43	12	2D	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 43				
Setting Input 44	12	2E	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 44				
Setting Input 45	12	2F	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 45				
Setting Input 46	12	30	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 46				
Setting Input 47	12	31	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 47				
Setting Input 48	12	32	Disabled	0 = Disabled, 1 = Enabled
Setting to allow control of setting Input 48				

Table 43 - Control Inputs

6.18 Control Input Configuration

The control inputs function as software switches that can be set or reset either locally or remotely. These inputs can be used to trigger any function that they are connected to as part of the PSL.
This column is visible when the “Control I/P Config” setting (“Configuration” column) = “visible”.

There are many of these inputs. These are all recorded in blocks of settings within the MiCOM relay. They all have the same Default and Available Settings and the same Description applies to all of them. The following table shows the first and last inputs in the sequence(s).

Menu Text	Col	Row	Default Setting	Available Settings
Description				
CTRL I/P CONFIG	13	00		
This column contains settings for the type of control input (32 in all)				
Hotkey Enabled	13	01	0xFFFFFFFF	0xFFFFFFFF to 32 step 1
Setting to allow the control inputs to be individually assigned to the Hotkey menu by setting ‘1’ in the appropriate bit in the Hotkey Enabled cell. The hotkey menu allows the control inputs to be set, reset or pulsed without the need to enter the CONTROL INPUTS column.				
Control Input 1	13	10	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’. A latched control input will remain in the set state until a reset command is given, either by the menu or the serial communications. A pulsed control input, however, will remain energized for 10 ms after the set command is given and will then reset automatically (i.e. no reset command required).				
Ctrl Command 1	13	11	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 2	13	14	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 2	13	15	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 3	13	18	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 3	13	19	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 4	13	1C	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 4	13	1D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 5	13	20	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 5	13	21	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 6	13	24	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 6	13	25	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 7	13	28	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 7	13	29	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 8	13	2C	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 8	13	2D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 9	13	30	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 9	13	31	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 10	13	34	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 10	13	35	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 11	13	38	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 11	13	39	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 12	13	3C	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 12	13	3D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 13	13	40	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 13	13	41	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 14	13	44	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 14	13	45	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 15	13	48	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 15	13	49	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 16	13	4C	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 16	13	4D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 17	13	50	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 17	13	51	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 18	13	54	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 18	13	55	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 19	13	58	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 19	13	59	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 20	13	5C	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 20	13	5D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 21	13	60	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 21	13	61	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 22	13	64	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 22	13	65	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 23	13	68	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 23	13	69	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 24	13	6C	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 24	13	6D	SET/RESET	0 = On/Off or 1 = Set/Reset or 2 = In/Out or 3 = Enabled/Disabled

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 25	13	70	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either 'latched' or 'pulsed'.				
Ctrl Command 25	13	71	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 26	13	74	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either 'latched' or 'pulsed'.				
Ctrl Command 26	13	75	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 27	13	78	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either 'latched' or 'pulsed'.				
Ctrl Command 27	13	79	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 28	13	7C	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either 'latched' or 'pulsed'.				
Ctrl Command 28	13	7D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 29	13	80	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either 'latched' or 'pulsed'.				
Ctrl Command 29	13	81	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 30	13	84	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either 'latched' or 'pulsed'.				
Ctrl Command 30	13	85	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 31	13	88	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either 'latched' or 'pulsed'.				
Ctrl Command 31	13	89	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 32	13	8C	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either 'latched' or 'pulsed'.				
Ctrl Command 32	13	8D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				

Table 44 - Control Input Configuration

6.19 Function Keys (P145 Model Only)

Menu Text	Col	Row	Default Setting	Available Settings
Description				
FUNCTION KEYS	17	00		
This column contains the function key definitions				
Fn Key Status	17	01	0	Not Settable
Displays the status of each function key.				
Fn Key 1	17	02	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The 'Lock' setting allows a function key output that is set to toggle mode to be locked in its current active state.				
Fn Key 1 Mode	17	03	Toggled	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In 'Toggle' mode, a single key press will set/latch the function key output as 'high' or 'low' in programmable scheme logic. This feature can be used to enable/disable IED functions. In the 'Normal' mode the function key output will remain 'high' as long as key is pressed.				
Fn Key 1 Label	17	04	Function Key 1	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 2	17	05	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The 'Lock' setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 2 Mode	17	06	Normal	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In 'Toggle' mode, a single key press will set/latch the function key output as 'high' or 'low' in programmable scheme logic. This feature can be used to enable/disable IED functions. In the 'Normal' mode the function key output will remain 'high' as long as key is pressed.				
Fn Key 2 Label	17	07	Function Key 2	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 3	17	08	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The 'Lock' setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 3 Mode	17	09	Normal	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In 'Toggle' mode, a single key press will set/latch the function key output as 'high' or 'low' in programmable scheme logic. This feature can be used to enable/disable IED functions. In the 'Normal' mode the function key output will remain 'high' as long as key is pressed.				
Fn Key 3 Label	17	0A	Function Key 3	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 4	17	0B	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The 'Lock' setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 4 Mode	17	0C	Toggled	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In 'Toggle' mode, a single key press will set/latch the function key output as 'high' or 'low' in programmable scheme logic. This feature can be used to enable/disable IED functions. In the 'Normal' mode the function key output will remain 'high' as long as key is pressed.				
Fn Key 4 Label	17	0D	Function Key 4	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 5	17	0E	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The 'Lock' setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 5 Mode	17	0F	Toggled	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In 'Toggle' mode, a single key press will set/latch the function key output as 'high' or 'low' in programmable scheme logic. This feature can be used to enable/disable IED functions. In the 'Normal' mode the function key output will remain 'high' as long as key is pressed.				
Fn Key 5 Label	17	10	Function Key 5	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 6	17	11	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Setting to activate function key. The ‘Lock’ setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 6 Mode	17	12	Toggled	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In ‘Toggle’ mode, a single key press will set/latch the function key output as ‘high’ or ‘low’ in programmable scheme logic. This feature can be used to enable/disable IED functions. In the ‘Normal’ mode the function key output will remain ‘high’ as long as key is pressed.				
Fn Key 6 Label	17	13	Function Key 6	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 7	17	14	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The ‘Lock’ setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 7 Mode	17	15	Toggled	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In ‘Toggle’ mode, a single key press will set/latch the function key output as ‘high’ or ‘low’ in programmable scheme logic. This feature can be used to enable/disable IED functions. In the ‘Normal’ mode the function key output will remain ‘high’ as long as key is pressed.				
Fn Key 7 Label	17	16	Function Key 7	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 8	17	17	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The ‘Lock’ setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 8 Mode	17	18	Normal	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In ‘Toggle’ mode, a single key press will set/latch the function key output as ‘high’ or ‘low’ in programmable scheme logic. This feature can be used to enable/disable IED functions. In the ‘Normal’ mode the function key output will remain ‘high’ as long as key is pressed.				
Fn Key 8 Label	17	19	Function Key 8	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 9	17	1A	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The ‘Lock’ setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 9 Mode	17	1B	Normal	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In ‘Toggle’ mode, a single key press will set/latch the function key output as ‘high’ or ‘low’ in programmable scheme logic. This feature can be used to enable/disable IED functions. In the ‘Normal’ mode the function key output will remain ‘high’ as long as key is pressed.				
Fn Key 9 Label	17	1C	Function Key 9	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 10	17	1D	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The ‘Lock’ setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 10 Mode	17	1E	Normal	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In ‘Toggle’ mode, a single key press will set/latch the function key output as ‘high’ or ‘low’ in programmable scheme logic. This feature can be used to enable/disable IED functions. In the ‘Normal’ mode the function key output will remain ‘high’ as long as key is pressed.				
Fn Key 10 Label	17	1F	Function Key 10	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				

Table 45 - Function Keys (P145 Model Only)

6.20 Process Bus (PB) Config

Menu Text	Col	Row	Default Setting	Available Settings
Description				
PB CONFIG	18	00		

Menu Text	Col	Row	Default Setting	Available Settings
Description				
This column contains settings and status parameters relative to process bus				
MU OOS CONFIG	18	01	00000000(bin)	8 bits setting, 0 = MU OOS Disabled, 1 = MU OOS Enabled
Used to set one or more Merging Units to be run in Out of Service mode .				
AntiAlais Filter	18	02	Disabled	0 = Disabled, 1 = Enabled
This cell activates or deactivates the anti-aliasing filter, which conditions the Sampled Values from the Process Bus network.				
SMV Version	18	03	IEC61850=9-2LE	0=IEC61850=9-2LE, 1 = IEC61869
This cell selects which version of sampled values are used, if it is set to IEC61850-9-2LE, device will subscribe the sampled value compliant with IEC61850-9-2LE, otherwise, device will subscribe the sampled value compliant with IEC61869. If the MU device is configured to published IEC61850-9-2 compatible frames, the setting should be set to IEC61850-9-2LE.				
MUs Delay Offset	18	04	0s	From 0s to 3ms step 250us
This cell adjusts the maximum time-delay offset starting at the reception of the Ethernet message from the “first” Merging Unit (MU) to the reception of the Ethernet message from the “last” Merging Unit (MU). This time-delay should be adjusted to ensure all MU samples for the same time instant are received before sending to the relay processor.				
Mon Delay Offset	18	05	No	0 = No, 1 = Yes
When sampled values are received at the IED from different Merging Units, they do not arrive simultaneously due to differences in Merging Unit performance or different network path delays. After this setting is set to Yes, a command to monitor the maximum time-delay will be sent to Process Bus board. After Process Bus board has calculated a delay, it will send the delay time to main board for users to set a proper MUs Delay Offset.				
Max Delay Offset	18	06		
This setting specifies the maximum time-delay supervised, supervision starting at the reception of the sampled value frame from the "first" Merging Unit to the reception of the sampled value frame from the last Merging Unit for each sample count. If >3ms, a -1 will be displayed.				
Synchro Mode	18	30	No SYNC CLK	0 = No SYNC CLK, 1 = Local 1 PPS, 2 = Global 1 PPS
This setting specifies the type of Sampled Value synchronization expected by the IED, depending on the application. Global Clock: The Sampled Values are synchronized with a global area clock (GPS like clock). Local Clock: The Sampled Values are synchronized with a local area clock signal at the substation. Sampled Value frames received with Global or Local synchronization are acceptable with this setting. No SYNC CLK: The Sampled Values do not need to be synchronized. With this setting the IED ignores the synchronization flag in the Sampled Value frames.				
SV Absence Alm	18	31	00000000(bin)	
This is a data cell with 8 binary flags. It indicates the presence or absence of Sampled Values from each of the Merging Units the IED is communicating with. The cell data for each Merging Unit is continuously refreshed. Unused MUs will indicate a 0. 0: Sampled Values being received from the Merging Unit. 1: No Sampled Values being received from the Merging Unit.				
SV SmpSynch Alm	18	32	00000000(bin)	
This is a data cell with 8 binary flags. It indicates whether the Sampled Values being received from each of the Merging Units has the Synchro as required by 1830 above. Unused MUs will indicate a 0 0: Sampled Values received are synchronized. 1: Sampled Values received are not synchronized.				
SV Test Alm	18	33	00000(bin)	
This is a data cell with a binary flag for each of the analogue groups within the relays. It indicates the status of the IEC 61850 Quality attribute ‘Test’ in the Sampled Value frame used for that channel. If a channel is marked Test then functions associated with that channel are blocked unless the relay is in ‘Test Mode’ or ‘Contacts Blocked’				
SV Test Alm	18	33	0000(bin)	
This is a data cell with a binary flag for each of the analogue groups within the relays. It indicates the status of the IEC 61850 Quality attribute ‘Test’ in the Sampled Value frame used for that channel. If a channel is marked Test then functions associated with that channel are blocked unless the relay is in ‘Test Mode’ or ‘Contacts Blocked’				
SV Invalid Alm	18	34	00000(bin)	

Menu Text	Col	Row	Default Setting	Available Settings
Description				
This is a data cell with a binary flag for each of the analogue groups within the relay. It indicates the status of the IEC 61850 Quality attribute 'Invalid' in the Sampled Value frame used for that channel. If a channel is marked Invalid then functions associated with that channel are blocked.				
SV Invalid Alm	18	34	0000(bin)	
This is a data cell with a binary flag for each of the analogue groups within the relay. It indicates the status of the IEC 61850 Quality attribute 'Invalid' in the Sampled Value frame used for that channel. If a channel is marked Invalid then functions associated with that channel are blocked.				
SV Quest Alm	18	35	00000(bin)	
This is a data cell with a binary flag for each of the analogue groups within the relay. It indicates the status of the IEC 61850 Quality attribute 'Questionable' in the Sampled Value frame used for that channel. If a channel is marked Questionable then functions associated with that channel are blocked.				
SV Quest Alm	18	35	0000(bin)	
This is a data cell with a binary flag for each of the analogue groups within the relay. It indicates the status of the IEC 61850 Quality attribute 'Questionable' in the Sampled Value frame used for that channel. If a channel is marked Questionable then functions associated with that channel are blocked.				

Table 46 – Process Bus (PB) Config

6.21 IED Configurator (for IEC 61850 Configuration)

The contents of the IED CONFIGURATOR column (for IEC 61850 configuration) are mostly data cells, displayed for information but not editable. To edit the configuration, you need to use the IED (Intelligent Electronic Device) configurator tool within the Schneider Electric MiCOM S1 Studio software.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
IED CONFIGURATOR	19	00		
This column contains IED Configurator settings				
Switch Conf.Bank	19	05	No Action	0 = No Action or 1 = Switch banks
Setting which allows the user to switch between the current configuration, held in the Active Memory Bank (and partly displayed below), to the configuration sent to and held in the Inactive Memory Bank.				
Restore Conf.	19	0A	No Action	0 = No Action or 1 = Restore MCL
Setting which allows the user to restore MCL or no action.				
Active Conf.Name	19	10	Not Available	Not Settable
IEC61850 versions only. The name of the configuration in the Active Memory Bank, usually taken from the SCL file.				
Active Conf.Rev	19	11	Not Available	Not Settable
IEC61850 versions only. Configuration Revision number of the configuration in the Active Memory Bank, usually taken from the SCL file.				
Inact.Conf.Name	19	20	Not Available	Not Settable
IEC61850 versions only. The name of the configuration in the Inactive Memory Bank, usually taken from the SCL file.				
Inact.Conf.Rev	19	21	Not Available	Not Settable
IEC61850 versions only. Configuration Revision number of the configuration in the Inactive Memory Bank, usually taken from the SCL file.				
IP PARAMETERS	19	30		Not Settable
IEC61850 versions only.				
IP Address 1	19	31	0.0.0.0	Not Settable
IEC61850 versions only. Displays the unique network IP address that identifies the IED.				
Subnet mask 1	19	32	0.0.0.0	Not Settable
IEC61850 versions only. Displays the sub-network the IED is connected to.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Gateway 1	19	33	0.0.0.0	Not Settable
IEC61850 versions only. Displays the IP address of the gateway (proxy) that the IED is connected to, if any.				
IP Address 2	19	34	0.0.0.0	Not Settable
2nd IP address for MPC8313				
Subnet mask 2	19	35	0.0.0.0	Not Settable
2nd sub-network for MPC8313				
Gateway 2	19	36	0.0.0.0	Not Settable
2nd Gateway for MPC8313				
SNTP PARAMETERS	19	40		Not Settable
IEC61850 versions only.				
SNTP Server 1	19	41	0.0.0.0	Not Settable
IEC61850 versions only. Displays the IP address of the primary SNTP server.				
SNTP Server 2	19	42	0.0.0.0	Not Settable
IEC61850 versions only. Displays the IP address of the secondary SNTP server.				
IEC 61850 SCL	19	50		Not Settable
IEC61850 versions only.				
IED Name	19	51	Not Available	Not Settable
IEC61850 versions only. 8 character IED name, which is the unique name on the IEC 61850 network for the IED, usually taken from the SCL file.				
IEC 61850 GOOSE	19	60		Not Settable
IEC61850 versions only.				
GoEna	19	70	0x0000	0 = Disabled or 1 = Enabled
IEC61850 versions only. Setting to enable GOOSE publisher settings.				
Pub.Simul.GOOSE	19	71	0x0000	0 = Disabled, 1 =Test Mode
IEC61850 versions only. The Test Mode cell allows the test pattern to be sent in the GOOSE message, for example for testing or commissioning. When 'Disabled' is selected, the test flag is not set. When 'Pass Through' is selected, the test flag is set, but the data in the GOOSE message is sent as normal. When 'Forced' is selected, the test flag is set, and the data sent in the GOOSE message is as per the 'VOP Test Pattern' setting below. Once testing is complete the cell must be set back to 'Disabled' to restore the GOOSE scheme back to normal service.				
Sub.Simul.GOOSE	19	73	No	0 = No or 1 = Yes
IEC61850 versions only. The Test Mode cell allows the test pattern to be sent in the GOOSE message, for example for testing or commissioning. When 'Disabled' is selected, the test flag is not set. When 'Pass Through' is selected, the test flag is set, but the data in the GOOSE message is sent as normal. When 'Forced' is selected, the test flag is set, and the data sent in the GOOSE message is as per the 'VOP Test Pattern' setting below. Once testing is complete the cell must be set back to 'Disabled' to restore the GOOSE scheme back to normal service.				

Table 47 - IED Configurator (for IEC 61850 Configuration)

6.22 Virtual Input Labels

There are many of these labels. These are all recorded in a block of settings within the MiCOM relay. They all have the same Default and Available Settings and the same Description applies to all of them. The following table shows the labels in the sequence.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
VIR I/P LABELS	26	00		
This column contains settings for Virtual Input Labels				
Virtual Input 1	26	01	Virtual Input 1	From 32 to 234 step 1
Text label to describe each individual Virtual input.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Virtual Input 2	26	02	Virtual Input 2	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 3	26	03	Virtual Input 3	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 4	26	04	Virtual Input 4	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 5	26	05	Virtual Input 5	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 6	26	06	Virtual Input 6	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 7	26	07	Virtual Input 7	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 8	26	08	Virtual Input 8	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 9	26	09	Virtual Input 9	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 10	26	0A	Virtual Input 10	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 11	26	0B	Virtual Input 11	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 12	26	0C	Virtual Input 12	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 13	26	0D	Virtual Input 13	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 14	26	0E	Virtual Input 14	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 15	26	0F	Virtual Input 15	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 16	26	10	Virtual Input 16	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 17	26	11	Virtual Input 17	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 18	26	12	Virtual Input 18	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 19	26	13	Virtual Input 19	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 20	26	14	Virtual Input 20	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 21	26	15	Virtual Input 21	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 22	26	16	Virtual Input 22	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 23	26	17	Virtual Input 23	From 32 to 234 step 1

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Text label to describe each individual Virtual input.				
Virtual Input 24	26	18	Virtual Input 24	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 25	26	19	Virtual Input 25	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 26	26	1A	Virtual Input 26	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 27	26	1B	Virtual Input 27	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 28	26	1C	Virtual Input 28	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 29	26	1D	Virtual Input 29	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 30	26	1E	Virtual Input 30	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 31	26	1F	Virtual Input 31	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 32	26	20	Virtual Input 32	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 33	26	21	Virtual Input 33	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 34	26	22	Virtual Input 34	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 35	26	23	Virtual Input 35	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 36	26	24	Virtual Input 36	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 37	26	25	Virtual Input 37	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 38	26	26	Virtual Input 38	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 39	26	27	Virtual Input 39	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 40	26	28	Virtual Input 40	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 41	26	29	Virtual Input 41	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 42	26	2A	Virtual Input 42	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 43	26	2B	Virtual Input 43	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 44	26	2C	Virtual Input 44	From 32 to 234 step 1
Text label to describe each individual Virtual input.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Virtual Input 45	26	2D	Virtual Input 45	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 46	26	2E	Virtual Input 46	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 47	26	2F	Virtual Input 47	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 48	26	30	Virtual Input 48	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 49	26	31	Virtual Input 49	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 50	26	32	Virtual Input 50	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 51	26	33	Virtual Input 51	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 52	26	34	Virtual Input 52	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 53	26	35	Virtual Input 53	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 54	26	36	Virtual Input 54	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 55	26	37	Virtual Input 55	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 56	26	38	Virtual Input 56	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 57	26	39	Virtual Input 57	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 58	26	3A	Virtual Input 58	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 59	26	3B	Virtual Input 59	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 60	26	3C	Virtual Input 60	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 61	26	3D	Virtual Input 61	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 62	26	3E	Virtual Input 62	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 63	26	3F	Virtual Input 63	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 64	26	40	Virtual Input 64	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 65	26	41	Virtual Input 65	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 66	26	42	Virtual Input 66	From 32 to 234 step 1

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Text label to describe each individual Virtual input.				
Virtual Input 67	26	43	Virtual Input 67	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 68	26	44	Virtual Input 68	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 69	26	45	Virtual Input 69	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 70	26	46	Virtual Input 70	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 71	26	47	Virtual Input 71	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 72	26	48	Virtual Input 72	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 73	26	49	Virtual Input 73	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 74	26	4A	Virtual Input 74	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 75	26	4B	Virtual Input 75	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 76	26	4C	Virtual Input 76	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 77	26	4D	Virtual Input 77	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 78	26	4E	Virtual Input 78	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 79	26	4F	Virtual Input 79	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 80	26	50	Virtual Input 80	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 81	26	51	Virtual Input 81	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 82	26	52	Virtual Input 82	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 83	26	53	Virtual Input 83	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 84	26	54	Virtual Input 84	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 85	26	55	Virtual Input 85	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 86	26	56	Virtual Input 86	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 87	26	57	Virtual Input 87	From 32 to 234 step 1
Text label to describe each individual Virtual input.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Virtual Input 88	26	58	Virtual Input 88	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 89	26	59	Virtual Input 89	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 90	26	5A	Virtual Input 90	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 91	26	5B	Virtual Input 91	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 92	26	5C	Virtual Input 92	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 93	26	5D	Virtual Input 93	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 94	26	5E	Virtual Input 94	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 95	26	5F	Virtual Input 95	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 96	26	60	Virtual Input 96	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 97	26	61	Virtual Input 97	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 98	26	62	Virtual Input 98	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 99	26	63	Virtual Input 99	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 100	26	64	Virtual Input 100	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 101	26	65	Virtual Input 101	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 102	26	66	Virtual Input 102	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 103	26	67	Virtual Input 103	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 104	26	68	Virtual Input 104	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 105	26	69	Virtual Input 105	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 106	26	6A	Virtual Input 106	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 107	26	6B	Virtual Input 107	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 108	26	6C	Virtual Input 108	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 109	26	6D	Virtual Input 109	From 32 to 234 step 1

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Text label to describe each individual Virtual input.				
Virtual Input 110	26	6E	Virtual Input 110	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 111	26	6F	Virtual Input 111	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 112	26	70	Virtual Input 112	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 113	26	71	Virtual Input 113	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 114	26	72	Virtual Input 114	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 115	26	73	Virtual Input 115	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 116	26	74	Virtual Input 116	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 117	26	75	Virtual Input 117	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 118	26	76	Virtual Input 118	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 119	26	77	Virtual Input 119	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 120	26	78	Virtual Input 120	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 121	26	79	Virtual Input 121	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 122	26	7A	Virtual Input 122	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 123	26	7B	Virtual Input 123	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 124	26	7C	Virtual Input 124	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 125	26	7D	Virtual Input 125	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 126	26	7E	Virtual Input 126	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 127	26	7F	Virtual Input 127	From 32 to 234 step 1
Text label to describe each individual Virtual input.				
Virtual Input 128	26	80	Virtual Input 128	From 32 to 234 step 1
Text label to describe each individual Virtual input.				

Table 48 - Virtual Input Labels

6.23 Virtual Output Labels

There are many of these labels. These are all recorded in a block of settings within the MiCOM relay. They all have the same Default and Available Settings and the same Description applies to all of them. The following table shows the labels in the sequence.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
VIR O/P LABELS	27	00		
This column contains settings for Virtual Output Labels				
Virtual Output 1	27	01	Virtual Output 1	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output 2	27	02	Virtual Output 2	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output 3	27	03	Virtual Output 3	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output 4	27	04	Virtual Output 4	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output 5	27	05	Virtual Output 5	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output 6	27	06	Virtual Output 6	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output 7	27	07	Virtual Output 7	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output 8	27	08	Virtual Output 8	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output 9	27	09	Virtual Output 9	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output10	27	0A	Virtual Output10	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output11	27	0B	Virtual Output11	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output12	27	0C	Virtual Output12	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output13	27	0D	Virtual Output13	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output14	27	0E	Virtual Output14	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output15	27	0F	Virtual Output15	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output16	27	10	Virtual Output16	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output17	27	11	Virtual Output17	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output18	27	12	Virtual Output18	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output19	27	13	Virtual Output19	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Virtual Output20	27	14	Virtual Output20	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output21	27	15	Virtual Output21	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output22	27	16	Virtual Output22	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output23	27	17	Virtual Output23	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output24	27	18	Virtual Output24	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output25	27	19	Virtual Output25	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output26	27	1A	Virtual Output26	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output27	27	1B	Virtual Output27	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output28	27	1C	Virtual Output28	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output29	27	1D	Virtual Output29	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output30	27	1E	Virtual Output30	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output31	27	1F	Virtual Output31	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				
Virtual Output32	27	20	Virtual Output32	From 32 to 234 step 1
Text label to describe each individual Virtual Output.				

Table 49 - Virtual Output Labels

6.24 User Alarm Labels

There are many of these labels. These are all recorded in a block of settings within the MiCOM relay. They all have the same Default and Available Settings and the same Description applies to all of them. The following table shows the labels in the sequence.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
USR ALARM LABELS	28	00		
This column contains settings for User Alarm Labels				
SR User Alarm 1	28	01	SR User Alarm 1	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 2	28	02	SR User Alarm 2	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 3	28	03	SR User Alarm 3	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
SR User Alarm 4	28	04	SR User Alarm 4	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 5	28	05	SR User Alarm 5	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 6	28	06	SR User Alarm 6	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 7	28	07	SR User Alarm 7	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 8	28	08	SR User Alarm 8	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 9	28	09	SR User Alarm 9	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 10	28	0A	SR User Alarm 10	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 11	28	0B	SR User Alarm 11	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 12	28	0C	SR User Alarm 12	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 13	28	0D	SR User Alarm 13	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 14	28	0E	SR User Alarm 14	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 15	28	0F	SR User Alarm 15	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 16	28	10	SR User Alarm 16	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
SR User Alarm 17	28	11	SR User Alarm 17	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 18	28	12	MR User Alarm 18	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 19	28	13	MR User Alarm 19	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 20	28	14	MR User Alarm 20	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 21	28	15	MR User Alarm 21	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 22	28	16	MR User Alarm 22	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 23	28	17	MR User Alarm 23	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 24	28	18	MR User Alarm 24	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 25	28	19	MR User Alarm 25	From 32 to 234 step 1

Menu Text	Col	Row	Default Setting	Available Settings
Description				
User Alarm label to describe each individual User Alarm.				
MR User Alarm 26	28	1A	MR User Alarm 26	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 27	28	1B	MR User Alarm 27	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 28	28	1C	MR User Alarm 28	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 29	28	1D	MR User Alarm 29	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 30	28	1E	MR User Alarm 30	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 31	28	1F	MR User Alarm 31	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 32	28	20	MR User Alarm 32	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 33	28	21	MR User Alarm 33	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 34	28	22	MR User Alarm 34	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				
MR User Alarm 35	28	23	MR User Alarm 35	From 32 to 234 step 1
User Alarm label to describe each individual User Alarm.				

Table 50 – User Alarm Labels

6.25 Control Input Labels

There are many of these labels. These are all recorded in a block of settings within the MiCOM relay. They all have the same Default and Available Settings and the same Description applies to all of them. The following table shows the labels in the sequence.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
CTRL I/P LABELS	29	00		
This column contains settings for Control Input Labels				
Control Input 1	29	01	Control Input 1	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 2	29	02	Control Input 2	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 3	29	03	Control Input 3	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 4	29	04	Control Input 4	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Control Input 5	29	05	Control Input 5	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 6	29	06	Control Input 6	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 7	29	07	Control Input 7	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 8	29	08	Control Input 8	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 9	29	09	Control Input 9	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 10	29	0A	Control Input 10	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 11	29	0B	Control Input 11	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 12	29	0C	Control Input 12	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 13	29	0D	Control Input 13	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 14	29	0E	Control Input 14	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 15	29	0F	Control Input 15	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 16	29	10	Control Input 16	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 17	29	11	Control Input 17	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 18	29	12	Control Input 18	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 19	29	13	Control Input 19	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 20	29	14	Control Input 20	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Control Input 21	29	15	Control Input 21	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 22	29	16	Control Input 22	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 23	29	17	Control Input 23	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 24	29	18	Control Input 24	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 25	29	19	Control Input 25	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 26	29	1A	Control Input 26	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 27	29	1B	Control Input 27	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 28	29	1C	Control Input 28	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 29	29	1D	Control Input 29	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 30	29	1E	Control Input 30	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 31	29	1F	Control Input 31	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 32	29	20	Control Input 32	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Ctrl Setg I/P 33	29	21	Ctrl Setg I/P 33	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				
Ctrl Setg I/P 34	29	22	Ctrl Setg I/P 34	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				
Ctrl Setg I/P 35	29	23	Ctrl Setg I/P 35	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				
Ctrl Setg I/P 36	29	24	Ctrl Setg I/P 36	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Ctrl Setg I/P 37	29	25	Ctrl Setg I/P 37	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				
Ctrl Setg I/P 38	29	26	Ctrl Setg I/P 38	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				
Ctrl Setg I/P 39	29	27	Ctrl Setg I/P 39	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				
Ctrl Setg I/P 40	29	28	Ctrl Setg I/P 40	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				
Ctrl Setg I/P 41	29	29	Ctrl Setg I/P 41	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				
Ctrl Setg I/P 42	29	2A	Ctrl Setg I/P 42	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				
Ctrl Setg I/P 43	29	2B	Ctrl Setg I/P 43	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				
Ctrl Setg I/P 44	29	2C	Ctrl Setg I/P 44	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				
Ctrl Setg I/P 45	29	2D	Ctrl Setg I/P 45	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				
Ctrl Setg I/P 46	29	2E	Ctrl Setg I/P 46	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				
Ctrl Setg I/P 47	29	2F	Ctrl Setg I/P 47	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				
Ctrl Setg I/P 48	29	30	Ctrl Setg I/P 48	From 32 to 234 step 1
Text label to describe each individual setting input. This text is displayed when a setting input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the setting input				

Table 51 - Control Input Labels

6.26 Disturbance Recorder Settings

The disturbance recorder settings include the record duration and trigger position, selection of analog and digital signals to record, and the signal sources that trigger the recording.

The precise event recorder column (“Disturb. Recorder” menu) is visible when the “Disturb recorder” setting (“Configuration” column) = “visible”.

There are many of these inputs. These are all recorded in blocks of settings within the MiCOM relay. They all have the same Default and Available Settings and the same Description applies to all of them. The following table shows the first and last inputs in the sequence(s).

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DISTURB RECORDER	0C	00		
This column contains settings for the Disturbance Recorder				
Duration	0C	01	1.5	0.1s to 10.5s step 0.01s
This sets the overall recording time.				
Trigger Position	0C	02	33.3	0 to 100 step 0.1
This sets the trigger point as a percentage of the duration. For example, the default settings show that the overall recording time is set to 1.5 s with the trigger point being at 33.3% of this, giving 0.5 s pre-fault and 1s post fault recording times.				
Trigger Mode	0C	03	Single	0 = Single or 1 = Extended
If set to single mode, if a further trigger occurs whilst a recording is taking place, the recorder will ignore the trigger. However, if this has been set to Extended, the post trigger timer will be reset to zero, thereby extending the recording time.				
Analog Channel 1	0C	04	VA	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Analog Channel 2	0C	05	VB	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Analog Channel 3	0C	06	VC	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Analog Channel 4	0C	07	IA	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Analog Channel 5	0C	08	IB	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Analog Channel 6	0C	09	IC	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Analog Channel 7	0C	0A	IN	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Analog Channel 8	0C	0B	IN Sensitive	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Analog Channel 9	0C	0C	Frequency	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Digital Input 1	0C	0D	Relay 1	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 1 Trigger	0C	0E	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 2	0C	0F	Relay 2	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 2 Trigger	0C	10	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 3	0C	11	Relay 3	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 3 Trigger	0C	12	Trigger L/H	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 4	0C	13	Relay 4	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 4 Trigger	0C	14	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 5	0C	15	Relay 5	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 5 Trigger	0C	16	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 6	0C	17	Relay 6	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 6 Trigger	0C	18	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 7	0C	19	Relay 7	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 7 Trigger	0C	1A	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 8	0C	1B	Opto Input 1 Relay 8	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 8 Trigger	0C	1C	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 9	0C	1D	Opto Input 2 Relay 9	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 9 Trigger	0C	1E	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 10	0C	1F	Opto Input 3 Relay 10	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 10 Trigger	0C	20	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 11	0C	21	Opto Input 4 Relay 11	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 11 Trigger	0C	22	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 12	0C	23	Opto Input 5 Relay 12	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 12 Trigger	0C	24	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 13	0C	25	Opto Input 6 Relay 13 Opto Input 1	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 13 Trigger	0C	26	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 14	0C	27	Opto Input 7 Relay 14 Opto Input 2	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 14 Trigger	0C	28	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 15	0C	29	Opto Input 8 Opto Input 1 Opto Input 3	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 15 Trigger	0C	2A	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Digital Input 16	0C	2B	Unused Opto Input 2 Opto Input 4	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 16 Trigger	0C	2C	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 17	0C	2D	Unused Opto Input 3 Opto Input 5	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 17 Trigger	0C	2E	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 18	0C	2F	Unused Opto Input 4 Opto Input 6	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 18 Trigger	0C	30	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 19	0C	31	Unused Opto Input 5 Opto Input 7	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 19 Trigger	0C	32	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 20	0C	33	Unused Opto Input 6 Opto Input 8	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 20 Trigger	0C	34	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 21	0C	35	Unused Opto Input 7 Opto Input 9	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 21 Trigger	0C	36	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 22	0C	37	Unused Opto Input 8 Opto Input 10	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 22 Trigger	0C	38	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				

Menu Text	Col	Row	Default Setting	Available Settings
		Description		
Digital Input 23	0C	39	Unused Opto Input 9 Opto Input 11	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 23 Trigger	0C	3A	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 24	0C	3B	Unused Opto Input 10 Opto Input 12	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 24 Trigger	0C	3C	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 25	0C	3D	Unused Opto Input 11	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 25 Trigger	0C	3E	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 26	0C	3F	Unused Opto Input 12	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 26 Trigger	0C	40	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 27	0C	41	Unused Opto Input 13	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 27 Trigger	0C	42	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 28	0C	43	Unused Opto Input 14	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 28 Trigger	0C	44	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 29	0C	45	Unused Opto Input 15	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 29 Trigger	0C	46	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 30	0C	47	Unused Opto Input 16	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 30 Trigger	0C	48	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 31	0C	49	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 31 Trigger	0C	4A	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 32	0C	4B	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 32 Trigger	0C	4C	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 33	0C	70	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 34	0C	71	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 35	0C	72	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 36	0C	73	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 37	0C	74	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 38	0C	75	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 39	0C	76	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 40	0C	77	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 41	0C	78	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 42	0C	79	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 43	0C	7A	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 44	0C	7B	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 45	0C	7C	Unused	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 46	0C	7D	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 47	0C	7E	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 48	0C	7F	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 49	0C	80	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 50	0C	81	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 51	0C	82	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 52	0C	83	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 53	0C	84	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 54	0C	85	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 55	0C	86	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 56	0C	87	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 57	0C	88	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 58	0C	89	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 59	0C	8A	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 60	0C	8B	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 61	0C	8C	Unused	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 62	0C	8D	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 63	0C	8E	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 64	0C	8F	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 65	0C	90	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 66	0C	91	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 67	0C	92	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 68	0C	93	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 69	0C	94	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 70	0C	95	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 71	0C	96	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 72	0C	97	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 73	0C	98	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 74	0C	99	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 75	0C	9A	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 76	0C	9B	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 77	0C	9C	Unused	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 78	0C	9D	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 79	0C	9E	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 80	0C	9F	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 81	0C	A0	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 82	0C	A1	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 83	0C	A2	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 84	0C	A3	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 85	0C	A4	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 86	0C	A5	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 87	0C	A6	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 88	0C	A7	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 89	0C	A8	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 90	0C	A9	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 91	0C	AA	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 92	0C	AB	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 93	0C	AC	Unused	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 94	0C	AD	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 95	0C	AE	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 96	0C	AF	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 97	0C	B0	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 98	0C	B1	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 99	0C	B2	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 100	0C	B3	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 101	0C	B4	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 102	0C	B5	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 103	0C	B6	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 104	0C	B7	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 105	0C	B8	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 106	0C	B9	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 107	0C	BA	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 108	0C	BB	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 109	0C	BC	Unused	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 110	0C	BD	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 111	0C	BE	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 112	0C	BF	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 113	0C	C0	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 114	0C	C1	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 115	0C	C2	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 116	0C	C3	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 117	0C	C4	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 118	0C	C5	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 119	0C	C6	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 120	0C	C7	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 121	0C	C8	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 122	0C	C9	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 123	0C	CA	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 124	0C	CB	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 125	0C	CC	Unused	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 126	0C	CD	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 127	0C	CE	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 128	0C	CF	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				

Table 52 - Disturbance Recorder Settings

Notes:

OPERATION

CHAPTER 5

Date:	07/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142 & P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

CONTENTS

Page (OP) 5-

TABLES

FIGURES

Page (OP) 5-

1 OPERATION OF INDIVIDUAL PROTECTION FUNCTIONS

The following sections detail the individual protection functions.

1.1 Overcurrent Protection

The overcurrent protection included in the relay provides four-stage non-directional/ directional three-phase overcurrent protection with independent time delay characteristics. All overcurrent and directional settings apply to all three phases but are independent for each of the four stages.

The first two stages of overcurrent protection have time-delayed characteristics which are selectable between Inverse Definite Minimum Time (IDMT), or Definite Time (DT). The third and fourth stages have definite time characteristics only.

Various methods are available to achieve correct relay co-ordination on a system; by means of time alone, current alone or a combination of both time and current. Grading by means of current is only possible where there is an appreciable difference in fault level between the two relay locations. Grading by time is used by some utilities but can often lead to excessive fault clearance times at or near source substations where the fault level is highest. For these reasons the most commonly applied characteristic in co-ordinating overcurrent relays is the IDMT type.

The inverse time delayed characteristics indicated above, comply with the following formula:

IEC curves or **IEEE curves**

$$t = Tx\left(\frac{\beta}{(M^{\alpha} - 1)} + L\right) + C$$

$$t = TD \times \left(\frac{\beta}{M^{\alpha} - 1} + L\right) + C$$

Where:

t	=	Operation time
β	=	Constant
M	=	I/Is
I	=	Measured current
Is	=	Current threshold setting
α	=	Constant
L	=	ANSI/IEEE constant (zero for IEC curves)
T	=	Time multiplier setting for IEC curves
TD	=	Time dial setting for IEEE curves
C	=	Definite time adder (zero for standard curves)

IDMT Curve description	Standard	β constant	α constant	L constant
Standard Inverse	IEC	0.14	0.02	0
Very Inverse	IEC	13.5	1	0
Extremely Inverse	IEC	80	2	0
Long Time Inverse	UK	120	1	0
Rectifier	UK	45900	5.6	0
Moderately Inverse	IEEE	0.0515	0.02	0.114
Very Inverse	IEEE	19.61	2	0.491
Extremely Inverse	IEEE	28.2	2	0.1217
Inverse	US	5.95	2	0.18
Short Time Inverse	US	0.16758	0.02	0.11858

Table 1 - Curve descriptions, standards and constants

The IEC/UK inverse characteristics can be used with a definite time reset characteristic, however, the IEEE/US curves may have an inverse or definite time reset characteristic. The following equation can used to calculate the inverse reset time for IEEE/US curves:

$$tRESET = \frac{TD \times S}{(1 - M^2)} \text{ in seconds}$$

Where:

TD = Time dial setting for IEEE curves
S = Constant
M = I/Is

Curve Description	Standard	S Constant
Moderately Inverse	IEEE	4.85
Very Inverse	IEEE	21.6
Extremely Inverse	IEEE	29.1
Inverse	US	5.95
Short Time Inverse	US	2.261

Table 2 - Curve descriptions, standards and constants

1.1.1 RI Curve

The RI curve (electromechanical) has been included in the first and second stage characteristic setting options for Phase Overcurrent and both Earth Fault (i.e. Earth Fault 1 and Earth Fault 2 where available) protections. The curve is represented by the following equation (where t is in seconds and K is adjustable from 0.1 to 10 in steps of 0.05).

$$t = K \times \left(\frac{1}{0.339 - \left(0.236 / M \right)} \right) \text{ in seconds}$$

1.1.2 Timer Hold Facility

The first two stages of overcurrent protection in the relay are provided with a timer hold facility, which may either be set to zero or to a definite time value. Setting of the timer to zero means the overcurrent timer for that stage will reset instantaneously once the current falls below 95% of the current setting. Setting of the hold timer to a value other than zero, delays the resetting of the protection element timers for this period. When the reset time of the overcurrent relay is instantaneous, the relay will be repeatedly reset and not be able to trip until the fault becomes permanent. By using the Timer Hold facility the relay will integrate the fault current pulses, thereby reducing fault clearance time.

The timer hold facility can be found for the first and second overcurrent stages as settings "**I>1 tRESET**" and "**I>2 tRESET**", respectively. Note that this cell is not visible for the IEEE/US curves if an inverse time reset characteristic has been selected, as the reset time is then determined by the programmed time dial setting.

The functional logic diagram for non-directional overcurrent is shown in the following *Non-directional overcurrent logic diagram*. The overcurrent block is a level detector that detects that the current magnitude is above the threshold. It provides a start and also initiates the IDMT/DT characteristic depending on the setting.

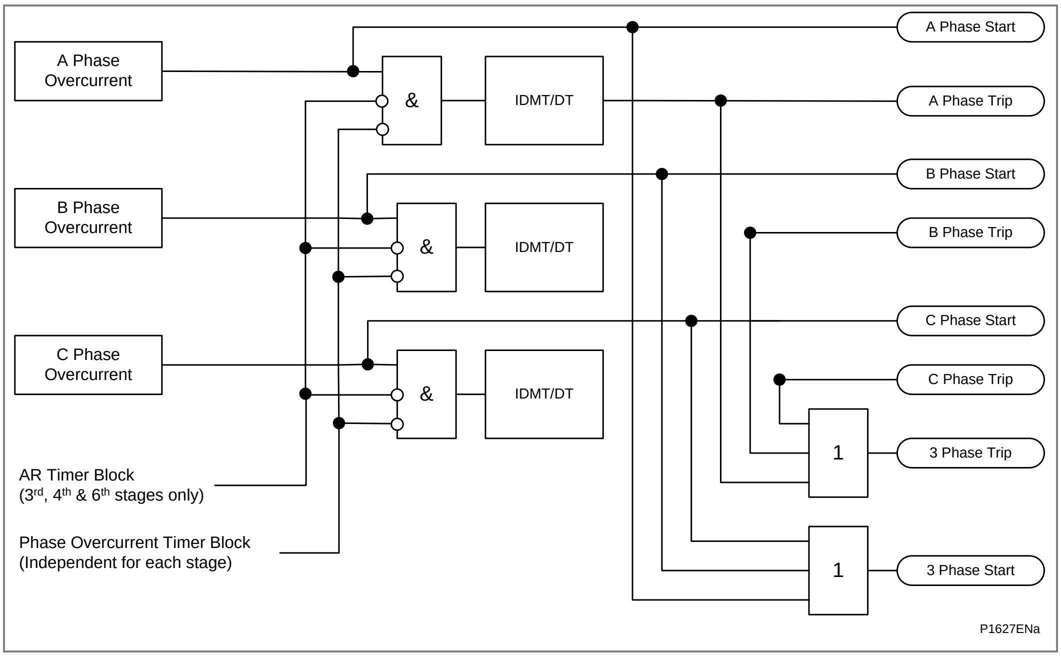


Figure 1 - Non-directional overcurrent logic diagram

A timer block input is available for each stage which will reset the overcurrent timers of all three phases if energized, taking account of the reset time delay if selected for the "**I>1**" and "**I>2**" stages.

The auto-reclose logic (A/R Block) can be set to block instantaneous overcurrent elements after a prescribed number of shots. This is set in the auto-reclose column. When a block instantaneous signal is generated then only those overcurrent stages i.e. "**I>3**" and "**I>4**" selected to **'1'** in the "**I> Blocking**" link will be blocked.

1.2 Directional Overcurrent Protection

The phase fault elements of the MiCOM P34x/P44y/P445/P54x/P841 relays are internally polarized by the quadrature phase-phase voltages, as shown in following *Phase, Operating Current and Polarizing Voltages* table.

Phase of Protection	Operate Current	Polarizing Voltage
A Phase	IA	VBC
B Phase	IB	VCA
C Phase	IC	VAB

Table 3 - Phase, Operating Current and Polarizing Voltages

Under system fault conditions, the fault current vector will lag its nominal phase voltage by an angle dependent upon the system X/R ratio. It is therefore a requirement that the relay operates with maximum sensitivity for currents lying in this region. This is achieved by means of the relay characteristic angle (RCA) setting; this defines the angle by which the current applied to the relay must be displaced from the voltage applied to the relay to obtain maximum relay sensitivity. This is set in cell "**I>Char Angle**" in the overcurrent menu. On the relays, it is possible to set characteristic angles anywhere in the range –95° to +95°.

The functional logic block diagram for directional overcurrent is shown in the following *Directional overcurrent logic* diagram.

The overcurrent block is a level detector that detects that the current magnitude is above the threshold and together with the respective polarizing voltage, a directional check is performed based on the following criteria:

Directional forward -90° < (angle(I) - angle(V) - RCA) < 90°

Directional reverse -90° > (angle(I) - angle(V) - RCA) > 90°

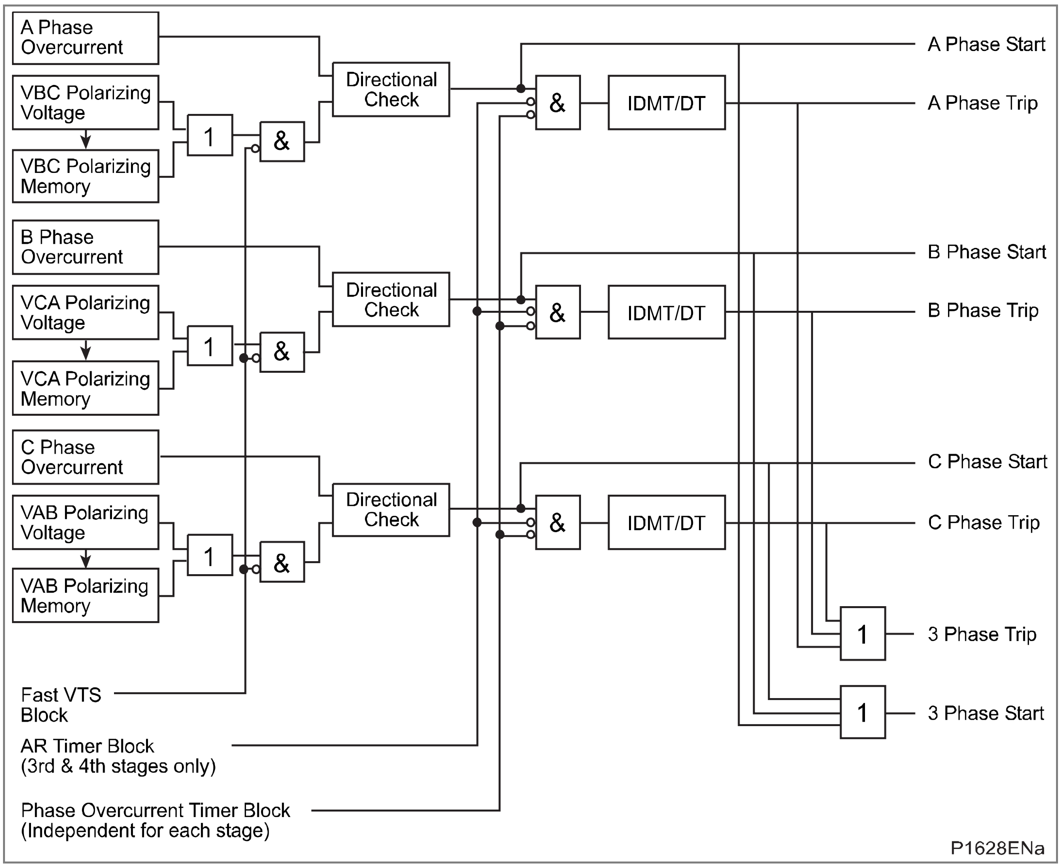


Figure 2 - Directional overcurrent logic

Any of the six overcurrent stages may be configured to be directional noting that IDMT characteristics are only selectable on the first two stages and I>5. When the element is selected as directional, a Voltage Transformer Supervision (VTS) Block option is available. When the relevant bit is set to 1, operation of the VTS, will block the stage if directionalized. When set to 0, the stage will revert to non-directional upon operation of the VTS.

1.2.1 Synchronous Polarization

For a close up three-phase fault, all three voltages will collapse to zero and no healthy phase voltages will be present. For this reason, the MiCOM relays include a synchronous polarization feature that stores the pre-fault voltage information and continues to apply it to the directional overcurrent elements for a time period of 3.2 seconds. This ensures that either instantaneous or time delayed directional overcurrent elements will be allowed to operate, even with a three-phase voltage collapse.

1.3 Thermal Overload Protection

The relay incorporates a current based thermal replica, using rms load current to model heating and cooling of the protected plant. The element can be set with both alarm and trip stages.

The heat generated within an item of plant, such as a cable or a transformer, is the resistive loss (I^2R x t). Thus, heating is directly proportional to current squared. The thermal time characteristic used in the relay is therefore based on current squared, integrated over time. The relay automatically uses the largest phase current for input to the thermal model.

Equipment is designed to operate continuously at a temperature corresponding to its full load rating, where heat generated is balanced with heat dissipated by radiation etc. Over-temperature conditions therefore occur when currents in excess of rating are allowed to flow for a period of time. It can be shown that temperatures during heating follow exponential time constants and a similar exponential decrease of temperature occurs during cooling.

The relay provides two characteristics that may be selected according to the application.

1.3.1 Single Time Constant Characteristic

This characteristic is used to protect cables, dry type transformers (e.g. type AN), and capacitor banks.

The thermal time characteristic is given by:

$$t = -\tau \log_e \left(\frac{I^2 - (K.I_{FLC})^2}{(I^2 - Ip^2)} \right)$$

$$\exp(-t/\tau) = (I^2 - (k.I_{FLC})^2) / (I^2 - I_P^2)$$

Where:

t	=	Time to trip, following application of the overload current, I;
τ	=	Heating and cooling time constant of the protected plant;
I	=	Largest phase current;
I_{FLC}	=	Full load current rating (relay setting ‘**Thermal Trip**’);
k	=	1.05 constant, allows continuous operation up to <1.05 I_{FLC};
I_P	=	Steady state pre-loading before application of the overload.

The time to trip varies depending on the load current carried before application of the overload, i.e. whether the overload was applied from '**hot**” or “**cold**”.

The thermal time constant characteristic may be rewritten as:

$$e^{(-t/\tau)} = \left(\frac{\theta - \theta p}{\theta - 1} \right)$$

Where:

$\theta = I^2/k^2 \, I_{FLC}^2$

and

$\theta p = Ip^2/k^2 \, I_{FLC}^2$

Where θ is the thermal state and is θ_p the pre-fault thermal state.

Note	*A current of 105%Is (kI_{FLC}) has to be applied for several time constants to cause a thermal state measurement of 100%*

1.3.2 Dual Time Constant Characteristic

This characteristic is used to protect oil-filled transformers with natural air cooling (e.g. type ONAN). The thermal model is similar to that with the single time constant, except that two timer constants must be set.

For marginal overloading, heat will flow from the windings into the bulk of the insulating oil. Thus, at low current, the replica curve is dominated by the long time constant for the oil. This provides protection against a general rise in oil temperature.

For severe overloading, heat accumulates in the transformer windings, with little opportunity for dissipation into the surrounding insulating oil. Thus, at high current, the replica curve is dominated by the short time constant for the windings. This provides protection against hot spots developing within the transformer windings.

Overall, the dual time constant characteristic provided within the relay serves to protect the winding insulation from ageing, and to minimize gas production by overheated oil. Note, however, that the thermal model does not compensate for the effects of ambient temperature change.

The thermal curve is defined as:

$$0.4e^{(-t/\tau)} + 0.6e^{(-t/\tau)} = \frac{I^2 - (k.I_{FLC})^2}{I^2 - Ip^2}$$

Where:

$\tau 1$ = Heating and cooling time constant of the transformer windings

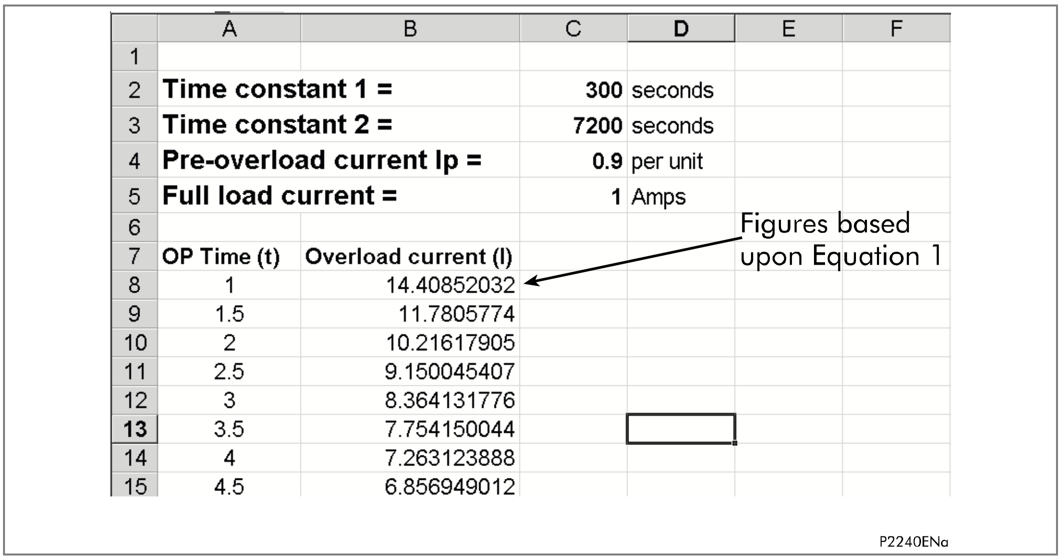
τ_2 = Heating and cooling time constant for the insulating oil

In practice, it is difficult to solve this equation to give the operating time (t), therefore a graphical solution, using a spreadsheet package, is recommended. The spreadsheet can be arranged to calculate the current that will give a chosen operating time. The equation to calculate the current is defined as:

Equation 1:

$$I = \sqrt{\frac{0.4Ip^2.e^{(-t/\tau 1)} + 0.6Ip^2.e^{(-t/\tau 2)} - k^2.I_{FLC}{}^2}{0.4\,e^{(-t/\tau 1)} + 0.6\,e^{(-t/\tau 2)} - 1}}$$

Figure 3 shows how this equation can be used within a spreadsheet to calculate the relay operating time.



	A	B	C	D	E	F
1						
2	**Time constant 1 =**		**300**	seconds		
3	**Time constant 2 =**		**7200**	seconds		
4	**Pre-overload current Ip =**		**0.9**	per unit		
5	**Full load current =**		**1**	Amps		
6						
7	**OP Time (t)**	**Overload current (I)**				
8	1	14.40852032				
9	1.5	11.7805774				
10	2	10.21617905				
11	2.5	9.150045407				
12	3	8.364131776				
13	3.5	7.754150044				
14	4	7.263123888				
15	4.5	6.856949012				

Figure 3 - Spreadsheet calculation for dual time constant thermal characteristic

The results from the spreadsheet can be plotted in a graph of current against time as shown in Figure 4.

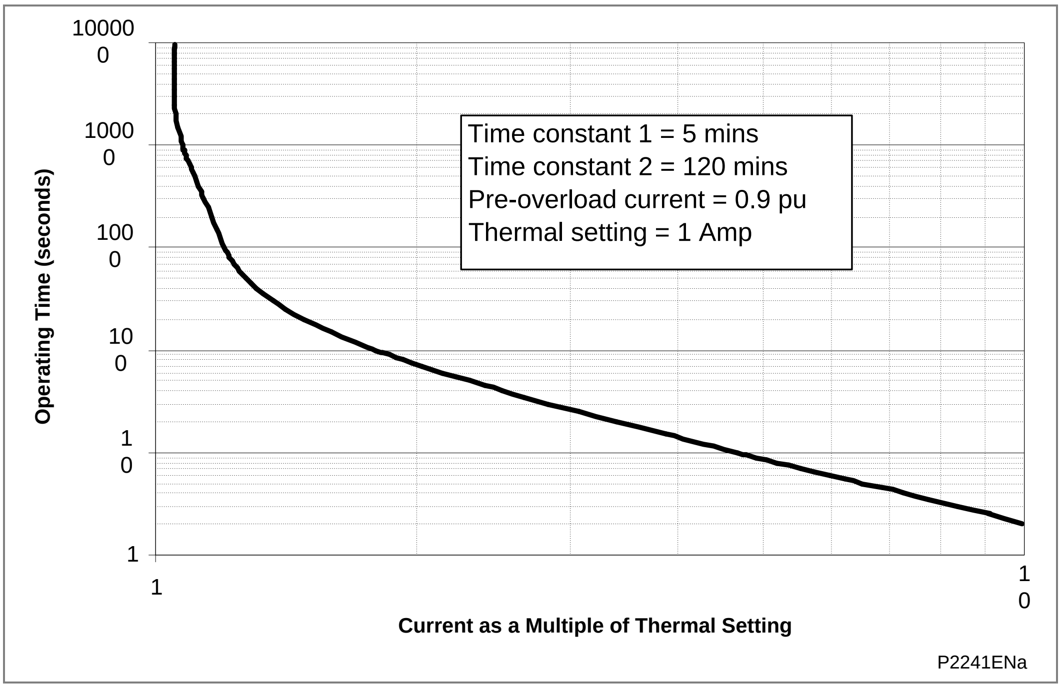


Figure 4 - Dual time constant thermal characteristic

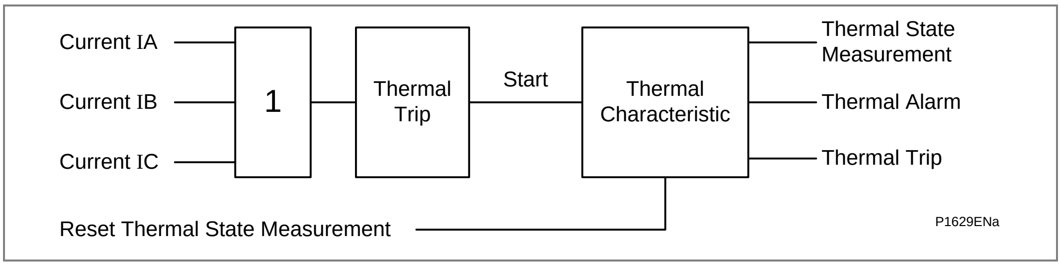


Figure 5 - Thermal overload protection logic diagram

The functional block diagram for the thermal overload protection is shown in the above diagram.

The magnitudes of the three phase input currents are compared and the largest magnitude taken as the input to the thermal overload function. If this current exceeds the thermal trip threshold setting a start condition is asserted.

The thermal protection also provides an indication of the thermal state in the '**MEASUREMENTS 3**' column of the relay. The thermal state can be reset by either an opto input (if assigned to this function using the programmable scheme logic) or the relay menu. The reset function in the menu is also found in the '**MEASUREMENTS 3**' column with the thermal state.

1.4 Earth Fault (EF) Protection

The P14x relays have a total of five input current transformers; one for each of the phase current inputs and two for supplying the Earth Fault (EF) protection elements. With this flexible input arrangement, various combinations of standard, Sensitive Earth Fault (SEF) and Restricted Earth Fault (REF) protection may be configured within the relay.

It should be noted that in order to achieve the sensitive setting range that is available in the P14x relays for SEF protection, the input CT is designed specifically to operate at low current magnitudes. This input is common to both the SEF and high impedance REF protection, so these features are treated as mutually exclusive within the relay menu.

1.4.1 Standard Earth Fault Protection Elements

The standard earth fault protection elements are duplicated within the P14x relays and are referred to in the relay menu as “Earth Fault 1” (EF1) and “Earth Fault 2” (EF2). EF1 operates from earth fault current which is measured directly from the system; either by means of a separate CT located in a power system earth connection or via a residual connection of the three line CTs. The EF2 element operates from a residual current quantity which is derived internally from the summation of the three-phase currents.

EF1 and EF2 are identical elements, each having four stages. The first and second stages have selectable IDMT or DT characteristics, whilst the third and fourth stages are DT only. Each stage is selectable to be either non-directional, directional forward or directional reverse. The Timer Hold facility, previously described for the overcurrent elements, is available on each of the first two stages.

The logic diagram for non-directional earth fault overcurrent is shown in the following *Non-directional EF logic (single stage)* diagram.

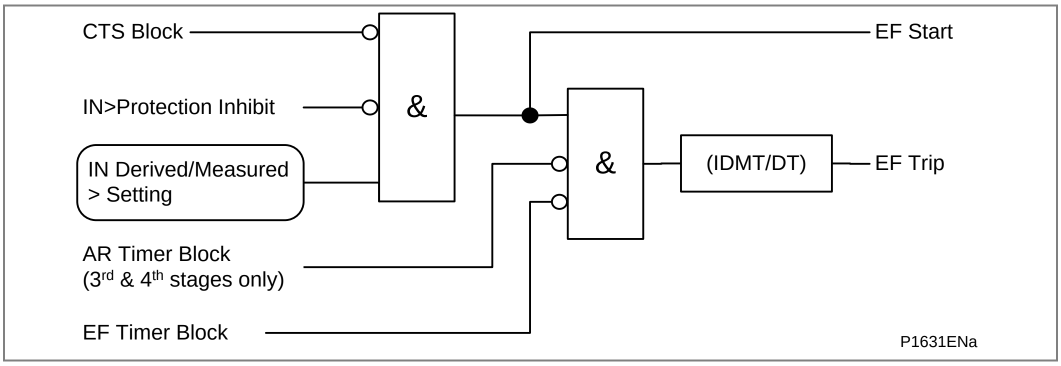


Figure 6 - Non-directional EF logic (single stage)

The earth fault protection can be set IN/OUT of service using the appropriate DDB inhibit signal that can be operated from an opto input or control command.

The auto-reclose logic (A/R Block) can be set to block instantaneous earth fault elements after a prescribed number of shots. This is set in the auto-reclose column. When a block instantaneous signal is generated then only those earth fault stages selected to '**1**' in the “**IN1> Function**” or “**IN2> Function**” link will be blocked.

For inverse time delayed characteristics refer to the phase overcurrent elements, the *Overcurrent Protection* section.

1.4.1.1 IDG Curve

The IDG curve is commonly used for time delayed earth fault protection in the Swedish market. This curve is available in stages 1 and 2 of Earth Fault 1, Earth Fault 2 and Sensitive Earth Fault protections.

The IDG curve is represented by the following equation:

$$t = 5.8 - 1.35 \log_e \left(\frac{I}{IN > Setting} \right) \text{ in seconds}$$

Where:

I	=	Measured current
IN>Setting	=	An adjustable setting which defines the start point of the characteristic

Although the start point of the characteristic is defined by the "**IN>**" setting, the actual relay current threshold is a different setting called "**IDG Is**". The "**IDG Is**" setting is set as a multiple of "**IN>**".

An additional setting "**IDG Time**" is also used to set the minimum operating time at high levels of fault current.

The following *IDG characteristic* diagram shows how the IDG characteristic is implemented.

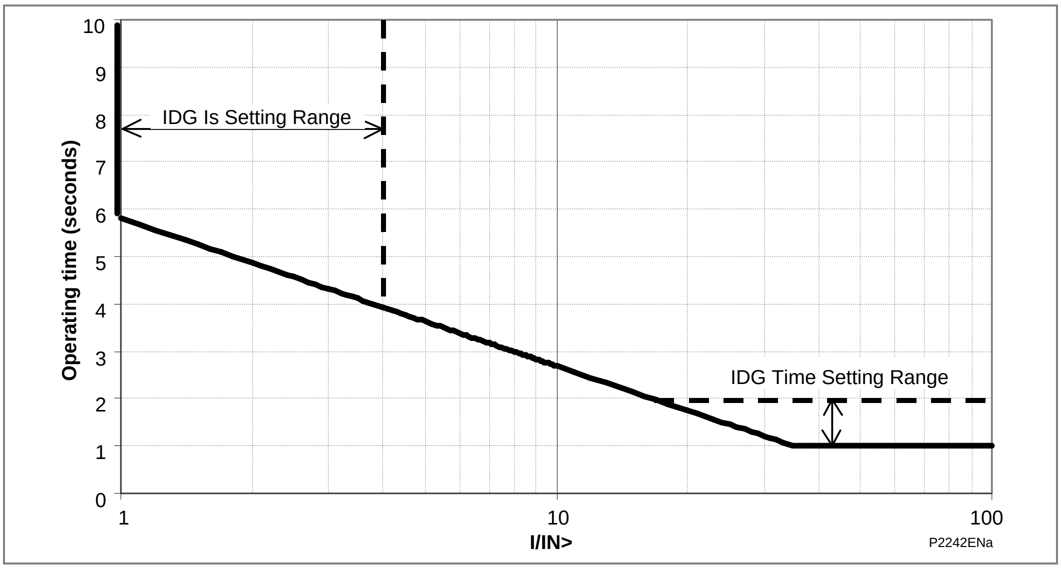


Figure 7 - IDG characteristic

1.4.2 Sensitive Earth Fault (SEF) Protection Element

A separate four-stage SEF element is provided within the P14x relay for this purpose, which has a dedicated input. The functionality of the SEF is the same as that illustrated in the previous *Non-directional EF logic (single stage) diagram for EF1/2*, bearing in mind that a separate input is used. The SEF protection can be set IN/OUT of service using the DDB 442 '**Inhibit SEF**' input signal that can be operated from an opto input or control command. This DDB signal blocks the starts and trips of all four stages of SEF protection. DDBs 216 - 219 '**ISEF>1/2/3/4 Timer Blk.**' can be used to block the four trip stages of SEF protection individually, however, these signals do not block the starts.

For the range of available inverse time delayed characteristics, refer to those of the phase overcurrent elements, in the *Overcurrent Protection* section.

From the settings menu, the "**SEF/REF options**" cell has a number of setting options. To enable standard, four stage SEF protection, the SEF option should be selected, which is the default setting. However, if wattmetric, restricted earth fault or a combination of both protections are required, then one of the remaining options should be selected. These are described in more detail in the *Directional Earth Fault (DEF) Protection* and *Restricted Earth Fault (REF) Protection* sections. The "**Wattmetric**" and "**Restricted E/F**" cells will only appear in the menu if the functions have been selected in the option cell.

Each SEF stage is selectable to be either non-directional, directional forward or directional reverse in the "**ISEF>Direction**" cell. The timer hold facility, previously described for the overcurrent elements in the *Overcurrent Protection* section is available on each of the first two stages and is set in the same manner.

1.4.2.1 EPATR B Curve

The EPATR B curve is commonly used for time delayed sensitive earth fault protection in certain markets. This curve is only available in the Sensitive Earth Fault protection stages 1 and 2.

The EPATR_B curve is based on primary current settings, employing a SEF CT Ratio of 100:1 A.

The EPATR_B curve has 3 separate segments defined in terms of the primary current and using the 100:1 fixed CT ratio and is defined as follows:

Segment	Primary Current Range Based on 100A:1A CT Ratio	Current/Time Characteristic
1	ISEF = 0.5A to 6.0A	t = 432 x TMS/ISEF $^{0.655}$ secs
2	ISEF = 6.0A to 200A	t = 800 x TMS/ISEF secs
3	ISEF above 200A	t = 4 x TMS secs

Note *Where TMS (time multiplier setting) is 0.025 - 1.2 in steps of 0.025.*

As stated in the previous sections, each of the four stages of EF1, EF2 and SEF protection may be set to be directional if required. Consequently, as with the application of directional overcurrent protection, a suitable voltage supply is required by the relay to provide the necessary polarization.

With the standard earth fault protection element in the P14x relay, two options are available for polarization; Residual Voltage or Negative Sequence. The Sensitive Earth Fault (SEF) protection element is available with only residual voltage polarization.

Figure 8 illustrates how the EPATR B characteristic is implemented.

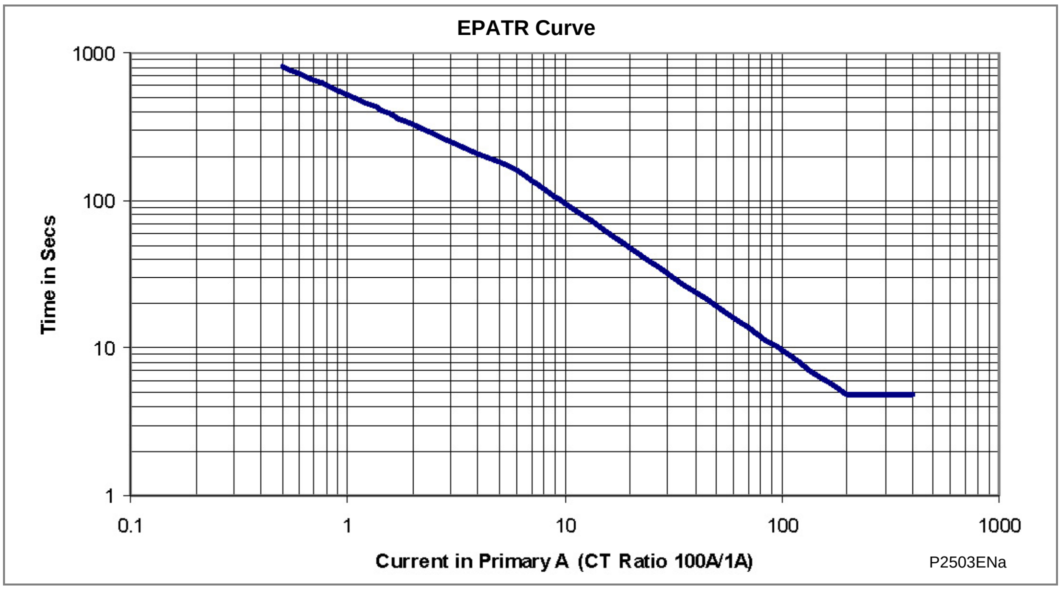


Figure 8 - EPATR B characteristic shown for TMS = 1.0

1.5 Directional Earth Fault (DEF) Protection

As stated in the previous sections, each of the four stages of EF1, EF2 and SEF protection may be set to be directional if required. Consequently, as with the application of directional overcurrent protection, a suitable voltage supply is required by the relay to provide the necessary polarization.

With the standard earth fault protection element in the P14x relay, two options are available for polarization; Residual Voltage or Negative Sequence. The Sensitive Earth Fault (SEF) protection element is available with only residual voltage polarization.

1.5.1 Residual Voltage Polarization

With earth fault protection, the polarizing signal must be representative of the earth fault condition. As residual voltage is generated during earth fault conditions, this quantity is commonly used to polarize DEF elements. The P141/P142/P143/P145 relay internally derives this voltage from the 3-phase voltage input that must be supplied from either a 5-limb or three single-phase VTs. These types of VT design allow the passage of residual flux and consequently permit the relay to derive the required residual voltage. In addition, the primary star point of the VT must be earthed. A three limb VT has no path for residual flux and is therefore unsuitable to supply the relay.

It is possible that small levels of residual voltage will be present under normal system conditions due to system imbalances, VT inaccuracies, relay tolerances etc. Hence, the relay includes a user settable threshold (***IN>VNPol set***) which must be exceeded for the DEF function to be operational. The residual voltage measurement provided in the "**Measurements 1**" column of the menu may assist in determining the required threshold setting during the commissioning stage, as this will indicate the level of standing residual voltage present.

Note	*Residual voltage is nominally 180° out of phase with residual current. Consequently, the DEF elements are polarized from the "**-Vres**" quantity. This 180° phase shift is automatically introduced within the P14x relay.*

The logic diagram for directional earth fault overcurrent with neutral voltage polarization is shown in the following diagram.

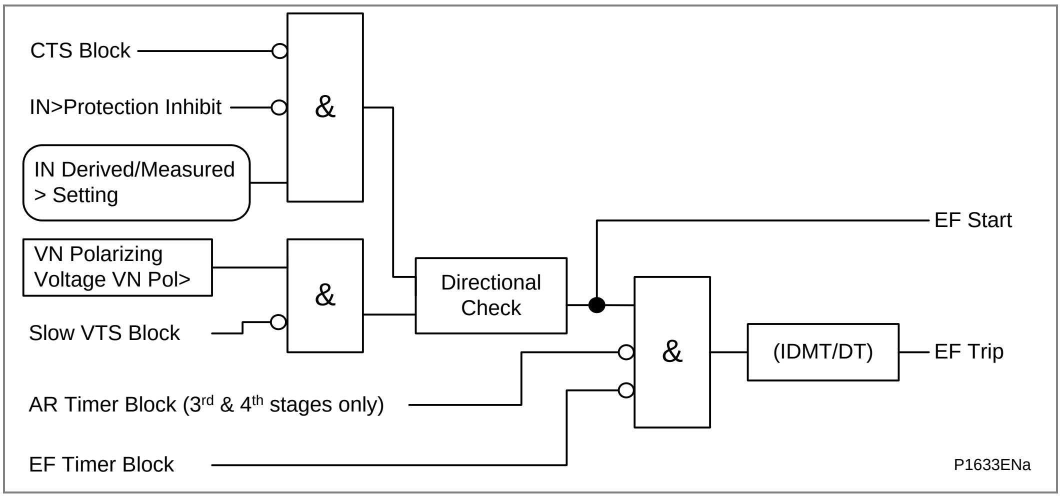


Figure 9 - Directional EF with neutral voltage polarization (single state)

VT Supervision (VTS) selectively blocks the directional protection or causes it to revert to non-directional operation. When selected to block the directional protection, VTS blocking is applied to the directional checking which effectively blocks the start outputs as well.

1.5.2 Negative Sequence Polarization

In certain applications, the use of residual voltage polarization of DEF may either be not possible to achieve, or problematic. An example of the former case would be where a suitable type of VT was unavailable, for example if only a three limb VT was fitted. An example of the latter case would be an HV/EHV parallel line application where problems with zero sequence mutual coupling may exist.

In either of these situations, the problem may be solved by the use of Negative Phase Sequence (NPS) quantities for polarization. This method determines the fault direction by comparison of NPS voltage with NPS current. The operate quantity, however, is still residual current.

This is available for selection on both the derived and measured standard earth fault elements (EF1 and EF2) but not on the SEF protection. It requires a suitable voltage and current threshold to be set in cells "**IN>V2pol set**" and "**IN>I2pol set**", respectively.

Negative sequence polarizing is not recommended for impedance earthed systems regardless of the type of VT feeding the relay. This is due to the reduced earth fault current limiting the voltage drop across the negative sequence source impedance (V2pol) to negligible levels. If this voltage is less than 0.5 volts the relay will cease to provide DEF.

The logic diagram for directional earth fault overcurrent with negative sequence polarization is shown in the following diagram.

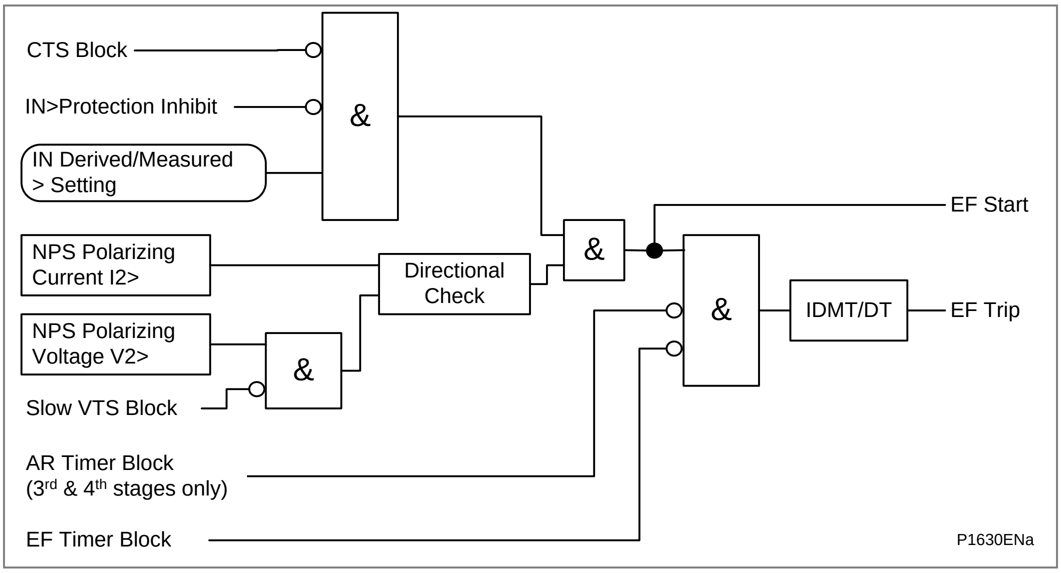


Figure 10 - Directional EF with negative sequence polarization (single stage)

The directional criteria with negative sequence polarization is given below:

Directional forward -90° < (angle(I2) - angle(V2 + 180°) - RCA) < 90°

Directional reverse -90° > (angle(I2) - angle(V2 + 180°) - RCA) > 90°

1.5.3 Operation of Sensitive Earth Fault (SEF) Element

The SEF element is designed to be applied to resistively earthed, insulated and compensated networks and have distinct functions to cater for these different requirements.

The logic diagram for sensitive directional earth fault overcurrent with neutral voltage polarization is shown in the following diagram.

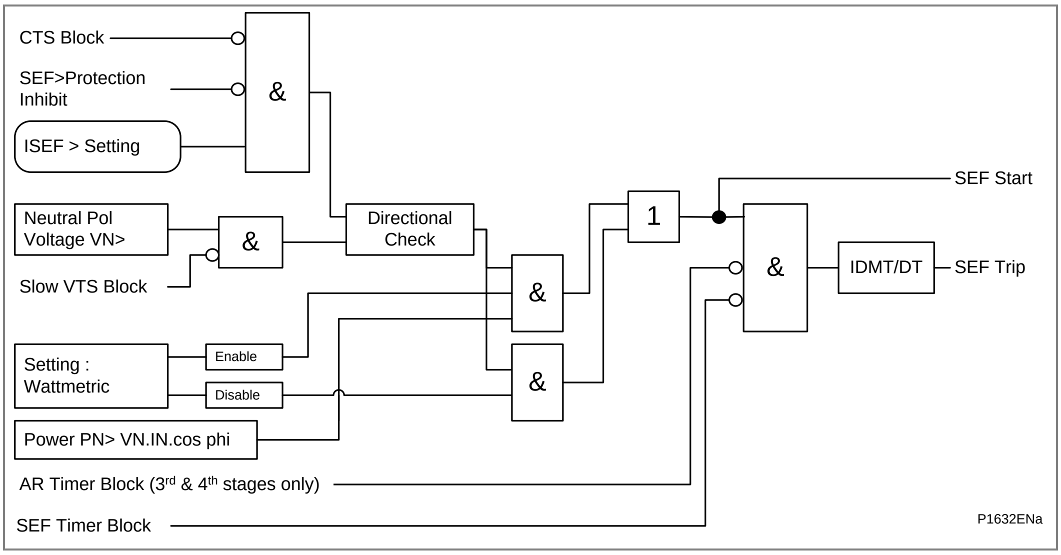


Figure 11 - Directional SEF with VN polarization (single stage)

The Sensitive Earth Fault (SEF) protection can be set IN/OUT of service using the appropriate DDB inhibit signal that can be operated from an opto input or control command. VT Supervision (VTS) selectively blocks the directional protection or causes it to revert to non-directional operation. When selected to block the directional protection, VTS blocking is applied to the directional checking which effectively blocks the start outputs as well.

The directional check criteria are given below for the standard directional sensitive earth fault element:

Directional forward $-90° < (\text{angle}(I_N) - \text{angle}(V_N + 180°) - \text{RCA}) < 90°$

Directional reverse $-90° > (\text{angle}(I_N) - \text{angle}(V_N + 180°) - \text{RCA}) > 90°$

Three possibilities exist for the type of protection element that may be applied for earth fault detection:

1. A suitably sensitive directional earth fault relay having a Relay Characteristic Angle setting (RCA) of zero degrees, with the possibility of fine adjustment about this threshold.
2. A sensitive directional zero sequence wattmetric relay having similar requirements to 1. Above with respect to the required RCA settings.
3. A sensitive directional earth fault relay having Icosϕ and Isinϕ characteristics.

All stages of the sensitive earth fault element of the P14x relay are settable down to 0.5% of rated current and would therefore fulfill the requirements of the first method listed above and could therefore be applied successfully. However, many utilities (particularly in central Europe) have standardized on the wattmetric method of earth fault detection, which is described in the following section.

Zero sequence power measurement, as a derivative of Vo and Io, offers improved relay security against false operation with any spurious core balance CT output for non earth fault conditions. This is also the case for a sensitive directional earth fault relay having an adjustable Vo polarizing threshold.

1.5.4 Wattmetric Characteristic

Analysis has shown (see the *Directional Earth Fault (DEF) Protection* section of the *Application Notes* chapter) that a small angular difference exists between the spill current on the healthy and faulted feeders for earth faults on compensated networks. Taking into account the efforts of coil and feeder resistance, it can be seen that this angular difference gives rise to active components of current which are in anti-phase to one another. This is shown in the following diagram.

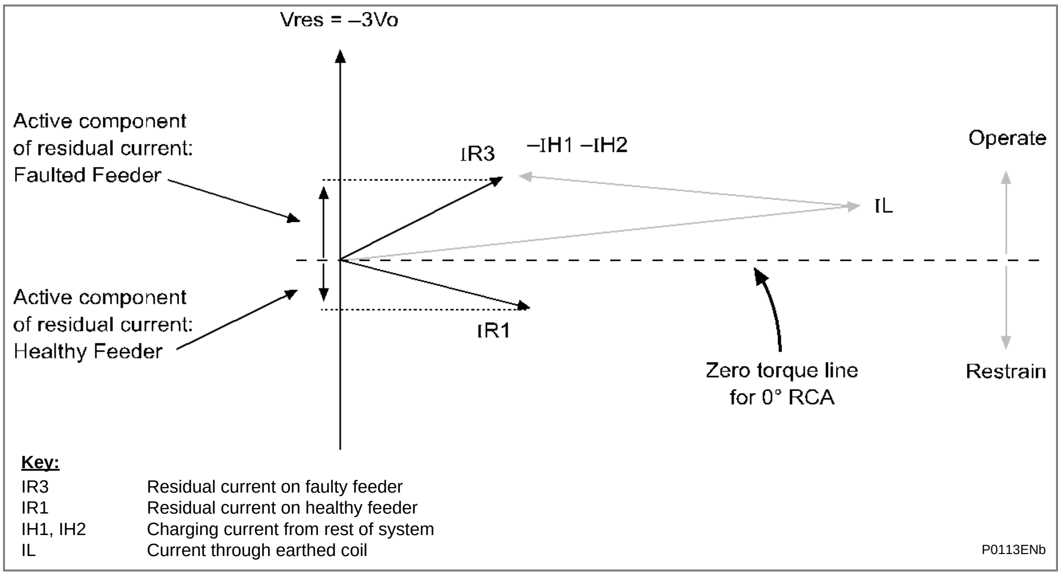


Figure 12 - Resistive components of spill current

Consequently, the active components of zero sequence power will also lie in similar planes and so a relay capable of detecting active power would be able to make a discriminatory decision. i.e. if the wattmetric component of zero sequence power was detected in the forward direction, then this would be indicative of a fault on that feeder; if power was detected in the reverse direction, then the fault must be present on an adjacent feeder or at the source.

For operation of the directional earth fault element within the P14x relays, all three of the settable thresholds on the relay must be exceeded; namely the current "**ISEF>**", the voltage "**ISEF>VNpol Set**" and the power "**PN> Setting**".

As can be seen from the following formula, the power setting within the relay menu is called PN> and is therefore calculated using residual rather than zero sequence quantities. Residual quantities are three times their respective zero sequence values and so the complete formula for operation is as shown below:

The PN> setting corresponds to:

$$Vres \times Ires \times \cos(\phi - \phi c) = 9 \times Vo \times Io \times \cos(\phi - \phi c)$$

Where:

ϕ	=	Angle between the Polarizing Voltage (-Vres) and the Residual Current
ϕc	=	Relay Characteristic Angle (RCA) Setting (ISEF> Char. Angle)
Vres	=	Residual Voltage
Ires	=	Residual Current
Vo	=	Zero Sequence Voltage
Io	=	Zero Sequence Current

The action of setting the PN> threshold to zero would effectively disable the wattmetric function and the relay would operate as a basic, sensitive directional earth fault element. However, if this is required, then the '**SEF**' option can be selected from the **'Sens. E/F Options**' cell in the menu.

Note	*The residual power setting, PN>, is scaled by the programmed CT and VT ratios in the relay.*

A further point to note is that when a power threshold other than zero is selected, a slight alteration is made to the angular boundaries of the directional characteristic. Rather than being ±90° from the RCA, they are made slightly narrower at ±85°.

The directional check criteria is as follows:

Directional Forward $-85° < (\text{angle}(I_N) - \text{angle}(V_N + 180°) - \text{RCA}) < 85°$

Directional Reverse $-85° > (\text{angle}(I_N) - \text{angle}(V_N + 180°) - \text{RCA}) > 85°$

1.5.5 Icosϕ/Isinϕ Characteristic

In some applications, the residual current on the healthy feeder can lie just inside the operating boundary following a fault condition. The residual current for the faulted feeder lies close to the operating boundary.

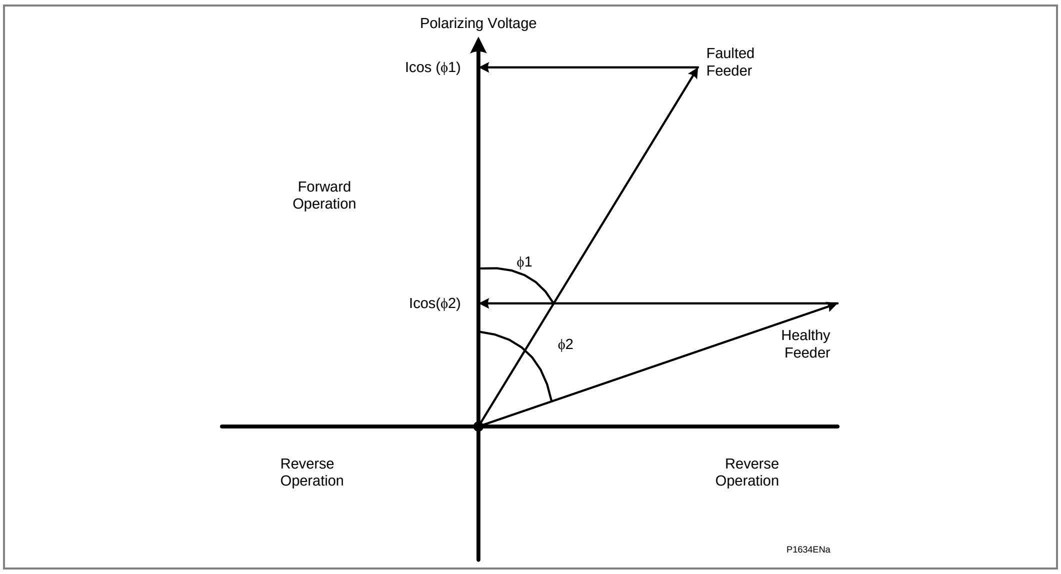


Figure 13 - Operating characteristic for Icosϕ

The above diagram shows the method of discrimination when the real (cosϕ) component is considered, since faults close to the polarizing voltage will have a higher magnitude than those close to the operating boundary. In the diagram, it is assumed that the actual magnitude of current is I in both the faulted and non-faulted feeders.

Active component Icosϕ

The criterion for operation is: I (cosϕ) > Isef

Reactive component Isinϕ

The criterion for operation is: I (sinϕ) > Isef

Where Isef is the relay stage sensitive earth fault current setting.

If any stage is set non-directional, the element reverts back to normal operation based on current magnitude I with no directional decision.

In this case, correct discrimination is achieved by means of an Icosϕ characteristic as the faulted feeder will have a large active component of residual current, whilst the healthy feeder will have a small value.

For insulated earth applications, it is common to use the Isinϕ characteristic.

All of the relevant settings can be found under the SENSITIVE E/F column within the relay menu. Within the Sens. E/F Options cell, there are two possibilities for selecting wattmetric earth fault protection; either on its own or in conjunction with low impedance REF protection, which is described in the *Biased Differential Protection* section. The SEF cosϕ and SEF sinϕ options are not available with low impedance REF protection.

1.6 Restricted Earth Fault (REF) Protection

The Restricted Earth Fault (REF) protection in the relays may be configured to operate as either a high impedance or low impedance element and the following sections describe the application of the relay in each mode.

The high impedance REF element of the relay shares the same CT input as the SEF protection hence, only one of these elements may be selected. However, the low impedance REF element does not use the SEF input and so may be selected at the same time.

1.6.1 Biased Differential Protection

In a biased differential relay, the through current is measured and used to increase the setting of the differential element. For heavy through faults, one CT in the scheme can be expected to become more saturated than the other and hence differential current can be produced. However, biasing will increase the relay setting such that the resulting differential current is insufficient to cause operation of the relay.

The following *REF bias characteristic* diagram and the *REF bias principle* diagram show the operating characteristic for the relay applied for biased REF protection.

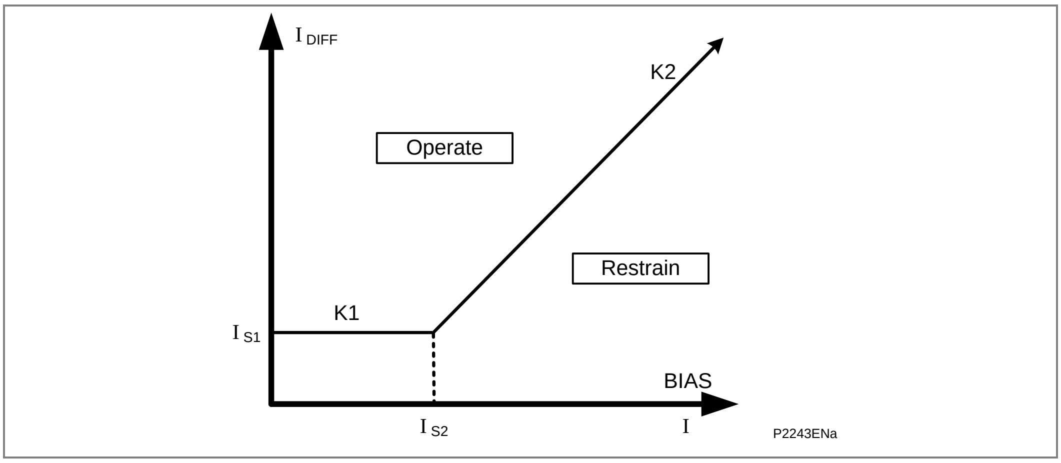


Figure 14 - REF bias characteristic

The actual operating characteristic of the element is shown in the previous *REF bias characteristic* diagram.

The formulae used by the relay to calculate the required bias quantity is therefore as follows:

Ibias = {(Highest of Ia, Ib or Ic) + (Ineutral x Scaling Factor)}/2

The reason for the scaling factor included on the neutral current is explained by referring to the following *REF bias principle* diagram.

For IBIAS < IS2	Operate when IDIFF > IS1 + K1.IBIAS
For IBIAS = IS2	Operate when IDIFF > IS1 + K1.IS2
For IBIAS > IS2	Operate when IDIFF > IS1 + K1.IS2 + K2.(IBIAS-IS2)

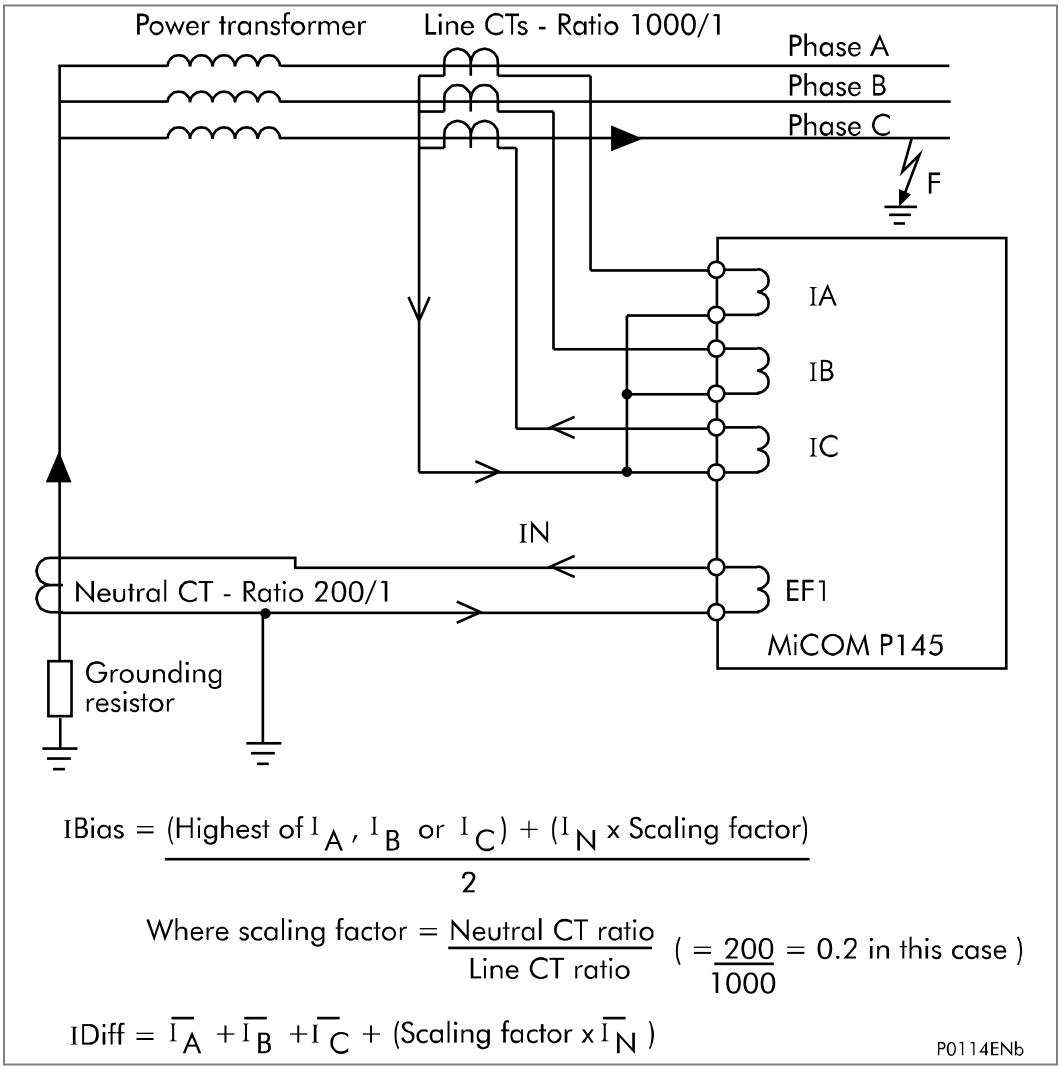


Figure 15 - REF bias principle

Where it is required that the neutral CT also drives the EF1 protection element to provide standby earth fault protection, it may be a requirement that the neutral CT has a lower ratio than the line CTs in order to provide better earth fault sensitivity. If this were not accounted for in the REF protection, the neutral current value used would be incorrect. For this reason, the relay automatically scales the level of neutral current used in the bias calculation by a factor equal to the ratio of the neutral to line CT primary ratings. The use of this scaling factor is shown in the previous *REF bias principle* diagram, where the formulae for bias and differential currents are given.

1.6.2 High Impedance Restricted Earth Protection

The high impedance principle is best explained by considering a differential scheme where one CT is saturated for an external fault, as shown in the following *High impedance principle* diagram.

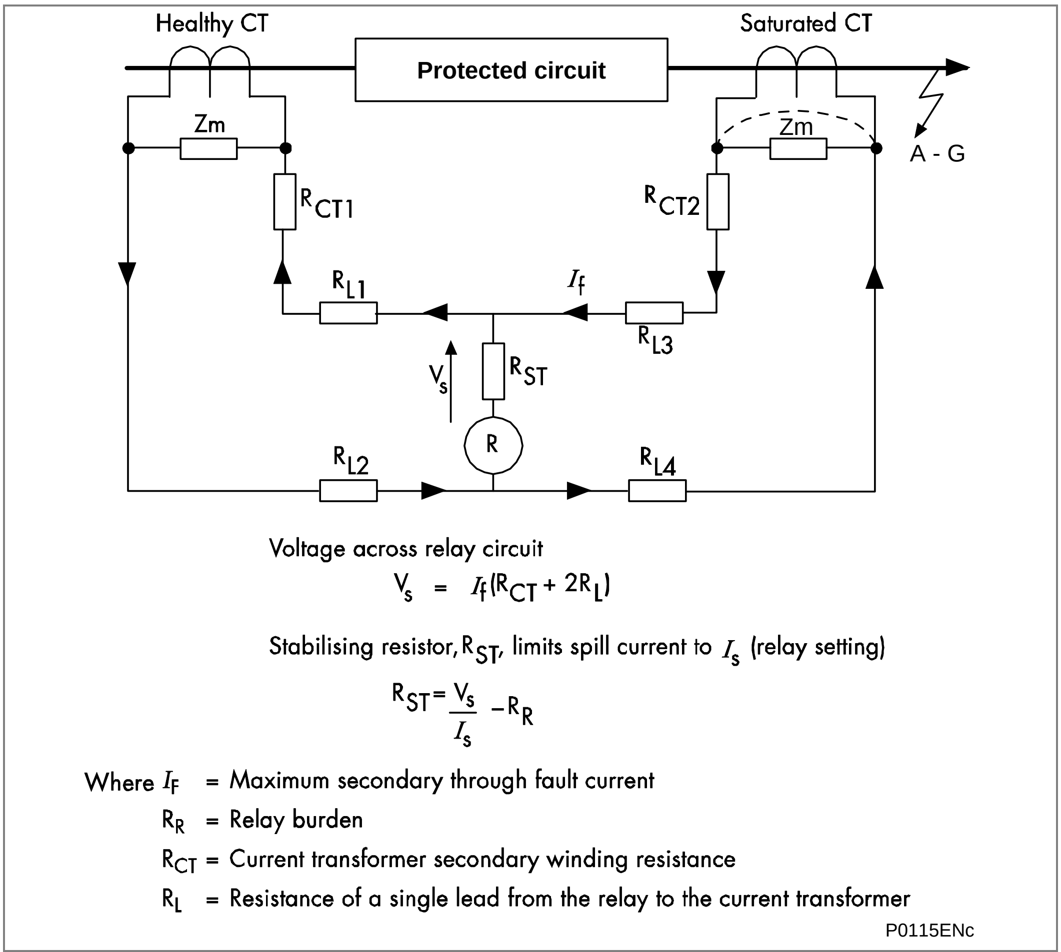


Figure 16 - High impedance principle

If the relay circuit is considered to be a very high impedance, the secondary current produced by the healthy CT will flow through the saturated CT. If CT magnetizing impedance of the saturated CT is considered to be negligible, the maximum voltage across the relay circuit will be equal to the secondary fault current multiplied by the connected impedance, (R_{L3} + R_{L4} + R_{CT2}).

The relay can be made stable for this maximum applied voltage by increasing the overall impedance of the relay circuit, such that the resulting current through the relay is less than its current setting. As the impedance of the relay input alone is relatively low, a series connected external resistor is required. The value of this resistor, R_{ST}, is calculated by the formula shown in the previous *High impedance principle* diagram An additional non-linear, metrosil, may be required to limit the peak secondary circuit voltage during internal fault conditions.

To ensure that the protection will operate quickly during an internal fault, the CT's used to operate the protection must have a kneepoint voltage of at least 4Vs.

The necessary relay connections for high impedance REF are shown in the following *High impedance REF relay/CT connections* diagram.

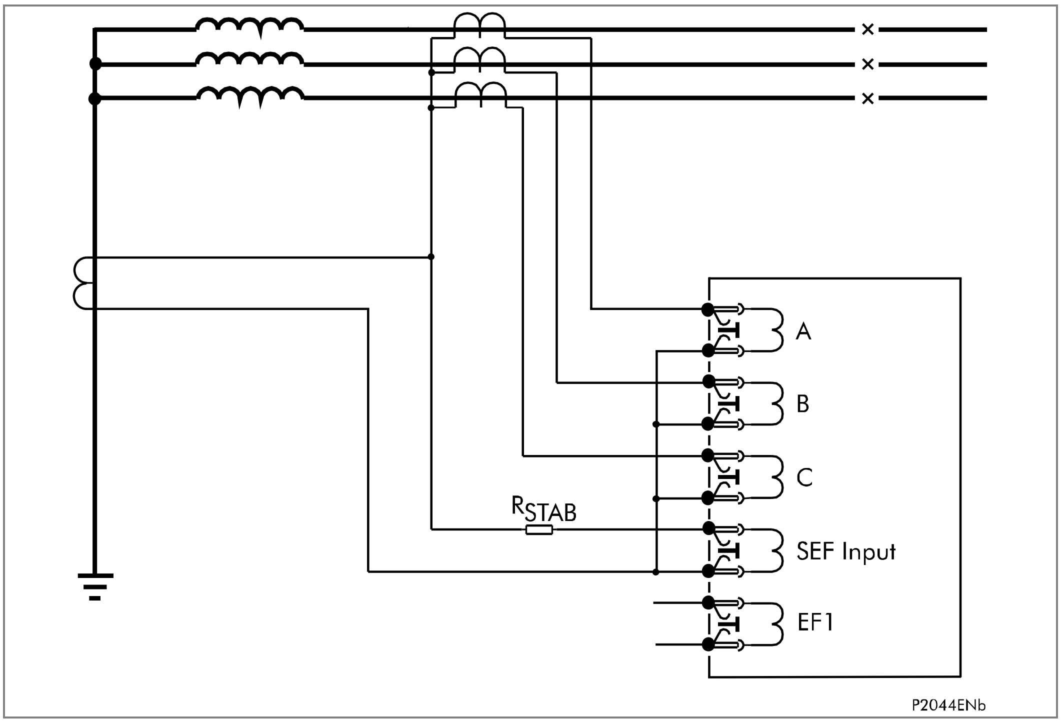


Figure 17 - High impedance REF relay/CT connections

1.7 Residual Overvoltage (Neutral Displacement) Protection

On a healthy three-phase power system, the addition of each of the three-phase to earth voltages is nominally zero, as it is the vector addition of three balanced vectors at 120° to one another. However, when an earth fault occurs on the primary system this balance is upset and a '**residual**' voltage is produced. This could be measured, for example, at the secondary terminals of a voltage transformer having a "**broken delta**" secondary connection. Hence, a residual voltage-measuring relay can be used to offer earth fault protection on such a system.

Note	*This condition causes a rise in the neutral voltage with respect to earth that is commonly referred to as "**neutral voltage displacement**" or NVD.*

The detection of a residual overvoltage condition is an alternative means of earth fault detection, which does not require any measurement of current. This may be particularly advantageous in high impedance earthed or insulated systems, where the provision of core balance CT's on each feeder may be either impractical, or uneconomic.

The MiCOM P14x relay internally derives this residual voltage from the three-phase voltage input that must be supplied from either a 5-limb or three single-phase VTs. The NVD element within the MiCOM P14x relays is of two-stage design, each stage having separate voltage and time delay settings. Stage 1 may be set to operate on either an IDMT or DT characteristic, whilst stage 2 may be set to DT only.
The IDMT characteristic available on the first stage is defined by the following formula:

$t = K/(M - 1)$

Where:
K = Time multiplier setting
t = Operating time in seconds
M = Derived residual voltage/relay setting voltage (VN> Voltage Set)

Two stages are included for the NVD protection to account for applications that require both alarm and trip stages, for example, an insulated system. It is common in such a case for the system to have been designed to withstand the associated healthy phase overvoltages for a number of hours following an earth fault. In such applications, an alarm is generated soon after the condition is detected, which serves to indicate the presence of an earth fault on the system. This gives time for system operators to locate and isolate the fault. The second stage of the protection can issue a trip signal if the fault condition persists.
The functional block diagram of the first stage residual overvoltage is shown in the following *Residual overvoltage logic (single stage)* diagram:

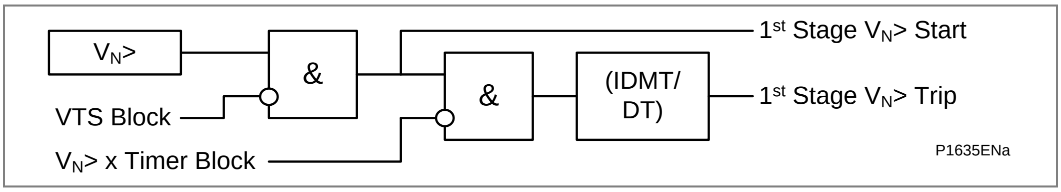


Figure 18 - Residual overvoltage logic (single stage)

VTS blocking when asserted, effectively blocks the start outputs.

When enabled, the following signals are set by the residual overvoltage logic according to the status of the monitored function:

VN>1 Start	(DDB 327)	1st Stage Residual Overvoltage Start
VN>2 Start	(DDB 328)	2nd Stage Residual Overvoltage Start
VN>1 Timer Blk.	(DDB 220)	Block Residual Overvoltage Stage 1 Time Delay
VN>2 Timer Blk.	(DDB 221)	Block Residual Overvoltage Stage 2 Time Delay
VN>1 Trip	(DDB 274)	1st Stage Residual Overvoltage Trip
VN>2 Trip	(DDB 275)	2nd Stage Residual Overvoltage Trip

1.8 Undervoltage Protection

Both the under and overvoltage protection functions can be found in the relay menu "**Volt Protection**". The undervoltage protection included in the relay consists of two independent stages. These are configurable as either phase to phase or phase to neutral measuring within the "**V<Measur't mode**" cell.

Stage 1 may be selected as IDMT, DT or Disabled, within the "**V<1 Function**" cell. Stage 2 is DT only and is enabled/disabled in the "**V<2 status**" cell.

The IDMT characteristic available on the first stage is defined by the following formula:

$$t = K/(1 - M)$$

Where:

K = Time multiplier setting
t = Operating time in seconds
M = Measured voltage/relay setting voltage (V< Voltage Set)

Two stages are included to provide both alarm and trip stages, where required. Alternatively, different time settings may be required depending upon the severity of the voltage dip, i.e. motor loads will be able to withstand a small voltage depression for a longer time than if a major voltage excursion were to occur.

Outputs are available for single or three-phase conditions via the "**V<Operate Mode**" cell.

The logic diagram of the first stage undervoltage function is shown in the *Undervoltage - single and three phase tripping mode (single stage)* diagram below:

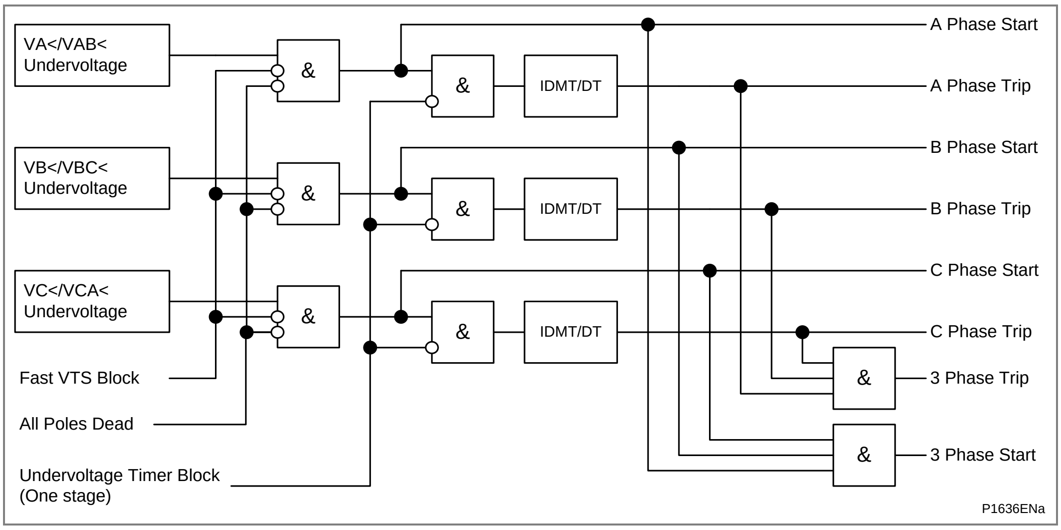


Figure 19 - Undervoltage - single and three phase tripping mode (single stage)

When the protected feeder is de-energized, or the circuit breaker is opened, an undervoltage condition would be detected. Therefore, the "**V<Poledead Inh**" cell is included for each of the two stages to block the undervoltage protection from operating for this condition. If the cell is enabled, the relevant stage will become inhibited by the in-built pole dead logic within the relay. This logic produces an output when it detects either an open circuit breaker via auxiliary contacts feeding the relay opto inputs or it detects a combination of both undercurrent and undervoltage on any one phase.

Note	*When the setting "**oper mode**" set to '**Any Phase**', the stage DDB will be from an OR gate output of the three individual phases start/trip and when it is set to '**Three Phase**', the stage DDB will be from an AND gate output of the three individual phases signal. This is applicable for over voltage and rate of change of voltage protection.*

1.9 Overvoltage Protection

Both the under and overvoltage protection functions can be found in the relay menu "**Volt Protection**". The overvoltage protection included within the P14x relays consists of two independent stages. These are configurable as either phase to phase or phase to neutral measuring within the "**V>Measur't mode**" cell.

Stage 1 may be selected as IDMT, DT or Disabled, within the "**V>1 Function**" cell. Stage 2 is DT only and is enabled/disabled in the "**V>2 status**" cell.

The IDMT characteristic available on the first stage is defined by the following formula:

$t = K/(M - 1)$

Where:

K = Time Multiplier Setting (TMS)
t = Operating Time in seconds
M = Measured voltage / relay setting voltage (V> Voltage Set)

The logic diagram of the first stage overvoltage function is shown in this diagram.

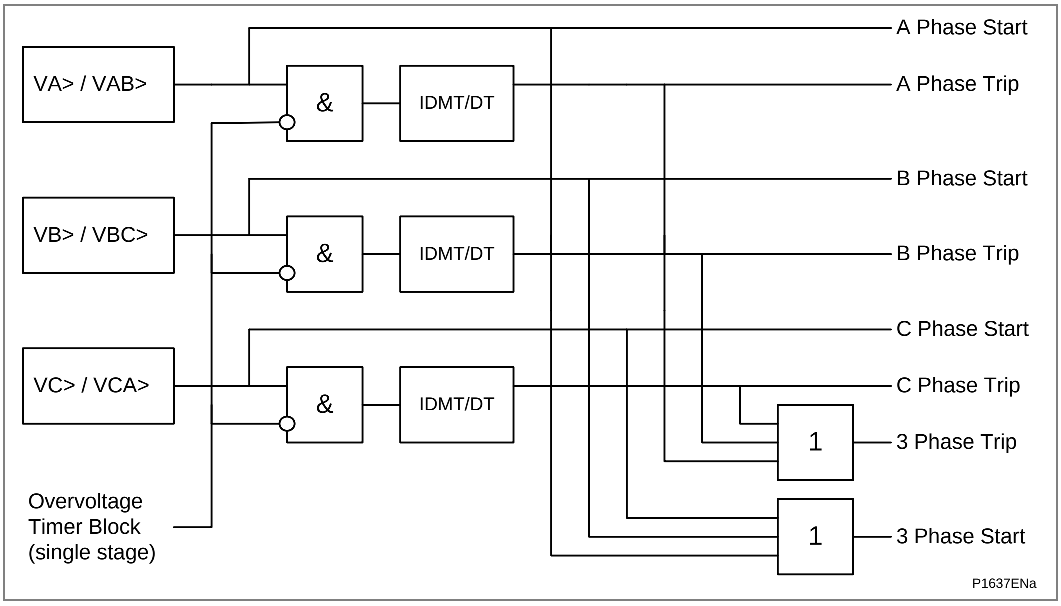


Figure 20 - Overvoltage - single and three phase tripping mode (single stage)

1.10 Negative Sequence Overvoltage Protection

The relay includes a Negative Phase Sequence (NPS) overvoltage element. This element monitors the input voltage rotation and magnitude (normally from a bus connected voltage transformer) and may be interlocked with the motor contactor or circuit breaker to prevent the motor from being energized whilst incorrect phase rotation exists.

This single stage is selectable as definite time only and is enabled within the "**V2>status**" cell.

The logic diagram for the negative sequence overcurrent protection is shown in the following diagram:

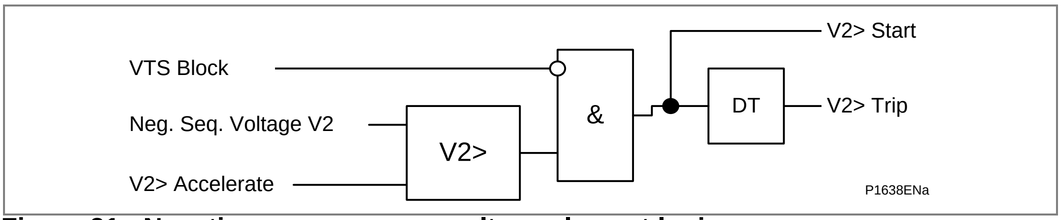


Figure 21 - Negative sequence overvoltage element logic

When enabled, the following signals are set by the negative sequence overvoltage logic according to the status of the monitored function.

V2> Accelerate	(DDB 517)	Accelerate the operating time of the function from typically 80msec. to 40msec. when set to instantaneous
V2> Start	(DDB 330)	Stage started when high
V2> Trip	(DDB 277)	Stage tripped when high

1.11 Negative Phase Sequence (NPS) Overcurrent Protection

The relay provides four independent stages of Negative Phase Sequence (NPS) overcurrent protection.

The NPS overcurrent protection included in the P14x relays provides four-stage non-directional/directional overcurrent protection with independent time delay characteristics. The first two stages of overcurrent protection have time-delayed characteristics which are selectable between Inverse Definite Minimum Time (IDMT), or Definite Time (DT). The third and fourth stages have DT characteristics only. The inverse time delayed characteristics support both IEC and IEEE curves and please refer to the *Overcurrent Protection* section for a detailed description. The user may choose to directionalize operation of the elements, for either forward or reverse fault protection for which a suitable relay characteristic angle may be set. Alternatively, the elements may be set as non-directional.

For the NPS directional elements to operate, the relay must detect a polarizing voltage above a minimum threshold, "**I2> V2pol Set**". When the element is selected as directional, a VTS Block option is available. When the relevant bit is set to 1, operation of the Voltage Transformer Supervision (VTS), will block the stage if directionalized. When set to 0, the stage will revert to non-directional upon operation of the VTS.

When enabled, the following signals are set by the negative sequence O/C logic according to the status of the monitored function.

I2> Inhibit	(DDB 504)	Inhibit all 4 stages when high
I2>1 Tmr. Block	(DDB 505)	Block timer on 1st stage when high
I2>2 Tmr. Block	(DDB 506)	Block timer on 1st stage when high
I2>3 Tmr. Block	(DDB 507)	Block timer on 1st stage when high
I2>4 Tmr. Block	(DDB 508)	Block timer on 1st stage when high
I2>1 Start	(DDB 509)	1st stage started when high
I2>2 Start	(DDB 510)	2nd stage started when high
I2>3 Start	(DDB 511)	3rd stage started when high
I2>4 Start	(DDB 512)	4th stage started when high
I2>1 Trip	(DDB 513)	1st stage tripped when high
I2>2 Trip	(DDB 514)	2nd stage tripped when high
I2>3 Trip	(DDB 515)	3rd stage tripped when high
I2>4 Trip	(DDB 516)	4th stage tripped when high

All the above signals are available as DDB signals for mapping in Programmable Scheme Logic (PSL). In addition the negative sequence overcurrent protection trips 1/2/3/4 are mapped internally to the block auto-reclose logic.

Negative sequence overcurrent protection starts 1/2/3/4 are mapped internally to the ANY START DDB signal - DDB 294.

The non-directional and directional operation is shown in *the Negative sequence overcurrent non-directional operation* diagram and the *Directionalizing the negative phase sequence overcurrent element* diagram:

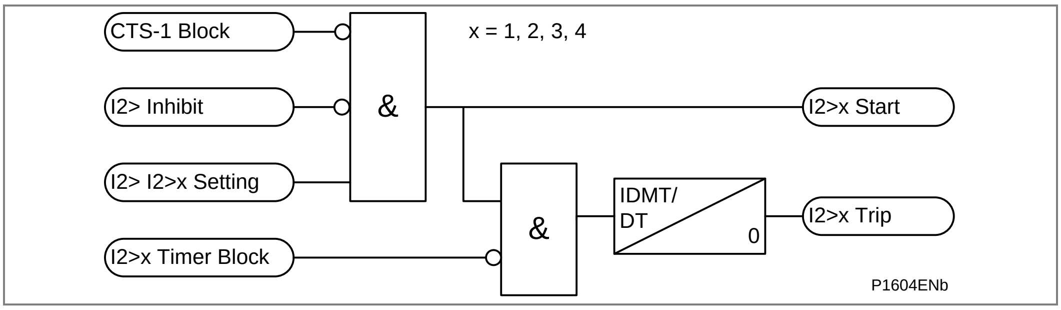


Figure 22 - Negative sequence overcurrent non-directional operation

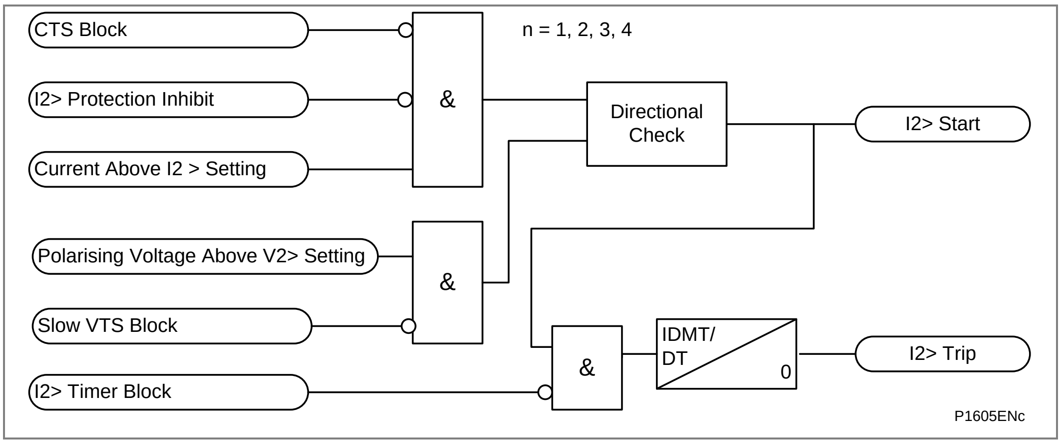


Figure 23 - Directionalizing the negative phase sequence overcurrent element

Directionality is achieved by comparison of the angle between NPS voltage and the NPS current and the element may be selected to operate in either the forward or reverse direction. A suitable relay characteristic angle setting (I2> Char Angle) is chosen to provide optimum performance. This setting should be set equal to the phase angle of the negative sequence current with respect to the inverted negative sequence voltage (–V2), in order to be at the center of the directional characteristic.

For the NPS directional elements to operate, the relay must detect a polarizing voltage above a minimum threshold, "**I2> V2pol Set**". This must be set in excess of any steady state NPS voltage. This may be determined during the commissioning stage by viewing the NPS measurements in the relay.

1.12 Voltage Dependent Overcurrent

A protection element linked to over current that can be configured as either voltage controlled or voltage restrained over current protection. The operation of the same is detailed in the following sections:

- 1.13 - Voltage Controlled Overcurrent (VCO) Protection (51V)
- 1.14 - Voltage Restrained Overcurrent Protection

1.13 Voltage Controlled Overcurrent (VCO) Protection (51V)

If the current seen by a local relay for a remote fault condition is below its overcurrent setting, a Voltage Controlled Overcurrent (VCO) element may be used to increase the relay sensitivity to such faults. In this case, a reduction in system voltage will occur; this may then be used to reduce the pick up level of the overcurrent protection.

The VCO function can be selectively enabled on the first two stages of the main overcurrent element, which was described in the *Overcurrent Protection* section. When VCO is enabled, the overcurrent setting is modified by the multiplier k when the voltage falls below a threshold as shown in the following table:

Element	Phase to Phase Voltage for Control	Element Pick Up when Control Voltage > Setting	Element Pick Up when Control Voltage < Setting
Ia>	Vab	I>1, I>2, I>5	k.I>
Ib>	Vbc	I>1, I>2, I>5	k.I>
Ic>	Vca	I>1, I>2, I>5	k.I>

Table 4 - Voltage Controlled Overcurrent settings

Note	*Voltage dependent overcurrent relays are more often applied in generator protection applications in order to give adequate overcurrent relay sensitivity for close up fault conditions. The fault characteristic of this protection must then co-ordinate with any of the downstream overcurrent relays that are responsive to the current decrement condition. It therefore follows that if the P14x relay is to be applied on an outgoing feeder from a generator station, the use of voltage controlled overcurrent protection in the feeder relay may allow better co-ordination with the VCO relay on the generator.*

1.14 Voltage Restrained Overcurrent Protection

In voltage restrained mode the effective operating current of the protection element is continuously variable as the applied voltage varies between two voltage thresholds, “V Dep. OC V<1 Set” and “V Dep. OC V<2 Set”, as shown in the figure below. In this mode, it is quite difficult to determine the behavior of the protection function during a fault. This protection mode is, however, considered to be better suited to applications where the generator is connected to the system via a generator transformer.

With indirect connection of the generator, a solid phase-phase fault on the local busbar will result in only a partial phase-phase voltage collapse at the generator terminals.

The voltage-restrained current setting is related to measured voltage as follows:

For V > V<1: Current setting (I_S) = I>
For V<2 < V < V<1: Current setting (I_S) = K.I> + (I > - K. I>) {V – V<2 / V<1 – V<2}
For V < V<2: Current setting (I_S) = K.I>

Where:
I> = Over current stage setting
I_S = Current setting at voltage V
V = Voltage applied to relay element
V<1 = “V Dep. OC V<1 Set”
V<2 = “V Dep. OC V<2 Set”

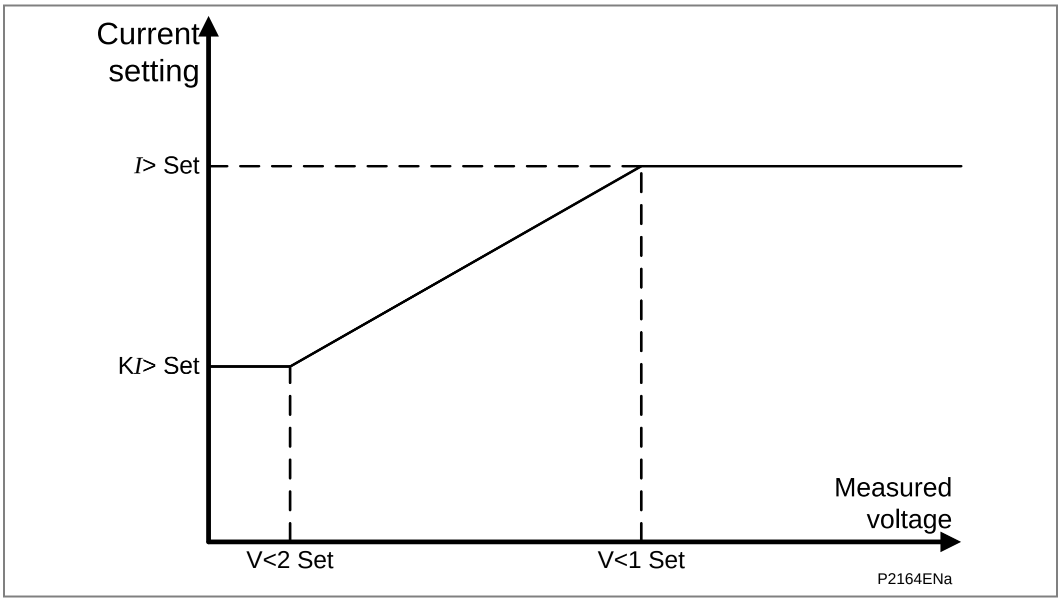


Figure 24 - Modification of current pickup level for voltage restrained overcurrent protection

1.15 Load Blinders

Load blinders are provided for phase fault elements to prevent maloperation / maltripping for heavy load flow. The purpose is to configure a blinder envelope which surrounds the expected worst case load limits, and to block tripping for any impedance measured within the blinder region. Only fault impedance which is outside the load area will be allowed to cause a trip. The phase overcurrent elements are settable independent of the load. Facility is provided to allow the load blinder to be bypassed any time the measured voltage for the phase in question falls below an undervoltage setting.
The load encroachment applies a characteristic as shown in the figure below:

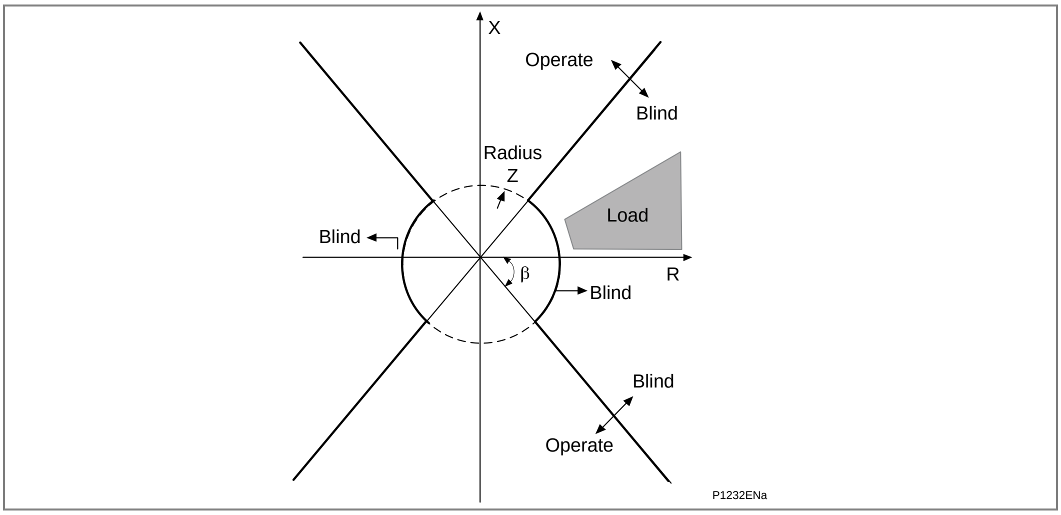


Figure 25 - Load blinder and angle

It is possible to set the impedance and angle setting independently for the forward and reverse regions in the Z plane.

There are two modes of operation, three phase mode and single phase mode. The three phase mode uses positive sequence impedance (Z1) and the single phase mode uses the normal impedance (Z) of each phase. The three phase mode uses I2> blocking in addition to under voltage. When single phase mode is selected, the over current blocking will be phase segregated.

1.16 Circuit Breaker Fail (CBF) Protection

The Circuit Breaker Failure (CBF) protection incorporates two timers, "CB Fail 1 Timer" and "CB Fail 2 Timer", allowing configuration for these scenarios:

- Simple CBF, where only "CB Fail 1 Timer" is enabled. For any protection trip, the "CB Fail 1 Timer" is started, and normally reset when the circuit breaker opens to isolate the fault. If breaker opening is not detected, "CB Fail 1 Timer" times out and closes an output contact assigned to breaker fail (using the programmable scheme logic). This contact is used to backtrip upstream switchgear, generally tripping all infeeds connected to the same busbar section
- A re-tripping scheme, plus delayed backtripping. Here, "CB Fail 1 Timer" is used to route a trip to a second trip circuit of the same circuit breaker. This requires duplicated circuit breaker trip coils, and is known as re-tripping. Should re-tripping fail to open the circuit breaker, a backtrip may be issued following an additional time delay. The backtrip uses "CB Fail 2 Timer", which is also started at the instant of the initial protection element trip.
- A DDB ‘CBF Inhibit’ has been added to enable / disable CB fail functionality.

The complete breaker fail logic is shown in the following *CB fail logic* diagram.

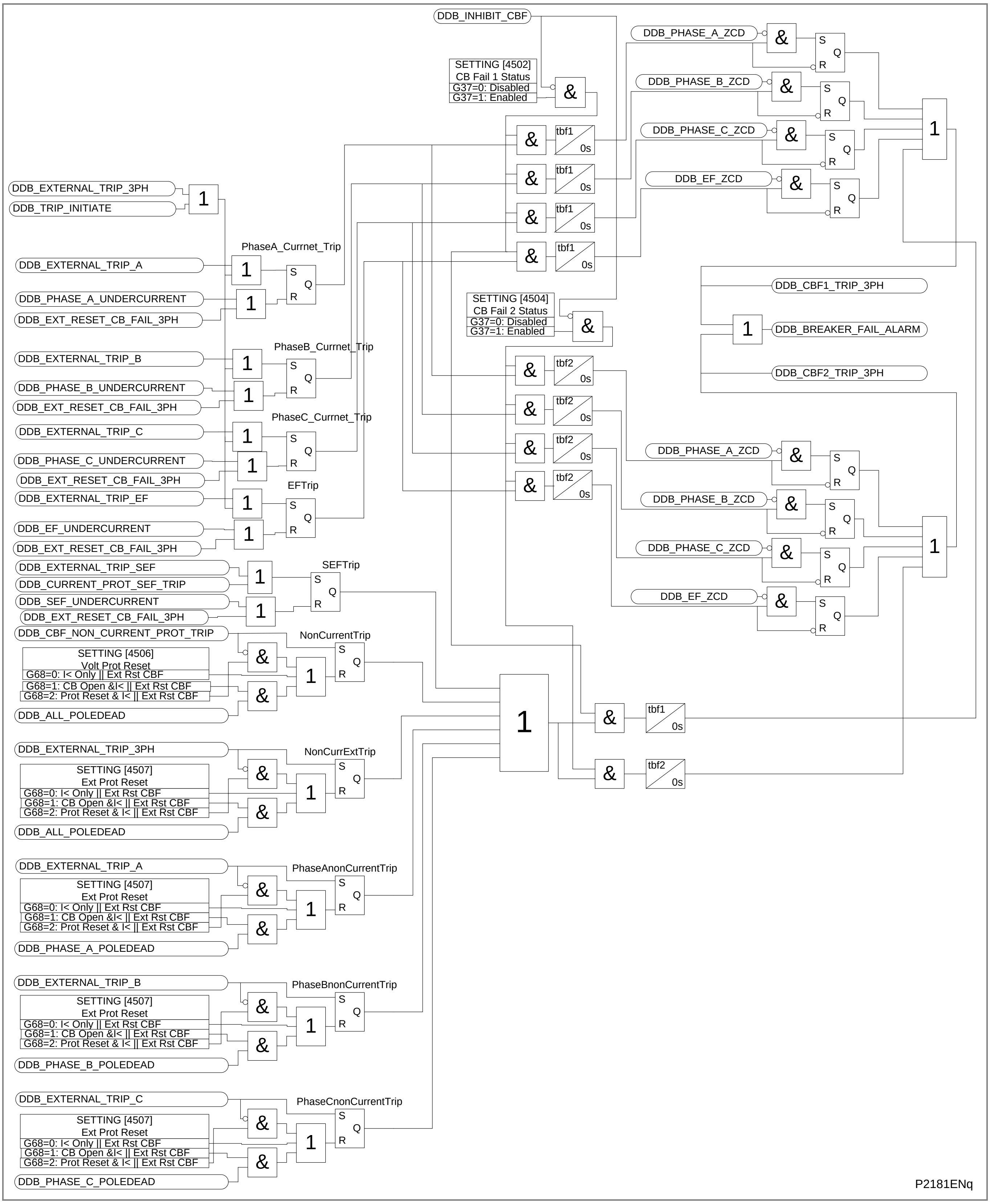


Figure 26 - CB fail logic

CBF elements "**CB Fail 1 Timer**" and "**CB Fail 2 Timer**" can be configured to operate for trips triggered by protection elements within the relay or via an external protection trip. The latter is achieved by allocating one of the relay opto-isolated inputs to "**External Trip**" using the programmable scheme logic.

Resetting of the CBF is possible from:

- DDB 1192 is set;
- A breaker open indication (from the relay's pole dead logic) and the undercurrent elements have reset;
- A protection reset and the undercurrent elements have reset

The resetting options are summarized in the following table:

Initiation (Menu Selectable)	CB Fail Timer Reset Mechanism
Current based protection	Two options are available. (e.g. 50/51/46/21/87..) [IA< operates] & [IB< operates] & [IC< operates] & [IN< operates] AND [DDB_EXT_RESET_CB_FAIL_3PH (1192) is set]
Sensitive earth fault element	Two options are available. [ISEF< Operates] AND [DDB_EXT_RESET_CB_FAIL_3PH (1192) is set]
Non-current based protection (e.g. 27/59/81/32L..)	Four options are available. The user can select from the following options. [All I< and IN< elements operate] [Protection element reset] AND [All I< and IN< elements operate] CB open (all 3 poles) AND [All I< and IN< elements operate] AND [DDB_EXT_RESET_CB_FAIL_3PH (1192) is set]
External protection	Four options are available. The user can select any or all of the options. [All I< and IN< elements operate] [External trip reset] AND [All I< and IN< elements operate] CB open (all 3 poles) AND [All I< and IN< elements operate] AND [DDB_EXT_RESET_CB_FAIL_3PH (1192) is set]

Table 5 - CB fail timer reset mechanism

The "**Remove I> Start**" and "**Remove IN> Start**" settings are available in the settings menu and used to remove starts issued from the overcurrent and earth elements respectively following a breaker fail time out. The start is removed when the cell is set to Enabled.

1.17 CB Fail External Reset

The CB Fail external reset functionality has been added to the relay.

New DDB signals have been added for these reasons:

- To reset individual phase failure logic triggers
- To trigger 3-phase signals for all phases
- For Sensitive Earth Fault (SEF) conditions

Four extra signals have also been added for the second circuit breaker for any relays which use two circuit breakers.

The DDB database now includes an Extra DDB signal and an Ext Rst CBF (DDB 1192) entry. To achieve the desired functionality, the 3 phase CBF external reset signal is connected via an OR gate together with the corresponding phase undercurrent signal at each stage of the logic in the CB failure logic. After modification, the resultant CB failure logic looks like that shown in the - *CB fail logic* diagram.

1.18 Broken Conductor Detection

The relay incorporates an element which measures the ratio of negative to positive phase sequence current (I_2/I_1). This will be affected to a lesser extent than the measurement of negative sequence current alone, since the ratio is approximately constant with variations in load current. Hence, a more sensitive setting may be achieved.

The *Broken conductor logic* diagram is as shown below. The ratio of I2/I1 is calculated and is compared with the threshold and if the threshold is exceeded then the delay timer is initiated. The CTS block signal is used to block the operation of the delay timer.

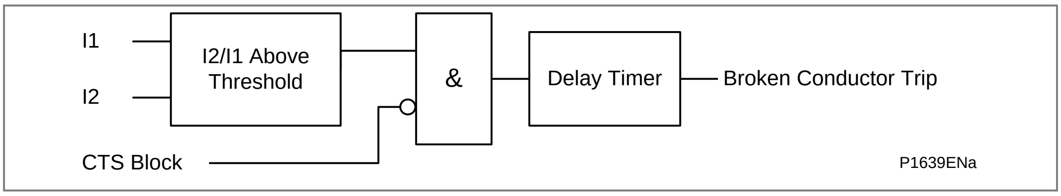


Figure 27 - Broken conductor logic

1.19 Frequency Protection

The P14x relay includes four stages of underfrequency and two stages of overfrequency protection to facilitate load shedding and subsequent restoration. The underfrequency stages may be optionally blocked by a pole dead (CB Open) condition. All the stages may be enabled/disabled in the "**F<n Status**" or "**F>n Status**" cell depending on which element is selected.

The logic diagram for the underfrequency logic is as shown in the following *Underfrequency logic (single stage)* diagram - only a single stage is shown. The other three stages are identical in functionality.

If the frequency is below the setting and not blocked the DT timer is started. Blocking may come from the All_Poledead signal (selectively enabled for each stage) or the underfrequency timer block.

If the frequency cannot be determined, the function is also blocked.

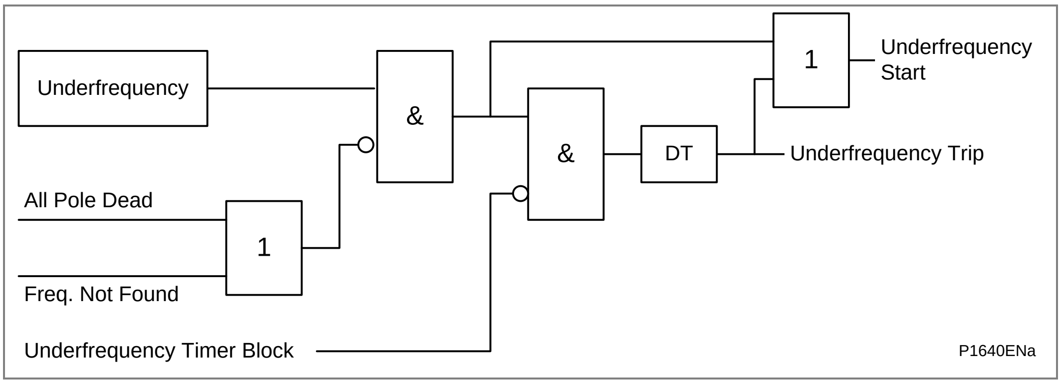


Figure 28 - Underfrequency logic (single stage)

The functional logic for the overfrequency function as shown in the *Overfrequency logic (single stage)* diagram. Only a single stage is shown as the other stages are functionally identical. If the frequency is above the setting and not blocked the DT timer is started and after this has timed out the trip is produced. Blocking may come from the All_Poledead signal (selectively enabled for each stage) or the overfrequency timer block.

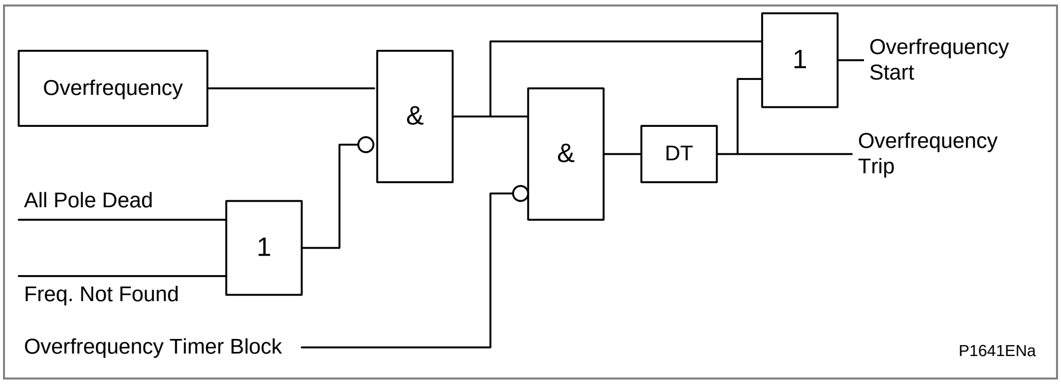


Figure 29 - Overfrequency logic (single stage)

When enabled, the following signals are set by the under/overfrequency logic according to the status of the monitored functions.

Summary	DDB	Description
Freq. Not Found	(DDB 411)	Frequency Not Found by the frequency tracking
F<1 Timer Block	(DDB 412)	Block Underfrequency Stage 1 Timer
F<2 Timer Block	(DDB 413)	Block Underfrequency Stage 2 Timer
F<3 Timer Block	(DDB 414)	Block Underfrequency Stage 3 Timer
F<4 Timer Block	(DDB 415)	Block Underfrequency Stage 4 Timer
F>1 Timer Block	(DDB 416)	Block Overfrequency Stage 1 Timer
F>2 Timer Block	(DDB 417)	Block Overfrequency Stage 2 Timer
F<1 Start	(DDB 418)	Underfrequency Stage 1 Start
F<2 Start	(DDB 419)	Underfrequency Stage 2 Start
F<3 Start	(DDB 420)	Underfrequency Stage 3 Start
F<4 Start	(DDB 421)	Underfrequency Stage 4 Start
F>1 Start	(DDB 422)	Overfrequency Stage 1 Start
F>2 Start	(DDB 423)	Overfrequency Stage 2 Start
F<1 Trip	(DDB 424)	Underfrequency Stage 1 Trip
F<2 Trip	(DDB 425)	Underfrequency Stage 2 Trip
F<3 Trip	(DDB 426)	Underfrequency Stage 3 Trip
F<4 Trip	(DDB 427)	Underfrequency Stage 4 Trip
F>1 Trip	(DDB 428)	Overfrequency Stage 1 Trip
F>2 Trip	(DDB 429)	Overfrequency Stage 2 Trip

1.20 Advanced Under/Over Frequency Protection

This feature is available only when advanced frequency protection option “**Adv. Freq. Prot’n**” is enabled in the configuration and “**Freq Protection**” is disabled.

The Feeder relay includes 9 stages of underfrequency and 9 stages of overfrequency protection to facilitate load shedding and subsequent restoration. The underfrequency stages may be optionally blocked by a pole dead (CB Open) condition. All the stages may be enabled/disabled in the "**F<n Status**" or "**F>n Status**" cell depending on which element is selected.

The logic diagram for the underfrequency logic is as shown in the following *Advanced underfrequency logic (single stage)* diagram. Only a single stage is shown. The other 8 stages are identical in functionality.

If the frequency is below the setting and not blocked the DT timer is started. Blocking may come from the All_Poledead signal (selectively enabled for each stage) or the underfrequency timer block.

If the frequency cannot be determined, the function is also blocked.

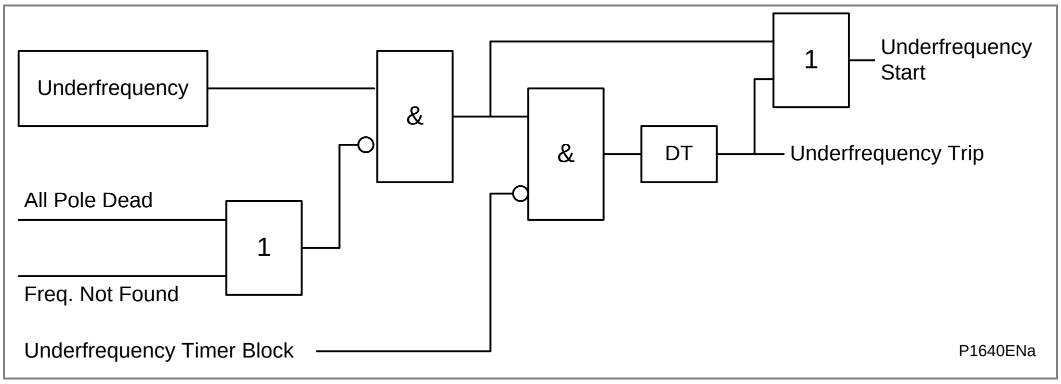


Figure 30 - Advanced underfrequency logic (single stage)

The functional logic diagram is for the overfrequency function as shown in the following *Advanced overfrequency logic (single stage)* diagram. Only a single stage is shown as the other stages are identical in functionality. If the frequency is above the setting and not blocked the DT timer is started and after this has timed out the trip is produced. Blocking may come from the All_Poledead signal (selectively enabled for each stage) or the overfrequency timer block.

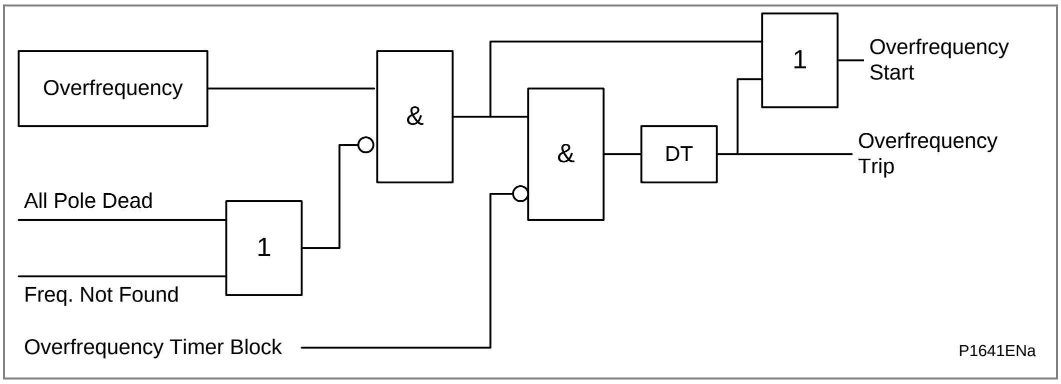


Figure 31 - Advanced overfrequency logic (single stage)

The P140 provides nine independent definite time delayed stages of frequency protection (f+t). Depending upon whether the threshold is set above or below the system nominal frequency, each stage can respond to either under or over frequency conditions. The relay will also indicate that an incorrect setting has been applied if the frequency threshold is set to the nominal system frequency. Although the elements are described as definite time delayed, by setting the time delay to zero, the element will operate instantaneously.

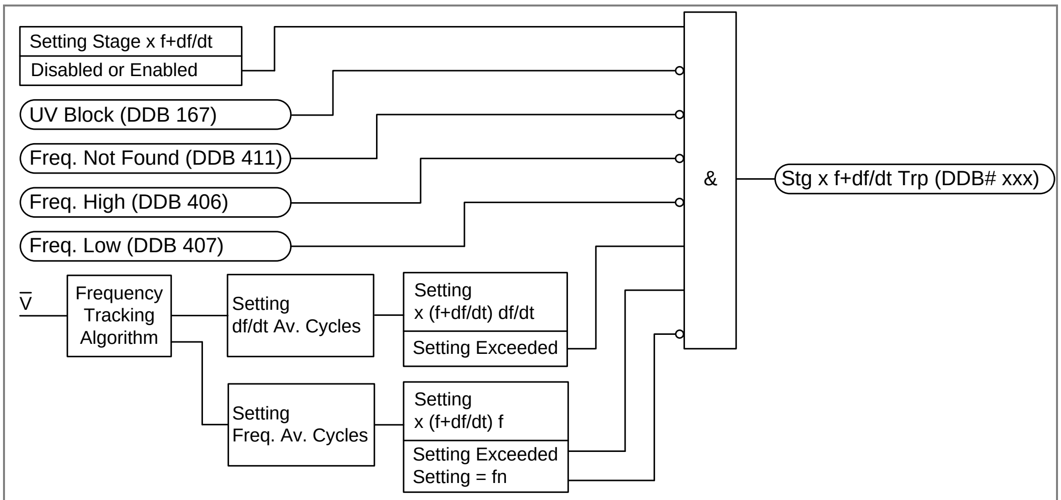
Within the Programmable Scheme Logic (PSL), signals are available to indicate the start and trip of each frequency stage (Starts: DDB 1281, DDB 1295, DDB 1309, DDB 1323, DDB 1337, DDB 1351, DDB 1365, DDB 1379 and DDB 1393; Trips: DDB 1282, DDB 1296, DDB 1310, DDB 1324, DDB 1338, DDB 1352, DDB 1366, DDB 1380 and DDB 1394). The state of the DDB signals can be programmed to be viewed in the "**Monitor Bit x**" cells of the "**COMMISSION TESTS**" column in the relay.

Note	*The "**Advanced Frequency Protection**" ported from P940 (firmware version 43) has IEC 61850 logical nodes only for df/dt. The frequency logical nodes (over and under frequency) remains as it is in P140 earlier (version 42). There is a 9 stage frequency protection in the Adv. Freq. prot ported from P940. However, as this is a non standard IEC 61850 logical node, the earlier available P140 feature for frequency protection shall be used for IEC 61850.*

1.21 Advanced Frequency Supervised Rate of Change of Frequency Protection 'f+df/dt' [81RF]

The P140 provides nine independent stages of frequency supervised rate of change of frequency protection (f+df/dt). Depending upon whether the frequency threshold is set above or below the system nominal frequency, each stage can respond to either rising or falling frequency conditions. For example, if the frequency threshold is set above nominal frequency, the df/dt setting is considered as positive and the element will operate for rising frequency conditions. If the frequency threshold is set below nominal frequency, the df/dt setting is considered as negative and the element will operate for falling frequency conditions. The relay will also indicate that an incorrect setting has been applied if the frequency threshold is set to the nominal system frequency. There is no intentional time delay associated with this element although using the Programmable Scheme Logic (PSL), time delays could be applied if required.

Within the PSL, signals are available to indicate the trip of each frequency supervised rate of change of frequency stage (DDB 1283, DDB 1297, DDB 1311, DDB 1325, DDB 1339, DDB 1353, DDB 1367, DDB 1381 and DDB 1395). The state of the DDB signals can be programmed to be viewed in the "**Monitor Bit x**" cells of the "**COMMISSION TESTS**" column in the relay.



Stage x f+df/dt	DDB# xxx Stg x f+df/dt Trp
Stage 1 f+df/dt	Stg 1 f+df/dt Trp (DDB 1283)
Stage 2 f+df/dt	Stg 2 f+df/dt Trp (DDB 1297)
Stage 3 f+df/dt	Stg 3 f+df/dt Trp (DDB 1311)
Stage 4 f+df/dt	Stg 4 f+df/dt Trp (DDB 1325)
Stage 5 f+df/dt	Stg 5 f+df/dt Trp (DDB 1339)
Stage 6 f+df/dt	Stg 6 f+df/dt Trp (DDB 1353)
Stage 7 f+df/dt	Stg 7 f+df/dt Trp (DDB 1367)
Stage 8 f+df/dt	Stg 8 f+df/dt Trp (DDB 1381)
Stage 9 f+df/dt	Stg 9 f+df/dt Trp (DDB 1395)

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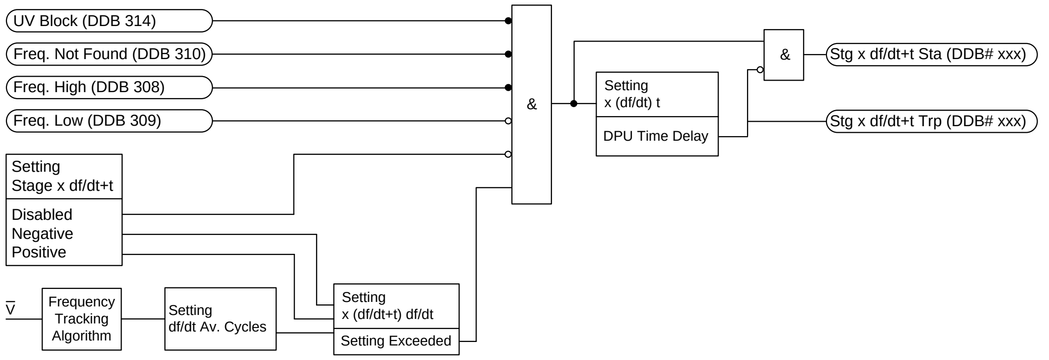
Figure 32 - Advanced frequency supervised rate of change of frequency logic (single stage shown)

1.22 Advanced Independent Rate of Change of Frequency Protection ‘df/dt+t’ [81R]

This feature is available only when advanced frequency protection option “**Adv. Freq. Prot’n**” is enabled in the configuration and “**df/dt Protection**” is disabled.

The P140 provides nine independent stages of rate of change of frequency protection (df/dt+t). The “**Stage X df/dt+t**” setting will define whether the stage is disabled, operates for rising frequency conditions (set to “**Positive”**) or operates for falling frequency conditions (set to “**Negative**”). The output of the element would normally be given a user-selectable time delay, although it is possible to set this to zero and create an instantaneous element.

Within the Programmable Scheme Logic (PSL), signals are available to indicate the start and trip of each rate of change of frequency stage. (Starts: DDB 1284, DDB 1298, DDB 1312, DDB 1326, DDB 1340, DDB 1354, DDB 1368, DDB 1382 & DDB 1396; Trips: DDB 1285, DDB 1299, DDB 1313, DDB 1327, DDB 1341, DDB 1355, DDB 1369, DDB 1383 & DDB 1397). The state of the DDB signals can be programmed to be viewed in the “**Monitor Bit x**” cells of the “**COMMISSION TESTS**” column in the relay.



Stage x df/dt+t	Stg x df/dt+t Sta	Stg x df/dt+t Trp
Stage 1 df/dt+t	Stg 1 df/dt+t Sta (DDB 148)	Stg 1 df/dt+t Trp (DDB 149)
Stage 2 df/dt+t	Stg 2 df/dt+t Sta (DDB 157)	Stg 2 df/dt+t Trp (DDB 158)
Stage 3 df/dt+t	Stg 3 df/dt+t Sta (DDB 166)	Stg 3 df/dt+t Trp (DDB 167)
Stage 4 df/dt+t	Stg 4 df/dt+t Sta (DDB 175)	Stg 4 df/dt+t Trp (DDB 176)
Stage 5 df/dt+t	Stg 5 df/dt+t Sta (DDB 184)	Stg 5 df/dt+t Trp (DDB 185)
Stage 6 df/dt+t	Stg 6 df/dt+t Sta (DDB 193)	Stg 6 df/dt+t Trp (DDB 194)

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Figure 33 - Advanced independent rate of change of frequency logic (single stage shown)

1.23 Advanced Average Rate of Change of Frequency Protection ‘f+Df/Dt’ [81RAV]

The rate of change of frequency elements described in earlier use an “**instantaneous**” measurement of “**df/dt**” based upon a 3 cycle, filtered “**rolling**” average technique. Due to the oscillatory nature of frequency excursions, this instantaneous value can sometimes be misleading, either causing unexpected operation or excessive stability. For this reason, the P140 relays also provide an element for monitoring the longer term frequency trend, thereby reducing the effects of non-linearities in the system and providing increased security to the rate of change of frequency decision.

Using the average rate of change of frequency element “**f+Df/Dt**”, when the measured frequency crosses the supervising frequency threshold a timer is initiated. At the end of this time period, Δt, the frequency difference, Δf, is evaluated and if this exceeds the setting, a trip output is given.

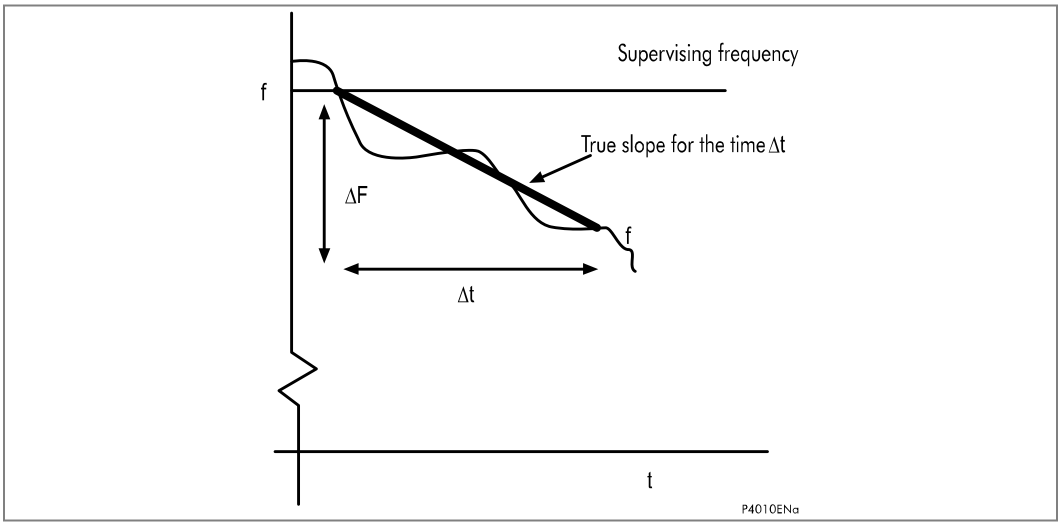
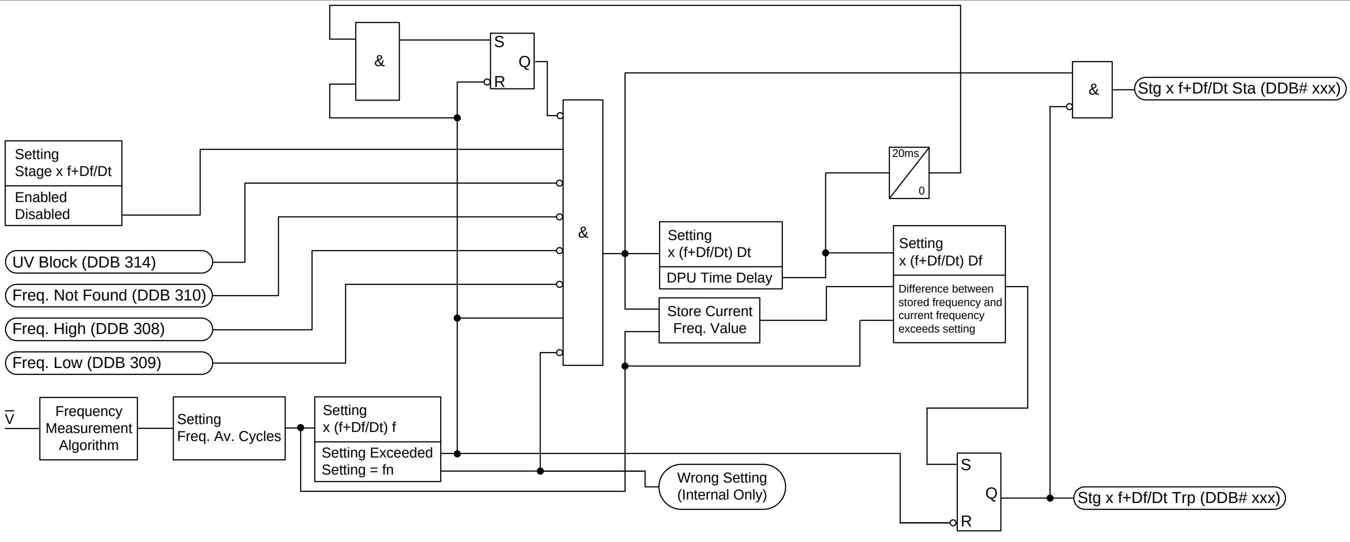


Figure 34 - Advanced average rate of change of frequency protection

After time Δt, regardless of the outcome of the comparison, the element is blocked from further operation until the frequency recovers to a value above the supervising frequency threshold (or below in the case where the element is configured for overfrequency operation). If the element has operated, the trip DDB signal will be on until the frequency recovers to a value above the supervising frequency threshold.

The P140 provides nine stages of average rate of change of frequency protection (f+Df/Dt). Depending upon whether the frequency threshold is set above or below the system nominal frequency, each stage can respond to either rising or falling frequency conditions. For example, if the frequency threshold is set above nominal frequency, the element will operate for rising frequency conditions. The average rate of change of frequency is then measured based upon the frequency difference, Df over the settable time period, Dt.

Within the Programmable Scheme Logic (PSL), signals are available to indicate the start and trip of each average rate of change of frequency stage. (Starts DDB 1286, DDB 1300, DDB 1314, DDB 1328, DDB 1342, DDB 1356, DDB 1370, DDB 1384 & DDB 1398; Trips: DDB 1287, DDB 1301, DDB 1315, DDB 1329, DDB 1343, DDB 1357, DDB 1371, DDB 1385 & DDB 1399). The state of the DDB signals can be programmed to be viewed in the “**Monitor Bit x**” cells of the “**COMMISSION TESTS**” column in the relay.



Stage x f+Df/Dt	Stg x f+Df/Dt Sta	Stg x f+Df/Dt Trp	Wrong Setting
Stage 1 f+Df/Dt	Stg 1 f+Df/Dt Sta (DDB 150)	Stg 1 f+Df/Dt Trp (DDB 151)	Wrong Setting 19 (DDB 290)
Stage 2 f+Df/Dt	Stg 2 f+Df/Dt Sta (DDB 159)	Stg 2 f+Df/Dt Trp (DDB 160)	Wrong Setting 20 (DDB 291)
Stage 3 f+Df/Dt	Stg 3 f+Df/Dt Sta (DDB 168)	Stg 3 f+Df/Dt Trp (DDB 169)	Wrong Setting 21 (DDB 292)
Stage 4 f+Df/Dt	Stg 4 f+Df/Dt Sta (DDB 177)	Stg 4 f+Df/Dt Trp (DDB 178)	Wrong Setting 22 (DDB 293)
Stage 5 f+Df/Dt	Stg 5 f+Df/Dt Sta (DDB 186)	Stg 5 f+Df/Dt Trp (DDB 187)	Wrong Setting 23 (DDB 294)
Stage 6 f+Df/Dt	Stg 6 f+Df/Dt Sta (DDB 195)	Stg 6 f+Df/Dt Trp (DDB 196)	Wrong Setting 24 (DDB 295)

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Figure 35 - Advanced average rate of change of frequency logic (single stage shown)

1.24 Advanced Load Restoration

The P140 uses the measurement of system frequency as its main criteria for load restoration. For each stage of restoration, it is necessary that the same stage of load shedding has occurred previously and that no elements within that stage are configured for overfrequency or rising frequency conditions. If load shedding has not occurred based upon the frequency protection elements, the load restoration for that stage is inactive.

Load restoration for a given stage begins when the system frequency rises above the "**RestoreX Freq.**" setting for that stage and the stage restoration timer "**RestoreX Time**" is initiated. If the system frequency remains above the frequency setting for the set time delay, load restoration of that stage will be triggered. Unfortunately, frequency recovery profiles are highly non-linear and it would be reasonably common for the system frequency to transiently fall below the restoration frequency threshold. If the restoration timer immediately reset whenever a frequency dip occurred, it is likely that load restoration would never be successful and for this reason a "**holding band**" is also implemented on the relay. The holding band is a region defined by the restoration frequency and the highest frequency setting used in the load shedding elements for that stage. The difference between these two settings must always be greater than 0.02Hz, otherwise a "**Wrong Setting**" alarm will be generated. Whenever the system frequency dips into the holding band, operation of the stage restoration timer is suspended until the frequency rises above the restoration frequency setting, at which point timing will continue. If the system frequency dip is sufficiently large to cause any frequency element to start or trip in this stage i.e. if the frequency falls below the lower limit of the holding band, the restoration timer will immediately be reset.

The following *Advanced load restoration with short deviation into holding band* diagram shows the operation of the load restoration facility and holding band.

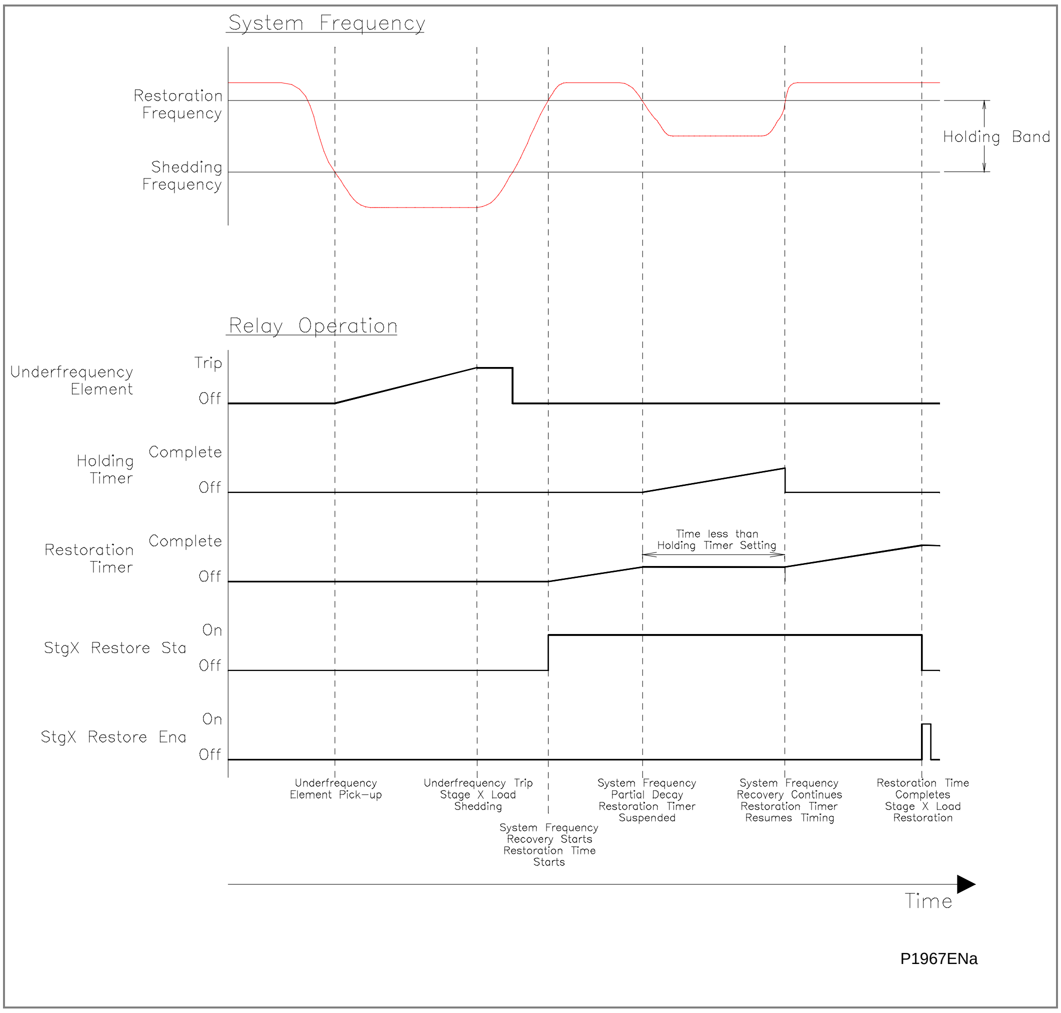


Figure 36 - Advanced load restoration with short deviation into holding band

If the system frequency remains in the holding band for too long it is likely that other system frequency problems are occurring and it would be prudent to reset the restoration timer for that stage. For this reason, as soon as the system frequency is measured to be within the holding band, the "**Holding Timer**" is initiated. If the system frequency doesn't leave the holding band before the holding timer setting has been exceeded, the load restoration time delay for that stage is immediately reset. It should be noted that the holding timer has a common setting for all stages of load restoration.

An example of the case when the time in the holding band is excessive is shown in the following *Advanced load restoration with long deviation into holding band* diagram.

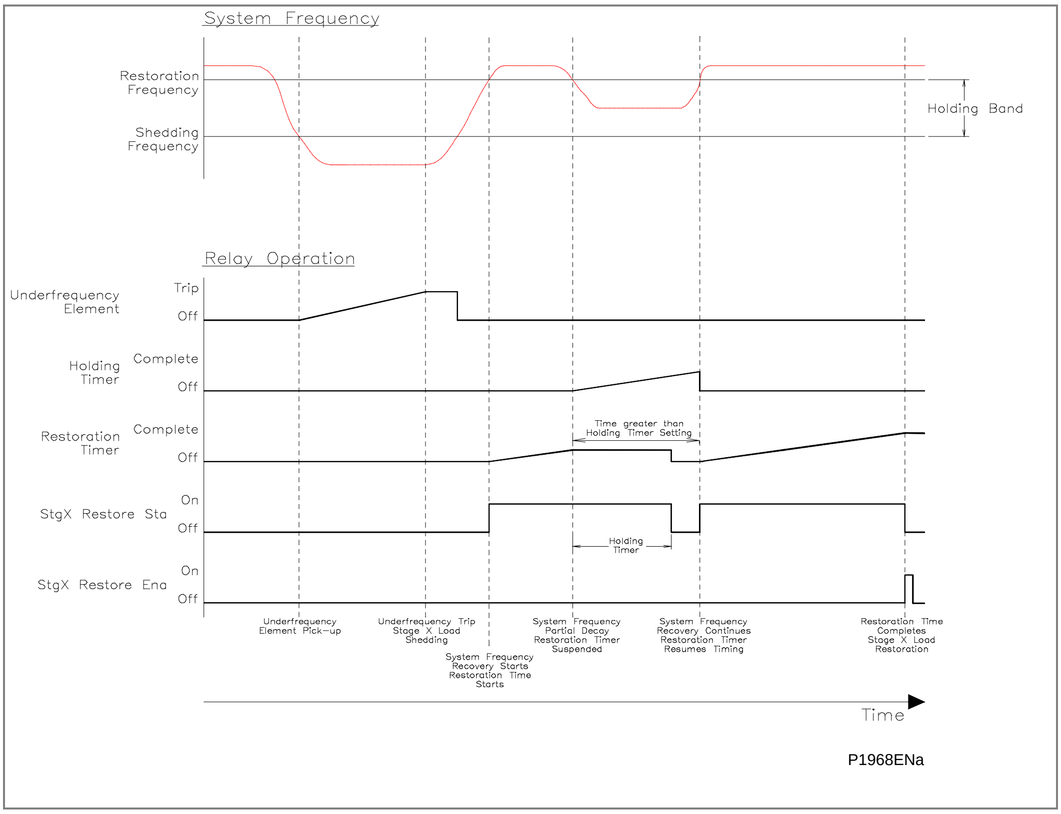
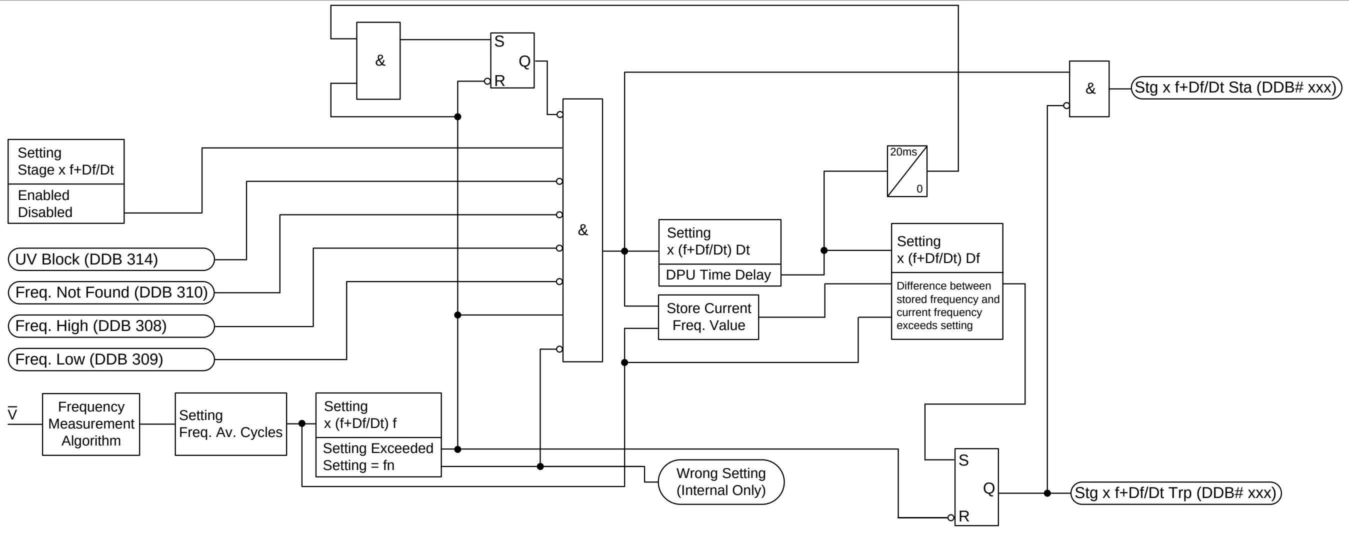


Figure 37 - Advanced load restoration with long deviation into holding band

The P140 provides up to nine stages of load restoration with individual restoration frequency and time delays. Each stage of load restoration can be enabled or disabled but operation is also linked to the number of load shedding stages that have been configured using the frequency protection elements. Within a stage, if any frequency protection element is set for overfrequency operation or has a positive rate of change of frequency setting, the load restoration for that stage is automatically inhibited and a wrong setting alarm will be raised. For example, if stage 5 frequency protection "**f+t**" was set above nominal frequency, it would not be possible to use the stage 5 load restoration facility, even if other stage 5 frequency protection elements were set for load shedding. This means that the number of load restoration stages is always less than or equal to the number of load shedding stages. In addition, the stage load restoration can only occur if that stage of load shedding has been tripped from any of the frequency protection elements. For example, for stage 5 load restoration to occur, a stage 5 frequency protection element must have previously operated to shed load. Although the load restoration on the P140 is based upon frequency measurement, it is possible to use the Programmable Scheme Logic (PSL) of the relay to interlock with other plant items.

Within the Programmable Scheme Logic (PSL), signals are available to indicate when the stage load restoration frequency has been reached (start) and when the restoration timer for that stage has completed thereby enabling a close command to be given (enable). (Starts: DDB 1291, DDB 1305, DDB 1319, DDB 1333, DDB 1347, DDB 1361, DDB 1375, DDB 1389, DDB 1403; Enable: DDB 1292, DDB 1306, DDB 1320, DDB 1334, DDB 1348, DDB 1362, DDB 1376, DDB 1390, DDB 1404. The state of the DDB signals can be programmed to be viewed in the "**Monitor Bit x**" cells of the "**COMMISSION TESTS**" column in the relay.



Stage x f+Df/Dt	Stg x f+Df/Dt Sta	Stg x f+Df/Dt Trp	Wrong Setting
Stage 1 f+Df/Dt	Stg 1 f+Df/Dt Sta (DDB 150)	Stg 1 f+Df/Dt Trp (DDB 151)	Wrong Setting 19 (DDB 290)
Stage 2 f+Df/Dt	Stg 2 f+Df/Dt Sta (DDB 159)	Stg 2 f+Df/Dt Trp (DDB 160)	Wrong Setting 20 (DDB 291)
Stage 3 f+Df/Dt	Stg 3 f+Df/Dt Sta (DDB 168)	Stg 3 f+Df/Dt Trp (DDB 169)	Wrong Setting 21 (DDB 292)
Stage 4 f+Df/Dt	Stg 4 f+Df/Dt Sta (DDB 177)	Stg 4 f+Df/Dt Trp (DDB 178)	Wrong Setting 22 (DDB 293)
Stage 5 f+Df/Dt	Stg 5 f+Df/Dt Sta (DDB 186)	Stg 5 f+Df/Dt Trp (DDB 187)	Wrong Setting 23 (DDB 294)
Stage 6 f+Df/Dt	Stg 6 f+Df/Dt Sta (DDB 195)	Stg 6 f+Df/Dt Trp (DDB 196)	Wrong Setting 24 (DDB 295)

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Figure 38 - Advanced load restoration logic

1.25 Cold Load Pick-Up (CLP) Logic

The Cold Load Pick-Up (CLP) logic included within the P14x relays serves to either inhibit one or more stages of the overcurrent protection for a set duration or, alternatively, to raise the settings of selected stages. This, therefore, allows the protection settings to be set closer to the load profile by automatically increasing them following circuit energization. The CLP logic thus provides stability, whilst maintaining protection during starting. Note that any of the overcurrent stages that have been disabled in the main relay menu will not appear in the CLP menu.

This function acts on these protection functions:

- Non-Directional/Directional phase overcurrent (all stages)
- Non-Directional/Directional earth fault - 1 (1st stage)
- Non-Directional/Directional earth fault - 2 (1st stage)

The functional logic diagram for the Cold Load Pick-up (CLP) function is shown in the following *Cold load pick-up logic* diagram, together with the example of its effect on phase A of the first stage overcurrent function. The principle of operation is identical for the 3-phase overcurrent function stages 1 to 6 and Earth Fault 1 Stage 1 and Earth Fault 2 Stage 1.

CLP operation occurs when the circuit breaker remains open for a time greater than tcold and is subsequently closed. CLP operation is applied after tcold and remains for a set time delay of tclp following closure of the circuit breaker. The status of the circuit breaker is provided either by means of the CB auxiliary contacts or by means of an external device via logic inputs. Whilst CLP operation is in force, the CLP settings are enabled for all the 3-phase overcurrent function stages 1 to 6 and associated time delayed elements, EF-1 function stage 1 and EF-2 stage 1. (Note that one setting option is the ability to disable (or block) a given overcurrent stage). After the time delay tclp has elapsed, the normal overcurrent settings are applied.

The impact of VCO is considered in the diagram since this function can also affect the 3 individual phase overcurrent settings for stages 1, 2 and 5.

In the quiescent state, the protection operates from the normal phase overcurrent and time delay settings. However, if a VCO undervoltage condition arises, the relay will operate from the normal settings multiplied by the VCO "**K**" factor. Where there is a simultaneous VCO undervoltage and CLP condition, the relay will operate from the normal settings multiplied by the VCO "**K**" factor. If the CLP condition prevails and the VCO function resets, the relay will operate using the CLP settings.

Time delayed elements are reset to zero if they are disabled during the transitions between normal settings and CLP settings.

It should be noted that in the event of a conflict between Selective Logic and CLP on the 3rd, 4th and 6th stages of the 3-phase overcurrent, EF and SEF protection functions, Selective Logic has greater priority.

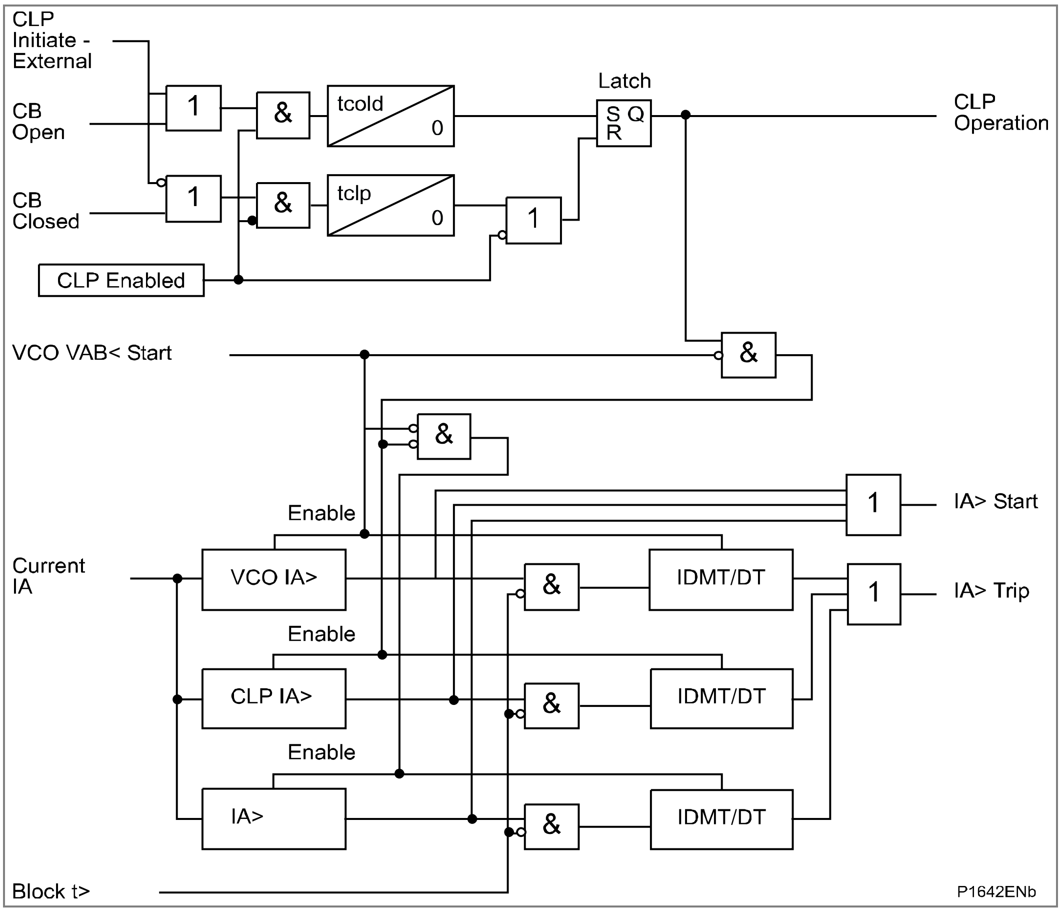


Figure 39 - Cold load pick-up logic

The normal settings will be applied to the directional phase overcurrent, standby earth fault and sensitive earth fault protection functions when the CLP element resets.

When enabled, the following signals are set by the CLP logic according to the status of the monitored function.

CLP Initiate	(DDB 226)	Initiate Cold load pick-up
CLP Operation	(DDB 347)	Indicates the Cold load pick-up logic is in operation

"**tcold**" and "**tclp**" are initiated via the CB open and CB closed signals generated within the relay. Connecting auxiliary contacts from the circuit breaker or starting device to the relay opto-inputs produces these signals. It is important to note that if both an open and closed contact are unavailable, the relay can be configured to be driven from either a single 52a, or 52b contact, as the relay will simply invert one signal to provide the other. This option is available in the "**CB control column**" in the "**CB status input**" cell and can be programmed as either "**None**", 52a, 52b or both 52a and 52b.

1.26 Selective Overcurrent Logic

The *Advanced Average Rate of Change of Frequency Protection 'f+Df/Dt' [81RAV]* section describes the use of non-cascade protection schemes that make use of start contacts from downstream relays connected to block operation of upstream relays. In the case of Selective Overcurrent Logic (SOL), the start contacts are used to raise the time delays of upstream relays, instead of blocking. This provides an alternative approach to achieving non-cascade types of overcurrent scheme. This may be more familiar to some utilities than the blocked overcurrent arrangement.

The SOL function provides the ability to temporarily increase the time delay settings of the third and fourth stages of phase overcurrent, derived and measured earth fault and sensitive earth fault protection elements. This logic is initiated by energization of the appropriate opto-isolated input.

To allow time for a start contact to initiate a change of setting, the time settings of the third and fourth stages should include a nominal delay.

This function acts upon the following protection functions:

- Non-Directional/Directional phase overcurrent (3rd and 4th stages)
- Non-Directional/Directional earth fault - 1 (3rd and 4th stages)
- Non-Directional/Directional earth fault - 2 (3rd and 4th stages)
- Non-Directional/Directional sensitive earth fault (3rd and 4th stages)

The logic diagram for the selective overcurrent function is shown for phase A of the third stage overcurrent function. The principle of operation is identical for the 3-phase phase overcurrent function stages 3 and 4, earth fault function -1 stages 3 and 4, earth fault function -2 stages 3 and 4 and the sensitive earth fault function stages 3 and 4.

When the selective logic function is enabled, the action of the blocking input is as follows:

1. No block applied

   In the event of a fault condition that continuously asserts the start output, the function will assert a trip signal after the normal time delay t>3 has elapsed.

2. Logic input block applied

   In the event of a fault condition that continuously asserts the start output, the function will assert a trip signal after the selective logic time delay t>3 sel has elapsed.

3. Auto-reclose input block applied

   In the event of a fault condition that continuously asserts the start output, when an auto-reclose block is applied the function will not trip. The auto-reclose block also overrides the logic input block and will block the t>3 sel timer.

   It is noted that the Auto-reclose function outputs two signals that block protection, namely; AR Block Maint. Protection and AR Block SEF Protection.

      AR Block Maint. Protection is common to the 3-phase overcurrent function stages 3 & 4, earth fault function -1 stages 3 & 4, and earth fault function -2 stages 3 & 4.

      AR Block SEF Protection is common to the sensitive earth fault function stages 3 & 4.

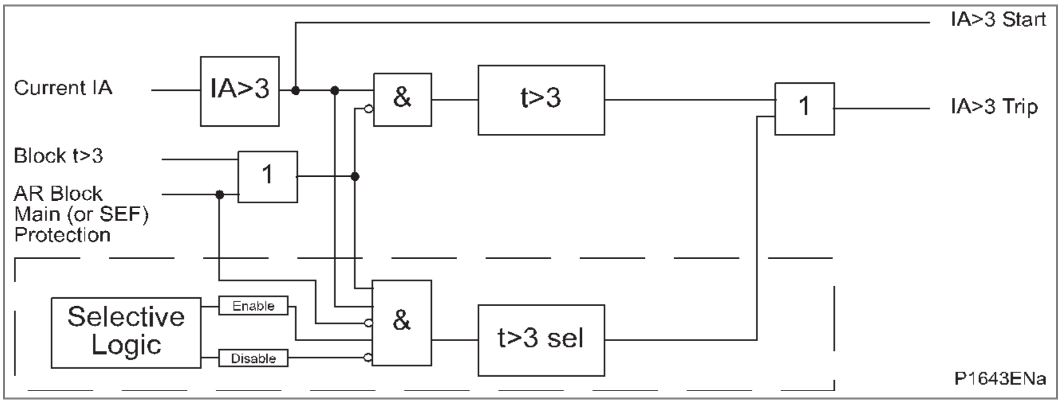


Figure 40 - Selective overcurrent logic

1.27 Blocked Overcurrent Scheme Logic

The P14x relay has start outputs available from each stage of the overcurrent and earth fault elements, including the sensitive earth fault element. These start signals may then be routed to output contacts by programming accordingly. Each stage is also capable of being blocked by being programmed to the relevant opto-isolated input.

To facilitate the implementation of a blocked overcurrent scheme the following logic is implemented to provide the "**I> Blocked O/C Start (DDB 348)**" signal.

The I> Blocked O/C Start is derived from the logical "**OR**" of the phase overcurrent start outputs.

The logical "**OR**" output is then gated with the signal BF Alarm (Block AR) and the setting {I> Start Blocked By CB Fail} as shown in the diagram below:

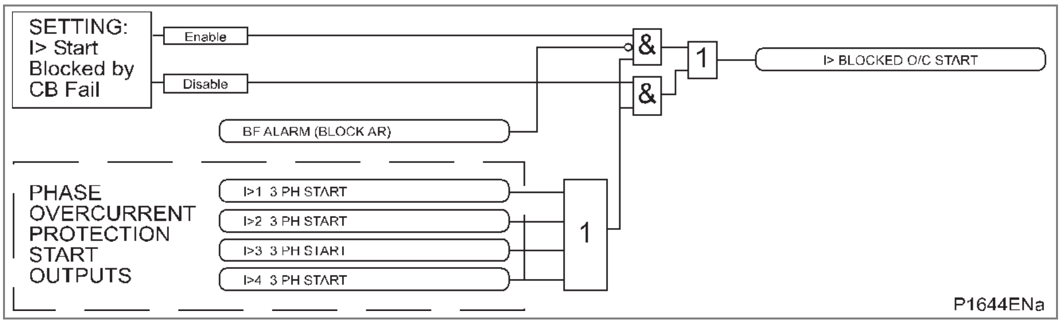


Figure 41 - Overcurrent blocked operation

For the earth fault and sensitive earth fault element, the following logic is implemented to provide the "**IN>/ISEF> Blocked O/C Start (DDB 349)**" signal.

The IN>/ISEF> Blocked O/C Start is derived from the logical "**OR**" of the earth fault and sensitive earth fault signals protection start outputs.

The logical "**OR**" output is then gated with the signal BF Alarm (Block AR) and the setting {IN>/ISEF> Start Blocked By CB Fail} as shown in the following *Earth fault blocked operation* diagram.

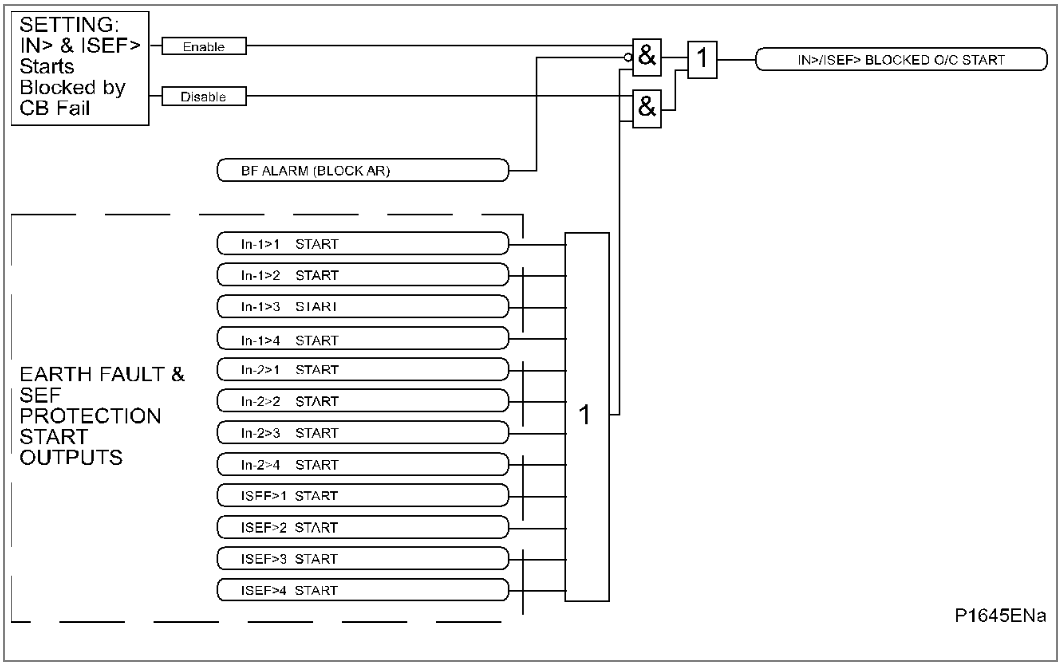


Figure 42 - Earth fault blocked operation

1.28 Neutral Admittance Protection

Neutral admittance protection is mandatory for the Polish market, deriving its neutral current input from either the E/F CT or the SEF CT by means of a setting. The neutral voltage is based on the internally derived quantity VN.

Three single stage elements are provided:

- Overadmittance YN> that is non-directional, providing both start and time delayed trip outputs. The trip may be blocked by a logic input
- Overconductance GN> that is non-directional/directional, providing both start and time delayed trip outputs. The trip may be blocked by a logic input
- Oversusceptance BN> that is non-directional/directional, providing both start and time delayed trip outputs. The trip may be blocked by a logic input

The overadmittance elements YN>, GN> and BN> will operate providing the neutral voltage remains above the set level for the set operating time of the element. They are blocked by operation of the fast VTS supervision output.

The overadmittance elements provide measurements of admittance, conductance and susceptance that also appear in the fault record, providing the protection is enabled.

The overadmittance elements are capable of initiating auto-reclose, similarly to the earth fault protection, by means of YN>, GN> and BN> settings in the AUTO-RECLOSE menu column.

1.28.1 Operation of Admittance Protection

The admittance protection is non-directional. Hence, provided the magnitude of admittance exceeds the set value YN> Set and the magnitude of neutral voltage exceeds the set value VN Threshold, the relay will operate.

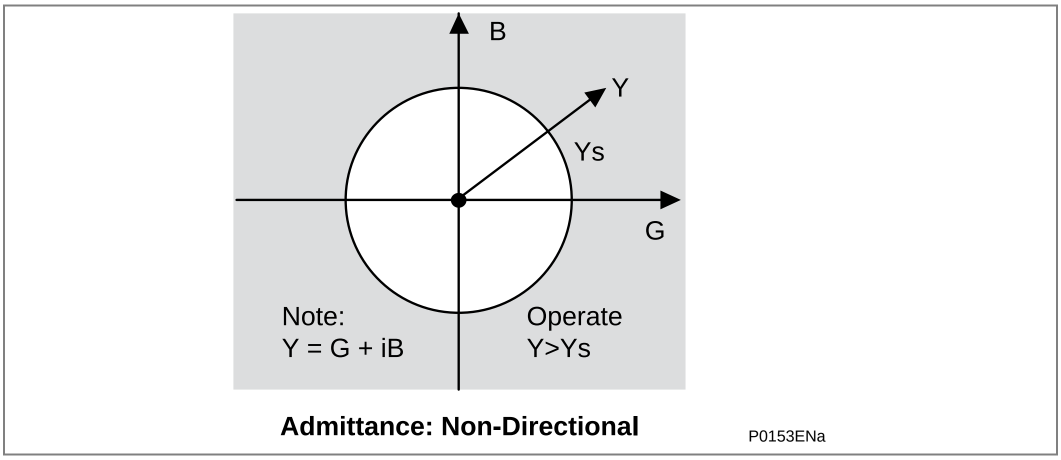


Figure 43 - Non-directional admittance

1.28.2 Operation of Conductance Protection

The conductance protection may be set non-directional, directional forward or directional reverse. Hence, provided the magnitude and the directional criteria are met for conductance and the magnitude of neutral voltage exceeds the set value VN Threshold, the relay will operate. The correction angle causes rotation of the directional boundary for conductance through the set correction angle.

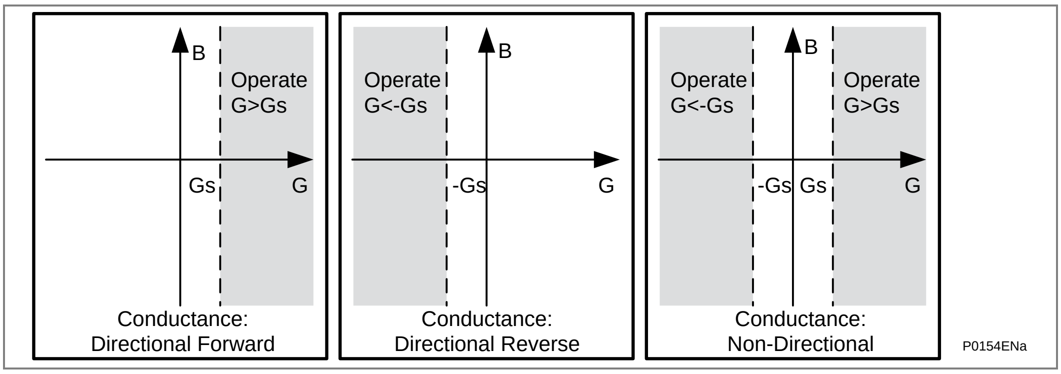


Figure 44 - Operation of Conductance Protection

Note the following:

Forward operation: Center of characteristic occurs when IN is in phase with VN.

If the correction angle is set to +30°, this rotates the boundary from 90° - 270° to 60° - 240°. It is assumed that the direction of the G axis indicates 0°.

1.28.3 Operation of Susceptance Protection

The susceptance protection may be set non-directional, directional forward or directional reverse. Hence, provided the magnitude and the directional criteria are met for susceptance and the magnitude of neutral voltage exceeds the set value VN Threshold, the relay will operate. The correction angle causes rotation of the directional boundary for susceptance through the set correction angle.

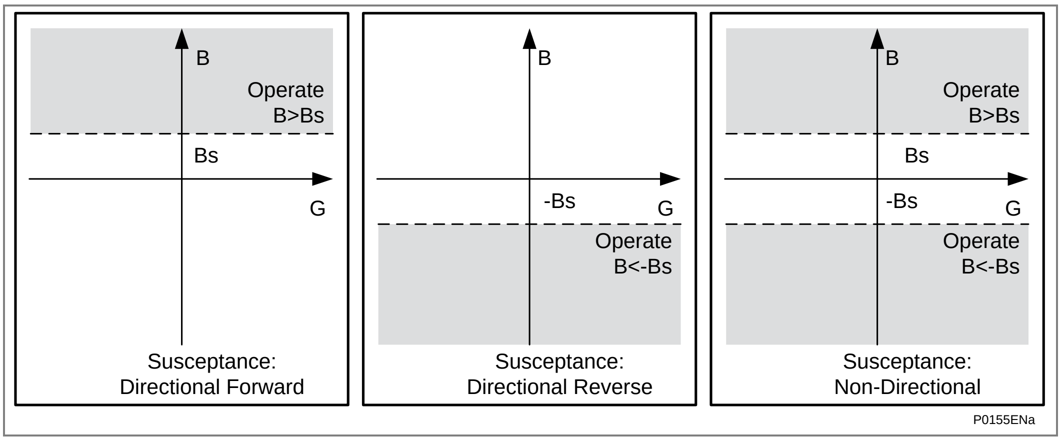


Figure 45 - Operation of Susceptance Protection

Note the following:

Forward operation: Center of characteristic occurs when IN leads VN by 90°.

If the correction angle is set to +30°, this rotates the boundary from 0° - 180° to 330° - 150°. It is assumed that the direction of the G axis indicates 0°.

1.29 2nd Harmonic Blocking

The 2nd Harmonic Blocking detects high inrush current flows that occur when transformers or machines are connected. The function will then block the following functions:

- Phase overcurrent stages 1,2,3,4,5,6 (selectable cross block/phase segregated block) - See Note *
- Earth Fault measured stages 1,2,3,4 cross block only
- Earth Fault derived stages 1,2,3,4 cross block only
- Sensitive Earth Fault stages 1,2,3,4 cross block only

*Note * The cross block/phase segregated block shall apply to all 6 stages for Phase overcurrent*

The 2nd Harmonic Blocking function identifies an inrush current by evaluating the ratio of the second harmonic current components to the fundamental wave. If this ratio exceeds the set thresholds, then the inrush stabilization function operates. Another settable current trigger blocks **(I> lift 2H)** 2nd Harmonic Blocking, if the current exceeds this trigger. By selecting the I> Blocking operating mode, the user determines whether 2nd Harmonic Blocking will operate phase selectively or across all phases.

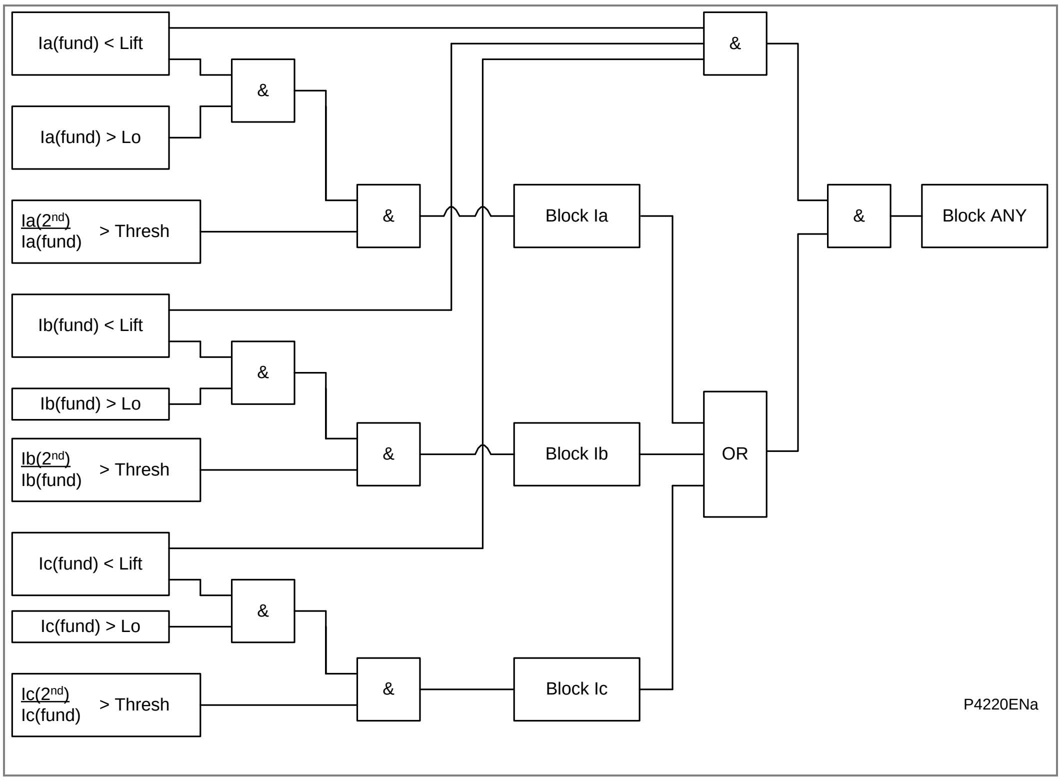


Figure 46 - 2nd Harmonic blocking

1.30 InterMiCOM Teleprotection

1.30.1 Introduction

The InterMiCOM application is an effective replacement to the traditional hardwired logic scheme presently used by the P140 range protection relays when applied in 2-relay blocking, direct or permissive type scheme applications.

8 binary input DDB signals and 8 binary output DDB signals, which may be mapped in PSL, are provided at each relay end and the InterMiCOM application provides a means of transferring data between two protection relays using a dedicated full-duplex communications channel.

It is possible to customize the individual signals for blocking, permissive or direct tripping applications which have different requirements for security, speed and dependability.

The loss of communications for a time greater than a set frame synchronization period will cause the signals to fall back to previous or set default values.

Communications statistics and a loopback mode are available for commissioning purposes.

1.30.2 Definition of Teleprotection Commands

The decision to send a command is made by a local protective relay operation, and three generic types of InterMiCOM signal are available:

<u>Intertripping</u> In intertripping (direct or transfer tripping applications), the command is not supervised at the receiving end by any protection relay and simply causes CB operation. Since no checking of the received signal by another protection device is performed, it is absolutely essential that any noise on the signaling channel isn't seen as being a valid signal. In other words, an intertripping channel must be very secure.

<u>Permissive</u> In permissive applications, tripping is only permitted when the command coincides with a protection operation at the receiving end. Since this applies a second, independent check before tripping, the signaling channel for permissive schemes do not have to be as secure as for intertripping channels.

<u>Blocking</u> In blocking applications, tripping is only permitted when no signal is received but a protection operation has occurred. In other words, when a command is transmitted, the receiving end device is blocked from operating even if a protection operation occurs. Since the signal is used to prevent tripping, it is imperative that a signal is received whenever possible and as quickly as possible. In other words, a blocking channel must be fast and dependable.

The requirements for the three channel types are shown in the *Pictorial comparison of operating modes* diagram. This diagram shows that a blocking signal should be fast and dependable; a direct intertrip signal should be very secure and a permissive signal is an intermediate compromise of speed, security and dependability. In MODEM applications, all three modes can be applied to selected signaling bits within each message.

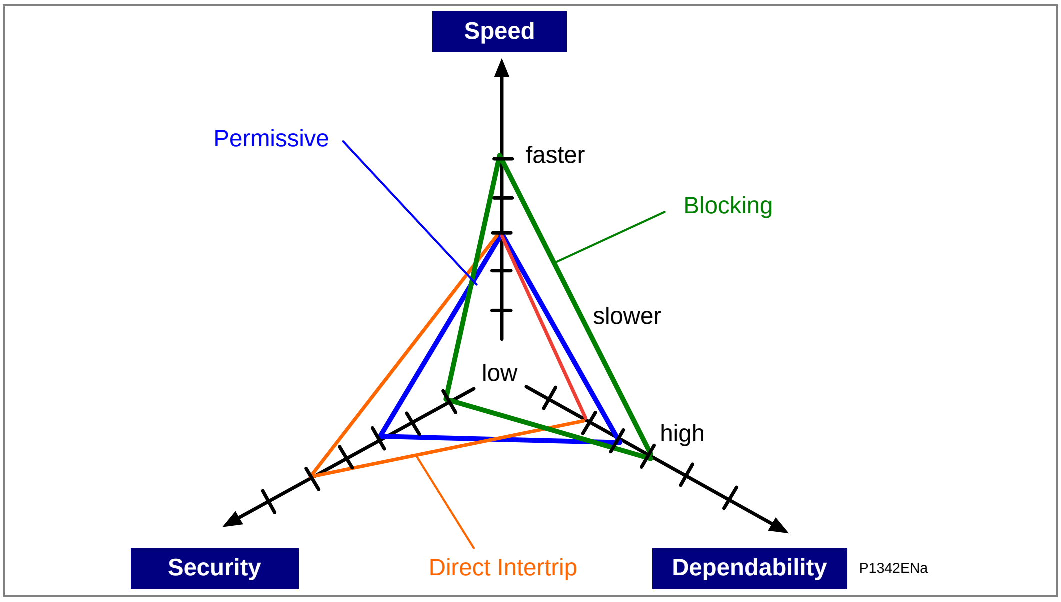


Figure 47 - Pictorial comparison of operating modes

1.31 EIA(RS)232 InterMiCOM

1.31.1 Communications Media

InterMiCOM can transfer up to eight commands over one communication channel. Due to recent expansions in communication networks, most signaling channels are now digital schemes using multiplexed fiber optics. For this reason, InterMiCOM provides a standard EIA(RS)232 output using digital signaling techniques. This digital signal can be converted using suitable devices to any communications media as required. The EIA(RS)232 output may alternatively be connected to a MODEM link.

Regardless of whether analogue or digital systems are being used, all the requirements of teleprotection commands are governed by an international standard IEC60834-1:1999 and InterMiCOM is compliant with the essential requirements of this standard. This standard governs the speed requirements of the commands as well as the probability of unwanted commands being received (security) and the probability of missing commands (dependability).

1.31.2 General Features and Implementation

InterMiCOM provides eight commands over a single communications link, with the mode of operation of each command being individually selectable within the **IM# Cmd Type** cell. **Blocking** mode provides the fastest signaling speed (available on commands 1 - 4), **Direct Intertrip** mode provides the most secure signaling (available on commands 1 - 8) and **Permissive** mode provides the most dependable signaling (available on commands 5 - 8). Each command can also be disabled so that it has no effect in the logic of the relay.

Since many applications will involve the commands being sent over a multiplexed communications channel, it is necessary to ensure that only data from the correct relay is used. Both relays in the scheme must be programmed with a unique pair of addresses that correspond with each other in the **Source Address** and **Receive Address** cells. For example, at the local end relay if we set the **Source Address** to 1, the **Receive Address** at the remote end relay must also be set to 1. Similarly, if the remote end relay has a **Source Address** set to 2, the **Receive Address** at the local end must also be set to 2. All four addresses must not be set identical in any given relay scheme if the possibility of incorrect signaling is to be avoided.

Noise in the communications channel should not be interpreted as valid messages by the relay. For this reason, InterMiCOM uses a combination of unique pair addressing described above, basic signal format checking and for **Direct Intertrip** commands an 8-bit Cyclic Redundancy Check (CRC) is also performed. This CRC calculation is performed at both the sending and receiving end relay for each message and then compared in order to maximize the security of the **Direct Intertrip** commands.

Most of the time the communications will perform adequately and the presence of the various checking algorithms in the message structure will ensure that InterMiCOM signals are processed correctly. However, careful consideration is also required for the periods of extreme noise pollution or the unlikely situation of total communications failure and how the relay should react.

During periods of extreme noise, it is possible that the synchronization of the message structure will be lost and it may become impossible to decode the full message accurately. During this noisy period, the last good command can be maintained until a new valid message is received by setting the “**IM# FallBackMode**” cell to “**Latched**”. Alternatively, if the synchronization is lost for a period of time, a known fallback state can be assigned to the command by setting the “**IM# FallBackMode**” cell to “**Default**”. In this latter case, the time period will need to be set in the “**IM# FrameSynTim**” cell and the default value will need to be set in “**IM# DefaultValue**” cell. As soon as a full valid message is seen by the relay all the timer periods are reset and the new valid command states are used. An alarm is provided if the noise on the channel becomes excessive.

If there is a total communications failure, the relay will use the fallback (failsafe) strategy as described above. Total failure of the channel is considered when no message data is received for four power system cycles or if there is a loss of the DCD line.

1.31.3 EIA(RS)232 Physical Connections

InterMiCOM on the Px40 relays is implemented using a 9-pin '**D**' type female connector (labeled SK5) located at the bottom of the 2nd Rear communication board. This connector on the Px40 relay is wired in DTE (Data Terminating Equipment) mode, as shown in the *EIA(RS)232 Physical Connections* table:

Pin	Acronym	InterMiCOM Usage
1	DCD	"Data Carrier Detect" is only used when connecting to modems otherwise this should be tied high by connecting to terminal 4.
2	RxD	"Receive Data"
3	TxD	"Transmit Data"
4	DTR	"Data Terminal Ready" is permanently tied high by the hardware since InterMiCOM requires a permanently open communication channel.
5	GND	"Signal Ground"
6	Not used	-
7	RTS	"Ready To Send" is permanently tied high by the hardware since InterMiCOM requires a permanently open communication channel.
8	Not used	-
9	Not used	-

Table 6 - EIA(RS)232 Physical Connections

Depending upon whether a direct or modem connection between the two relays in the scheme is being used, the required pin connections are described below.

1.31.4 Direct Connection

The EIA(RS)232 protocol only allows for short transmission distances due to the signaling levels used and therefore the connection shown below is limited to less than 15m. However, this may be extended by introducing suitable EIA(RS)232 to fiber optic converters, such as the Schneider Electric CILI203. Depending upon the type of converter and fiber used, direct communication over a few kilometers can easily be achieved.

This type of connection should also be used when connecting to multiplexers that have no ability to control the DCD line.

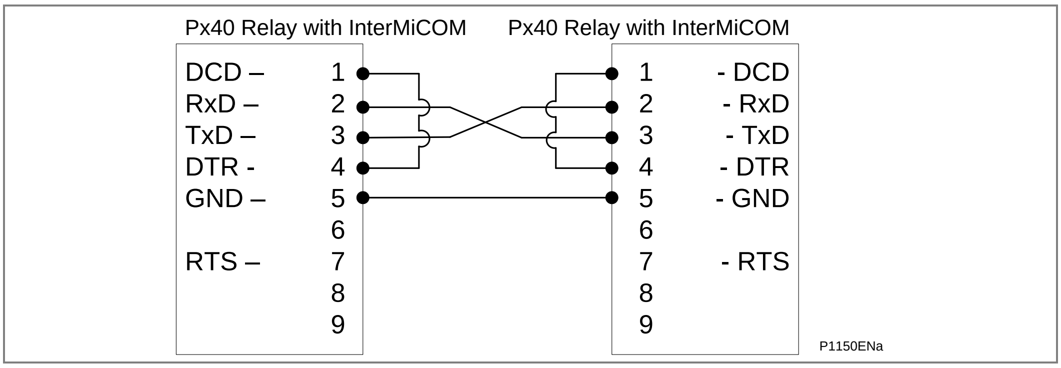


Figure 48 - Direct connection within the local substation

1.31.5 Modem Connection

For long distance communication, modems may be used in which the case the following connections should be made.

This type of connection should also be used when connecting to multiplexers that have the ability to control the DCD line. With this type of connection it should be noted that the maximum distance between the Px40 relay and the modem should be 15m, and that a baud rate suitable for the communications path used should be selected.

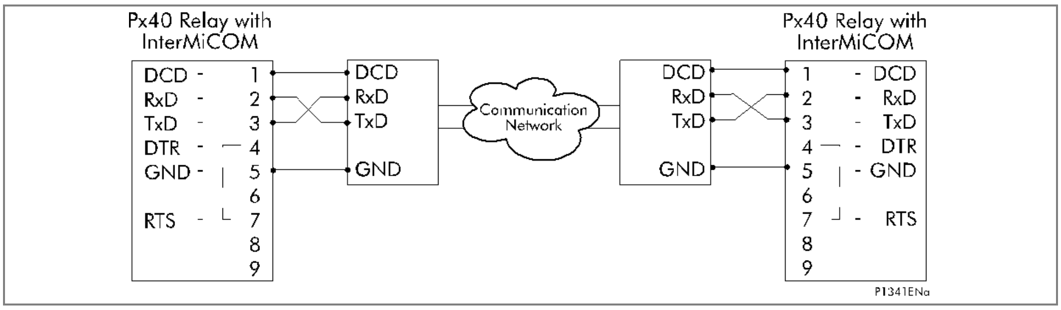


Figure 49 - InterMiCOM teleprotection via a MODEM link

1.31.6 RS422 Connection

RS232 to RS422 converter such as Schneider Electric CK212 may also be used for a longer distance application; it can be formed as shown in the *InterMiCOM teleprotection via a RS422 protocol* diagram:

With this type of connection, the maximum distance between the Px40 relay and the converter should be 15m.

Up to 1.2km length can be achieved with this type of protocol, depending on the converter performance.

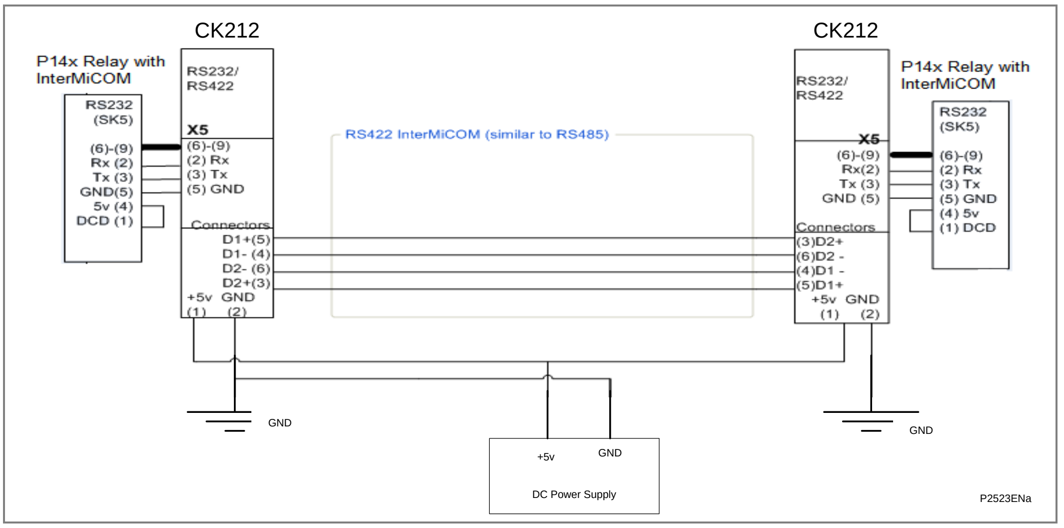


Figure 50 - InterMiCOM teleprotection via a RS422 protocol

1.31.7 Fiber Optic Connection

For long distance communication, a fiber optic converter may be used connected as shown in the *InterMiCOM teleprotection via fiber optic* diagram.

With this type of connection, the maximum distance between the Px40 relay and the converter should be 15m.

The length that can be achieved is depending on the converter performance.

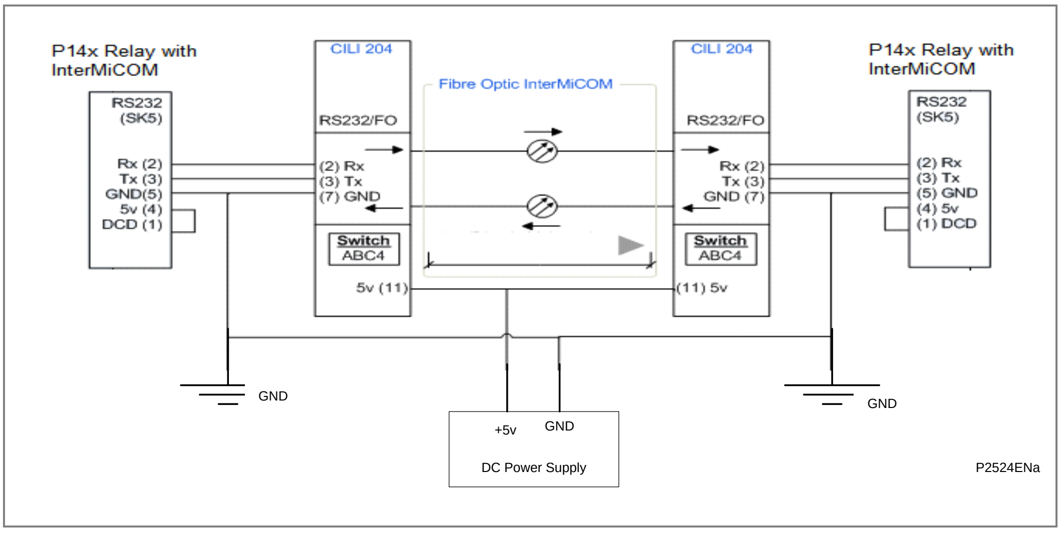


Figure 51 - InterMiCOM teleprotection via fiber optic

1.31.8 Functional Assignment

Even though settings are made on the relay to control the mode of the intertrip signals, it is necessary to assign InterMiCOM input and output signals in the relay Programmable Scheme Logic (PSL) if InterMiCOM is to be successfully implemented. Two icons are provided on the PSL editor of MiCOM S1 for "**Integral tripping In**" and "**Integral tripping out**" which can be used to assign the 8 intertripping commands. The example shown in the *Example assignment of signals within the PSL* diagram shows a "**Control Input_1**" connected to the "**Intertrip O/P1**" signal which would then be transmitted to the remote end. At the remote end, the "**Intertrip I/P1**" signal could then be assigned within the PSL. In this example, we can see that when intertrip signal 1 is received from the remote relay, the local end relay would operate an output contact, R1.

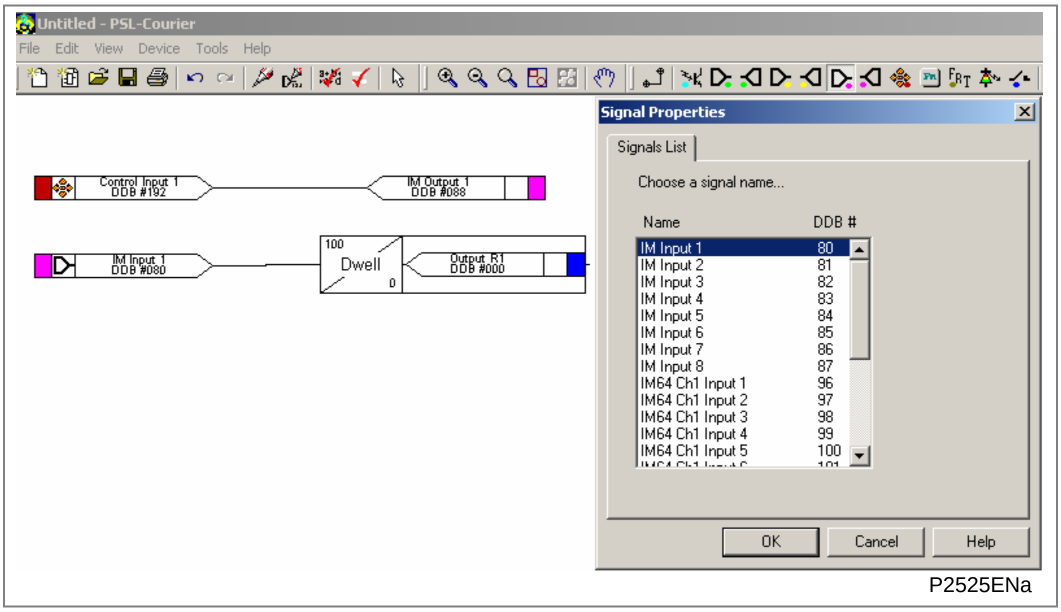


Figure 52 - Example assignment of signals within the PSL

It should be noted that when an InterMiCOM signal is sent from the local relay, only the remote end relay will react to this command. The local end relay will only react to InterMiCOM commands initiated at the remote end. InterMiCOM is thus suitable for teleprotection schemes requiring Duplex signaling.

1.32 InterMiCOM Statistics and Diagnostics

It is possible to hide the channel diagnostics and statistics from view by setting the "**Ch Statistics**" and/or "**Ch Diagnostics**" cells to "**Invisible**". All channel statistics are reset when the relay is powered up, or by user selection using the "**Reset Statistics**" cell.

1.33 Sensitive Power Protection

Two stages of sensitive power protection are provided, these can be independently selected as reverse power, over power, low forward power or disabled, and operation in each mode is described in the following sections.

It is assumed that when the sensitive power function is used, the SEF CT is connected to Phase A current therefore the measured power is ISEF x VA.

1.33.1 A Phase Sensitive Power Calculation

Input Quantities:

Sensitive power will be calculated from VA Ph-N voltage and I sensitive current input (which is assumed to be connected to phase A).

The calculation for active power with the correction angle is shown in the equation below, where VA is A-phase voltage, IAS is A-phase sensitive current, ϕ is the angle of IAS with respect to VA and θC is the CT correction angle.

Equation 2:

$$P(Aph.) = I_{AS} V_A \cos(\phi - \theta_C)$$

Calculations within the relay are based upon quadrature components obtained from the Fourier analysis of the input signals. The quadrature values for VA and IAS available from the ADB will be used for the sensitive power calculation as shown:

$\bar{V}_A = V_{AR} + jV_{Ai}$

$\bar{I}_{AS} = I_{ASr} + jI_{ASi}$

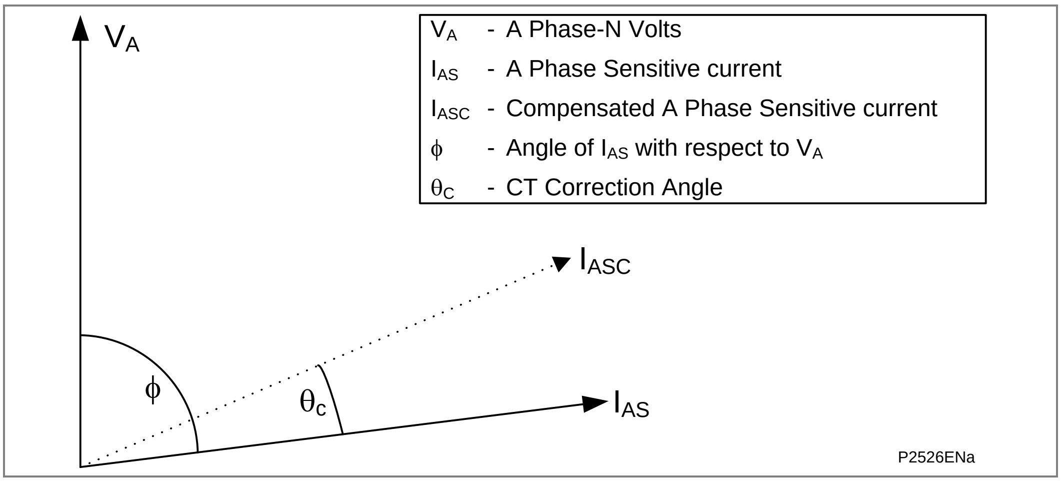


Figure 53 - Sensitive power input vectors

CT Correction:

The CT correction will rotate the I_{AS} vector by the correction angle, as shown in the *Sensitive power input vectors* diagram. This correction is performed before the power calculation and can be achieved with the use of a rotation matrix.

$$\bar{I}_{AS} = \begin{bmatrix} I_{ASr} \\ I_{ASi} \end{bmatrix}$$

Using rotation matrix - $\begin{bmatrix} \cos\theta_C & -\sin\theta_C \\ \sin\theta_C & \cos\theta_C \end{bmatrix}$

The corrected phase A sensitive current I_{ASC} is calculated as follows:

$$\bar{I}_{ASC} = \begin{bmatrix} I_{ASCr} \\ I_{ASCi} \end{bmatrix} = \begin{bmatrix} I_{ASr} \\ I_{ASi} \end{bmatrix} \begin{bmatrix} \cos\theta_C & -\sin\theta_C \\ \sin\theta_C & \cos\theta_C \end{bmatrix}$$

$$= \begin{bmatrix} I_{ASr} \cos\theta_C - I_{ASi} \sin\theta_C \\ I_{ASr} \sin\theta_C + I_{ASi} \cos\theta_C \end{bmatrix}$$

Therefore:

Equation 3:

$$I_{ASCr} = I_{ASr} \cos\theta_C - I_{ASi} \sin\theta_C$$

And

Equation 4:

$$I_{ASCi} = I_{ASr} \sin\theta_C + I_{ASi} \cos\theta_C$$

The $\sin\theta_c$ and $\cos\theta_c$ values will be stored and only calculated when the compensation angle setting is changed. The stored values can then be used to calculate I_{ASC} and I_{ASC}.

Active Power Calculation:

The corrected A-phase sensitive current vector can now be used to calculate the sensitive A-Phase active power P_{AS}.

Using the equation: $P_{AS} = \mathrm{Re}\,\overline{V}_A \overline{I}^*_{ASC}$

Therefore:

$$P_{AS} = \mathrm{Re}\left((V_{Ar} + jV_{Ai})(I_{ASCr} + jI_{ASCi})^*\right)$$

$$P_{AS} = \mathrm{Re}\left((V_{Ar} + jV_{Ai})(I_{ASCr} - jI_{ASCi})\right)$$

Equation 5:

$$P_{AS} = \mathrm{Re}\left((V_{Ar} I_{ASCr} + V_{Ai} I_{ASCi}) + j(V_{Ai} I_{ASCr} - V_{Ar} I_{ASCi})\right)$$

$$P_{AS} = V_{Ar} I_{ASCr} + V_{Ai} I_{ASCi}$$

1.33.2 Sensitive Power Measurements

Three sensitive power related measurements are added to the Measurements column, the visibility of which will depend on the protection configuration.

- A-Phase Sensitive Active Power (Watts)
- A-Phase Sensitive Re-active Power (VArs)
- A-Phase Sensitive Power Angle

1.34 Phase Segregated Power Protection

The power protection element provides 2 stages of directional underpower and 2 stages of directional overpower for both active and reactive power. The directional element shall be configurable as forward or reverse to set 3 phase and single phase trip.

The basis of operation is that the elements use three phase power/single phase power, based on Fourier measurement, as the energising quantity. For overpower, a start condition occurs when two consecutive measurements exceed the setting threshold in the absence of an inhibit condition from VTS slow block and pole dead (if selected). A trip condition occurs if the start condition is present for the set trip time.

The start (and trip if operated) and the trip timer shall reset if the power falls below the drop-off level or if an inhibit condition occurs. The reset mechanism shall be similar to the overcurrent functionality for a pecking fault condition, where the amount of travel for the operate timer is memorised for a set reset time delay. If the start condition returns before the reset timer has timed out, the operate time initialises from the memorised travel value. Otherwise the memorised value is reset to zero after the reset time times out.

For underpower, the operation occurs when the energising quantity goes below setting.

The logic diagram for any phase (or for the three phase) is shown in the *Under/Over Power Protection Stage* diagram:

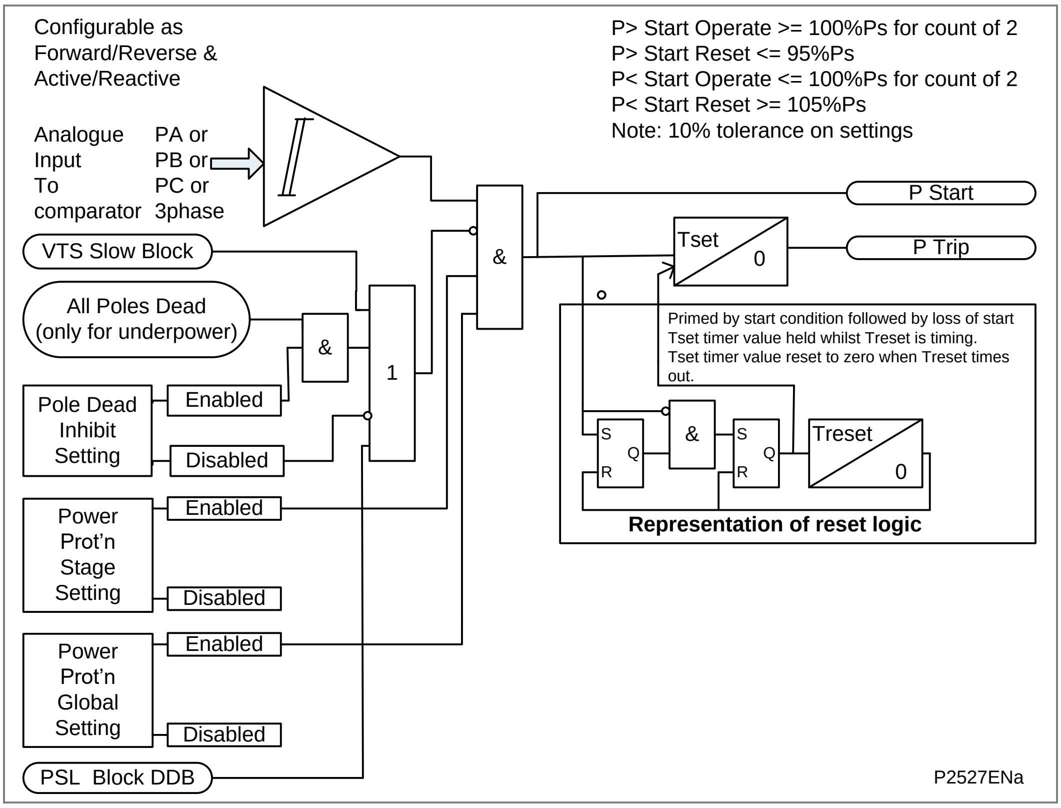


Figure 54 - Under/Over Power Protection Stage

The overall functionality of the power protection is summarised as follows:

Starting:	The Start DDB will be raised if the power is above setting (100%) and drops off at 95% of setting.
Tripping:	The Trip DDB will be raised if the Start DDB is on for more than the TimeDelay setting (Trip Timer timeout).
	The Trip will reset when the Start is reset.
tRESET:	The Trip Timer will get reset if the Start is off for more than the tRESET setting.
Blocking:	VTS: VTS Slow Block is hardcoded into the protection and will block the start condition provided no trip condition is present.
Poledead:	If (DDB_ALL_POLEDEAD) is on and the Poledead is set, the protection will be reset and blocked.
PSL:	If the PSL block DDB is on, the protection will be reset and blocked.

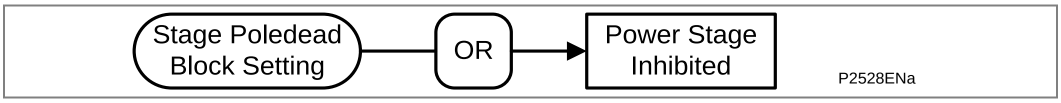


Figure 55 - Stage Poledead Block Settings or Power Stage Inhibited

1.35 Rate of Change of Voltage (dv/dt) Protection

Instantaneous dv/dt:

- The P14x samples the 3 voltages (ph-N) 24 samples per cycle and the frequency tracking secure that sampling by tracking on a certain channel frequency. Every PCON (every 12 samples in P14x) the sampling buffer (24 samples length) get updated with last new 12 samples therefore the Fourier fundamental magnitude will be updated. The Instant dv/dt will then be based on the VoltageNow - VoltageLastCycle (stored in a length of 2 buffer) as shown in this graph:

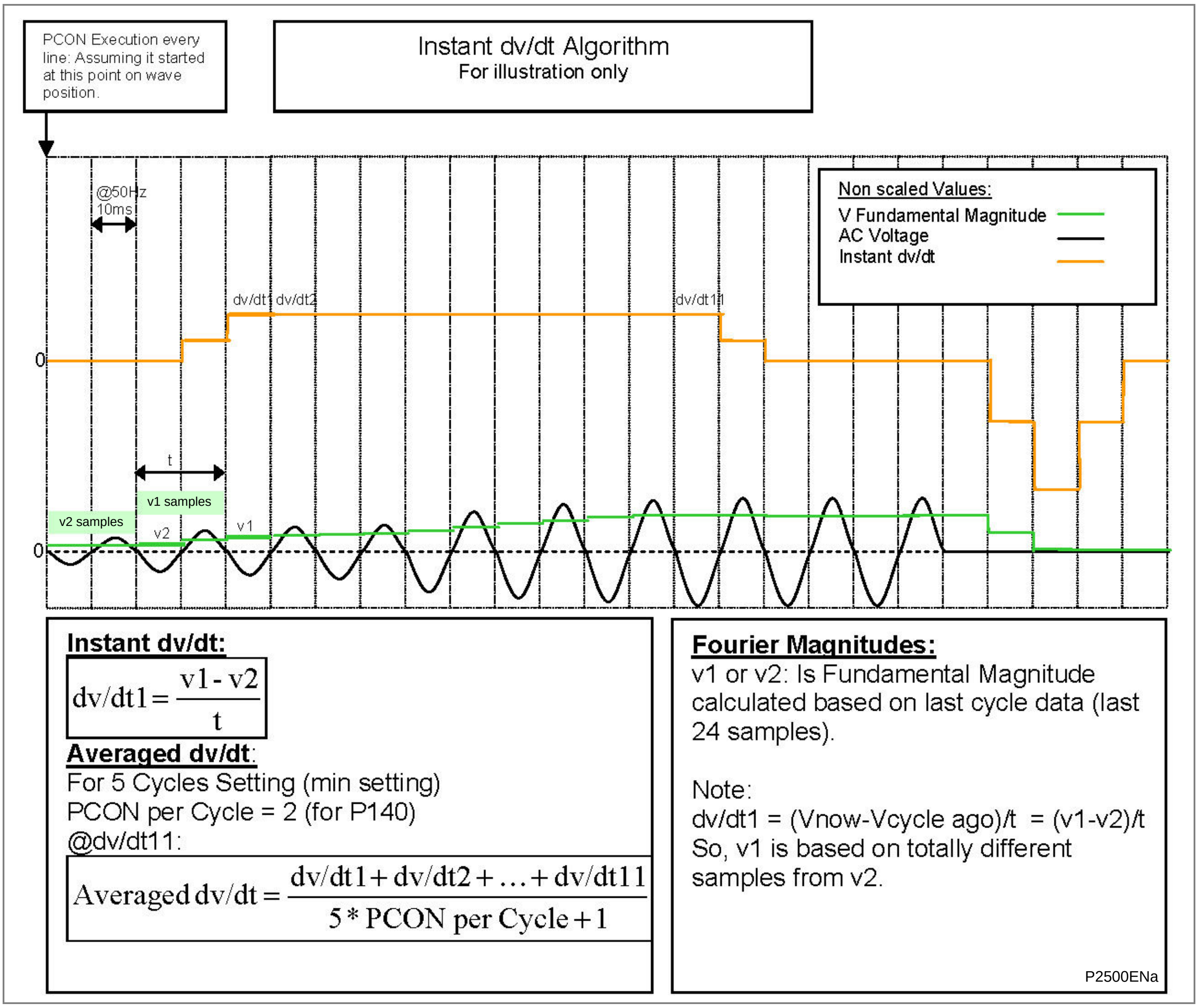


Figure 56 - Instant dv/dt Algorithm

The buffers of the dv/dt protection will be reset and a “**buffers not full**” flag will be raised (which then gives no dv/dt response until the buffers are full again after about 1.04s):

- In case of “**Frequency Not Found**” is raised from the frequency Tracking algorithm.
- When “**dv/dt Meas Mode**” setting changes.

Setting	Action
Phase - Phase	Phase - Phase voltages used
Phase - Neutral	Phase - Neutral voltages used

- Relay Power up
- Both dv/dt Stages are disabled

1.35.1 Averaged dv/dt

The averaging will consist of averaging the rate of change over a set number of cycles (rolling window) similar to the advanced frequency df/dt+t. Each stage will have its own "**dv/dt AvgCycles**".

The instant dv/dt (mentioned previously) will be stored in a 101 length buffer to cover the MAX setting of 50 cycles averaging. Therefore both stages will access the same buffer but with the capability of having different Averaging Cycles Setting. Dependent on the averaging cycles, the averaged dv/dt will be based on the instant dv/dt now and the previous ones as shown in the figure above.

All the above operations will be blocked (and buffers reset) in case of "**Frequency Not Found**" is raised from the frequency Tracking algorithm.

The buffer resets also when "**dv/dt Meas Mode**" setting changes.

If the buffer resets (for any of the above reasons) or the relay just powered up, the dv/dt will wait until the 101 buffer is filled again (about 1s).

1.35.2 Start DDBs

A start will be raised if the averaged dv/dt is above setting two times consecutively (2 PCON, which is maximum delay of 20ms@50Hz) and then will not drop off unless averaged dv/dt is below (setting-Hyst) for four times consecutively (4 PCON, which is maximum delay of 40ms@50Hz).

Hyst = 0.07 @110 VT rating and 0.28 @440 VT (derived from ripple in dv/dt reading while having no dv/dt at 11v and 5 Cycles averaging).

1.35.3 Trip DDBs

Trip will be raised if:

- The start is raised continuously for more than TimeDelay setting. or
- If start goes off for less than the tRESET setting and the overall time is above TimeDelay setting.

1.35.4 Blocking DDBs

For each stage there is a PSL blocking signal "**dv/dt Blocking**" which will reset the whole stage (timers and DDBs).

1.35.5 Generic DDB

For each stage there is a generic Start and Trip DDB ("**dv/dt Start**" and "**dv/dt Trip**") controlled by setting "**dv/dt Oper Mode**". For Any-Phase setting this DDB will be the logical OR of the 3 phases DDBs and for Three-Phase setting this DDB will be the logical AND of the 3 phases DDBs.

1.35.6 dv/dt Start Operating Times

Here is a V/s graph for a sudden dv/dt.

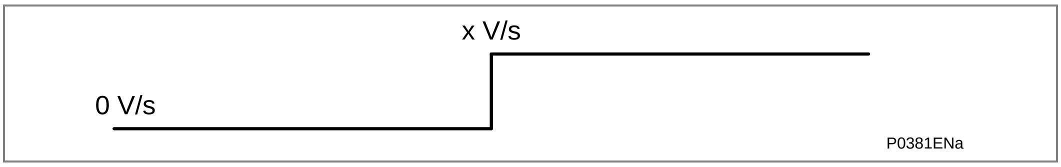


Figure 57 – V/s graph

When applying a sudden dv/dt:

@50Hz,

Operating times for any start signal = No of Averaging Cycles x 2x10ms + 5x10ms ±10ms
(1) (2) (3)

@60Hz the 10ms becomes 8.33ms

1. It is controlled by no. of averaging cycles setting
2. It is a combination of:

   2 cycles (40ms which is the time required to see a change in the Inst dv/dt due to having the dv from Voltage now - Voltage cycle ago, see the above figure)

   10ms for 2 counts strategies till the start is raised
3. Tolerance

2 OPERATION OF NON-PROTECTION FUNCTIONS

2.1 Three-Phase Auto-Reclosing

The P14x will initiate auto-reclose for fault clearances by the phase overcurrent, earth fault and SEF protections.

In addition to these settings, function links in the "**OVERCURRENT**", "**EARTH FAULT1**", "**EARTH FAULT2**" and "**SEF/REF PROT'N**" columns are also required to fully integrate the auto-reclose logic in the relay.

The auto-reclose function provides multi-shot three-phase auto-reclose control. It can be adjusted to perform a single shot, two shot, three shot or four shot cycle, selectable via "**Number of Shots**". There is also the option to initiate a separate auto-reclose cycle with a different number of shots, "**Number of SEF Shots**", for the SEF protection. Dead times for all shots (re-close attempts) are independently adjustable.

An auto-reclose cycle can be internally initiated by operation of a protection element or externally by a separate protection device, provided the circuit breaker is closed until the instant of protection operation. The dead time "**Dead Time 1**", "**Dead Time 2**", "**Dead Time 3**", "**Dead Time 4**" starts when the circuit breaker has tripped and optionally when the protection has reset, selectable via "**Start Dead t On**". At the end of the relevant dead time, a CB close signal is given, provided system conditions are suitable. The system conditions to be met for closing are that the system voltages are in synchronism or dead line/live bus or live line/dead bus conditions exist, indicated by the internal check synchronizing element and that the circuit breaker closing spring, or other energy source, is fully charged indicated from the "**DDB 230: CB Healthy**" input. The CB close signal is cut-off when the circuit breaker closes.

When the CB has closed the reclaim time "**Reclaim Time**" starts. If the circuit breaker does not trip again, the auto-reclose function resets at the end of the reclaim time. If the protection operates during the reclaim time the relay either advances to the next shot in the programmed auto-reclose cycle, or, if all programmed re-close attempts have been made, goes to lockout.

CB Status signals must also be available within the relay, i.e. the default setting for "**CB Status Input**" should be modified accordingly for the application. The default PSL requires 52A, 52B and CB Healthy logic inputs, so a setting of "**Both 52A and 52B**" is required for the CB Status Input.

2.1.1 Logic Functions

2.1.1.1 Logic Inputs

The auto-reclose function has several Digital Data Bus (DDB) logic inputs, which can be mapped in PSL to any of the opto-isolated inputs on the relay or to one or more of the DDB signals generated by the relay logic. The function of these inputs is described below, identified by their signal text.

CB Healthy

The majority of circuit breakers are only capable of providing one trip-close-trip cycle. Following this, it is necessary to re-establish if there is sufficient energy in the circuit breaker (spring charged, gas pressure healthy, etc.) before the CB can be re-closed. The "**DDB 230: CB Healthy**" input is used to ensure that there is sufficient energy available to close and trip the CB before initiating a CB close command. If on completion of the dead time, the "**DDB 230: CB Healthy**" input is low, and remains low for a period given by the "**CB Healthy Time**" timer, lockout will result and the CB will remain open

This check can be disabled by not allocating an opto input for "**DDB 230: CB Healthy**". The signal defaults to high if no logic is mapped to DDB 230 within the PSL in the relay.

BAR

The "**DDB 239: Block AR**" input will block auto-reclose and cause a lockout if auto-reclose is in progress. It can be used when protection operation without auto-reclose is required. A typical example is on a transformer feeder, where auto-reclosing may be initiated from the feeder protection but blocked from the transformer protection.

Reset Lockout

The "**DDB 237: Reset Lockout**" input can be used to reset the auto-reclose function following lockout and reset any auto-reclose alarms, provided that the signals which initiated the lockout have been removed.

Auto Mode

The "**DDB 241: Auto Mode**" input is used to select the Auto operating mode; auto-reclose in service. When the "**DDB 241: Auto Mode**", "**DDB 240: Live Line Mode**" and "**DDB 242: Telecontrol**" inputs are off the "**Non Auto Mode**" of operation is selected; auto-reclose out of service.

Live Line Mode

The "**DDB 240: Live Line Mode**" input is used to select the Live Line operating mode where auto-reclose is out of service and all blocking of instantaneous protection by auto-reclose is disabled. This operating mode takes precedence over all other operating modes for safety reasons, as it indicates that utility personnel are working near live equipment.

Telecontrol Mode

The "**DDB 242: Telecontrol**" input is used to select the Telecontrol operating mode whereby the Auto and Non Auto modes of operation can be selected remotely.

Live/Dead Ccts OK

DDB 461: "**Live/Dead Ccts** OK" is an input to the auto-reclose logic. When AR is enabled with one or both sides of the CB dead (AUTO-RECLOSE GROUP 1 - SYSTEM CHECKS setting [49 43] - Live/Dead Ccts: Enabled), DDB 461 should be mapped in PSL to appropriate combinations of Live Line, Dead Line, Live Bus and Dead Bus signals from the system check logic (DDB 443, 444, 445 & 446), as required for the specific application. If setting 49 43 is Disabled, DDB 461 mapping is irrelevant.

AR SysChecks OK

DDB 403: "**AR Sys. Checks OK**" can be mapped in PSL from system checks output DDB 449: "**Sys. Chks. Inactive**", to enable auto-reclosing without any system checks, if the system check function is disabled (CONFIGURATION setting 09 23 - System Checks: Disabled). This mapping is not essential, because AUTO-RECLOSE GROUP 1 - SYSTEM CHECKS setting [49 44] - No System Checks can be set to Enabled to achieve the same effect.

DDB 403 can also be mapped to an opto input, to enable the P14x to receive a signal from an external system monitoring relay to indicate that system conditions are suitable for CB closing. This should not normally be necessary, since the P14x has comprehensive built in system check functionality.

Ext. AR Prot. trip/start

DDB 439: "**Ext. AR Prot. Trip**" and/or DDB 440: "**Ext. AR Prot. Start**" allow initiation of auto-reclosing by a separate protection relay. Please refer to the Auto-Reclose Initiation section.

DAR Complete

At least one major utility, which uses delayed auto-reclosing (DAR) on most of its transmission network, requires a "**DAR in Progress**" signal from AR initiation up to the application of the CB Close command, but not during the reclaim time following CB re-closure. DDB 453: "**DAR Complete**" can, if required, be mapped in PSL to be activated for a short pulse when a CB Close command is given at the end of the dead time. If DDB 453: "**DAR Complete**" is activated during an auto-reclose cycle, output DDB 456: "**AR in Progress 1**" resets, even though the reclaim time may still be running and DDB 360: "**AR in Progress**" remains set until the end of the reclaim time. For most applications, DDB 453 can be ignored, i.e. not mapped in PSL; in such cases, output DDB 456: AR in Progress 1 operates and resets in parallel with DDB 360: AR in Progress.

CB In Service

One of the interlocks in the auto-reclose initiation logic is DDB 454: "**CB in Service**". This input must be high until the instant of protection operation for an auto-reclose cycle to be initiated. For most applications, this DDB can be mapped simply from the "**CB Closed**" DDB 379. More complex PSL mapping can be programmed if required, e.g. where it is necessary to confirm not only that the CB is closed but also that the line and/or bus VT is actually live up to the instant of protection operation.

AR Restart

In a very small number of applications, it is sometimes necessary to initiate an auto-reclose cycle via an external signal to an opto input when the normal interlock conditions are not all satisfied, i.e. the CB is open and the associated feeder is dead. If input DDB 455: "**AR Restart**" is mapped to an opto input, activation of that opto input will initiate an auto-reclose cycle irrespective of the status of the "**CB in Service**" input, provided the other interlock conditions, such as AR enabled, are still satisfied.

DT OK to Start

This is an optional extra interlock in the dead time initiation logic. In addition to the CB being open and the protection reset, DDB 458: "**DT OK to Start**" has to be high to enable the dead time function to be "**primed**" after an AR cycle has started. Once the dead time function is primed, DDB 458 has no further effect – the dead time function stays primed even if DDB 458 subsequently goes low. A typical PSL mapping for this input is from a "**Dead Line**" signal (DDB 444) from the system check logic, to enable dead time priming only when the feeder has gone dead after CB tripping. If this extra dead time priming interlock is not required, DDB 458 can be left unmapped, and will then default to high.

Dead Time Enabled

This is another optional interlock in the dead time logic. In addition to the CB open, protection reset and "**dead time primed**" signals, DDB 457: "**Dead Time Enabled**" has to be high to allow the dead time to run. If DDB 457 goes low, the dead time stops and resets, but stays primed, and will restart from zero when DDB 457 goes high again. A typical PSL mapping for DDB 457 is from the CB Healthy input DDB 230, or from selected Live Bus, Dead Line etc. signals from the system check logic. It could also be mapped to an opto input to provide a "**hold off**" function for the follower CB in a "**master/follower**" application with 2 CBs. If this optional interlock is not required, DDB 457 can be left unmapped, and will then default to high.

AR Init. Trip Test

If DDB 464: "**AR Init. Trip Test**" is mapped to an opto input, and that input is activated momentarily, the relay logic generates a CB trip output via DDB 372, mapped in default PSL to output R3, and initiates an auto-reclose cycle.

AR Skip Shot 1

If DDB 530: "**AR Skip Shot 1**" is mapped to an opto input, and that input is activated momentarily, the relay logic will cause the auto-reclose sequence counter to increment by 1. This will therefore decrease the available re-close shots and will lockout the re-closer should the re-closer be on its maximum re-close attempt e.g. if the re-closer is set to two re-close shots, initiation of the DDB 530 will cause the re-close counter to 1, thus the re-closer only has one re-close cycle before it locks out.

Inhibit Reclaim Time

If DDB 532: "**Inh Reclaim Time**" is mapped to an opto input, and that input is active at the start of the reclaim time, the relay logic will cause the reclaim timers to be blocked.

2.1.1.2 Auto-Reclose Logic Outputs

The following DDB signals can be assigned to a relay contact in the PSL or assigned to a Monitor Bit in "**Commissioning Tests**", to provide information about the status of the auto-reclose cycle. They can also be applied to other PSL logic as required. The logic output DDBs are described below, identified by their DDB signal text.

AR In Progress

The "**DDB 360: AR in Progress**" signal is present during the complete re-close cycle from protection initiation to the end of the reclaim time or lockout. DDB 456: "**AR in Progress 1**" operates with DDB 360 at auto-reclose initiation, and, if DDB 453: "**DAR Complete**" does not operate, remains operated until DDB 360 resets at the end of the cycle. If DDB 453 goes high during the auto-reclose cycle, DDB 456 resets (see notes on logic input "**DAR Complete**" above).

Sequence Counter Status

During each auto-reclose cycle, a "**Sequence Counter**" increments by 1 after each fault trip, and resets to zero at the end of the cycle.

- DDB 362: "**Seq. Counter = 0**" is set when the counter is at zero;
- DDB 363: "**Seq. Counter = 1**" is set when the counter is at 1;
- DDB 364: "**Seq. Counter = 2**" is set when the counter is at 2;
- DDB 365: "**Seq. Counter = 3**" is set when the counter is at 3; and
- DDB 366: "**Seq. Counter = 4**" is set when the counter is at 4.

Successful Close

The "**DDB 367: Successful Close**" output indicates that an auto-reclose cycle has been successfully completed. A successful auto-reclose signal is given after the CB has tripped from the protection and re-closed whereupon the fault has been cleared and the reclaim time has expired resetting the auto-reclose cycle. The successful auto-reclose output is reset at the next CB trip or from one of the reset lockout methods; see the *Reset from Lockout* section.

AR In Service

The "**DDB 361: AR in service**" output indicates whether the auto-reclose is in or out of service. Auto-reclose is in service when the relay is in Auto mode and out of service when in the Non Auto and Live Line modes.

Block Main Prot.

The "**DDB 358: Block Main Prot.**" output indicates that the instantaneous protection "**I>3**", "**I>4**", "**IN1>3**", "**IN1>4**", "**IN2>3**", "**IN2>4**" is being blocked by the auto-reclose logic during the auto-reclose cycle. Blocking of the instantaneous stages for each trip of the auto-reclose cycle is programmed using the Overcurrent and Earth Fault 1/2 function link settings, "**I> Function Link**", "**IN1> Func. Link**", "**IN2> Func. Link**", and the "**Trip 1/2/3/4/5 Main**" settings; see the *Blocking Instantaneous Protection during an AR Cycle* section.

Block SEF Prot.

The "**DDB 359: Block SEF Prot.**" output indicates that the instantaneous SEF protection "**ISEF>3, ISEF>4**" is being blocked by the auto-reclose logic during the auto-reclose cycle. Blocking of the instantaneous SEF stages for each trip of the auto-reclose cycle is programmed using the SEF/REF Prot'n. function link setting, "**ISEF> Func. Link**", and the "**Trip 1/2/3/4/5 SEF**" settings; the *Blocking Instantaneous Protection during an AR Cycle* section.

Re-Close Checks

DDB 460: "**Re-close Checks**" operates when the dead time function is "**primed**" (see notes on logic input "**DT OK to Start**", above).

Dead T in Prog.

The "**DDB 368: Dead T in Prog.**" output indicates that the dead time is in progress. This signal is set when DDB 460: "**Re-close Checks**" is set AND input DDB 457: "**Dead Time Enabled**" is high, and may be useful during relay commissioning to check the operation of the auto-reclose cycle.

DT Complete

DDB 459: "**DT Complete**" operates at the end of the set dead time, and remains operated until either the scheme resets at the end of the reclaim time or a further protection operation/AR initiation occurs. It can be applied purely as an indication, or included in PSL mapping to logic input DDB 453: "**DAR Complete**" if required (see logic input notes).

System Checks Indication

DDB 462: "**AR Sync. Check**" operates when either of the synchro check modules, if selected for auto-reclosing, confirms an "**in synchronism**" condition.
DDB 463: "**AR Sys. Checks OK**" operates when any selected system check condition (synchro check, live bus/dead line etc.) is confirmed.

Auto-Close

The "**DDB 371: Auto Close**" output indicates that the auto-reclose logic has issued a close signal to the CB. This output feeds a signal to the control close pulse timer and remains on until the CB has closed. This signal may be useful during relay commissioning to check the operation of the auto-reclose cycle.

"Trip when AR Blocked" Indication

DDB 369: "**Protection Lockt.**" operates if AR lockout is triggered by protection operation either during the inhibit period following a manual CB close (see the *Auto-Reclose Inhibit following Manual Close* section or when the relay is in Non Auto or Live Line mode (see the *AR Lockout* section).

Reset Lockout Indication

DDB 370: "**Reset Lckout Alm.**" operates when the relay is in Non Auto mode, if setting 49 22 - "**Reset Lockout by**" - is set to "**Select Non Auto**". See the *Reset from Lockout* section.

Reclaim In Progress

The "**DDB 533: Reclaim in Prog**" output indicates that a reclaim timer is in progress and will drop-off once the reclaim timer resets.

Reclaim Complete

The "**DDB 534: Reclaim Complete**" operates at the end of the set reclaim time and is a fast reset. To maintain the output indication a dwell timer will have to be implemented in PSL.

2.1.1.3 Auto-Reclose Alarms

The following DDB signals will produce a relay alarm. These are described below, identified by their DDB signal text.

AR no checksync. (latched)

The "**DDB 165: AR No Check Sync.**" alarm indicates that the system voltages were not suitable for auto-reclosing at the end of the check sync. window time (Sys. Check Time), leading to a lockout condition. This alarm can be reset using one of the reset lockout methods; see the *Reset from Lockout* section.

AR CB unhealthy (latched)

The "**DDB 164: AR CB Unhealthy**" alarm indicates that the "**DDB 230: CB Healthy**" input was not energized at the end of the "**CB Healthy Time**", leading to a lockout condition. The "**DDB 230: CB Healthy**" input is used to indicate that there is sufficient energy in the CB operating mechanism to close and trip the CB at the end of the dead time. This alarm can be reset using one of the reset lockout methods; see the *Reset from Lockout* section.

AR Lockout (Self Reset)

The "**DDB 163: AR Lockout**" alarm indicates that the relay is in a lockout status and that further re-close attempts will not be made; see the *AR Lockout* section for more details. This alarm can be reset using one of the reset lockout methods; see the *Reset from Lockout* section.

2.1.2 87B Main Operating Features

2.1.2.1 110B Operation Modes

The auto-reclosing function has three operating modes:

- AUTO MODE — Auto-reclose in service
- NON AUTO MODE — Auto-reclose out of service - selected protection functions are blocked if setting "**AR Deselected**" [4914] = Block Inst. Prot.
- LIVE LINE MODE — Auto-reclose out of service - protection functions are NOT blocked, even if setting "**AR Deselected**" [4914] = Block Inst. Prot. LIVE LINE MODE is a functional requirement by some utilities, for maximum safety during live line working on the protected feeder.

For any operating mode to be selected, CONFIGURATION menu setting "**Auto-reclose**" [0924] must first be set to "**Enabled**". The required operating mode can then be selected by different methods, to suit specific application requirements. The basic method of mode selection is determined by AUTO-RECLOSE Group n menu setting "**AR Mode Select**" [4091], as summarized in the following table:

A/R Mode Select Setting	Description
COMMAND MODE	Auto/Non Auto is selected by command cell “Auto-reclose Mode”.
OPTO SET MODE	If DDB 241: Auto Mode input is high Auto operating mode is selected (Auto-reclose is in service). If DDB 241: Auto Mode input is low Non Auto operating mode is selected (Auto-reclose is out of service and instantaneous protection is blocked).
USER SET MODE	If DDB 242: Telecontrol input is high, the CB Control Auto-reclose Mode is used to select Auto or Non Auto operating mode. If DDB 242: Telecontrol input is low, behaves as OPTO SET setting.
PULSE SET MODE	If DDB 242: Telecontrol input is high, the operating mode is toggled between Auto and Non Auto Mode on the falling edge of DDB 241: Auto Mode input pulses. The pulses are produced by SCADA system. If DDB 242: Telecontrol input is low, behaves as OPTO SET setting.
Note *If “**Live Line Mode**” input DDB 240 is active, the scheme is forced into LIVE LINE MODE, irrespective of the AR Mode Select setting and Auto Mode and Telecontrol input DDBs.*	

Table 7 - A/R Mode Select Setting and description

Live Line Mode input DDB 240 and Telecontrol input DDB 242 are provided to meet the requirements of some utilities who apply a four position selector switch to select AUTO, NON AUTO or LIVE Line operating modes, as shown in the *A/R Mode Select Setting and description* diagram.

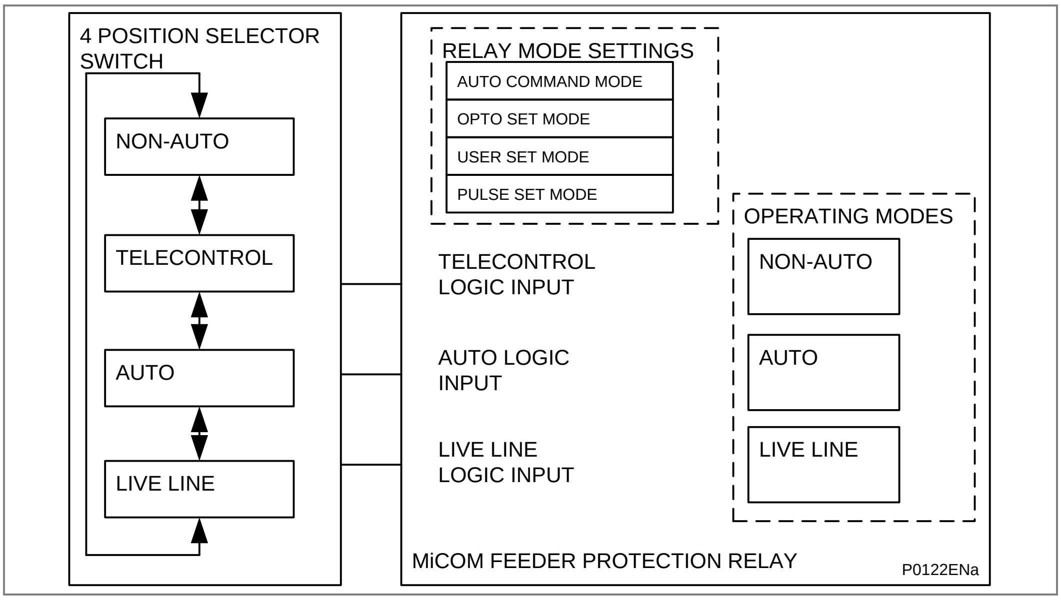


Figure 58 - Operating modes

For this application, the four position switch is arranged to activate relay inputs as shown in the table below:

Switch	Input Logic Signals		
Position	Auto	Telecontrol	Live Line
Non Auto	0	0	0
Telecontrol	0 or SCADA Pulse	1	0
Auto	1	0	0
Live Line	0	0	1

Table 8 - Switches and input logic signals

Operating mode selection logic is shown in the *Operating modes* diagram.

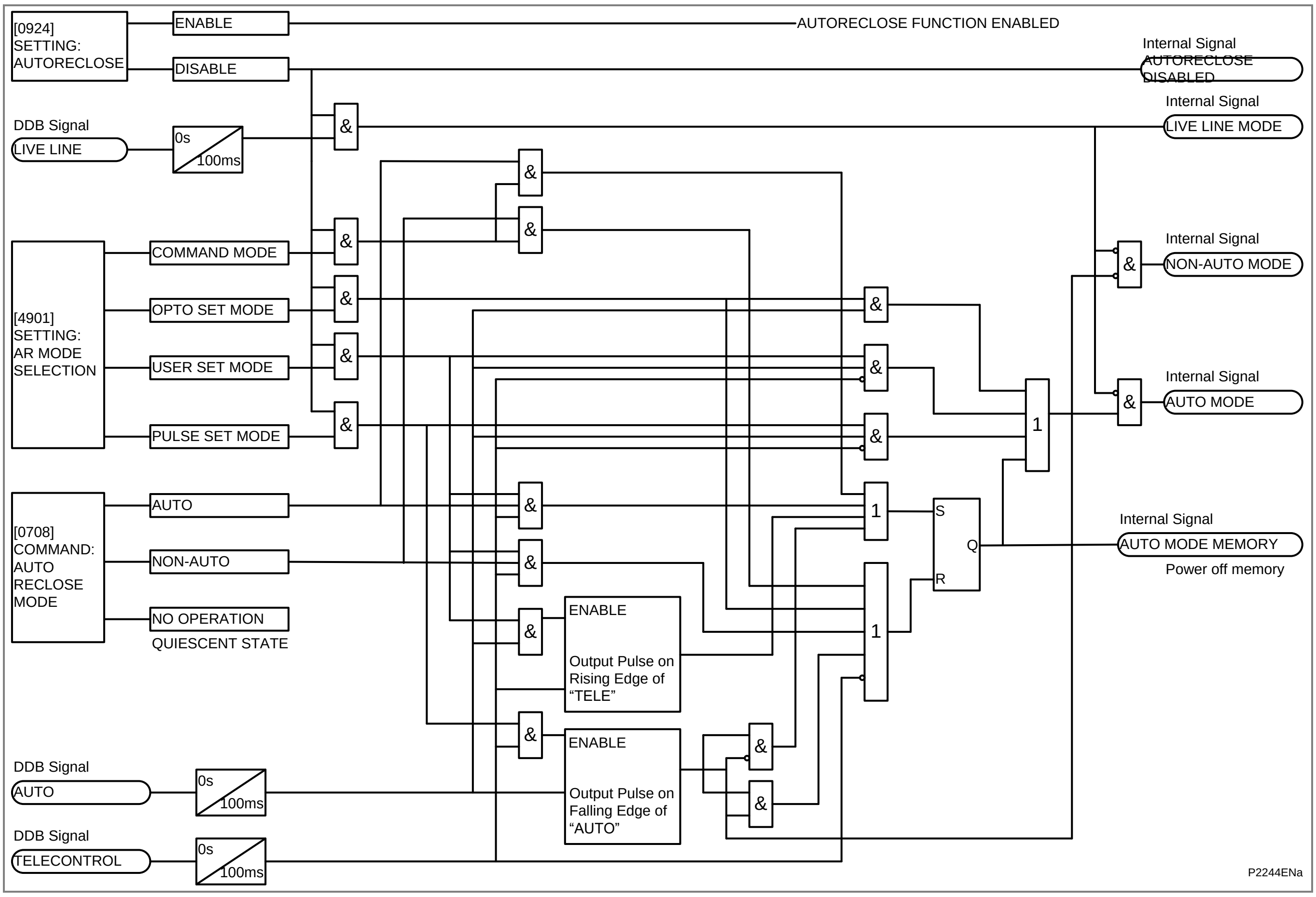


Figure 59 - Mode select functional diagram

The mode selection logic includes a 100ms delayed drop off on Auto Mode, Telecontrol and Live Line Mode logic inputs, to ensure a predictable change of operating modes even if the four position switch does not have make-before-break contacts. The logic also ensures that when the switch is moved from Auto or Non-Auto position to Telecontrol, the scheme remains in the previously selected mode (Auto or Non-Auto) until a different mode is selected by remote control.

The status of the AUTO MODE MEMORY signal is stored in non-volatile memory to ensure that the selected operating mode is restored following an auxiliary power interruption.

For applications where live line operating mode and remote selection of Auto/Non-auto modes are not required, a simple two position switch can be arranged to activate Auto Mode input DDB 241, with DDB 240 and DDB 242 being unused.

2.1.2.2 Auto-Reclose Initiation

Auto-reclose is usually initiated from the internal protection of the relay. The stages of overcurrent and earth fault protection can be programmed to initiate auto-reclose, "**Initiate Main AR**", not initiate auto-reclose, "**No Action**", or block auto-reclose, "**Block AR**". High set instantaneous protection may be used to indicate a transformer fault on a transformer feeder and so be set to "**Block AR**". The stages of sensitive earth fault protection can be programmed to initiate auto-reclose, "**Initiate Main AR**", initiate SEF auto-reclose, "**Initiate SEF AR**", not initiate auto-reclose, "**No Action**", or block auto-reclose, "**Block AR**". Normally, SEF protection operation is due to a permanent fault and is set for "**No Action**". These settings are found under the "**AR INITIATION**" settings. For example if "**I>1**" is set to "**Initiate Main AR**", operation of the "**I>1**" protection stage will initiate auto-reclose; if ISEF>1 is set to "**No Action**", operation of the ISEF>1 protection stage will lead to a CB trip but no re-close.

A selection must be made for each protection stage that is enabled.

A separate protection device may also externally initiate auto-reclose. In this case, the following DDB signals should be mapped to logic inputs:

DDB 439: Ext. AR Prot. Trip

DDB 440: Ext. AR Prot. Start (if appropriate)

The setting EXT. PROT. should be set to "**Initiate Main AR**".

The auto-reclose can be initiated from a protection start, when sequence co-ordination is required, and from a protection trip.

The *“Protection start”* signals diagram shows how the start signal is generated

The *“Protection start” signals* diagram shows how the protection trip signal is produced.

The *Auto-reclose blocking logic* diagram shows how the block auto-reclose is performed together with external AR initiation.

Auto-reclose blocking is discussed in detail in the *AR Lockout* section.

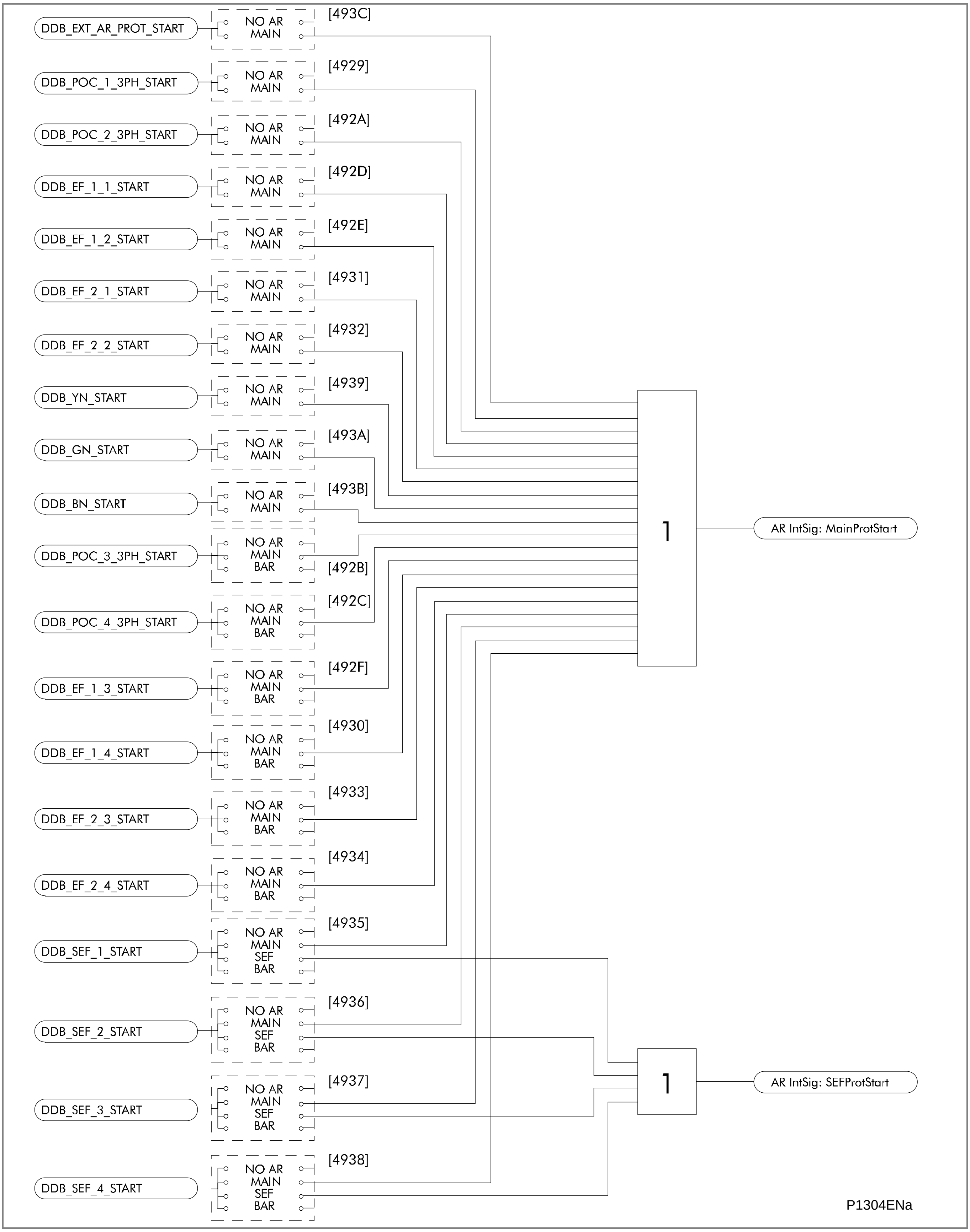


Figure 60 - "Protection start" signals

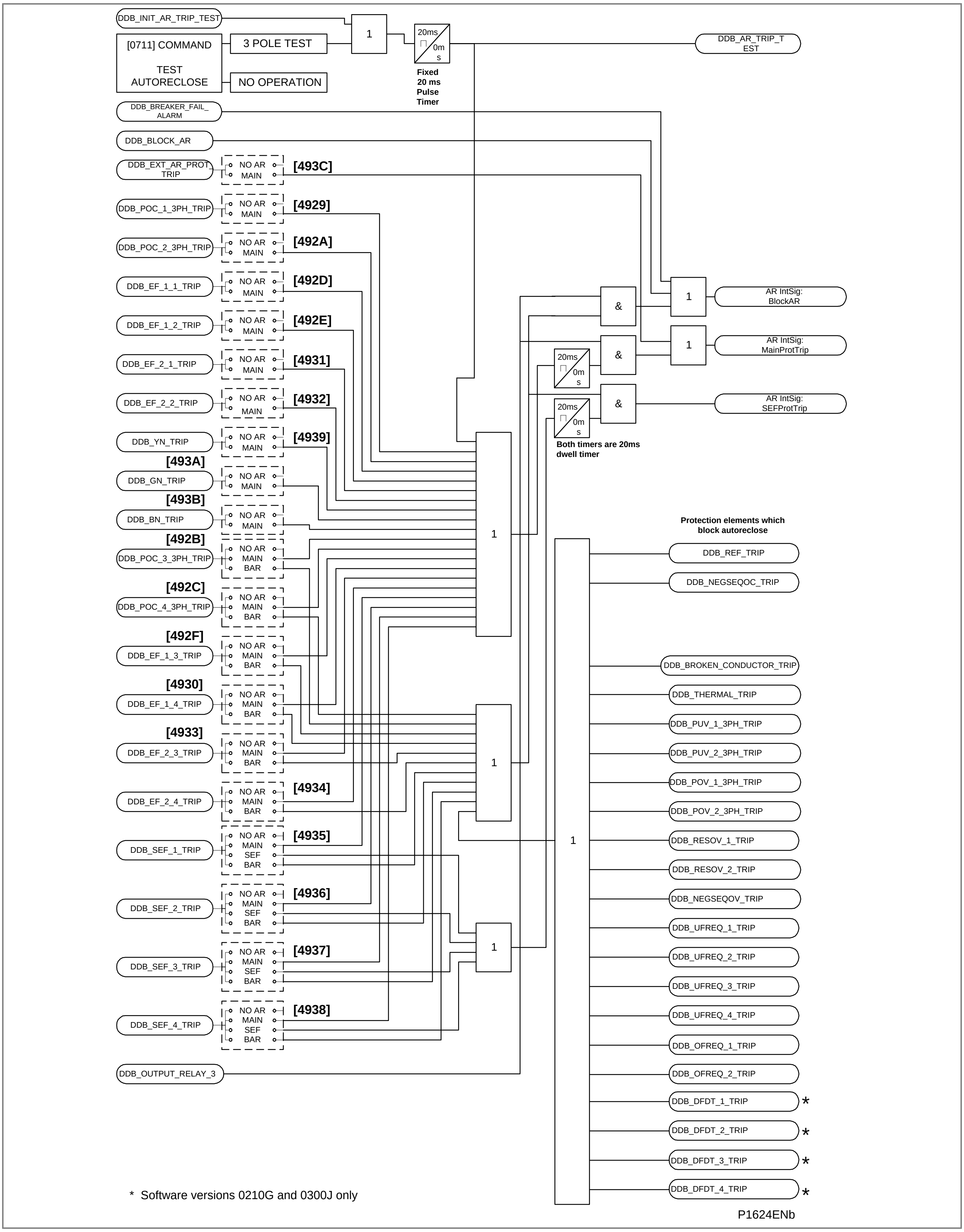


Figure 61 - Auto-reclose blocking logic

Although a protection start and a protection trip can initiate an AR cycle, several checks still have to be performed before the initiate signal is given. Some of the checks are listed below:

- Auto mode has been selected (AR in service)
- Live line mode is disabled
- The number of main protection and SEF shots have not been reached ("**Man High Shots**" and SEF "**High Shots**" Signals see the *Auto-reclose blocking logic* diagram)
- Sequence co-ordination enabled (required only for protection start to initiate AR; not necessary for protection trip)
- CB lockout not set
- CB "**In Service**" (DDB 454 is high)

Note	*For auto reclose cycle to commence, the protection trip (e.g., I>1 trip, DDB # 243) needs to be mapped to a DDB (trip command In DDB # 536). This is applicable for Firmware releases 40 and later versions. It shall be noted that in Firmware versions 39 and lower ones, the any trip DDB signal was dependent on R3.*

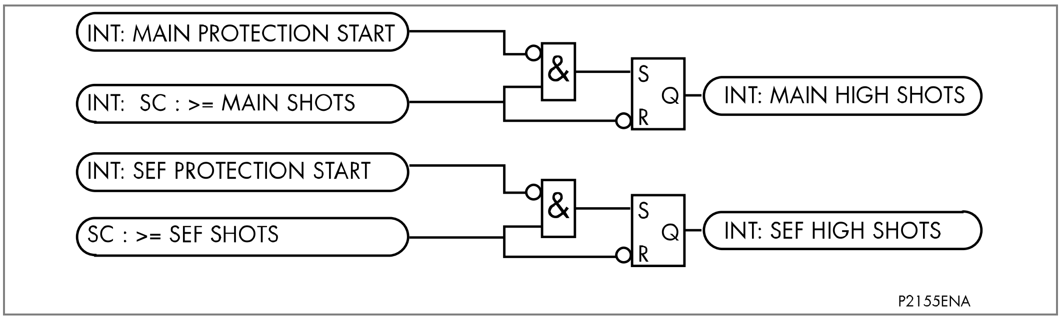


Figure 62 - Shots exceeded logic

The *AR initiation and sequence counter* diagram shows how the auto-reclose is initiated.

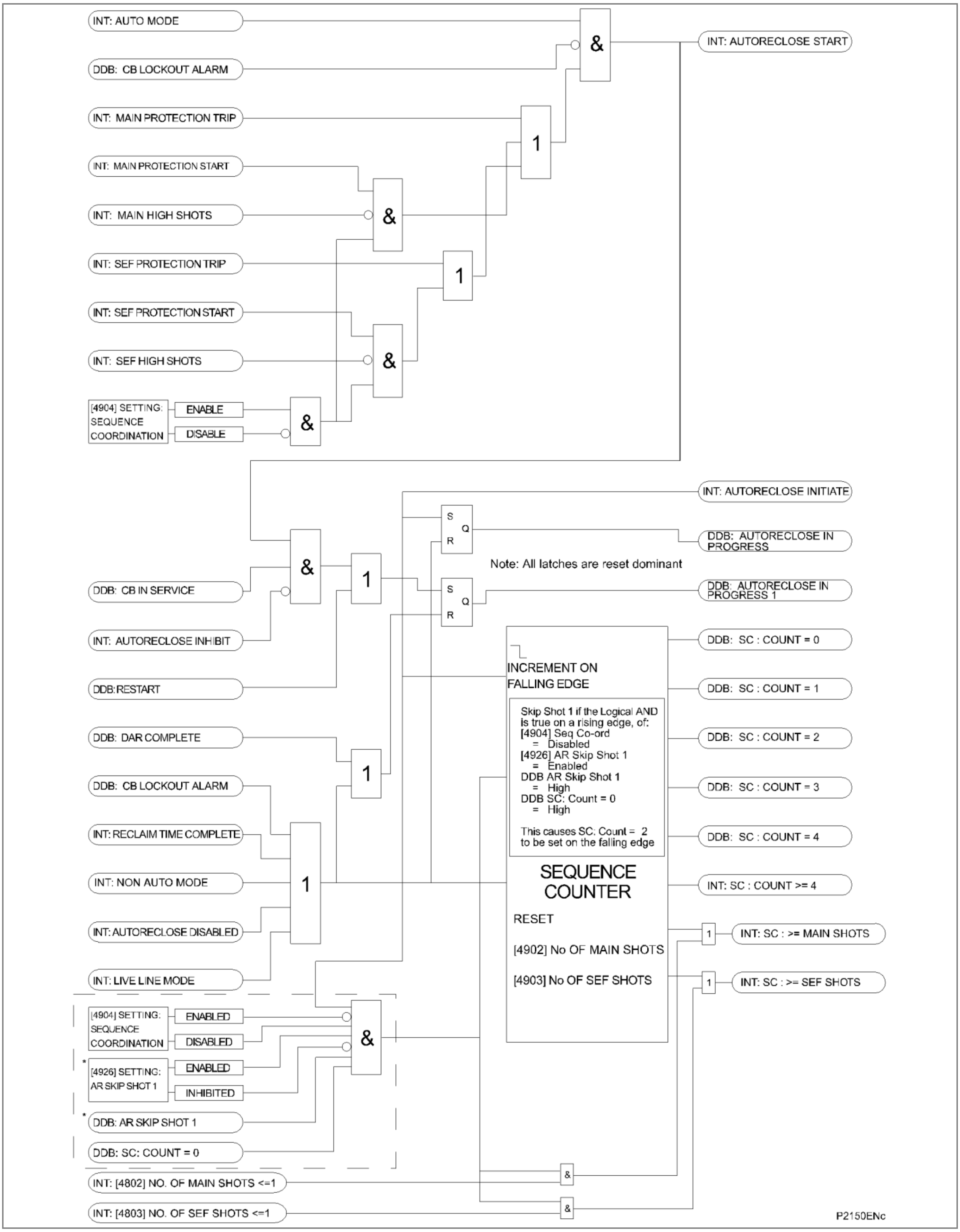


Figure 63 - AR initiation and sequence counter

2.1.2.3 Blocking Instantaneous Protection during an AR Cycle

Instantaneous protection may be blocked or not blocked for each trip in an auto-reclose cycle. This is selected using the "**Trip 1/2/3/4/5 Main**" and "**Trip 1/2/3/4/5 SEF**" settings. These allow the instantaneous elements of phase, earth fault and SEF protection to be selectively blocked for a CB trip sequence. For example, if "**Trip 1 Main**" is set to "**No Block**" and "**Trip 2 Main**" is set to "**Block Inst. Prot.**", the instantaneous elements of the phase and earth fault protection will be available for the first trip but blocked afterwards for the second trip during the auto-reclose cycle. This is clearly illustrated in the *"Block instantaneous protection" for selected trips* diagram.

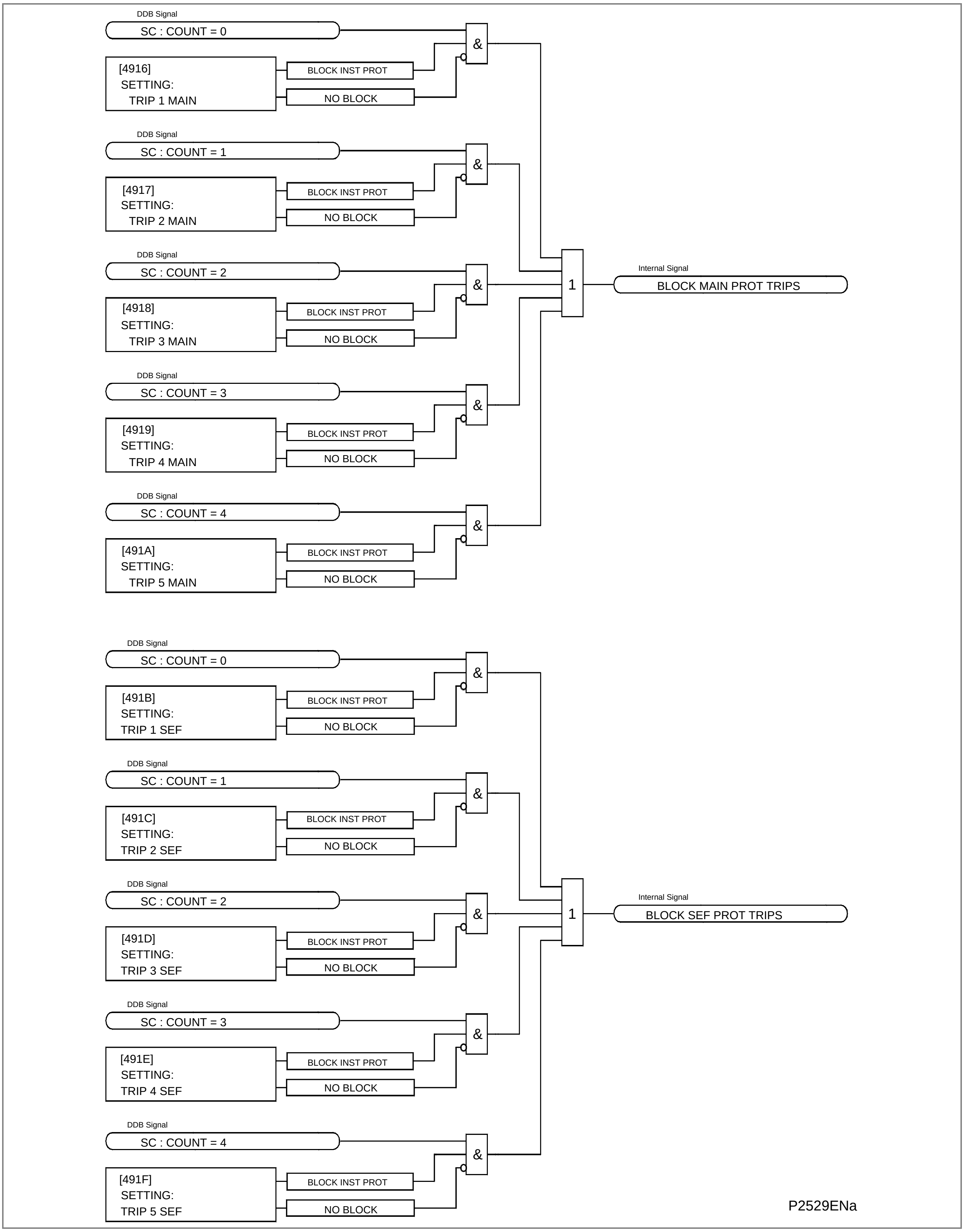


Figure 64 - "Block instantaneous protection" for selected trips

Instantaneous protection can also be blocked when the CB maintenance lockout counter or excessive fault frequency lockout has reached its penultimate value. For example, if "**No CB Ops. Lock**" is set to 100 and the "**CB Operations = 99**", the instantaneous protection can be blocked to ensure that the last CB trip before lockout will be due to discriminative protection operation.

This is controlled using the "**EFF Maint. Lock**" setting, if this is set to "**Block Inst. Prot.**" the instantaneous protection will be blocked for the last CB Trip before lockout occurs.

Instantaneous protection can also be blocked when the relay is locked out, using the "**A/R Lockout**" setting, "**No Block/Block Inst. Prot.**". It can also be blocked after a manual close using the "**Manual Close**" setting, "**No Block/Block Inst. Prot.**" or when the relay is in the Non Auto mode using the "**A/R Deselected**" setting "**No Block/Block Inst. Prot.**". The logic for these features is shown in the *“Block instantaneous protection” for AR unavailable or maintenance/EFF lockout* diagram.

Note	*The instantaneous protection stages must be identified in the Overcurrent, Earth Fault1, Earth Fault2 and SEF/REF Prot’n. function link settings, "**I> Blocking**", "**IN1> Blocking**", "**IN2> Blocking**" and "**ISEF> Blocking**" respectively.*

External protection may be blocked by mapping DDB 358 "**Block Main Prot.**" Or DDB 359 "**Block SEF Prot.**" to appropriate output relay contacts.

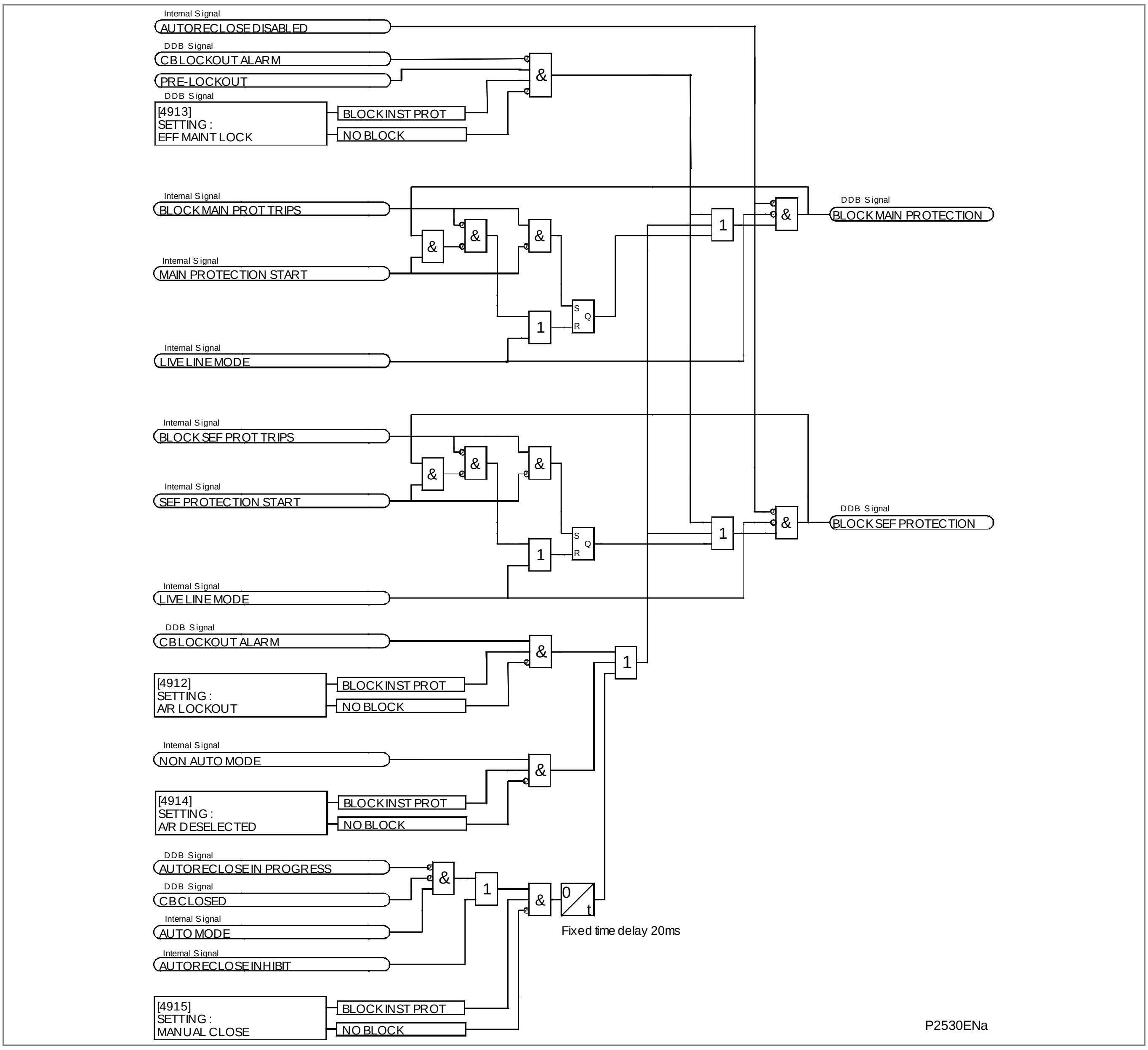


Figure 65 - “Block instantaneous protection” for AR unavailable or maintenance/EFF lockout

2.1.2.4 Dead Time Control

Dead time is “**primed**” (DDB 460 - Re-close Checks - set) when:

- the CB has tripped, and
- (optionally via setting “**Start Dead t On**”), the protection has reset, and
- DDB 458 - DT OK to Start - goes high

Dead time remains “**primed**” until the protection re-operates, or the scheme resets at the end of the auto-reclose cycle.

Once primed, the dead timer starts to run when DDB 457 - Dead Time Enabled is high.

Setting “**CS AR Immediate**” Enabled allows immediate re-closure of the circuit breaker provided both sides of the circuit breaker are live and in synchronism at any time after the dead time has started. This allows for quicker load restoration, as it is not necessary to wait for the full dead time.

If “**CS AR Immediate**” is disabled, or Line and Bus volts are not both live, the dead timer will continue to run, assuming the “**DDB 457: Dead Time Enabled**” (mapped in PSL) is asserted high. The “**Dead Time Enabled**” function could be mapped to an opto input to indicate that the circuit breaker is healthy i.e. spring charged etc. Mapping the “**Dead Time Enabled**” function in PSL increases the flexibility by allowing it, if necessary, to be triggered by other conditions such as “**Live Line/Dead Bus**” for example. If “**Dead Time Enabled**” is not mapped in PSL, it defaults to high, so the dead time can run.

The dead time control logic is shown in the following diagram.

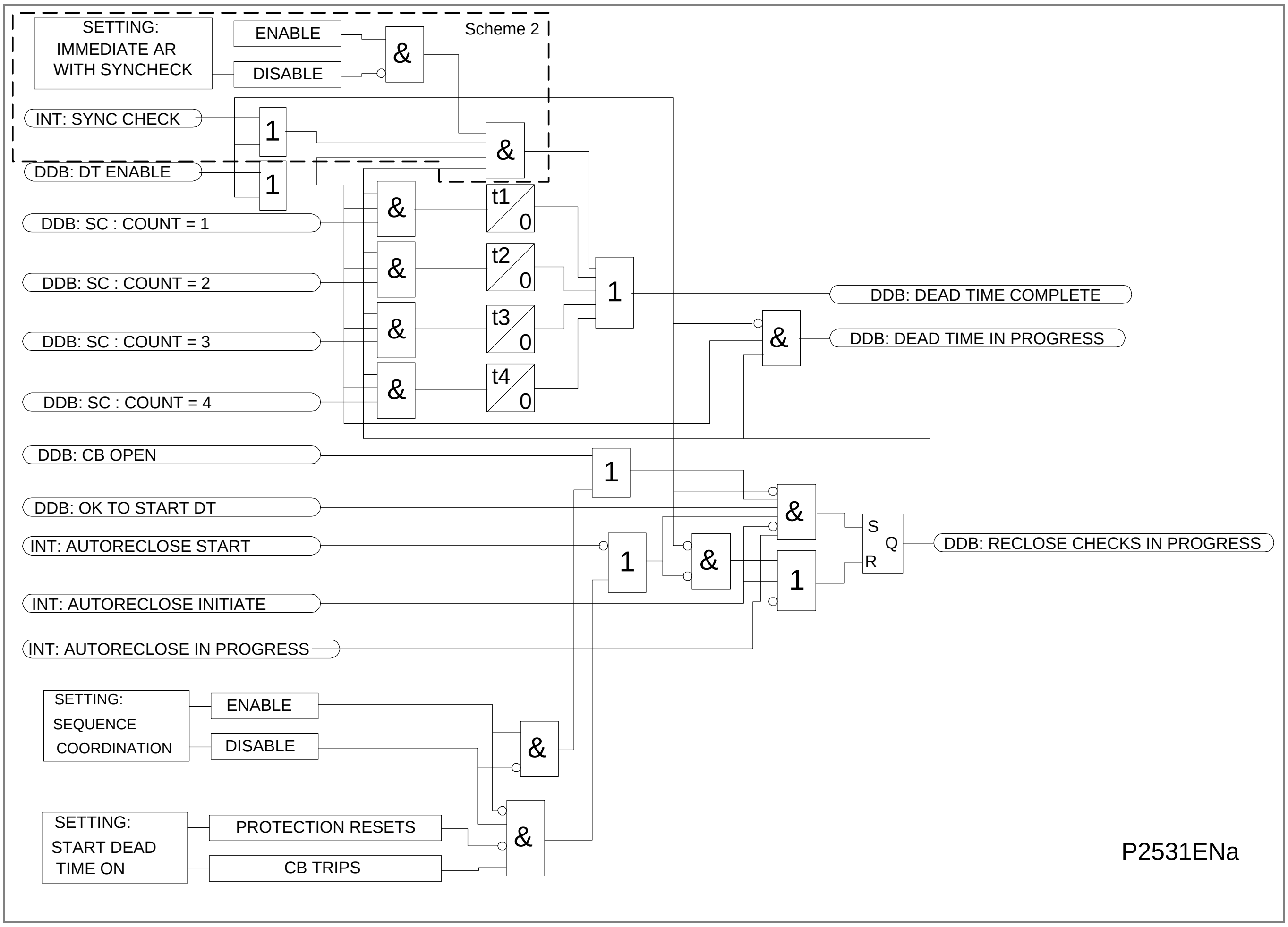


Figure 66 - Dead time control

Once the dead time is completed or a synchronism check is confirmed, the “**Auto-close**” signal is given, provided both the “**CB Healthy**” and the “**System Checks**” are satisfied. (as shown in the following diagram). The “**Auto-close**” signal triggers a “**CB Close**” command via the CB Control functionality (see the *Circuit Breaker Control* section).

The “**AR CB Close Control**” Logic is shown in the following diagram.

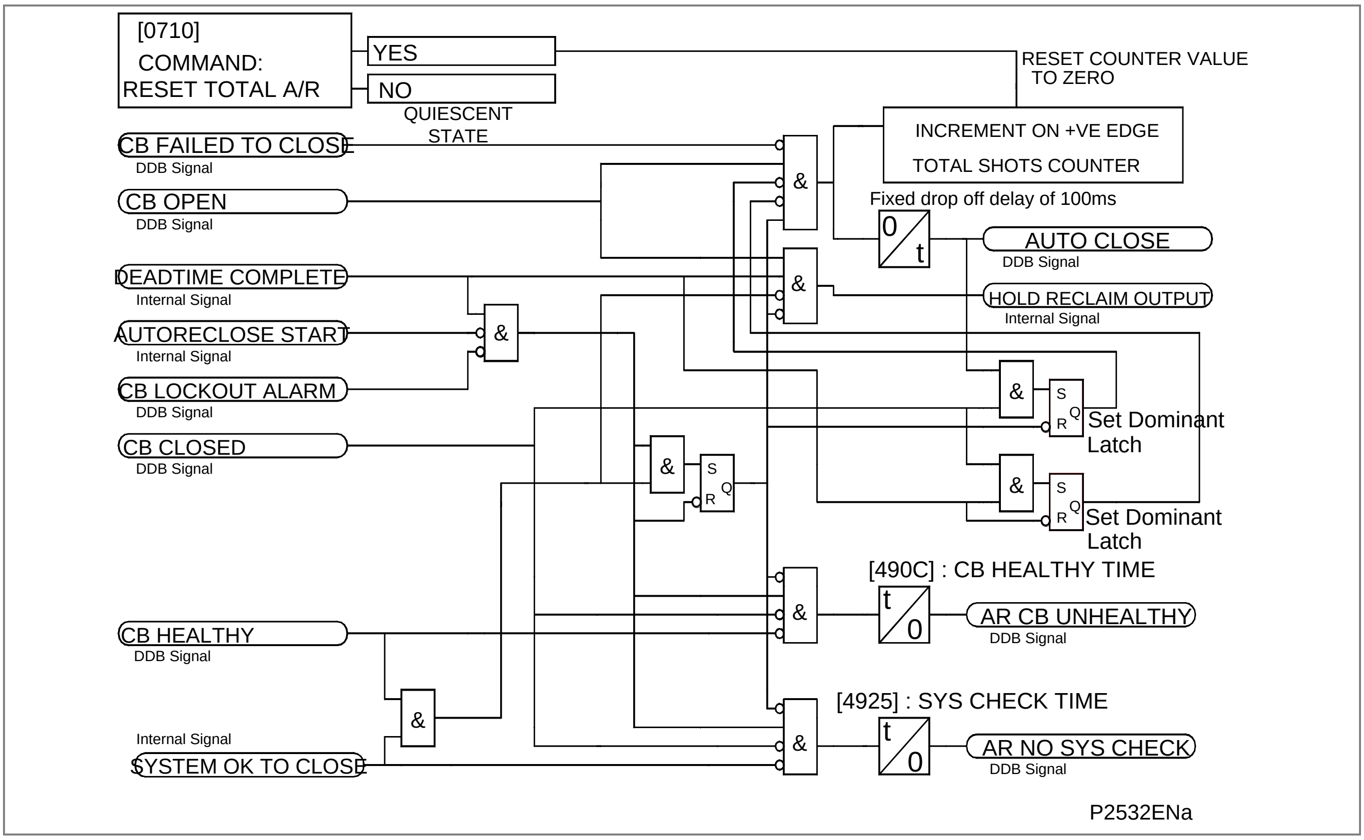


Figure 67 - AR CB close control

2.1.2.5 System Checks

The permission to initiate an auto-reclose depends upon these System Check settings:

- **Live/Dead Ccts** When enabled this setting will give an "**AR Check Ok**" signal when the "**DDB 461 Circuits OK**" is asserted high. This logic input DDB would normally be mapped in PSL to appropriate combinations of Line Live, Line Dead, Bus Live and Bus Dead DDB signals. Auto-reclose can be initiated once DDB 461 is asserted high
- **No System Checks** When enabled this setting completely disables system checks thus allowing auto-reclose initiation
- **Sys. Chk. on Shot 1** Can be used to disable system checks on first AR shot
- **AR with Chk. Sync.** Only allows auto-reclose when the system satisfies the "**Check Sync. Stage 1**" settings (SYSTEM CHECKS menu)
- **AR with Sys. Sync.** Only allows auto-reclose when the system satisfies the "**Check Sync. Stage 2**" settings (SYSTEM CHECKS menu)

The "**SYSTEM CHECKS**" logic can be found in this diagram.

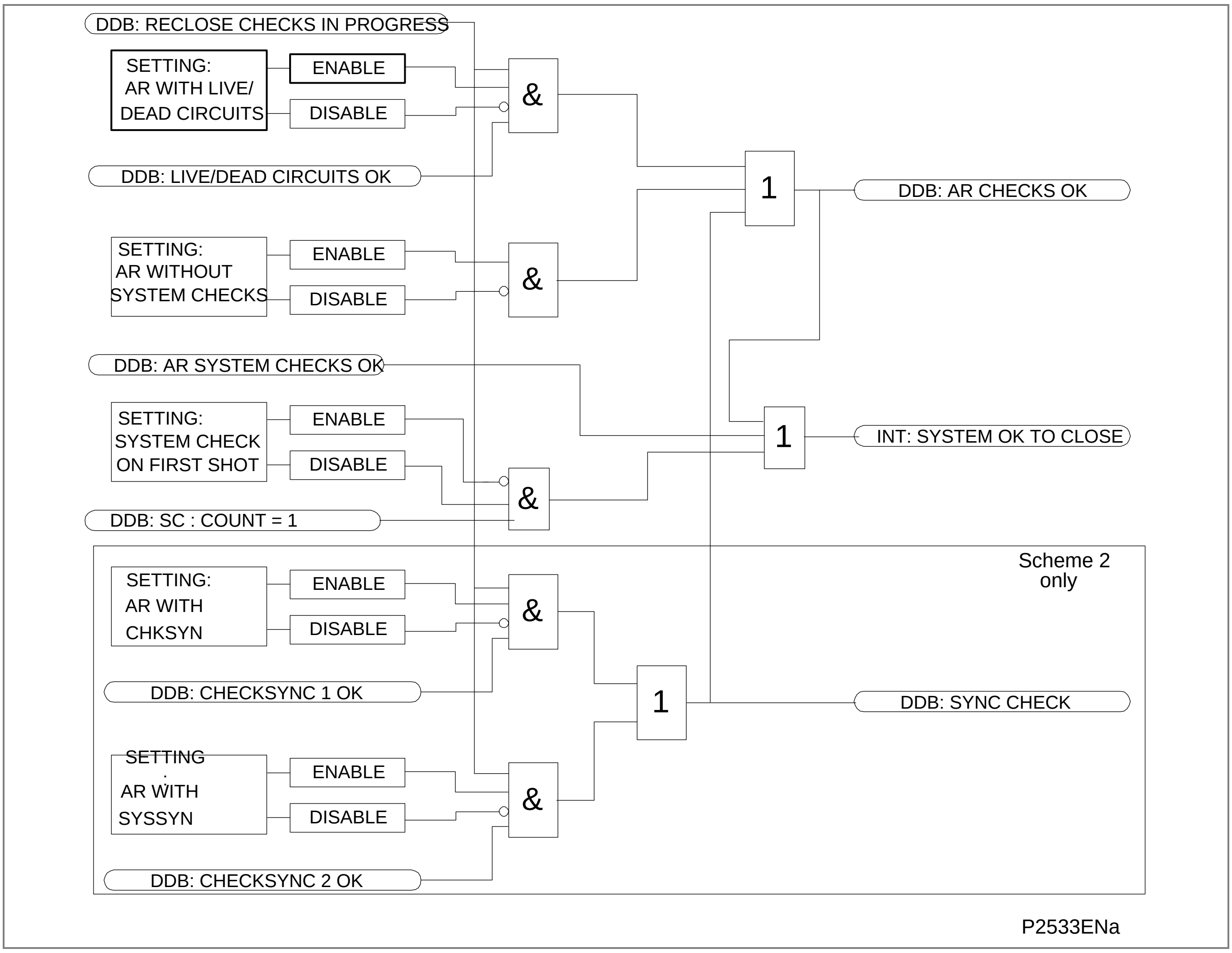


Figure 68 - System checks

2.1.2.6 Reclaim Timer Initiation

The “**tReclaim Extend**” setting allows the user to control whether the timer is suspended from the protection start contacts or not. When a setting of “**No Operation**” is used the Reclaim Timer will operate from the instant that the CB is closed and will continue until the timer expires. The "**Reclaim Time**" must, therefore, be set in excess of the time delayed protection operating time to ensure that the protection can operate before the auto-reclose function is reset. If the auto-reclose function resets before the time delayed protection has operated instantaneous protection could be re-enabled and discriminating tripping lost.

For certain applications it is advantageous to set “**tReclaim Extend**” to “**On Prot. Start**”. This facility allows the operation of the reclaim timer to be suspended after CB re-closure by a signal from the main protection start or SEF protection start signals. The main protection start signal is initiated from the start of any protection which has been selected to "**Initiate Main AR**" (initiate auto-reclose) in the "**AR Initiation**" settings. The SEF protection start signal is initiated from the start of any SEF protection that has been selected to "**Initiate SEF AR**" (initiate SEF auto-reclose) in the "**AR Initiation**" settings. This feature ensures that the reclaim time cannot time out and reset the auto-reclose before the time delayed protection has operated. Since the Reclaim Timer will be suspended, it is unnecessary to use a timer setting in excess of the protection operating time, therefore a short reclaim time can be used. Short reclaim time settings can help to prevent unnecessary lockout for a succession of transient faults in a short period, for example during a thunderstorm. For more information, please refer to the Reclaim Timer logic in the *Reclaim time/AR successful logic* diagram below.

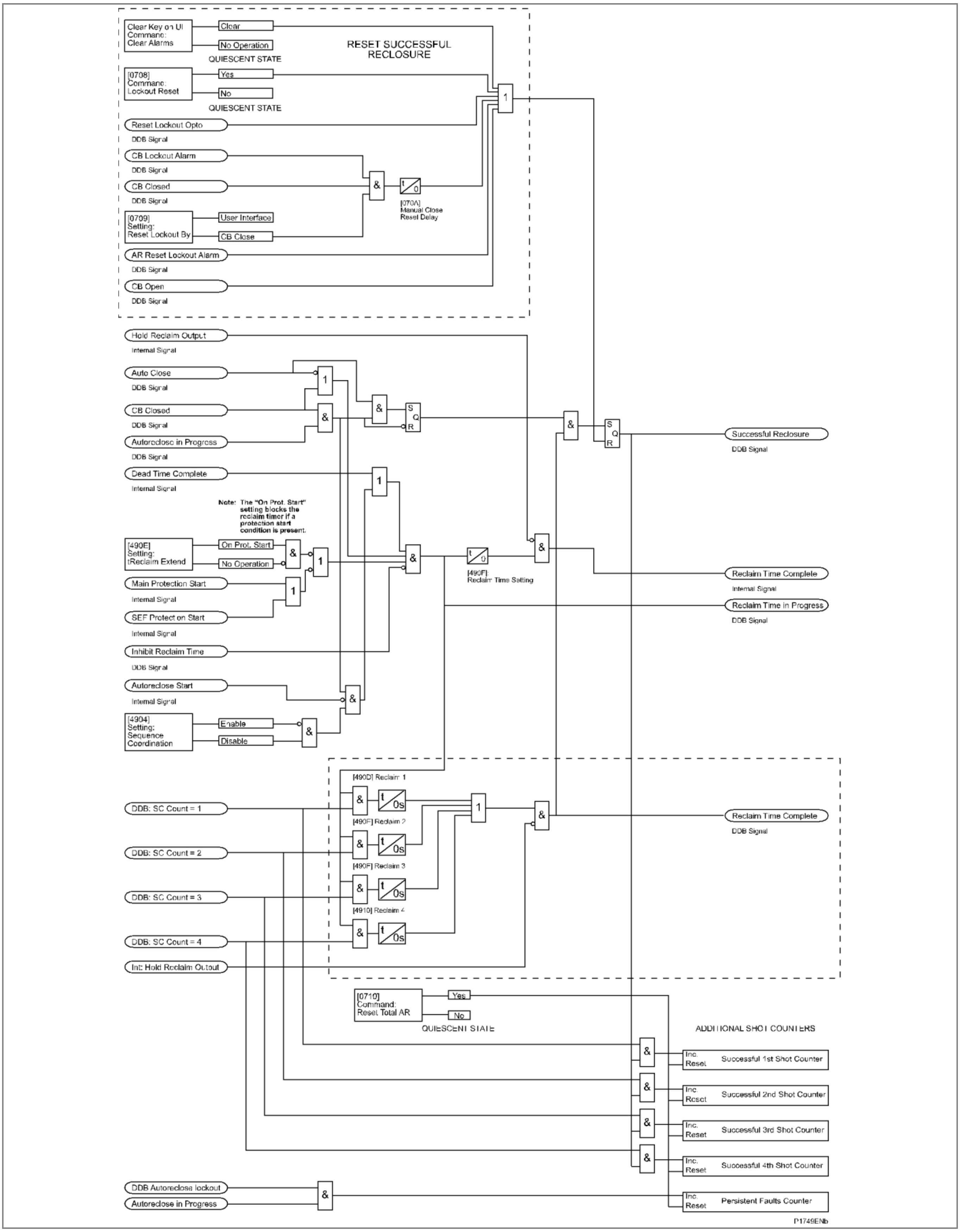


Figure 69 - Reclaim time/AR successful logic

2.1.2.7 Auto-Reclose Inhibit following Manual Close

To ensure that auto-reclosing is not initiated for a manual CB closure on to a pre-existing fault (switch on to fault), AUTO-RECLOSE menu setting "**A/R on Man Close**" can be set to "**Inhibited**". With this setting, auto-reclose initiation is inhibited for a period equal to setting "**A/R Inhibit Time**" following a manual CB closure. The logic for A/R Inhibit is shown in the following diagram.

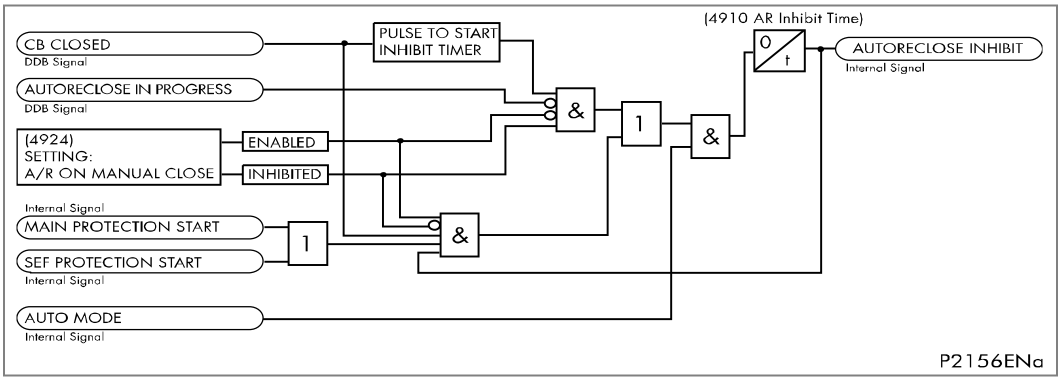


Figure 70 - AR initiation inhibit

If a protection operation occurs during the inhibit period, auto-reclosing is not initiated. A further option is provided by setting "**Man Close on Flt**"; if this is set to "**Lockout**", auto-reclose is locked out (DDB 163: AR Lockout) for a fault during the inhibit period following manual CB closure. If "**Man Close on Flt**" is set to "**No Lockout**", the CB trips without re-closure, but auto-reclose is not locked out.

If it is required to block selected fast non-discriminating protection to obtain fully discriminative tripping during the AR initiation inhibit period following CB manual close, setting "**Manual Close**" can be set to "**Block Inst. Prot.**". A "**No Block**" setting will enable all protection elements immediately on CB closure.

If setting "**A/R on Man Clo**se" is set to "**Enabled**", auto-reclosing can be initiated immediately on CB closure, and settings "**A/R Inhibit Time**", "**Man Close on Flt**" and "**Manual Close**" are irrelevant.

Settings "**A/R on Man Close**", "**A/R Inhibit Time**", "**Man Close on Flt**" and "**Manual Close**" are all in the AUTO-RECLOSE menu.

2.1.2.8 AR Lockout

If protection operates during the reclaim time, following the final reclose attempt, the relay will be driven to lockout and the auto-reclose function will be disabled until the lockout condition is reset. This will produce an alarm, "**DDB 163: AR Lockout**". The "**DDB 239: Block AR**" input will block auto-reclose and cause a lockout if auto-reclose is in progress.

Auto-reclose lockout can also be caused by the CB failing to close because the CB springs are not charged/low gas pressure or there is no synchronism between the system voltages indicated by the "**DDB 164: AR CB Unhealthy**" and "**DDB 165: AR No Check Sync.**" alarms. The functionality, described above, is shown in the AR Lockout logic diagram in this diagram.

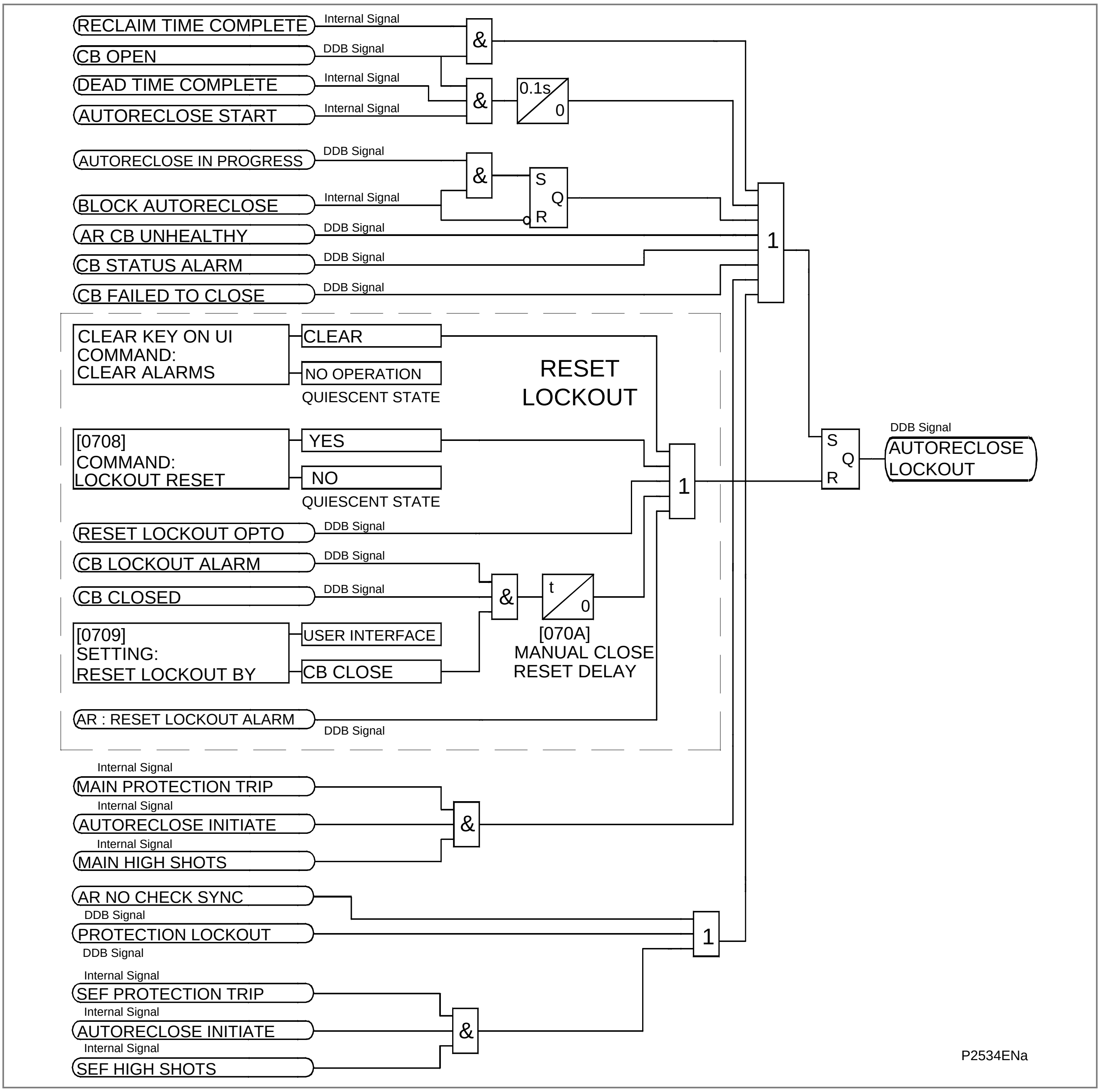


Figure 71 - Overall AR lockout logic

AR lockout may also be due to a protection operation when the relay is in the Live Line or Non Auto modes when "**Trip AR Inactive**" is set to "**Lockout**". Auto-reclose lockout can also be caused by a protection operation after manual closing during the "**AR Inhibit Time**" when the "**Manual Close on Flt.**" setting is set to Lockout.

The following diagram shows the logic associated with these functions.

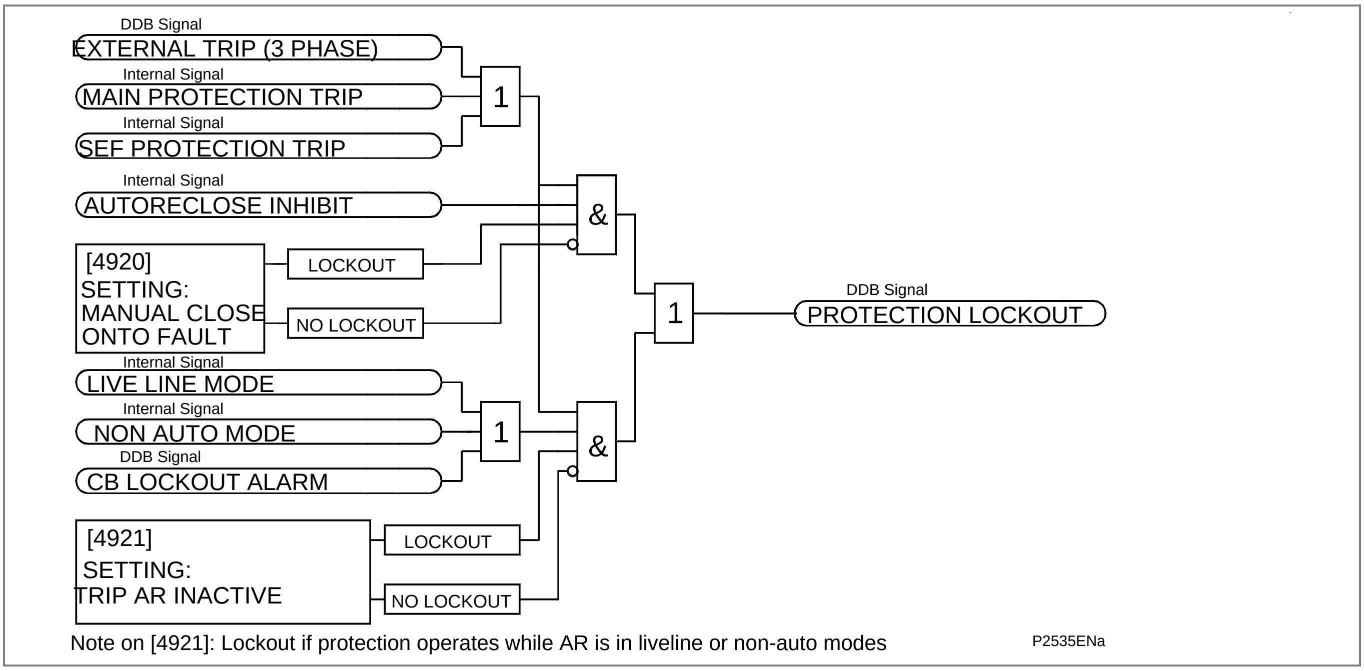


Figure 72 - Lockout for protection trip when AR not available

Note	*Lockout can also be caused by the CB condition monitoring functions, maintenance lockout, excessive fault frequency lockout, broken current lockout, CB failed to trip, CB failed to close, manual close no check synchronism and CB unhealthy.*

2.1.2.8.1 Reset from Lockout

The "**DDB 237: Reset Lockout**" input can be used to reset the auto-reclose function following lockout and reset any auto-reclose alarms, provided that the signals which initiated the lockout have been removed. Lockout can also be reset from the clear key or the "**CB CONTROL**" command "**Lockout Reset**".

The "**Reset Lockout by**" setting, "**CB Close/User interface**" in "**CB CONTROL**" (0709) is used to enable/disable reset of lockout automatically from a manual close after the manual close time "**Man. Close Rst. Dly.**". The "**Reset Lockout by**" setting, "**Select Non Auto/User interface**" in "**AUTO-RECLOSE**" (4922) is used to enable/disable the resetting of lockout when the relay is in the Non Auto operating mode. The reset lockout methods are summarized in the following table:

Reset Lockout Method	When Available?
User Interface via the “Clear” key. *Note* *This will also reset all other protection flags*	Always
User interface via “CB Control” Command “Lockout Reset	Always
Via opto input “Reset lockout”	Always
Following a successful manual close if “Reset Lockout by” (CB CONTROL menu) is set to “CB Close” after “Man. Close Rst. Dly.” time	Only when set
By selecting “Non Auto” mode, provided “Reset Lockout by” (AUTO-RECLOSE menu) is set to “Select Non Auto”	Only when set

Table 9 - Reset lockout method availability

2.1.2.9 Sequence Co-Ordination

The auto-reclose setting "**Sequence Co-ord.**" can be used to enable the selection of sequence co-ordination with other protection devices, such as downstream pole mounted re-closers. The main protection start or SEF protection start signals indicate to the relay when fault current is present, advance the sequence count by one and start the dead time whether the breaker is open or closed. When the dead time is complete and the protection start inputs are off the reclaim timer will be initiated. This is shown in the *Lockout for protection trip when AR not available* diagram.

Both the upstream and downstream auto-reclose relay should be programmed with the same number of shots to lockout and number of instantaneous trips before instantaneous protection is blocked. Thus, for a persistent downstream fault using sequence co-ordination both auto-reclose relays will be on the same sequence count and will be blocking instantaneous protection at the same time and so correct discrimination can be obtained. When sequence co-ordination is disabled, the breaker has to be tripped to start the dead time and advance the sequence count by one.

For some applications with downstream pole mounted re-closers when using sequence co-ordination it may be desirable to re-enable instantaneous protection when the re-closer has locked out. When the downstream re-closer has locked out there is no need for discrimination. This allows the user to have instantaneous then IDMT and then instantaneous trips again during an auto-reclose cycle. Instantaneous protection may be blocked or not blocked for each trip in an auto-reclose cycle using the "**Trip 1/2/3/4/5 Main**" and "**Trip 1/2/3/4/5 SEF**" settings, "**Block Inst. Prot./No Block**".

2.1.2.10 Check Synchronizing for first Re-close

The “**Sys. Chk. on Shot 1**”, (within SYSTEM CHECKS sub menu of AUTO-RECLOSE) setting is used to "**Enable/Disable**" system checks for the first re-close in an auto-reclose cycle. This may be preferred when high speed auto-reclose is applied to avoid the extra time for a synchronism check. Subsequent re-close attempts in a multi-shot cycle will still require a synchronism check.

2.2 Trip LED Logic

The trip LED can be reset when the flags for the last fault are displayed. The flags are displayed automatically after a trip occurs, or can be selected in the fault record menu. The reset of trip LED and the fault records is performed by pressing the Ⓒ key once the fault record has been read.

Setting "**Sys. Fn. Links**" (SYSTEM DATA Column) to logic "**1**" sets the trip LED to automatic reset. Resetting will occur when the circuit is re-closed and the "**Any Pole Dead**" signal (DDB 380) has been reset for three seconds. Resetting, however, will be prevented if the "**Any start**" signal is active after the breaker closes. This function is particularly useful when used in conjunction with the auto-reclose logic, as it will prevent unwanted trip flags being displayed after a successful re-closure of the breaker.

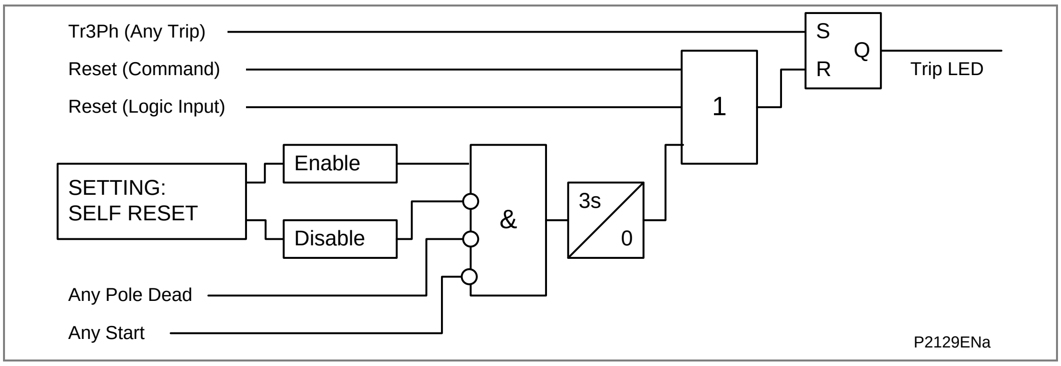


Figure 73 - Trip LED logic diagram

2.3 Check Synchronism (P143 and P145 only)

2.3.1 Overview

In some situations it is possible for both "**bus**" and "**line**" sides of a circuit breaker to be live when the circuit breaker is open, for example at the ends of a feeder which has a power source at each end. Therefore, when closing the circuit breaker, it is normally necessary to check that the network conditions on both sides are suitable, before giving a CB Close command. This applies to both manual circuit breaker closing and auto-reclosure. If a circuit breaker is closed when the line and bus voltages are both live, with a large phase angle, frequency or magnitude difference between them, the system could be subjected to an unacceptable shock, resulting in loss of stability, and possible damage to connected machines.

System checks involve monitoring the voltages on both sides of a circuit breaker, and, if both sides are live, performing a synchronism check to determine whether the phase angle, frequency and voltage magnitude differences between the voltage vectors, are within permitted limits.

The pre-closing system conditions for a given circuit breaker depend on the system configuration and, for auto-reclosing, on the selected auto-reclose program. For example, on a feeder with delayed auto-reclosing, the circuit breakers at the two line ends are normally arranged to close at different times. The first line end to close usually has a live bus and a dead line immediately before reclosing, and charges the line (dead line charge) when the circuit breaker closes. The second line end circuit breaker sees live bus and live line after the first circuit breaker has re-closed. If there is a parallel connection between the ends of the tripped feeder, they are unlikely to go out of synchronism, i.e. the frequencies will be the same, but the increased impedance could cause the phase angle between the two voltages to increase. Therefore the second circuit breaker to close might need a synchronism check, to ensure that the phase angle has not increased to a level that would cause unacceptable shock to the system when the circuit breaker closes.

If there are no parallel interconnections between the ends of the tripped feeder, the two systems could lose synchronism, and the frequency at one end could "**slip**" relative to the other end. In this situation, the second line end would require a synchronism check comprising both phase angle and slip frequency checks.

If the second line end busbar has no power source other than the feeder that has tripped; the circuit breaker will see a live line and dead bus assuming the first circuit breaker has re-closed. When the second line end circuit breaker closes the bus will charge from the live line (dead bus charge).

2.3.2 VT Selection

The P14x has a three-phase "**Main VT**" input and a single-phase "**Check Sync. VT**" input. Depending on the primary system arrangement, the main three-phase VT for the relay may be located on either the busbar side or the line side of the circuit breaker, with the check sync. VT being located on the other side. Hence, the relay has to be programmed with the location of the main VT. This is done via the "**Main VT Location**" setting in the CT & VT RATIOS menu.

The Check Sync. VT may be connected to either a phase to phase or phase to neutral voltage, and for correct synchronism check operation, the relay has to be programmed with the required connection. The "**C/S Input**" setting in the CT & VT RATIOS menu should be set to A-N, B-N, C-N, A-B, B-C or C-A as appropriate.

2.3.3 Basic Functionality

System check logic is collectively enabled or disabled as required, by setting "**System Checks**" in the CONFIGURATION menu. The associated settings are available in SYSTEM CHECKS, sub-menus VOLTAGE MONITORS, CHECK SYNC. and SYSTEM SPLIT. If "**System Checks**" is selected to Disabled, the associated SYSTEM CHECKS menu becomes invisible, and a **Sys. checks inactive** DDB signal is set.

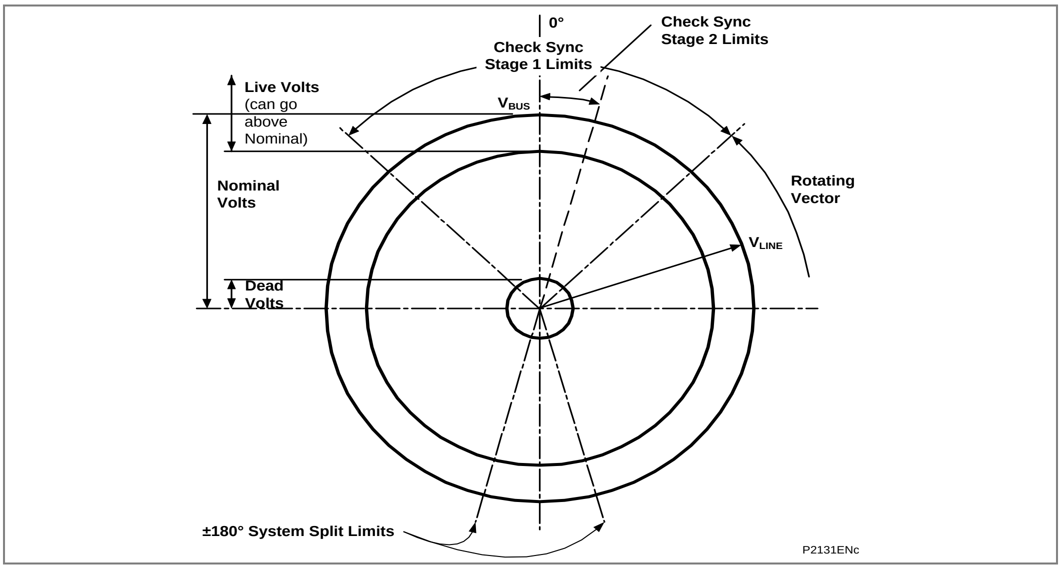


Figure 74 - Synchro check and synchro split functionality

The overall "**Check Sync.**" and "**System Split**" functionality is shown in the previous diagram.

In most situations where synchronism check is required, the Check Sync. 1 function alone will provide the necessary functionality, and the Check Sync. 2 and System Split signals can be ignored.

2.3.3.1 Synchronism Check

Check Sync. 1 and Check Sync. 2 are two synchro check logic modules with similar functionality, but independent settings (see the *Synchro check and synchro split functionality* diagram).

For either module to function:

the System Checks setting must be Enabled

AND

the individual Check Sync. 1(2) Status setting must be Enabled

AND

the module must be individually "**enabled**", by activation of DDB signal Check Sync. 1(2) Enabled, mapped in PSL.

When enabled, each logic module sets its output signal when:

Line volts and bus volts are both live (Line Live and Bus Live signals both set)

AND

measured phase angle is < Check Sync. 1(2) Phase Angle setting

AND

(for Check Sync. 2 only), the phase angle magnitude is decreasing (Check Sync. 1 can operate with increasing or decreasing phase angle provided other conditions are satisfied)

AND

if Check Sync. 1(2) Slip Control is set to Frequency or Frequency + Timer, the measured slip frequency is < Check Sync. 1(2) Slip Freq. Setting

AND

if Check Sync. Voltage Blocking is set to OV, UV + OV, OV + DiffV or UV + OV + DiffV, both line volts and bus volts magnitudes are < Check Sync. Overvoltage setting

AND

if Check Sync. Voltage Blocking is set to UV, UV + OV, UV + DiffV or UV + OV + DiffV, both line volts and bus volts magnitudes are > Check Sync. Undervoltage setting

AND

if Check Sync. Voltage Blocking is set to DiffV, UV + DiffV, OV + DiffV or UV + OV + DiffV, the voltage magnitude difference between line volts and bus volts is < Check Sync. Diff. Voltage setting

AND

if Check Sync. 1(2) Slip Control is set to Timer or Frequency + Timer, the above conditions have been true for a time > or = Check Sync. 1(2) Slip Timer setting

Note	*Live Line/Dead Bus and Dead Bus/Line functionality is provided as part of the default PSL (see the **Check sync. default PSL** diagram).*

2.3.3.2 Slip Control by Timer

If Slip Control by Timer or Frequency + Timer is selected, the combination of Phase Angle and Timer settings determines an effective maximum slip frequency, calculated as:

$$\frac{2 \times A}{T \times 360} \text{ Hz. for Check Sync 1} \quad \text{or} \quad \frac{A}{T \times 360} \text{ Hz. for Check Sync 2}$$

A = Phase Angle setting (°)
T = Slip Timer setting (seconds)

For example, with Check Sync. 1 Phase Angle setting 30° and Timer setting 3.3 sec., the "**slipping**" vector has to remain within ±30° of the reference vector for at least 3.3 seconds. Therefore a synchro check output will not be given if the slip is greater than 2 x 30° in 3.3 seconds. Using the formula: 2 x 30 ÷ (3.3 x 360) = 0.0505 Hz (50.5 mHz).

For Check Sync. 2, with Phase Angle setting 10° and Timer setting 0.1 sec., the slipping vector has to remain within 10° of the reference vector, with the angle decreasing, for 0.1 sec. When the angle passes through zero and starts to increase, the synchro check output is blocked. Therefore an output will not be given if slip is greater than 10° in 0.1 second. Using the formula: 10 ÷ (0.1 x 360) = 0.278 Hz (278 mHz).

Slip control by Timer is not practical for "**large slip/small phase angle**" applications, because the timer settings required are very small, sometimes < 0.1s. For these situations, slip control by frequency is recommended.

If Slip Control by Frequency + Timer is selected, for an output to be given, the slip frequency must be less than BOTH the set Slip Freq. value and the value determined by the Phase Angle and Timer settings.

2.3.4 Check Sync. 2 and System Split

Check sync. 2 and system split functions are included for situations where the maximum permitted slip frequency and phase angle for synchro check can change according to actual system conditions. A typical application is on a closely interconnected system, where synchronism is normally retained when a given feeder is tripped, but under some circumstances, with parallel interconnections out of service, the feeder ends can drift out of synchronism when the feeder is tripped. Depending on the system and machine characteristics, the conditions for safe circuit breaker closing could be, for example:

Condition 1: For synchronized systems, with zero or very small slip:

Slip ≦50 mHz; phase angle <30°

Condition 2: For unsynchronized systems, with significant slip:

Slip ≦250 mHz; phase angle <10° and decreasing

By enabling both Check Sync. 1, set for condition 1, and Check Sync. 2, set for condition 2, the P14x can be configured to allow CB closure if either of the two conditions is detected.

For manual circuit breaker closing with synchro check, some utilities might prefer to arrange the logic to check initially for condition 1 only. However, if a System Split is detected before the condition 1 parameters are satisfied, the relay will switch to checking for condition 2 parameters instead, based upon the assumption that a significant degree of slip must be present when system split conditions are detected. This can be arranged by suitable PSL logic, using the system check DDB signals.

2.3.4.1 Predictive Closure of Circuit Breaker

The "**Freq.+Comp.**" (Frequency + CB Time Compensation) setting modifies the Check Sync. 2 function to take account of the circuit breaker closing time. When set to provide CB Close Time compensation, a predictive approach is used to close the circuit breaker ensuring that closing occurs at close to 0º thus minimising the impact to the power system. The actual closing angle is subject to the constraints of the existing product architecture, i.e. the protection task runs twice per power system cycle, based on frequency tracking over the frequency range of 40Hz to 70Hz.

2.3.4.2 System Split

For the System Split module to function (see Figure 75):

The System Checks setting must be Enabled

AND

the SS Status setting must be Enabled

AND

the module must be individually “**enabled**”, by activation of DDB signal System Split Enabled, mapped in PSL.

When enabled, the System Split module sets its output signal when:

Line volts and bus volts are both live (Line Live and Bus Live signals both set)

AND

measured phase angle is > SS Phase Angle setting

AND

if SS Volt Blocking is set to Undervoltage, both line volts and bus volts magnitudes are > SS Undervoltage setting

The System Split output remains set for as long as the above conditions are true, or for a minimum period equal to the SS Timer setting, whichever is longer.

The overall system checks functionality and default PSL for the function is shown in Figure 75 and Figure 76 respectively.

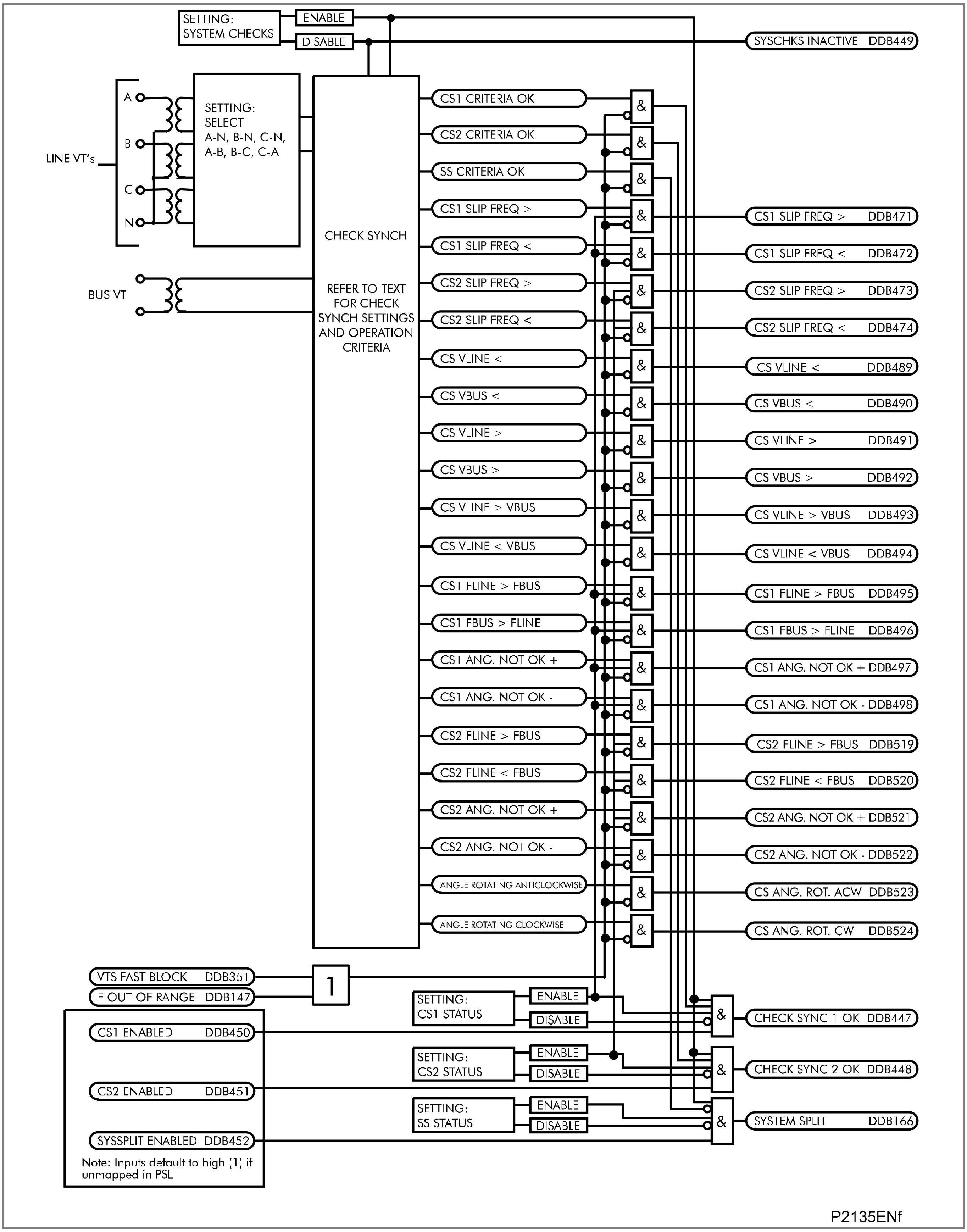


Figure 75 - System checks functional logic diagram

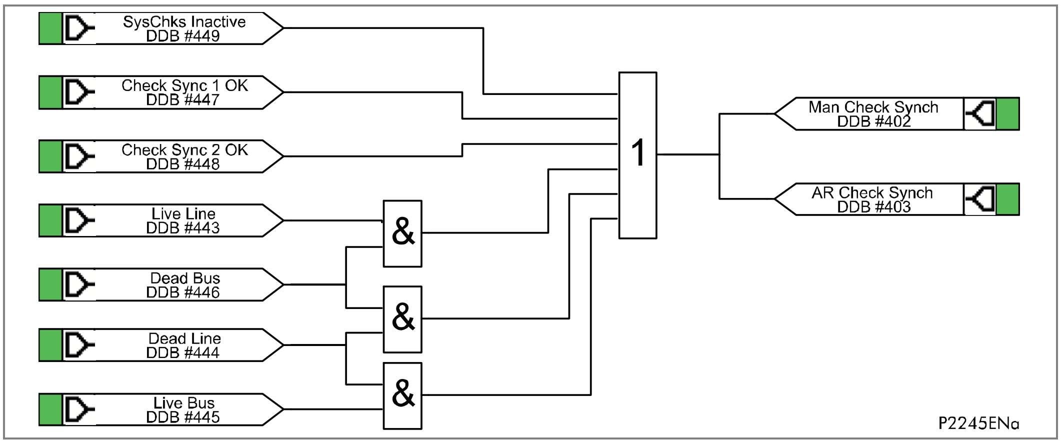


Figure 76 - Check sync. default PSL

2.3.4.3 Voltage and Phase Angle Correction

This feature involves the Check Synchronizing function with different VT ratios. The relay needs to convert the measured secondary voltages into primary voltage, which in turn shall be used for check synchronizing function. This is used in applications where the VTs are having different ratios on bus/line sides of the circuit breaker. Likewise, the transformer may be of any vector group (say Dy11, Yd5, etc.), in which case an angular correction factor is required in case the VTs mounted on different sides are used for synchronizing.

There are some applications where the main VT is in the HV side of a transformer and the check sync VT is in the LV side or vice-versa. Due to the group index of the transformer, if this is different from "**0**", both voltages are not "**in phase**", so the Check Synchronizing feature must have a ‘**k**’ factor (correction factor) in order to give this vectorial correction.

kSM, setting ranges from 0.1 to 3, in steps of 0.001, where kSM is the voltage correction factor.

kSA, setting ranges from -150 to 180º, in steps of 30º, where kSA is the angle correction factor.

After adding ‘k’ factors:

For the check synch the following will be used:

For matching magnitudes, assuming C/S input setting [0A0F] is A-N:

If:

$$V_{cs(\sec)} \times kSM = V_{a(\sec)}$$ then line and bus voltages magnitudes are matched

For matching angles:

If:

$$\angle V_{cs(\sec)}{}^{\circ} + kSA^{\circ} = \angle V_{a(\sec)}{}^{\circ}$$

then line and bus voltage angles are matched

Where kSM is [0A14] C/S V kSM

and kSA is [0A15] C/S Phase kSA

Important	***Setting the right VT ratios will not adjust the k factors and will have no impact on the check synch functionality, check synch will only take into account the k factors setting. The VT ratios have impacts on the presentation of the related measurements or settings in terms of primary or secondary values. The CS voltage settings in system check column are all referenced by the Main VT ratios. The Bus-Line Ang [0230] measurement takes into account the C/S Phase kSA setting.***

Following are various possible application scenarios, wherein voltage correction factor and angular correction factors are applied to match different VT ratios:

Scenario	Physical Ratio's (ph-N Values)				Relay Setting Ratio's				CS Correction Factors	
	Main VT Ratio		CS VT Ratio		Main VT Ratio (ph-ph) Always		CS VT Ratio		kSM [0A14]	kSA [0A15]
	Pri (kV)	Sec (V)	Pri (kV)	Sec (V)	[0A01]Pri (kV)	[0A02]Sec (V)	[0A03]Pri (kV)	[0A04]Sec (V)		
1	220/√3	110/√3	132/√3	100/√3	220	110	132	100	1.1	30º
2	220/√3	110/√3	220/√3	110	220	110	127	110	0.577	0º
3	220/√3	110/√3	220/√3	110/3	220	110	381	110	1.732	0º

Table 10 - Physical and Relay Setting Ratios and Correction Factors

In the above examples, the CS VT ratio settings in the relay are so adjusted to a value such that they are within the acceptable range of the relay inputs and by multiplying a voltage correction factor, kSA, they are corrected and made equal to the physical ratios. This does not directly match the physical ratios. It can be phase - phase, phase - neutral or any ratio which can match the physical VT ratio.

2.4 Function Keys (P145 only)

The P145 relay offers users 10 function keys for programming any operator control functionality such as auto-reclose ON/OFF, earth fault1 ON/OFF etc. via PSL. Each function key has an associated programmable tri-color LED that can be programmed to give the desired indication on function key activation.

These function keys can be used to trigger any function that they are connected to as part of the PSL. The function key commands can be found in the '**Function Keys**' menu (see Settings section, P14x/EN ST). In the '**Fn. Key Status**' menu cell there is a 10 bit word which represent the 10 function key commands and their status can be read from this 10 bit word.

In the programmable scheme logic editor 10 function key signals, DDB 712 - 721, which can be set to a logic 1 or On state, as described above, are available to perform control functions defined by the user.

The "**Function Keys**" column has '**Fn. Key n Mode**' cell which allows the user to configure the function key as either '**Toggled**' or '**Normal**'. In the '**Toggle**' mode the function key DDB signal output will remain in the set state until a reset command is given, by activating the function key on the next key press. In the '**Normal**' mode, the function key DDB signal will remain energized for as long as the function key is pressed and will then reset automatically. A minimum pulse duration can be programmed for a function key by adding a minimum pulse timer to the function key DDB output signal.

The "**Fn. Key n Status**" cell is used to enable/unlock or disable the function key signals in PSL. The '**Lock**' setting has been specifically provided to allow the locking of a function key thus preventing further activation of the key on consequent key presses. This allows function keys that are set to '**Toggled**' mode and their DDB signal active '**high**', to be locked in their active state thus preventing any further key presses from deactivating the associated function. Locking a function key that is set to the "**Normal**" mode causes the associated DDB signals to be permanently off. This safety feature prevents any inadvertent function key presses from activating or deactivating critical relay functions.

The "**Fn. Key Labels**" cell makes it possible to change the text associated with each individual function key. This text will be displayed when a function key is accessed in the function key menu, or it can be displayed in the PSL.

The status of the function keys is stored in battery backed memory. In the event that the auxiliary supply is interrupted the status of all the function keys will be recorded. Following the restoration of the auxiliary supply the status of the function keys, prior to supply failure, will be reinstated. If the battery is missing or flat the function key DDB signals will set to logic 0 once the auxiliary supply is restored. Please also note the relay will only recognize a single function key press at a time and that a minimum key press duration of approximately 200msec. is required before the key press is recognized in PSL. This deglitching feature avoids accidental double presses.

2.5 Voltage Transformer Supervision (VTS)

The Voltage Transformer Supervision (VTS) feature is used to detect failure of the ac voltage inputs to the relay. This may be caused by internal voltage transformer faults, overloading, or faults on the interconnecting wiring to relays. This usually results in one or more VT fuses blowing. Following a failure of the ac voltage input there would be a misrepresentation of the phase voltages on the power system, as measured by the relay, which may result in mal-operation.

The VTS logic in the relay is designed to detect the voltage failure, and automatically adjust the configuration of protection elements whose stability would otherwise be compromised. A time-delayed alarm output is also available.

There are three main aspects to consider regarding the failure of the VT supply:

- Loss of one or two phase voltages
- Loss of all three phase voltages under load conditions
- Absence of three phase voltages on line energization

The VTS feature within the relay operates on detection of Negative Phase Sequence (NPS) voltage without the presence of NPS current. This gives operation for the loss of one or two-phase voltages. Stability of the VTS function is assured during system fault conditions, by the presence of NPS current. The use of negative sequence quantities ensures correct operation even where three-limb or '**V**' connected VT's are used.

Negative Sequence VTS Element:

> The negative sequence thresholds used by the element are V_2 = 10V (or 40V on a 380/440V rated relay), and I_2 = 0.05 to 0.5In settable (defaulted to 0.05In).

2.5.1 Loss of all 3-Phase Voltages under Load Conditions

Under the loss of all three phase voltages to the relay, there will be no negative phase sequence quantities present to operate the VTS function. However, under such circumstances, a collapse of the three phase voltages will occur. If this is detected without a corresponding change in any of the phase current signals (which would be indicative of a fault), a VTS condition will be raised. In practice, the relay detects the presence of superimposed current signals, which are changes in the current applied to the relay. These signals are generated by comparison of the present value of the current with that exactly one cycle previously. Under normal load conditions, the value of superimposed current should therefore be zero. Under a fault condition a superimposed current signal will be generated which will prevent operation of the VTS.

The phase voltage level detectors are fixed and will drop off at 10V (40V on 380/440V relays) and pickup at 30V (120V on 380/440V relays).

The sensitivity of the superimposed current elements is fixed at 0.1 In.

2.5.2 Absence of 3-Phase Voltages on Line Energization

If a VT were inadvertently left isolated prior to line energization, incorrect operation of voltage dependent elements could result. The previous VTS element detected 3-phase VT failure by absence of all 3-phase voltages with no corresponding change in current. On line energization there will, however, be a change in current (as a result of load or line charging current for example). An alternative method of detecting 3-phase VT failure is therefore required on-line energization.

The absence of measured voltage on all three phases on line energization can result from two conditions:

- The first is a three-phase VT failure.
- The second is a close up three-phase fault.

The first condition would require blocking of the voltage dependent function and the second would require tripping.

To differentiate between these two conditions an overcurrent level detector (VTS I> Inhibit) is used which will prevent a VTS block from being issued if it operates. This element should be set in excess of any non-fault based currents on line energization (load, line charging current, transformer inrush current if applicable) but below the level of current produced by a close up three-phase fault. If the line is now closed where a three-phase VT failure is present the overcurrent detector will not operate and a VTS block will be applied. Closing onto a three-phase fault will result in operation of the overcurrent detector and prevent a VTS block being applied.

This logic will only be enabled during a live line condition (as indicated by the relay's pole dead logic) to prevent operation under dead system conditions, where no voltage will be present and the **VTS I> Inhibit** overcurrent element will not be picked up.

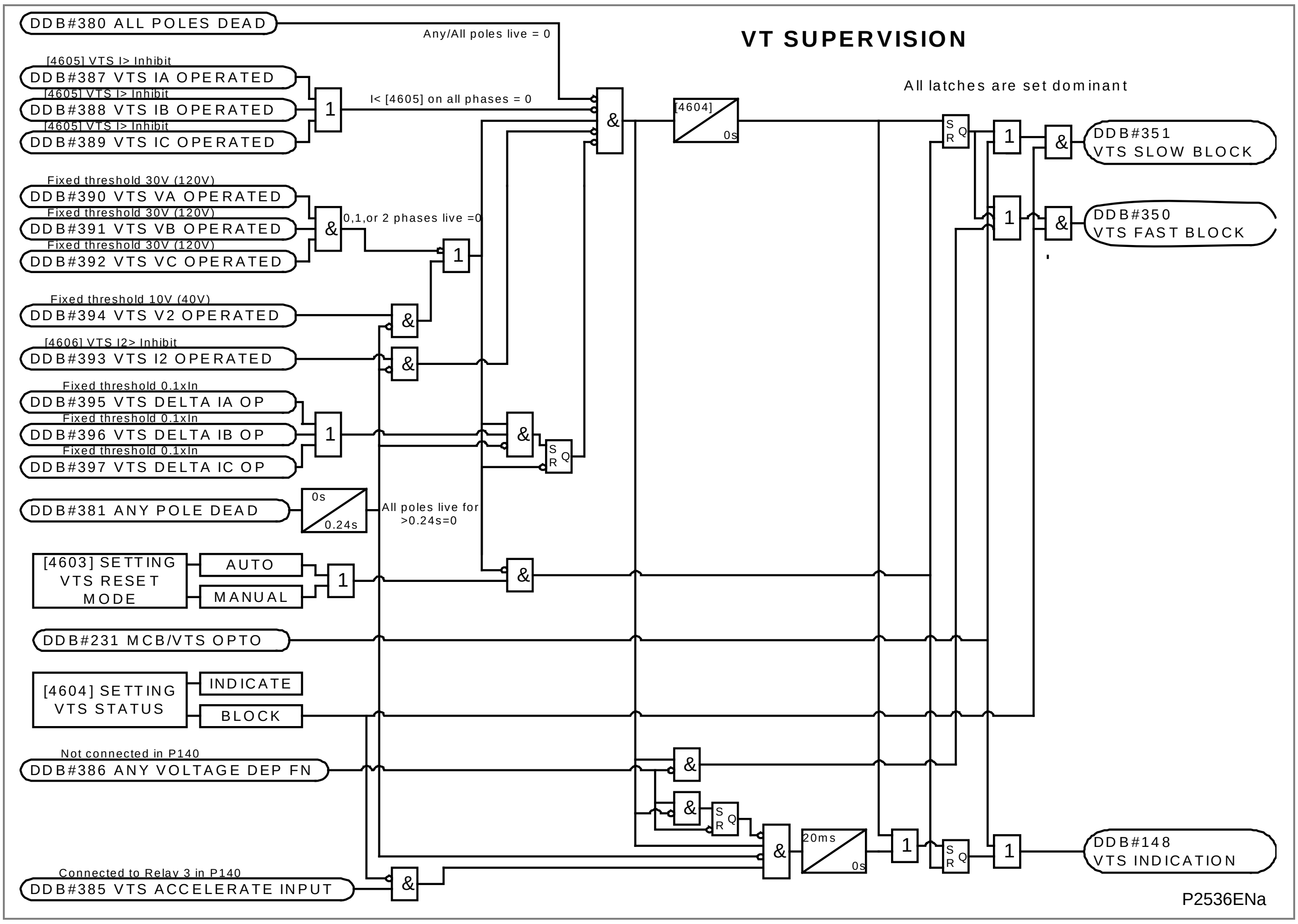


Figure 77 - VTS Logic

POLE DEAD = CB OPEN OR (I<0.05xIn AND V<10V AND VTS SLOW BLOCK=0)

i.e. Pole live = CB CLOSED AND (I>0.055xIn OR V>30V OR VTS SLOW BLOCK =1)

Required to drive the VTS logic are a number of dedicated level detectors as follows:

- IA>, IB>, IC> these level detectors operate in less than 20ms and their settings should be greater than load current. This setting is specified as VTS current threshold

- I2> this level detector operates on negative sequence current and has a user setting
- ∆IIA>, ∆IB>, ∆IC> these are level detectors operating on superimposed phase currents and have a fixed setting of 10% of nominal
- VA>, VB>, VC> these are level detectors operating on phase voltages and have a fixed setting Pickup level 30V (Vn 100/120V), 120V (Vn 380/440V), Drop Off level 10V (Vn 100/120V), 40V (Vn 380/440V)
- V2> this level detector operates on negative sequence voltage, it has a fixed setting of 10V/40V depending on VT ratio (100/120 or 380/440)

2.5.2.1 Outputs

Signal Name	Description
VTS Fast Block	Used to block voltage dependent functions
VTS Slow block	Used to block the Any Pole dead signal
VTS Indication	Signal used to indicate a VTS operation

Table 11 - Signal name outputs

2.6 Current Transformer Supervision (CTS)

The CT supervision feature operates on detection of derived zero sequence current, in the absence of corresponding derived zero sequence voltage that would normally accompany it. The CTS logic is shown in Figure 78.

The voltage transformer connection used must be able to refer zero sequence voltages from the primary to the secondary side. Thus, this element should only be enabled where the VT is of five limb construction, or comprises three single-phase units, and has the primary star point earthed.

Operation of the element will produce a time-delayed alarm visible on the LCD and event record (plus DDB 149: CT Fail Alarm), with an instantaneous block (DDB 352: CTS Block) for inhibition of protection elements. Protection elements operating from derived quantities (Broken Conductor, Earth Fault2, Neg. Seq. O/C) are always blocked on operation of the CT supervision element; other protections can be selectively blocked by customizing the PSL, integrating DDB 352: CTS Block with the protection function logic.

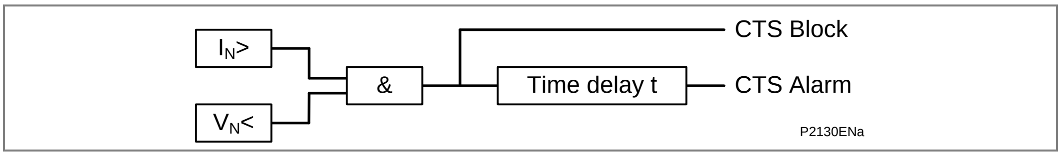


Figure 78 - CT supervision logic diagram

2.7 Circuit Breaker State Monitoring

The relay incorporates circuit breaker state monitoring, giving an indication of the position of the circuit breaker, or, if the state is unknown, an alarm is raised.

2.7.1 Circuit Breaker State Monitoring Features

MiCOM relays can be set to monitor normally open (52a) and normally closed (52b) auxiliary contacts of the circuit breaker. Under healthy conditions, these contacts will be in opposite states. Should both sets of contacts be open, this would indicate one of the following conditions:

- Auxiliary contacts/wiring defective
- Circuit Breaker (CB) is defective
- CB is in isolated position

Should both sets of contacts be closed, only one of the following two conditions would apply:

- Auxiliary contacts/wiring defective
- Circuit Breaker (CB) is defective

If any of the above conditions exist, an alarm will be issued after a 5s time delay. A normally open/normally closed output contact can be assigned to this function via the Programmable Scheme Logic (PSL). The time delay is set to avoid unwanted operation during normal switching duties.

In the CB CONTROL column of the relay menu there is a setting called '**CB Status Input**'. This cell can be set at one of the following four options:

- None
- 52A
- 52B
- Both 52A and 52B

Where '**None**' is selected no CB status will be available. This will directly affect any function within the relay that requires this signal, for example CB control, auto-reclose, etc. Where only 52A is used on its own then the relay will assume a 52B signal from the absence of the 52A signal. Circuit breaker status information will be available in this case but no discrepancy alarm will be available. The above is also true where only a 52B is used. If both 52A and 52B are used then status information will be available and in addition a discrepancy alarm will be possible, according to the following table. 52A and 52B inputs are assigned to relay opto-isolated inputs via the PSL. The CB State Monitoring logic is shown in Figure 78.

Auxiliary Contact Position		CB State Detected	Action
52A	52B		
Open	Closed	Breaker open	Circuit breaker healthy
Closed	Open	Breaker closed	Circuit breaker healthy
Closed	Closed	CB failure	Alarm raised if the condition persists for greater than 5s
Open	Open	State unknown	Alarm raised if the condition persists for greater than 5s

Table 12 - CB state monitoring logic

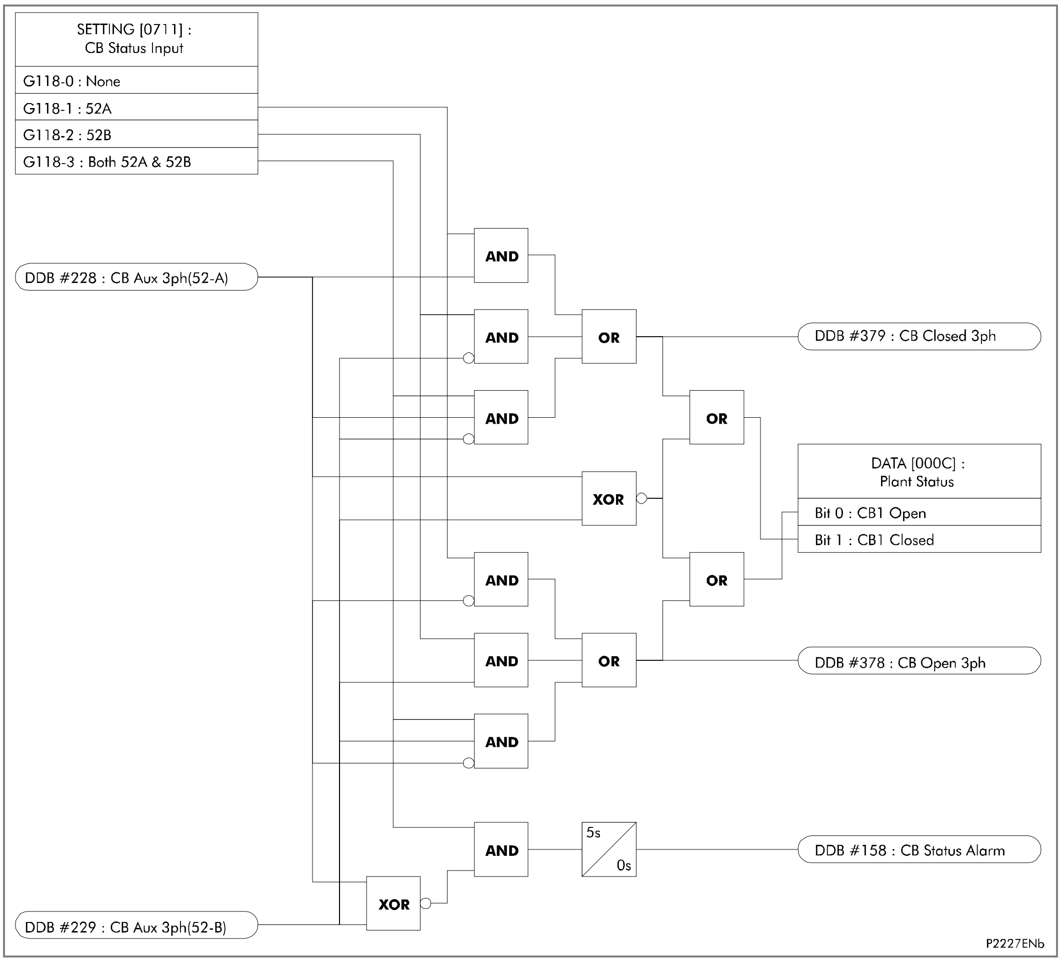


Figure 79 - CB state monitoring

2.8 Pole Dead Logic

The Pole Dead Logic can be used to give an indication if one or more phases of the line are dead. It can also be used to selectively block operation of both the under frequency and under voltage elements. The under voltage protection will be blocked by a pole dead condition provided the “**Pole Dead Inhibit**” setting is enabled. Any of the four under frequency elements can be blocked by setting the relevant “**F< function links**”.

A pole dead condition is determined by either monitoring the status of the circuit breaker auxiliary contacts or by measuring the line currents and voltages. The status of the circuit breaker is provided by the “**CB State Monitoring**” logic. If a “**CB Open**” signal (DDB 378) is given the relay will automatically initiate a pole dead condition regardless of the current and voltage measurement. Similarly if both the line current and voltage fall below a pre-set threshold the relay will also initiate a pole dead condition. This is necessary so that a pole dead indication is still given even when an upstream breaker is opened. The under voltage (V<) and under current (I<) thresholds have the following, fixed, pickup and drop-off levels:

Settings	Range	Step Size
V< Pick-up and drop off	10V and 30V (100/120V) 40V and 120V (380/440V)	Fixed
I< Pick-up and drop off	0.05 In and 0.055In	Fixed

Table 13 - Settings, range and step size

If one or more poles are dead the relay will indicate which phase is dead and will also assert the ANY POLE DEAD DDB signal (DDB 384). If all phases were dead the ANY POLE DEAD signal would be accompanied by the ALL POLE DEAD DDB signal (DDB 380).

In the event that the VT fails a signal is taken from the VTS logic (DDB 351 - Slow Block) to block the pole dead indications that would be generated by the under voltage and undercurrent thresholds. However, the VTS logic will not block the pole dead indications if they are initiated by a “**CB Open**” signal (DDB 378).

The pole dead logic diagram is shown in Figure 79.

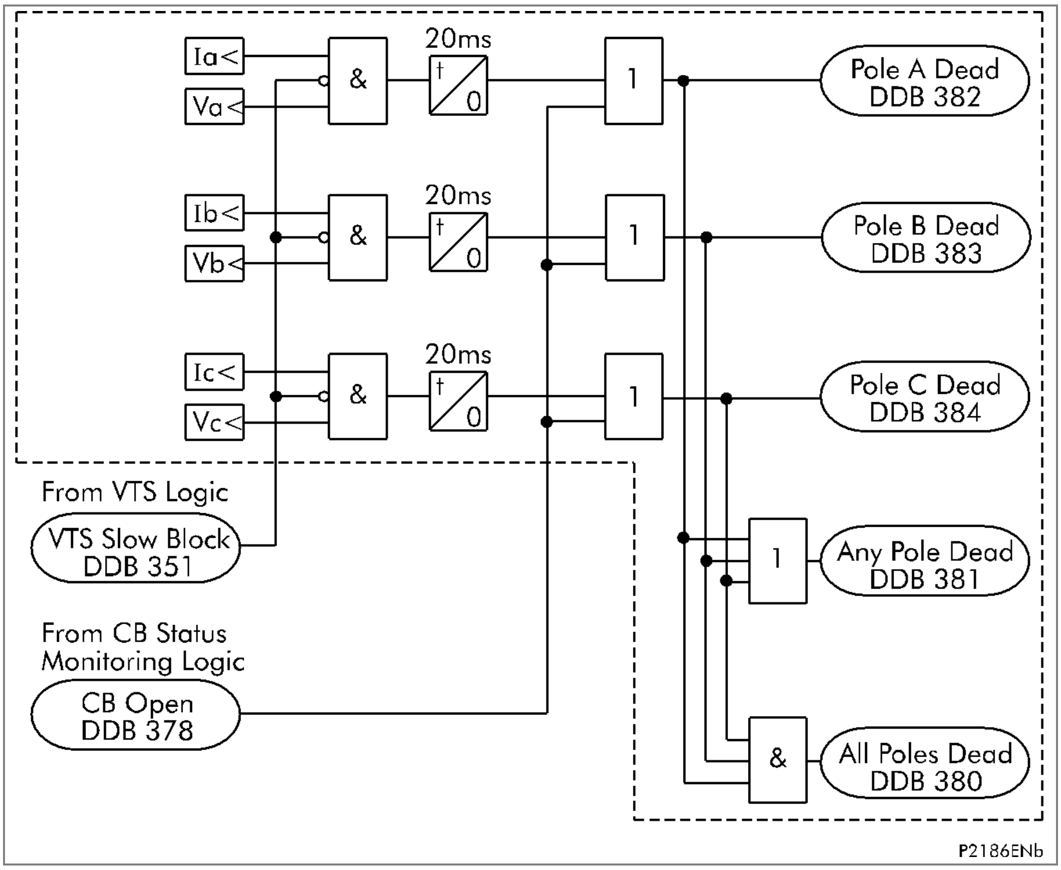


Figure 80 - Pole dead logic

2.9 Circuit Breaker Condition Monitoring

The P14x relays record various statistics related to each circuit breaker trip operation, allowing a more accurate assessment of the circuit breaker condition to be determined. These monitoring features are discussed in the following section.

2.9.1 Circuit Breaker Condition Monitoring Features

For each circuit breaker trip operation the relay records statistics as shown in the following table taken from the relay menu. The menu cells shown are counter values only. The Min./Max. values in this case show the range of the counter values. These cells can not be set.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	**Max.**	
CB Operations {3 pole tripping}	0	0	10000	1
Displays the total number of 3 pole trips issued by the relay.				
Total IA Broken	0	0	25000In^	1
Displays the total fault current interrupted by the relay for the A phase.				
Total IB Broken	0	0	25000In^	1
Displays the total fault current interrupted by the relay for the A phase.				
Total IC Broken	0	0	25000In^	1In^
Displays the total fault current interrupted by the relay for the A phase.				
CB Operate Time	0	0	0.5s	0.001
Displays the calculated CB operating time.				
Reset CB Data	No		Yes, No	
Setting to reset the CB condition counters.				

Table 14 - CB Settings

The above counters may be reset to zero, for example, following a maintenance inspection and overhaul. The circuit breaker condition monitoring counters will be updated every time the relay issues a trip command. In cases where the breaker is tripped by an external protection device it is also possible to update the CB condition monitoring. This is achieved by allocating one of the relays opto-isolated inputs (via the programmable scheme logic) to accept a trigger from an external device. The signal that is mapped to the opto is called '**External Trip**'.

Note	*When in Commissioning test mode the CB condition monitoring counters will not be updated.*

2.10 Circuit Breaker Control

The relay includes the following options for control of a single circuit breaker:

- Local tripping and closing, via the relay menu, hotkeys or function keys
- Local tripping and closing, via relay opto-isolated inputs
- Remote tripping and closing, using the relay communications

It is recommended that separate relay output contacts are allocated for remote circuit breaker control and protection tripping. This enables the control outputs to be selected via a local/remote selector switch as shown in Figure 80. Where this feature is not required the same output contact(s) can be used for both protection and remote tripping.

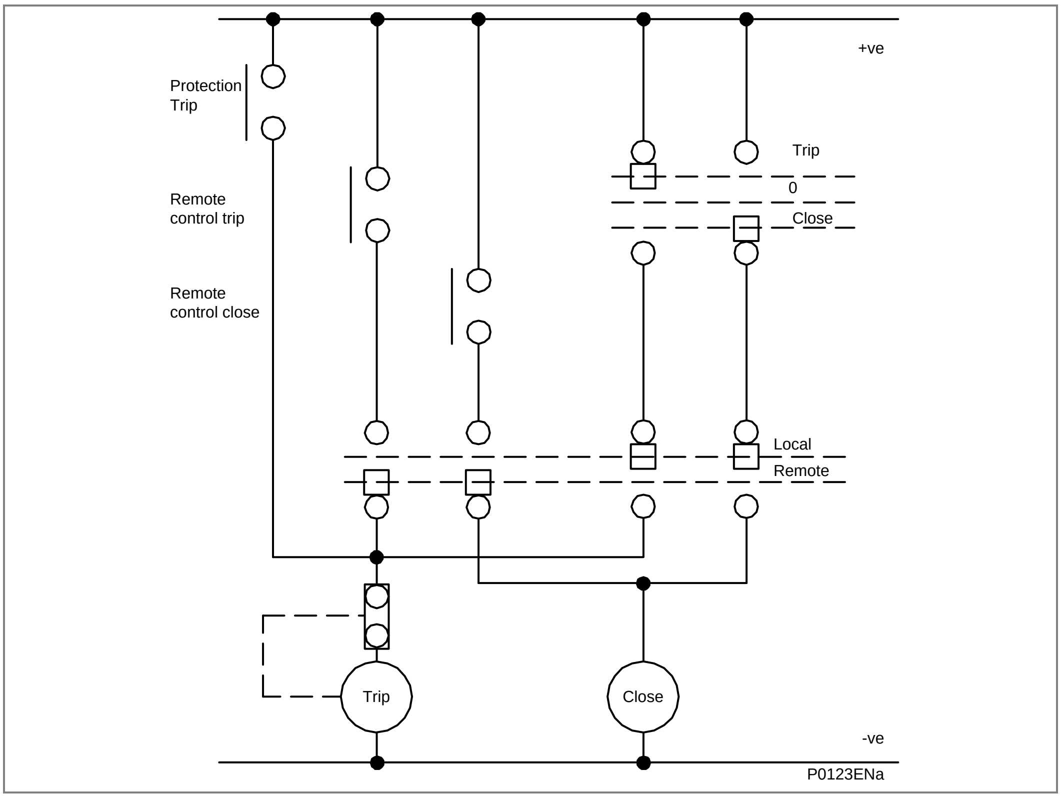


Figure 81 - Remote control of circuit breaker

A manual trip will be permitted provided that the circuit breaker is initially closed. Likewise, a close command can only be issued if the CB is initially open. To confirm these states it will be necessary to use the breaker 52A and/or 52B contacts (the different selection options are given from the '**CB Status Input**'). If no CB auxiliary contacts are available then this cell should be set to None. Under these circumstances no CB control (manual or auto) will be possible.

Once a CB Close command is initiated the output contact can be set to operate following a user defined time delay ('**Man. Close Delay**'). This would give personnel time to move safely away from the circuit breaker following the close command. This time delay will apply to all manual CB Close commands.

The length of the trip or close control pulse can be set via the '**Trip Pulse Time**' and '**Close Pulse Time**' settings respectively. These should be set long enough to ensure the breaker has completed its open or close cycle before the pulse has elapsed.

Note	*The manual trip and close commands are found in the SYSTEM DATA column and the hotkey menu.*

If an attempt to close the breaker is being made, and a protection trip signal is generated, the protection trip command overrides the close command.

Where the check synchronism function is set, this can be enabled to supervise manual circuit breaker close commands. A circuit breaker close output will only be issued if the check synchronism criteria are satisfied. A user settable time delay is included ('**C/S Window**') for manual closure with check synchronizing. If the check sync. criteria are not satisfied in this time period following a close command the relay will lockout and alarm.

In addition to a synchronism check before manual re-closure there is also a CB Healthy check if required. This facility accepts an input to one of the relays opto-isolators to indicate that the breaker is capable of closing (circuit breaker energy for example). A user settable time delay is included "**CB Healthy Time**" for manual closure with this check. If the CB does not indicate a healthy condition in this time period following a close command then the relay will lockout and alarm.

The "**Reset Lockout by**" setting, "**CB Close/User interface**" in "**CB CONTROL**" (0709) is used to enable/disable reset of lockout automatically from a manual close after the manual close time "**Man. Close Rst. Dly.**".

If the CB fails to respond to the control command (indicated by no change in the state of CB Status inputs) a "**CB Failed to Trip**" or "**CB Failed to Close**" alarm will be generated after the relevant trip or close pulses have expired. These alarms can be viewed on the relay LCD display, remotely via the relay communications, or can be assigned to operate output contacts for annunciation using the relays programmable scheme logic (PSL).

Note	*The "**CB Healthy Time**" timer and "**Check Sync. Time**" timer set under this menu section are applicable to manual circuit breaker operations only. These settings are duplicated in the auto-reclose menu for auto-reclose applications.*

The "**Lockout Reset**" and "**Reset Lockout by**" setting cells in the menu are applicable to CB Lockouts associated with manual circuit breaker closure, CB Condition monitoring (Number of circuit breaker operations, for example) and auto-reclose lockouts.

The CB Control logic is shown in Figure 81.

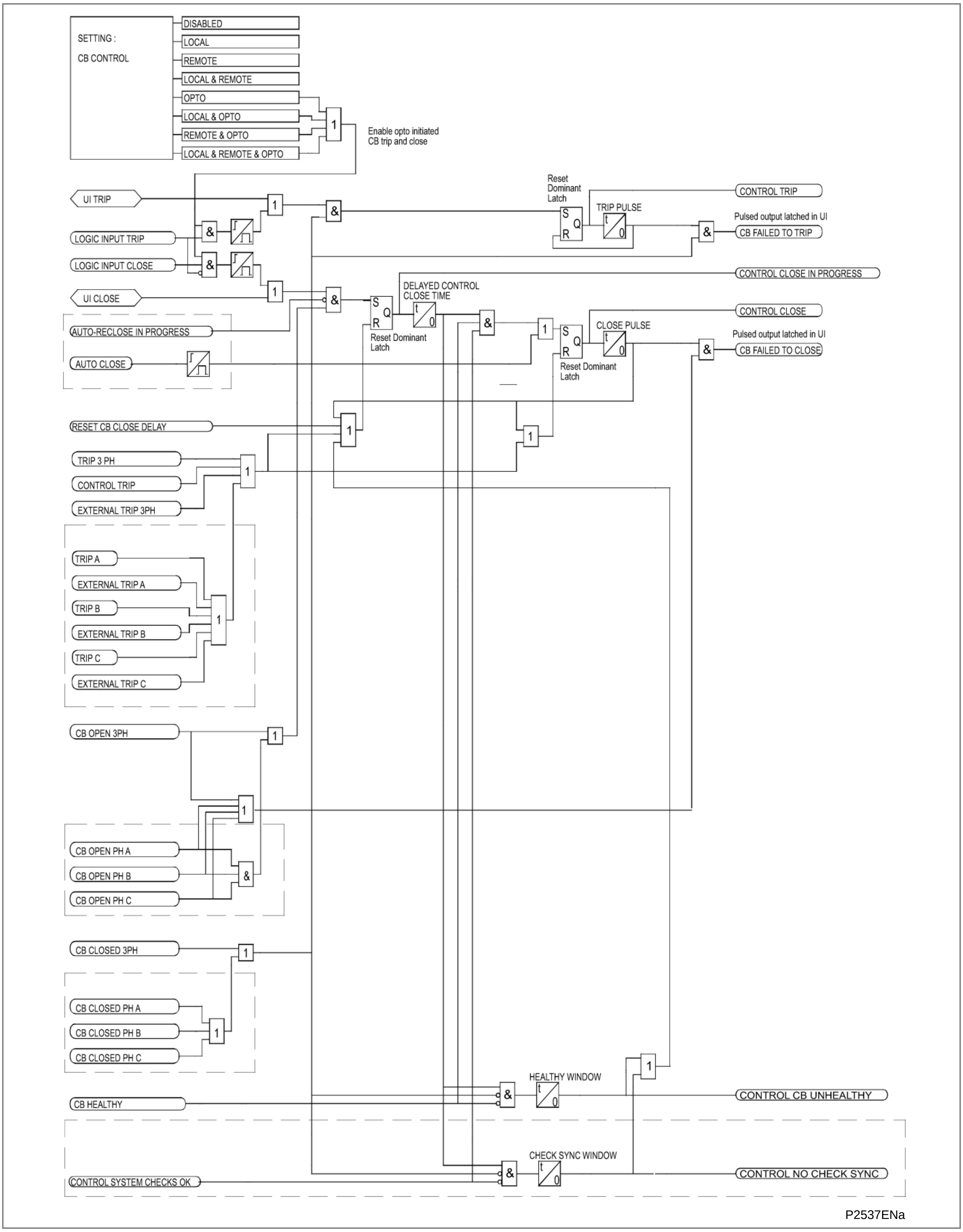


Figure 82 - Circuit breaker control

2.10.1 CB Control using Hotkeys

The hotkeys allow direct access to the manual trip and close commands without the need to enter the SYSTEM DATA column. Hotkeys supplement the direct access possible via the function keys described in section 2.4. Red or green color coding can be applied when used in CB control applications.

IF <<TRIP>> or <<CLOSE>> is selected the user is prompted to confirm the execution of the relevant command. If a trip is executed a screen with the CB status will be displayed once the command has been completed. If a close is executed a screen with a timing bar will appear while the command is being executed. This screen has the option to cancel or restart the close procedure. The timer used is taken from the manual close delay timer setting in the CB Control menu. When the command has been executed, a screen confirming the present status of the circuit breaker is displayed. The user is then prompted to select the next appropriate command or exit - this will return to the default relay screen.

If no keys are pressed for a period of 25 seconds while waiting for the command confirmation, the relay will revert to showing the CB Status. If no key presses are made for a period of 25 seconds while displaying the CB status screen, the relay will revert to the default relay screen. Figure 82 shows the hotkey menu associated with CB control functionality.

To avoid accidental operation of the trip and close functionality, the hotkey CB control commands will be disabled for 10 seconds after exiting the hotkey menu.

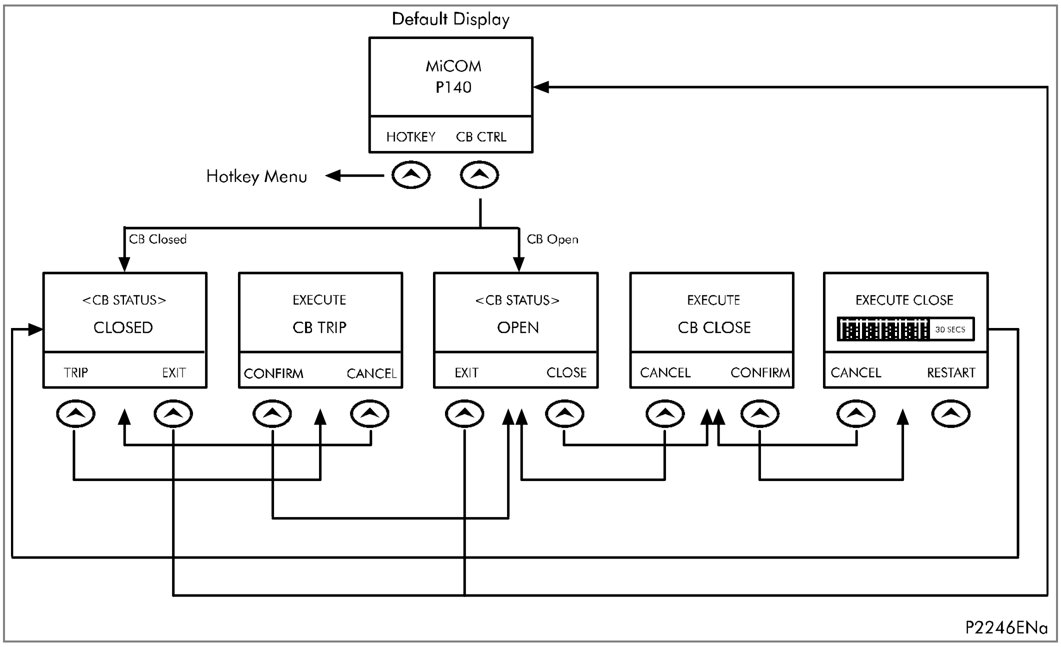


Figure 83 - CB control hotkey menu

2.10.2 CB Control using Function Keys

The function keys allow direct control of the circuit breaker if programmed to do this in PSL. local tripping and closing, via relay opto-isolated inputs must be set in the "**CB Control**" menu '**CB control by**' cell to enable this functionality. All CB manual control settings and conditions will apply for manual tripping and closing via function keys.

The following default logic can be programmed to activate this feature:

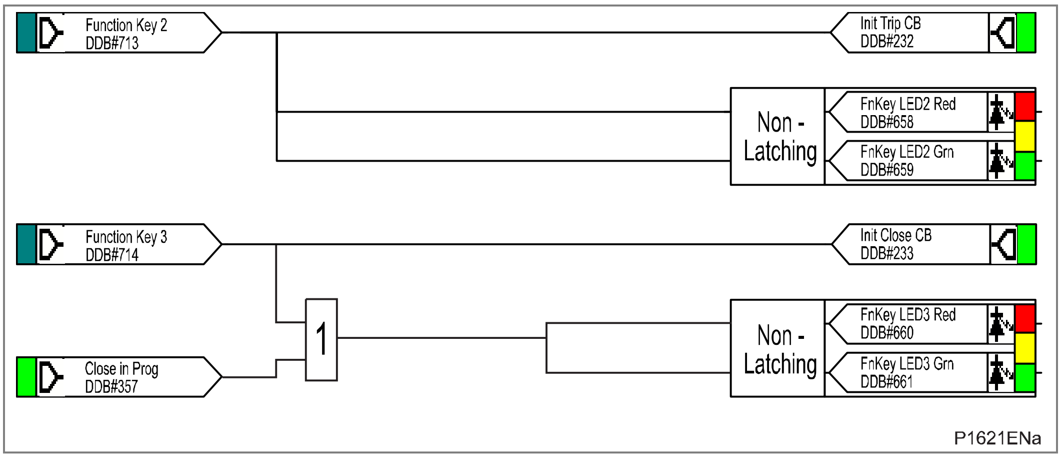


Figure 84 - CB control via function keys default PSL

Function key 2 and function key 3 are both enabled and set to '**Normal**' Mode and the associated DDB signals '**DDB 713**' and '**DDB 714**' will be active high '**1**' on key press.

The following DDB signal must be mapped to the relevant function key:

Init. Trip CB	(DDB 232)	Initiate manual circuit breaker trip
Init. Close CB	(DDB 233)	Initiate manual circuit breaker close

The programmable function key LED's have been mapped such that the LED's will indicate yellow whilst the keys are activated.

2.11 Setting Groups Selection

The setting groups can be changed either via opto inputs, via a menu selection, via the hotkey menu or via function keys (P145 model only). In the Configuration column if **'Setting Group - select via optos**' is selected then any opto input or function key can be programmed in PSL to select the setting group as shown in the table below. If **'Setting Group - select via menu**' is selected then in the Configuration column the **'Active Settings - Group1/2/3/4**' can be used to select the setting group.

The setting group can be changed via the hotkey menu providing '**Setting Group select via menu**' is chosen.

Two DDB signals are available in PSL for selecting a setting group via an opto input or function key selection (see default PSL in the Programmable Scheme Logic section, P14x/EN PL). The following table illustrates the setting group that is active on activation of the relevant DDB signals.

DDB 527 SG Select 1X	DDB 526 SG Select X1	Selected Setting Group
0	0	1
0	1	2
1	0	3
1	1	4

Note *Each setting group has its own PSL. Once a PSL has been designed it can be sent to any one of 4 setting groups within the relay. When downloading a PSL to the relay the user will be prompted to enter the desired setting group to which it will be sent. This is also the case when extracting a PSL from the relay.*

Table 15 - DDB setting groups

2.12 Control Inputs

The control inputs function as software switches that can be set or reset either locally or remotely. These inputs can be used to trigger any function that they are connected to as part of the PSL. There are three setting columns associated with the control inputs that are: "**CONTROL INPUTS**", "**CTRL. I/P CONFIG.**" and "**CTRL. I/P LABELS**". The function of these columns is described below:

Menu Text	Default Setting	Setting Range	Step Size
CONTROL INPUTS			
Ctrl I/P Status	00000000000000000000000000000000		
Control Input 1	No Operation	No Operation, Set, Reset	
Control Input 2 to 32	No Operation	No Operation, Set, Reset	

Table 16 - Control Inputs

The Control Input commands can be found in the '**Control Input**' menu. In the '**Ctrl. I/P status**' menu cell there is a 32 bit word which represent the 32 control input commands. The status of the 32 control inputs can be read from this 32-bit word. The 32 control inputs can also be set and reset from this cell by setting a 1 to set or 0 to reset a particular control input. Alternatively, each of the 32 Control Inputs can be set and reset using the individual menu setting cells '**Control Input 1, 2, 3**' etc. The Control Inputs are available through the relay menu as described above and also via the rear communications.

In the programmable scheme logic editor 32 Control Input signals, DDB 800 - 831, which can be set to a logic 1 or On state, as described above, are available to perform control functions defined by the user.

Menu Text	Default Setting	Setting Range	Step Size
CTRL. I/P CONFIG.			
Hotkey Enabled	11111111111111111111111111111111		
Control Input 1	Latched	Latched, Pulsed	
Ctrl Command 1	SET/RESET	SET/RESET, IN/OUT, ENABLED/DISABLED, ON/OFF	
Control Input 2 to 32	Latched	Latched, Pulsed	
Ctrl Command 2 to 32	SET/RESET	SET/RESET, IN/OUT, ENABLED/DISABLED, ON/OFF	

Table 17 - Ctrl. I/P Config.

Menu Text	Default Setting	Setting Range	Step Size
CTRL. I/P LABELS			
Control Input 1	Control Input 1	16 character text	
Control Input 2 to 32	Control Input 2 to 32	16 character text	

Table 18 - Ctrl. I/P Labels

The "**CTRL. I/P CONFIG.**" column has several functions one of which allows the user to configure the control inputs as either '**latched**' or '**pulsed**'. A latched control input will remain in the set state until a reset command is given, either by the menu or the serial communications. A pulsed control input, however, will remain energized for 10ms after the set command is given and will then reset automatically (i.e. no reset command required).

In addition to the latched/pulsed option this column also allows the control inputs to be individually assigned to the "**Hotkey**" menu by setting '**1'** in the appropriate bit in the "**Hotkey Enabled**" cell. The hotkey menu allows the control inputs to be set, reset or pulsed without the need to enter the "**CONTROL INPUTS**" column. The "**Ctrl. Command**" cell also allows the SET/RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as "**ON/OFF", "IN/OUT**" etc.

The "**CTRL. I/P LABELS**" column makes it possible to change the text associated with each individual control input. This text will be displayed when a control input is accessed by the hotkey menu, or it can be displayed in the PSL.

Note	*The status of the control inputs is stored in (non-volatile) FLASH memory.*

2.13 Custom Inputs

The custom inputs will be similar to the control inputs but the value will be a setting stored in flash, and will produce events. There are two setting columns associated with the custom inputs that are: "**CONTROL INPUTS**" and "**CTRL. I/P LABELS**". The function of these columns is described below:

Menu Text	Default Setting	Setting Range	Step Size
CONTROL INPUTS			
Ctl Stg I/P Stat	0000000000000000		
Ctrl Setg I/P 33	Disabled	Disabled, Enabled	
Ctrl Setg I/P 34 to 48	Disabled	Disabled, Enabled	

Table 19 – Ctrl Setg I/P Inputs

The Custom Input commands can be found in the '**Control Input**' menu. In the '**Ctl Stg I/P Stat**' menu cell there is a 16-bit word which represent the 16 custom input commands. The status of the 16 custom inputs can be read from this 16-bit word. The 16 custom inputs can also be set and reset from this cell by setting a 1 to set or 0 to reset a particular custom input. Alternatively, each of the 16 Custom Inputs can be set and reset using the individual menu setting cells 'Ctrl Setg I/P **33, 34, 35**' etc. Each of the custom inputs needs to be adjustable from Courier, CS103 and the User Interface.

In the programmable scheme logic editor 16 Custom Input signals, DDB 1197 - 1212, which can be set to a logic 1 or On state.

Menu Text	Default Setting	Setting Range	Step Size
CTRL I/P LABELS			
Ctrl Setg I/P 33	Ctrl Setg I/P 33	16 character text	
Ctrl Setg I/P 34 to 48	Ctrl Setg I/P 34 to 48	16 character text	

Table 20 – Ctrl Setg I/P Labels

The "**CTRL. I/P LABELS**" column makes it possible to change the text associated with each individual custom input.

Note	*The status of the custom inputs is stored in FLASH memory and will produce events*

2.14 User Alarms

2.14.1 User Alarms

The User Alarms have settable labels (these are similar to input / output labels). These are provided for customized labels such as binary inputs, output relays and control inputs.

The relay now includes a new "USER ALARM COLUMN LABELS" column to store the labels for each User Alarm.

Note	*The relay provides 35 USER ALARMS from 1 to 35.*

The User Alarm labels are used in the PSL configuration as for the binary inputs, output relays and control inputs.

2.14.2 Virtual IO User Alarms

The user can edit these labels to have customizable relays. This is useful where user alarm DDBs and GOOSE DDBs can have different names according to the customer requirements. Changes can be applied via the HMI or by using a setting file. The user needs to make sure that these changes are reflected in the PSL, in HMI and in the setting file.

Customers can change their usage of the IEC61850-DNP3 protocol. This may be useful if they are more familiar with or prefer to use DNP3 over other options.

The relay now includes new “VIRTUAL INPUT COLUMN LABELS” and “VIRTUAL OUTPUT COLUMN LABELS” columns.

2.14.3 Custom Input

The user inputs are similar to the control inputs but the value is a setting stored in flash memory. Each custom input has an individual customizable label. The inputs are adjustable from a Bit Field or separate enable/disable selection. Each of the inputs can be adjusted from Courier, CS103 and the User Interface.

2.15 Real Time Clock Synchronization via Opto-Inputs

In modern protective schemes it is often desirable to synchronize the relays real time clock so that events from different relays can be placed in chronological order. This can be done using the IRIG-B input, via the communication interface connected to the substation control system. DDB 610 (IRIG-B Signal Valid) will be true if IRIG-B signal is present and IRIG-B Sync. is Enabled. In addition to these methods the P14x range offers the facility to synchronize via an opto-input by routing it in PSL to DDB 475 (Time Sync.). Pulsing this input will result in the real time clock snapping to the nearest minute. The recommended pulse duration is 20ms to be repeated no more than once per minute. An example of the time sync. function is shown.

Time of "Sync. Pulse"	Corrected Time
19:47:00 to 19:47:29	19:47:00
19:47:30 to 19:47:59	19:48:00
Note *The above assumes a time format of hh:mm:ss*	

Table 21 - Time of "Sync. Pulse" and corrected time

To avoid the event buffer from being filled with unnecessary time sync. events, it is possible to ignore any event that is generated by the time sync. opto input. This can be done by applying the following settings:

Menu Text	Value
RECORD CONTROL	
Opto Input Event	Enabled
Protection Event	Enabled
DDB 63 – 32 (Opto Inputs)	Set "Time Sync." associated opto to 0

Table 22 - Record control

To improve the recognition time of the time sync. opto input by approximately 10ms, the opto input filtering could be disabled. This is achieved by setting the appropriate bit to 0 in the "**Opto Filter Cntl.**" cell (OPTO CONFIG. column). Disabling the filtering may make the opto input more susceptible to induced noise. Fortunately, the effects of induced noise can be minimized by using the methods described in the Product Design chapter.

The relay now has some new DDB signals. These have been added to validate the existence of IRIG-B card signals. IRIG-B signals are validated when the IRIG-B card signal setting which is enabled occurs at the same time as when the IRIG-B signal status setting is present. This logic is shown in Figure 84 below.

This is useful because it allows a customer to map an additional DDB in the PSL to indicate the IRIG-B status. This means that the customer can then monitor the validation of the IRIG-B signals. For example, they could then assign it to an output relay and send it (via the relevant protocol) using a SCADA communications system.

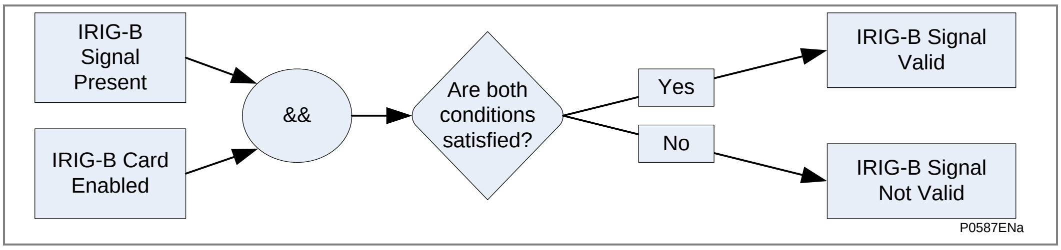


Figure 85 – IRIG-B signals validation chart

2.16 Enhanced Opto Time Stamping

Each opto-input sample will be time stamped within a tolerance of ±1ms with respect to the relay's Real Time Clock. These time stamps shall be utilized for the opto event logs and for the disturbance recording. The relay needs to be synchronized accurately to an external clock source such as the GPS clock and the synchronization shall consist of IRIG-B and SNTP through Ethernet communication. The P14x time synchronization accuracy will be 1ms through IRIG-B (both modulated and de-modulated) and SNTP. The total time stamping accuracy, with reference to an external clock source, also takes the time synchronization accuracy into consideration.

For both the filtered and unfiltered opto inputs, the time stamp of an opto change event will be the sampling time at which the opto change of state has occurred. If a mixture of filtered and unfiltered optos changes state at the same sampling interval, these state changes will be reported as a single event. The enhanced opto event time stamping is consistent across all the implemented protocols. The GOOSE messages will be published in a timely manner and will not be delayed by any event filtering mechanisms that is used to align the event time stamps.

2.17 Read Only Mode

With IEC 61850 and Ethernet / Internet communication capabilities, security has become a pressing issue. The Px40 relay provides a facility to allow the user to enable or disable the change in configuration remotely. Note that in the IEC 60870-5-103 protocol, the Read Only Mode function is different from the existing Command block feature.

2.17.1 Protocol/Port Implementation

2.17.1.1 IEC 60870-5-103 Protocol on Rear Port 1

The protocol does not support settings but the indications, measurands and disturbance records commands are available at the interface.

Allowed:

Poll Class 1 (read spontaneous events)

Poll Class 2 (read measurands)

GI sequence (ASDU7 '**Start GI**', Poll Class 1)

Transmission of Disturbance Records sequence (ASDU24, ASDU25, Poll Class 1)

Time Synchronization (ASDU6)

General Commands (ASDU20), namely:

- INF23 activate characteristic 1
- INF24 activate characteristic 2
- INF25 activate characteristic 3
- INF26 activate characteristic 4

Blocked:

Write parameter (=change setting) (private ASDUs)

- General Commands (ASDU20), namely:
- INF16 auto-recloser on/off
- INF19 LED reset
- Private INFs (e.g. CB open/close, control inputs)

2.17.1.2 Courier Protocol on Rear Port 1/2 and Ethernet

Allowed:

Read settings, statuses, measurands

Read records (event, fault, disturbance)

Time Synchronization

Change active setting group

Blocked:
Write settings
All controls, including:
Reset Indication (Trip LED)
Operate control inputs
CB operations
Auto-reclose operations
Reset demands
Clear event/fault/maintenance/disturbance records
Test LEDs & contacts

2.17.1.3 IEC 61850

Allowed:
Read statuses, measurands
Generate reports
Extract disturbance records
Time synchronization
Change active setting group
Blocked:
All controls, including:
Enable/disable protection
Operate control inputs
CB operations (Close/Trip, Lock)
Reset LEDs

2.17.2 Courier Database Support

Three new settings, one for each remote communications port at the back of the relay are created to support the enabling and disabling of the read only mode at each port.

The '**NIC Read Only**' setting will apply to all the communications protocols (including the Tunnelled Courier) that are transmitted via the Ethernet Port. Their default values are '**Disabled**'.

The MODBUS and DNP3 communications interfaces that do not support the feature will ignore these settings.

2.17.3 New DDB Signals

The remote read only mode is also available in the PSL via three dedicated DDB signals:

- RP1 Read Only
- RP2 Read Only
- NIC Read Only

Through careful scheme logic design, the activations of these read only signals can be facilitated via Opto Inputs, Control Inputs and Function Keys.

APPLICATION NOTES

CHAPTER 6

Date:	07/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142 & P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

CONTENTS

TABLES

FIGURES

EQUATIONS

1 INTRODUCTION

1.1 Frequency Protection

Generation and utilization need to be well balanced in any industrial, distribution or transmission network. As load increases, the generation needs to be stepped up to maintain frequency of the supply because there are many frequency sensitive electrical apparatus that can be damaged when network frequency departs from the allowed band for safe operation. At times, when sudden overloads occur, the frequency drops at a rate decided by the system inertia constant, magnitude of overload, system damping constant and various other parameters. Unless corrective measures are taken at the appropriate time, frequency decay can go beyond the point of no return and cause widespread network collapse. In a wider scenario, this can result in “Blackouts”. To put the network back in healthy condition, considerable amount of time and effort is required to re-synchronize and re-energize.

Protective relays that can detect a low frequency condition are generally used in such cases to disconnect unimportant loads in order to save the network, by re-establishing the “generation-load equation”. However, with such devices, the action is initiated only after the event and while some salvaging of the situation can be achieved, this form of corrective action may not be effective enough and cannot cope with sudden load increases, causing large frequency decays in very short times. In such cases a device that can anticipate the severity of frequency decay and act to disconnect loads before the frequency actually reaches dangerously low levels, can become very effective in containing damage.

During severe disturbances, the frequency of the system oscillates as various generators try to synchronize on to a common frequency. The measurement of instantaneous rate of change of frequency can be misleading during such a disturbance. The frequency decay needs to be monitored over a longer period of time to make the correct decision for load shedding.

Normally, generators are rated for a lifetime operation in a particular band of frequency and operation outside this band can cause mechanical damage to the turbine blades. Protection against such contingencies is required when frequency does not improve even after load shedding steps have been taken and can be used for operator alarms or turbine trips in case of severe frequency decay.

Whilst load shedding leads to an improvement in the system frequency, the disconnected loads need to be reconnected after the system is stable again. Loads should only be restored if the frequency remains stable for some period of time, but minor frequency excursions can be ignored during this time period. The number of load restoration steps are normally less than the load shedding steps to reduce repeated disturbances while restoring load.

This 9 stage advance frequency protection is available in P14x relays only when this feature “Adv. Freq. Prot’n” is enabled in the configuration menu and disabling the 4 stage Under/Over/Rate of Change frequency protection.

2 APPLICATION OF INDIVIDUAL PROTECTION FUNCTIONS

These sections detail the individual protection functions in addition to where and how they may be applied. Worked examples show how the settings are applied to the relay.

2.1 Overcurrent Protection

Overcurrent relays are the most commonly used protective devices in any industrial or distribution power system. They provide main protection to both feeders and busbars when unit protection is not used. They are also commonly applied to provide back-up protection when unit systems, such as pilot wire schemes, are used.
There are a few application considerations to make when applying overcurrent relays.

2.1.1 Transformer Magnetizing Inrush

When applying overcurrent protection to the HV side of a power transformer it is usual to apply a high set instantaneous overcurrent element in addition to the time delayed low-set, to reduce fault clearance times for HV fault conditions. Typically, this will be set to approximately 1.3 times the LV fault level, such that it will only operate for HV faults. A 30% safety margin is sufficient due to the low transient overreach of the third and fourth overcurrent stages. Transient overreach defines the response of a relay to DC components of fault current and is quoted as a percentage.

The second requirement for this element is that it should remain inoperative during transformer energization, when a large primary current flows for a transient period. In most applications, the requirement to set the relay above the LV fault level will automatically result in settings that will be above the level of magnetizing inrush current.

As an alternative, inrush blocking can be applied.

In applications where the sensitivity of overcurrent thresholds need to be set below the prospective peak inrush current, the inrush block function can be used to block the overcurrent, earth fault and negative sequence overcurrent stages.

During transformer inrush conditions, the second harmonic component of the inrush current may be as high as 70%. In practice, the second harmonic level may not be the same for all phases during inrush and therefore the relay will provide an Inrush Blocking signal for any phase above the set threshold. In general, a setting of 15% to 20% for the Inrush H2 ratio can be applied in most cases taking care that setting it too high, inrush blocking may not operate for low levels of second harmonic current which may result in the O/C element tripping during transformer energization. Similarly applying a too low a setting, inrush blocking may prevent tripping during some internal transformer faults with significant second harmonic current.

2.1.2 Application of Timer Hold Facility

This feature may be useful in certain applications, for example when grading with upstream electromechanical overcurrent relays, which have inherent reset time delays. Setting of the hold timer to a value other than zero, delays the resetting of the protection element timers for this period thus allowing the element to behave similar to an electromechanical relay.
Another possible situation where the timer hold facility may be used to reduce fault clearance times is where intermittent faults may be experienced. An example of this may occur in a plastic insulated cable. In this application it is possible that the fault energy melts and reseals the cable insulation, thereby extinguishing the fault. This process repeats to give a succession of fault current pulses, each of increasing duration with reducing intervals between the pulses, until the fault becomes permanent.
When the reset time of the overcurrent relay is instantaneous, the relay will be repeatedly reset and not be able to trip until the fault becomes permanent. By using the Timer Hold facility the relay will integrate the fault current pulses, thereby reducing fault clearance time.

2.1.3 Setting Guidelines

When applying the overcurrent protection provided in the P145 relays, standard principles should be applied in calculating the necessary current and time settings for co-ordination The Network Protection and Automation Guide (NPAG) textbook offers further assistance. The example detailed below shows a typical setting calculation and describes how the settings are applied to the relay.

Assume the following parameters for a relay feeding an LV switchboard:

CT Ratio	=	500/1
Full load current of circuit	=	450A
Slowest downstream protection	=	100A Fuse

The current setting employed on the P145 relay must account for both the maximum load current and the reset ratio of the relay itself:

I> must be greater than: 450/0.95 = 474A

The P145 relay allows the current settings to be applied to the relay in either primary or secondary quantities. This is done by programming the "Setting Values" cell of the "CONFIGURATION" column to either primary or secondary. When this cell is set to primary, all phase overcurrent setting values are scaled by the programmed CT ratio. This is found in the "VT & CT Ratios" column of the relay menu, where cells "Phase CT Primary" and "Phase CT Secondary" can be programmed with the primary and secondary CT ratings, respectively.

In this example, assuming primary currents are to be used, the ratio should be programmed as 500/1.

The required setting is therefore 0.95A in terms of secondary current or 475A in terms of primary.

A suitable time delayed characteristic will now need to be chosen. When co-ordinating with downstream fuses, the applied relay characteristic should be closely matched to the fuse characteristic. Therefore, assuming IDMT co-ordination is to be used, an Extremely Inverse (EI) characteristic would normally be chosen. As previously described, this is found under "I>1 Function" and should therefore be programmed as "IEC E Inverse".

Finally, a suitable time multiplier setting (TMS) must be calculated and entered in cell "I>1 TMS".

Also note that the final 4 cells in the overcurrent menu refer to the voltage controlled overcurrent (VCO) protection which is separately described in the *Voltage Controlled Overcurrent (VCO) Protection (51V)* section.

2.1.3.1 Protection for Silicon Rectifiers

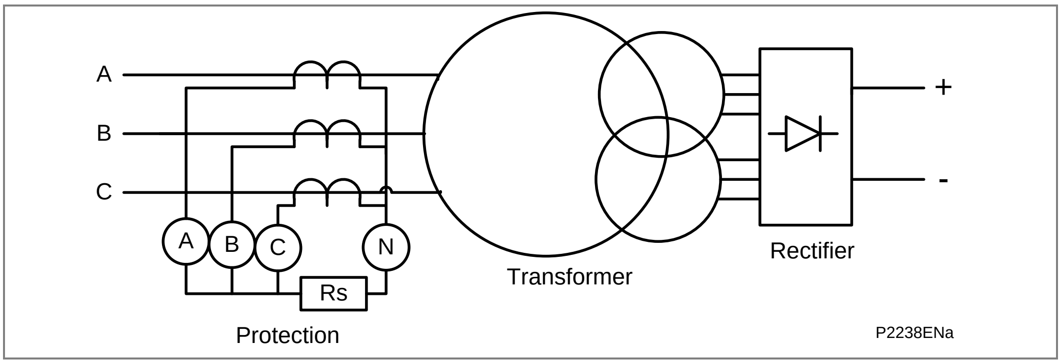


Figure 1 - Protection for silicon rectifiers

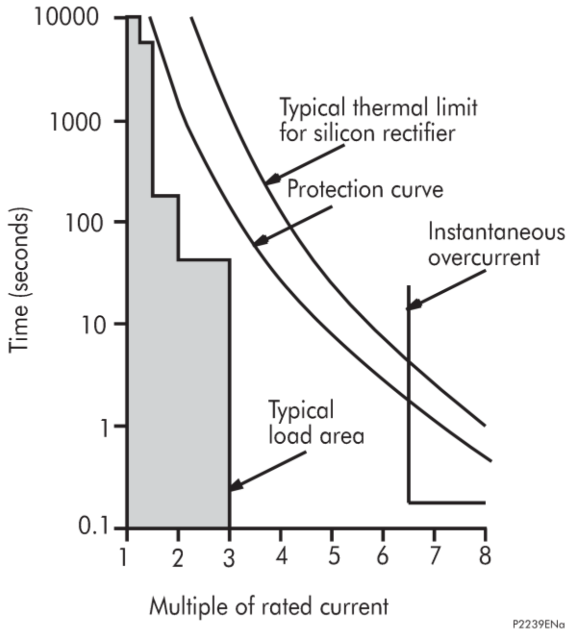


Figure 2 - Matching curve to load and thermal limit of rectifier

The rectifier protection feature has been based upon the inverse time/current characteristic as used in the MCTD 01 (Silicon Rectifier Protection Relay) and the above diagram show a typical application.

The protection of a rectifier differs from the more traditional overcurrent applications in that many rectifiers can withstand relatively long overload periods without damage, typically 150% for 2 hours and 300% for 1 min.

The I> setting should be set to typically 110% of the maximum allowable continuous load of the rectifier. The relay gives start indications when the I> setting has been exceeded, but this is of no consequence, as this function is not used in this application. The rectifier curve should be chosen for the inverse curve as it allows for relatively long overloads even with a 110% I> setting.

Typical settings for the TMS are:

Light industrial service	TMS	=	0.025
Medium duty service	TMS	=	0.1
Heavy duty traction	TMS	=	0.8

The high set is typically set at 8 times rated current as this ensures HV AC protection will discriminate with faults covered by the LV protection. However, it has been known for the high set to be set to 4, or 5 times where there is more confidence in the AC protection.

Use of the thermal element to provide protection between 70% and 160% of rated current could enhance the protection. It is also common practice to provide restricted earth fault protection for the transformer feeding the rectifier. See the appropriate section dealing with restricted earth fault protection.

2.2 Directional Overcurrent Protection

If fault current can flow in both directions through a relay location, it is necessary to add directionality to the overcurrent relays to obtain correct co-ordination. Typical systems that require such protection are parallel feeders (both plain and transformer) and ring main systems, each of which are relatively common in distribution networks.

Two common applications, which require the use of directional relays, are considered in these sections:

- Parallel Feeders

- Ring Main Arrangements
- Setting Guidelines

2.2.1 Parallel Feeders

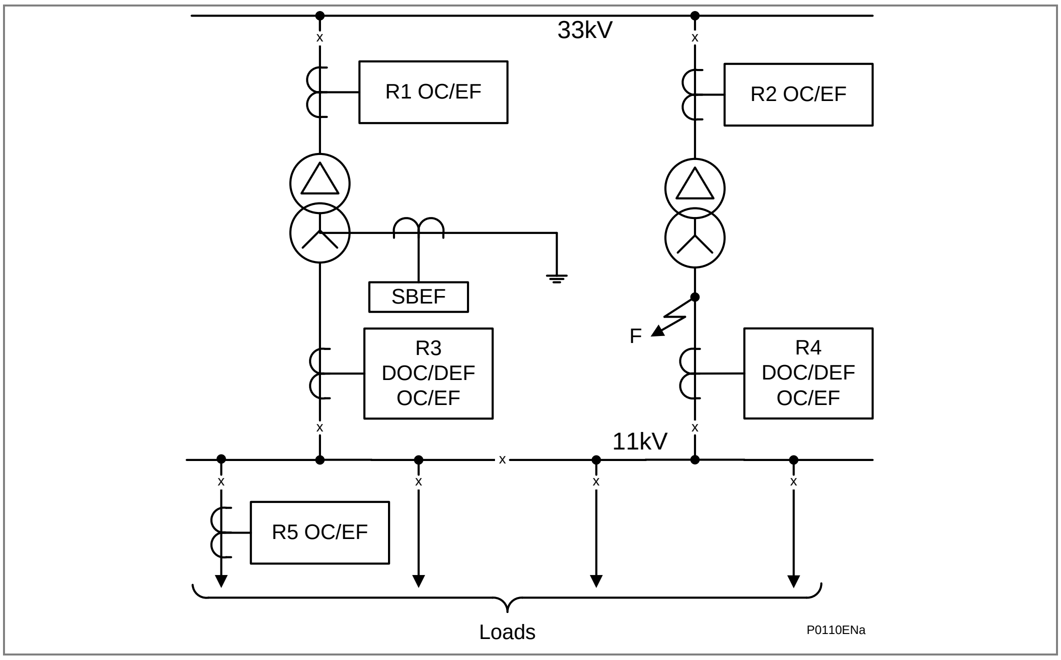


Figure 3 - Typical distribution system using parallel transformers

The *Typical distribution system using parallel transformers* diagram shows a typical distribution system utilizing parallel power transformers. In such an application, a fault at ‘F’ could result in the operation of both R3 and R4 relays and the subsequent loss of supply to the 11kV busbar. Hence, with this system configuration, it is necessary to apply directional relays at these locations set to 'look into' their respective transformers. These relays should co-ordinate with the non-directional relays, R1 and R2; hence ensuring discriminative relay operation during such fault conditions.

In such an application, relays R3 and R4 may commonly require non-directional overcurrent protection elements to provide protection to the 11kV busbar, in addition to providing a back-up function to the overcurrent relays on the outgoing feeders (R5).

When applying the relays in the above application, stage 1 of the overcurrent protection of relays R3 and R4 would be set non-directional and time graded with R5, using an appropriate time delay characteristic. Stage 2 could then be set directional, looking back into the transformer, also having a characteristic which provided correct co-ordination with R1 and R2 IDMT or DT characteristics are selectable for both stages 1 and 2 and directionality of each of the overcurrent stages is set in cell "I> Direction".

Note	*The principles previously outlined for the parallel transformer application are equally applicable for plain feeders that are operating in parallel.*

2.2.2 Ring Main Arrangements

A typical ring main with associated overcurrent protection is shown in the *Typical ring main with associated overcurrent protection* diagram.

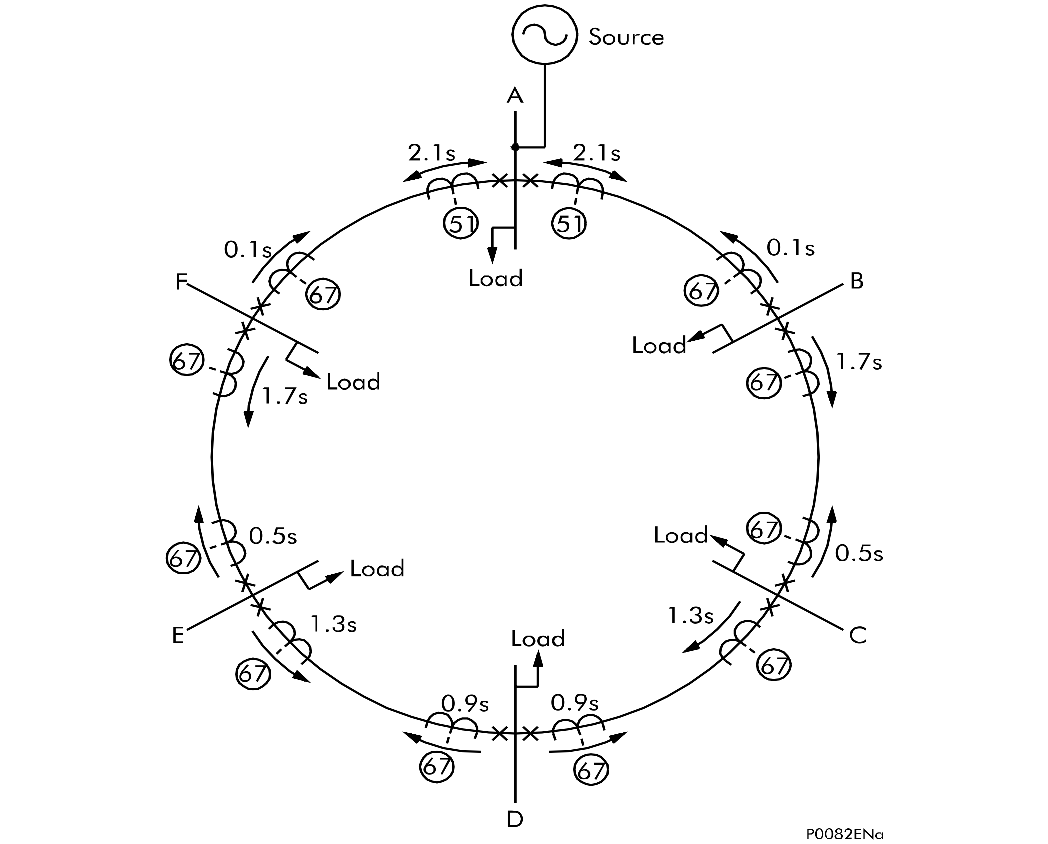


Figure 4 - Typical ring main with associated overcurrent protection

As with the previously described parallel feeder arrangement, current may flow in either direction through the various relay locations. Therefore, directional overcurrent relays are again required to provide a discriminative protection system.

The normal grading procedure for overcurrent relays protecting a ring main circuit is to open the ring at the supply point and to grade the relays first clockwise and then anti-clockwise. The arrows shown at the various relay locations in the *Typical ring main with associated overcurrent protection* diagram depict the direction for forward operation of the respective relays, i.e. in the same way as for parallel feeders, the directional relays are set to look into the feeder that they are protecting. The *Typical ring main with associated overcurrent protection* diagram shows typical relay time settings (if definite time co-ordination was employed), from which you can see that any faults on the inter-connectors between stations are cleared discriminatively by the relays at each end of the feeder.

Again, any of the four overcurrent stages may be configured to be directional and co-ordinated as per the previously outlined grading procedure, noting that IDMT characteristics are only selectable on the first two stages.

2.2.3 Setting Guidelines

The applied current settings for directional overcurrent relays are dependent upon the application in question. In a parallel feeder arrangement, load current is always flowing in the non-operate direction. Hence, the relay current setting may be less than the full load rating of the circuit; typically 50% of In.

Note	*The minimum setting that may be applied has to take into account the thermal rating of the relay. Some electro-mechanical directional overcurrent relays have continuous withstand ratings of only twice the applied current setting and hence 50% of rating was the minimum setting that could be applied. With the P145/P341, the continuous current rating is 4 x rated current and so it is possible to apply much more sensitive settings if required. However, there are minimum safe current setting constraints to be observed when applying directional overcurrent protection at the receiving-ends of parallel feeders. The minimum safe settings to ensure that there is no possibility of an unwanted trip during clearance of a source fault are as follows for linear system load:*

Parallel plain feeders:	Set>50% Prefault load current
Parallel transformer feeders:	Set>87% Prefault load current

When the above setting constraints are infringed, independent-time protection is more likely to issue an unwanted trip during clearance of a source fault than dependent-time protection.

Where the above setting constraints are unavoidably infringed, secure phase fault protection can be provided with relays which have 2-out-of-3 directional protection tripping logic.

In a ring main application, it is possible for load current to flow in either direction through the relaying point. Hence, the current setting must be above the maximum load current, as in a standard non-directional application.

The required characteristic angle settings for directional relays will differ depending on the exact application in which they are used. Recommended characteristic angle settings are as follows:

- Plain feeders, or applications with an earthing point (zero sequence source) behind the relay location, should utilize a +30° RCA setting
- Transformer feeders, or applications with a zero sequence source in front of the relay location, should utilize a +45° RCA setting

Whilst it is possible to set the RCA to exactly match the system fault angle, it is recommended that the above guidelines are adhered to, as these settings have been shown to provide satisfactory performance and stability under a wide range of system conditions.

2.3 Thermal Overload Protection

Thermal overload protection can be used to prevent electrical plant from operating at temperatures higher than the designed maximum withstand. Prolonged overloading causes excessive heating, which may result in premature ageing of the insulation, or in extreme cases, insulation failure.

The relay incorporates a current based thermal replica, using rms load current to model heating and cooling of the protected plant. The element can be set with both alarm and trip stages.

The heat generated within an item of plant, such as a cable or a transformer, is the resistive loss (I2R x t). Thus, heating is directly proportional to current squared. The thermal time characteristic used in the relay is therefore based on current squared, integrated over time. The relay automatically uses the largest phase current for input to the thermal model.

Equipment is designed to operate continuously at a temperature corresponding to its full load rating, where heat generated is balanced with heat dissipated by radiation etc. Over-temperature conditions therefore occur when currents in excess of rating are allowed to flow for a period of time. It can be shown that temperatures during heating follow exponential time constants and a similar exponential decrease of temperature occurs during cooling.

2.3.1 Setting Guidelines

2.3.1.1 Single Time Constant Characteristic

The current setting is calculated as:

Thermal Trip = Permissible continuous loading of the plant item/CT ratio.

Typical time constant values are given in in the following tables. The relay setting, "Time Constant τ", is in minutes.

Paper insulated lead sheathed cables or polyethylene insulated cables, laid above ground or in conduits:

CSA mm^2	6 - 11 kV	22 kV	33 kV	66 kV
25 – 50	10	15	40	–
70 – 120	15	25	40	60
150	25	40	40	60
185	25	40	60	60
240	40	40	60	60
300	40	60	60	90

Typical time constant values

Other plant items:

The following table shows it in minutes, for different cable rated voltages and conductor cross-sectional areas:

	Time Constant τ (Minutes)	Limits
Dry-type Transformers	40 60 - 90	Rating <400 kVA Rating 400 - 800 kVA
Air-core Reactors	40	
Capacitor Banks	10	
Overhead Lines	10	Cross section ≥100 mm2 Cu or 150mm2 Al
Busbars	60	

Typical time constant values

An alarm can be raised on reaching a thermal state corresponding to a percentage of the trip threshold. A typical setting might be "Thermal Alarm" = 70% of thermal capacity.

2.3.1.2 Dual Time Constant Characteristic

The current setting is calculated as:

Thermal Trip = Permissible continuous loading of the transformer / CT ratio.

Typical time constant values are shown in the following table:

An alarm can be raised on reaching a thermal state corresponding to a percentage of the trip threshold. A typical setting might be ‘Thermal Alarm’ = 70% of thermal capacity.

> *Note* *The thermal time constants given in the above tables are typical only. Reference should always be made to the plant manufacturer for accurate information.*

	τ1 (minutes)	τ2 (minutes)	Limits
Oil-filled transformer	5	120	Rating 400 - 1600 kVA

2.4 Earth Fault (EF) Protection

The fact that both EF1 and EF2 elements may be enabled in the relay at the same time leads to a number of applications advantages. For example, the parallel transformer application shown previously requires directional earth fault protection at locations R3 and R4, to provide discriminative protection. However, in order to provide back-up protection for the transformer, busbar and other downstream earth fault devices, Standby Earth Fault (SBEF) protection is also commonly applied. This function has traditionally been fulfilled by a separate earth fault relay, fed from a single CT in the transformer earth connection. The EF1 and EF2 elements of the P145 relay may be used to provide both the Directional Earth Fault (DEF) and SBEF functions, respectively.

Where a Neutral Earthing Resistor (NER) is used to limit the earth fault level to a particular value, it is possible that an earth fault condition could cause a flashover of the NER and hence a dramatic increase in the earth fault current. For this reason, it may be appropriate to apply two stage SBEF protection. The first stage should have suitable current and time characteristics which co-ordinate with downstream earth fault protection. The second stage may then be set with a higher current setting but with zero time delay; hence providing fast clearance of an earth fault which gives rise to an NER flashover.

The remaining two stages are available for customer specific applications.

The previous examples relating to transformer feeders utilize both EF1 and EF2 elements. In a standard feeder application requiring three-phase overcurrent and earth fault protection, only one of the earth fault elements would need to be applied. If EF1 were to be used, the connection would be a standard arrangement of the three-phase currents feeding into the phase inputs, with the EF1 input connected into the residual path (this is shown in the *P141/P142/P143/P145 - three-phase overcurrent & residually connected earth fault protection* diagram). In this application, EF2 should be disabled in the menu. Alternatively, where the EF2 element is used, no residual connection of the CT’s will be required.

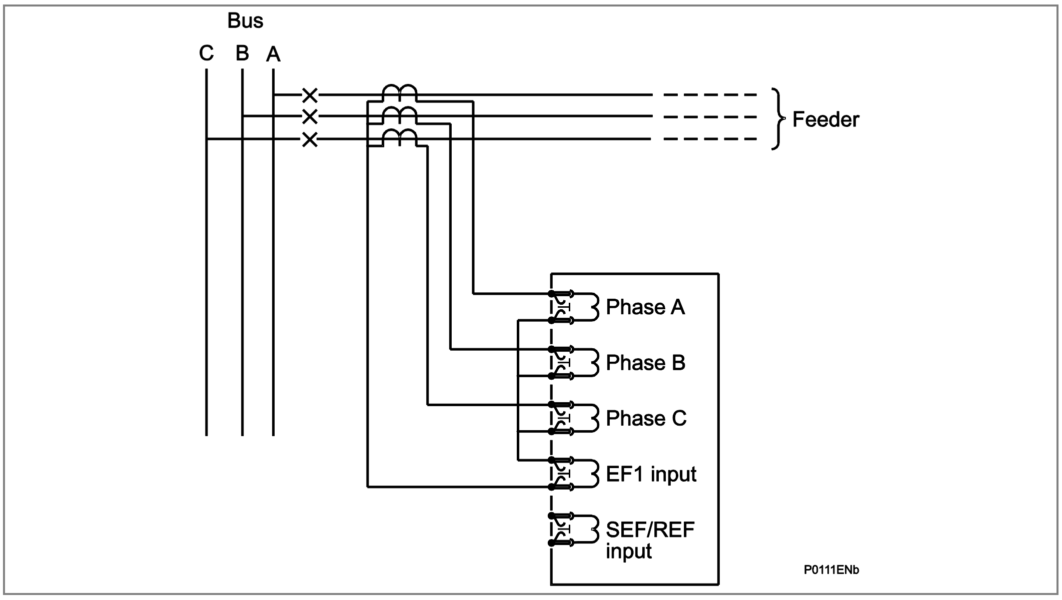


Figure 5 - P141/P142/P143/P145 - three-phase overcurrent & residually connected earth fault protection

2.4.1 Sensitive Earth Fault (SEF) Protection Element

Sensitive Earth Fault (SEF) would normally be fed from a Core Balance Current Transformer (CBCT) mounted around the three phases of the feeder cable. However, care must be taken in the positioning of the CT with respect to the earthing of the cable sheath. See below.

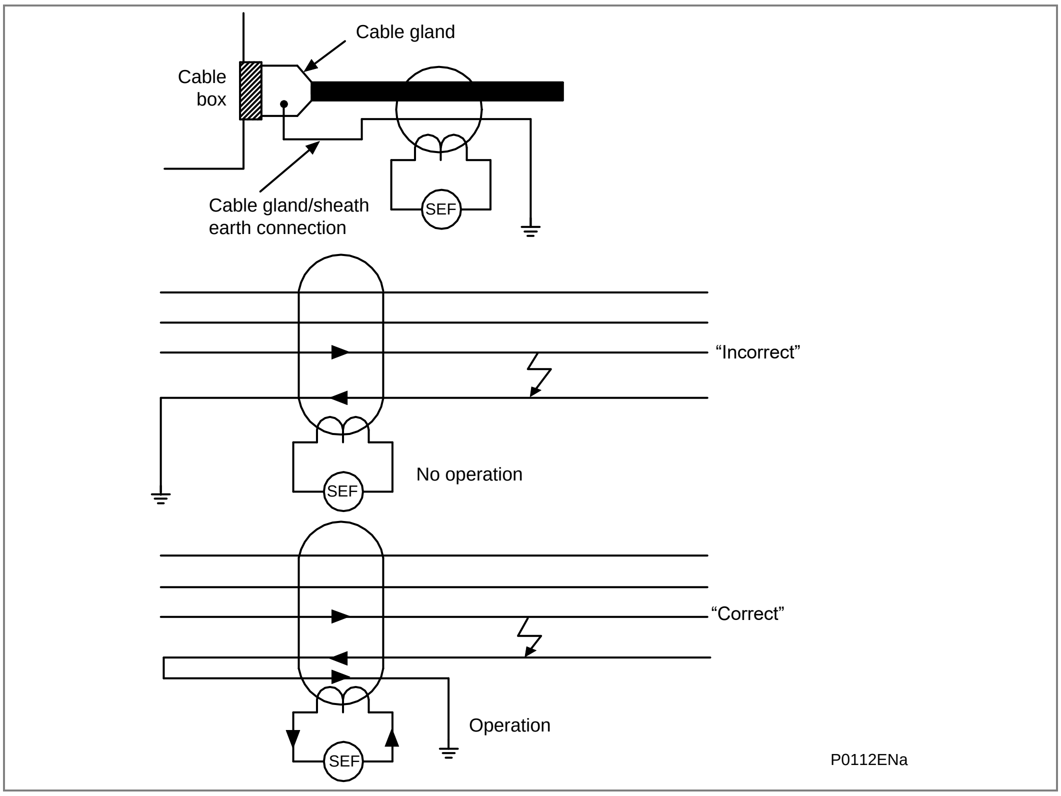


Figure 6 - Positioning of core balance current transformers

As can be seen from the above illustration, if the cable sheath is terminated at the cable gland and earthed directly at that point, a cable fault (from phase to sheath) will not result in any unbalance current in the core balance CT. Hence, prior to earthing, the connection must be brought back through the CBCT and earthed on the feeder side. This then ensures correct relay operation during earth fault conditions.

2.5 Directional Earth Fault (DEF) Protection

As stated in the previous sections, each of the four stages of EF1, EF2 and SEF protection may be set to be directional if required. Consequently, as with the application of directional overcurrent protection, a suitable voltage supply is required by the relay to provide the necessary polarization.

With the standard earth fault protection element in the P14x relay, two options are available for polarization; Residual Voltage or Negative Sequence. The Sensitive Earth Fault (SEF) protection element is available with only residual voltage polarization.

2.5.1 General Setting Guidelines for DEF Applied to Earthed Systems

When setting the Relay Characteristic Angle (RCA) for the directional overcurrent element, a positive angle setting was specified. With DEF, the residual current under fault conditions lies at an angle lagging the polarizing voltage. Hence, negative RCA settings are required for DEF applications. This is set in cell "I>Char Angle" in the relevant earth fault menu.

The following angle settings are recommended for a residual voltage polarized relay:

Resistance earthed systems	=	0°
Distribution systems (solidly earthed)	=	–45°
Transmission systems (solidly earthed)	=	–60°

For negative sequence polarization, the RCA settings must be based on the angle of the nps source impedance, much the same as for residual polarizing. Typical settings would be:

Distribution systems	–45°
Transmission systems	–60°

2.5.2 Application to Insulated Systems

Operational advantages may be gained by the use of insulated systems. However, it is still vital that detection of the fault is achieved. This is not possible by means of standard current operated earth fault protection. One possibility for fault detection is by means of a residual overvoltage device. This functionality is included within the P145 relays and is detailed in the *Residual Overvoltage (Neutral Displacement) Protection* section. However, fully discriminative earth fault protection on this type of system can only be achieved by the application of a sensitive earth fault element. This type of relay is set to detect the resultant imbalance in the system charging currents that occurs under earth fault conditions. It is therefore essential that a core balance CT be used for this application.

This eliminates the possibility of spill current that may arise from slight mismatches between residually connected line CTs. It also enables a much lower CT ratio to be applied, thereby allowing the required protection sensitivity to be more easily achieved.

When considering the fault distribution on an insulated system for a C phase fault, it can be seen that the relays on the healthy feeders see the unbalance in the charging currents for their own feeder. The relay on the faulted feeder, however, sees the charging current from the rest of the system (IH1 and IH2 in this case), with it's own feeders charging current (IH3) becoming cancelled out. The the *Phasor diagrams for insulated system with C phase fault* diagram further illustrate this.

Referring to the phasor diagram, it can be seen that the C phase to earth fault causes the voltages on the healthy phases to rise by a factor of $\sqrt{3}$. The A phase charging current (Ia1), is then shown to be leading the resultant A phase voltage by 90°. Likewise, the B phase charging current leads the resultant Vb by 90°.

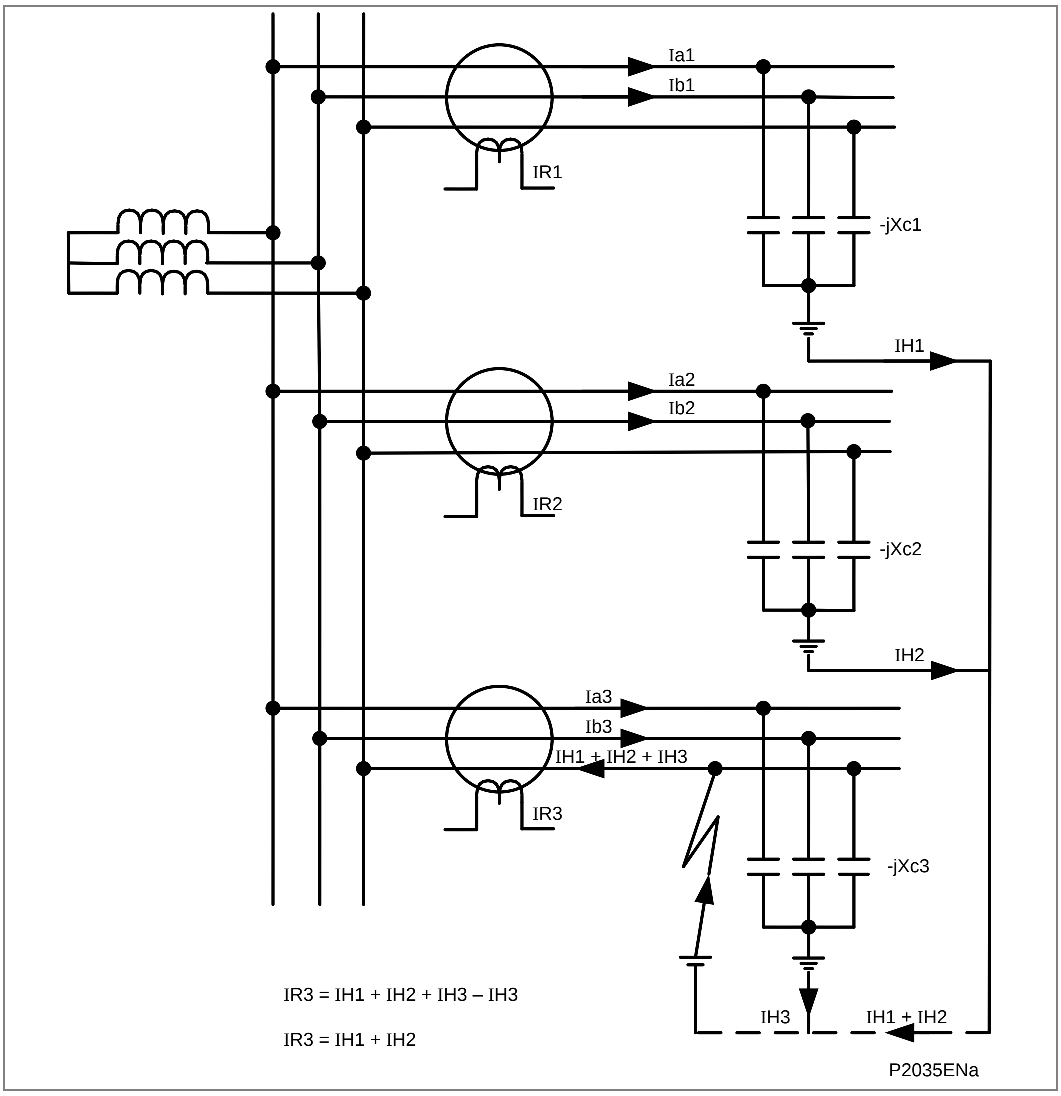


Figure 7 - Current distribution in an insulated system with C phase fault

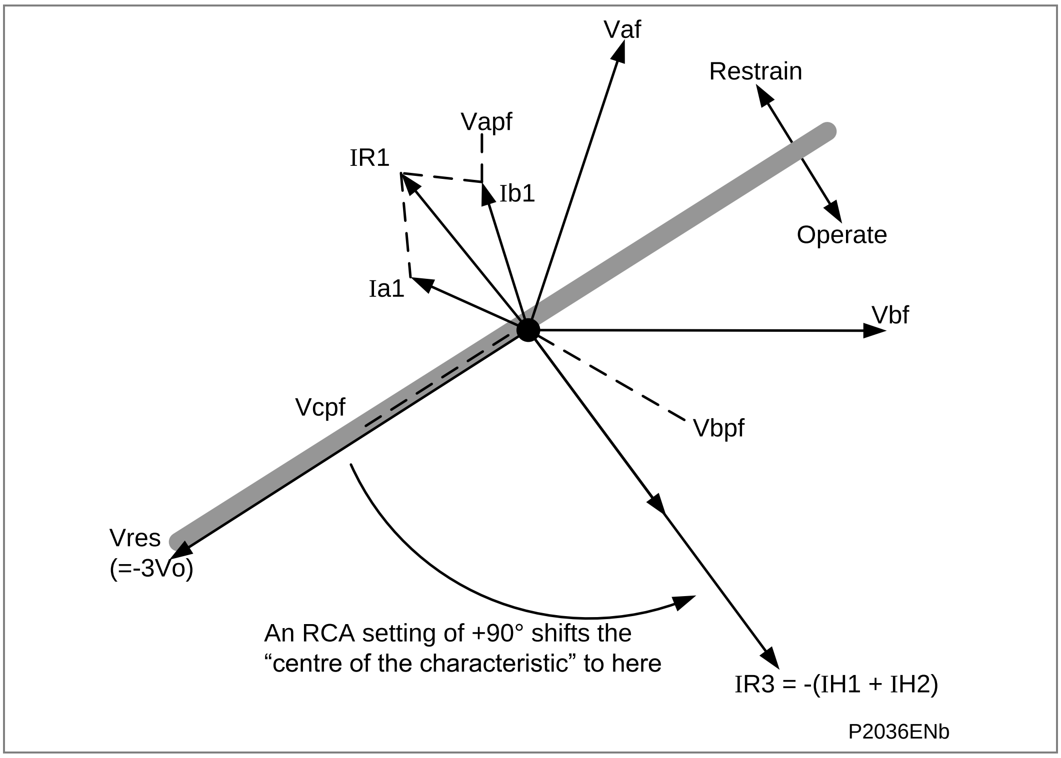


Figure 8 - Phasor diagrams for insulated system with C phase fault

The unbalance current detected by a core balance current transformer on the healthy feeders can be seen to be the vector addition of Ia1 and Ib1, giving a residual current which lies at exactly 90° lagging the polarizing voltage (–3Vo). As the healthy phase voltages have risen by a factor of √3, the charging currents on these phases will also be √3 times larger than their steady state values. Therefore, the magnitude of residual current, IR1, is equal to 3 x the steady state per phase charging current.

The phasor diagrams indicate that the residual currents on the healthy and faulted feeders, IR1 and IR3 respectively, are in anti-phase. A directional element could therefore be used to provide discriminative earth fault protection.

If the polarizing voltage of this element, equal to –3Vo, is shifted through +90°, the residual current seen by the relay on the faulted feeder will lie within the operate region of the directional characteristic and the current on the healthy feeders will fall within the restrain region.

As previously stated, the required characteristic angle setting for the SEF element when applied to insulated systems, is +90°. It should be noted though, that this recommended setting corresponds to the relay being connected such that it's direction of current flow for operation is from the source busbar towards the feeder, as would be the convention for a relay on an earthed system. However, if the forward direction for operation were set as being from the feeder into the busbar, (which some utilities may standardize on), then a –90° RCA would be required. The correct relay connections to give a defined direction for operation are shown on the relay connection diagram.

Note	*Discrimination can be provided without the need for directional control. This can only be achieved if it is possible to set the relay in excess of the charging current of the protected feeder and below the charging current for the rest of the system.*

2.5.2.1 Setting Guidelines - Insulated Systems

As has been previously shown, the residual current detected by the relay on the faulted feeder is equal to the sum of the charging currents flowing from the rest of the system. Further, the addition of the two healthy phase charging currents on each feeder gives a total charging current which has a magnitude of three times the per phase value. Therefore, the total unbalance current detected by the relay is equal to three times the per phase charging current of the rest of the system. A typical relay setting may therefore be in the order of 30% of this value, i.e. equal to the per phase charging current of the remaining system. Practically though, the required setting may well be determined on site, where suitable settings can be adopted based upon practically obtained results. The use of the P145 relays' comprehensive measurement and fault recording facilities may prove useful in this respect.

2.5.3 Application to Petersen Coil Earthed Systems

Power systems are usually earthed in order to limit transient overvoltages during arcing faults and also to assist with detection and clearance of earth faults. Impedance earthing has the advantage of limiting damage incurred by plant during earth fault conditions and also limits the risk of explosive failure of switchgear, which is a danger to personnel. In addition, it limits touch and step potentials at a substation or in the vicinity of an earth fault.

If a high impedance device is used for earthing the system, or the system is unearthed, the earth fault current will be reduced but the steady state and transient overvoltages on the sound phases can be very high. Consequently, it is generally the case that high impedance earthing will only be used in low/medium voltage networks in which it does not prove too costly to provide the necessary insulation against such overvoltages. Higher system voltages would normally be solidly earthed or earthed via a low impedance.

A special case of high impedance earthing via a reactor occurs when the inductive earthing reactance is made equal to the total system capacitive reactance to earth at system frequency. This practice is widely referred to as Petersen (or resonant) Coil Earthing. With a correctly tuned system, the steady state earth fault current will be zero, so that arcing earth faults become self-extinguishing. Such a system can, if designed to do so, be run with one phase earthed for a long period until the cause of the fault is identified and rectified.

The *Current distribution in Petersen Coil earthed system* diagram shows a source of generation earthed through a Petersen Coil, with an earth fault applied on the A Phase. Under this situation, it can be seen that the A phase shunt capacitance becomes short-circuited by the fault. Consequently, the calculations show that if the reactance of the earthing coil is set correctly, the resulting steady state earth fault current will be zero.

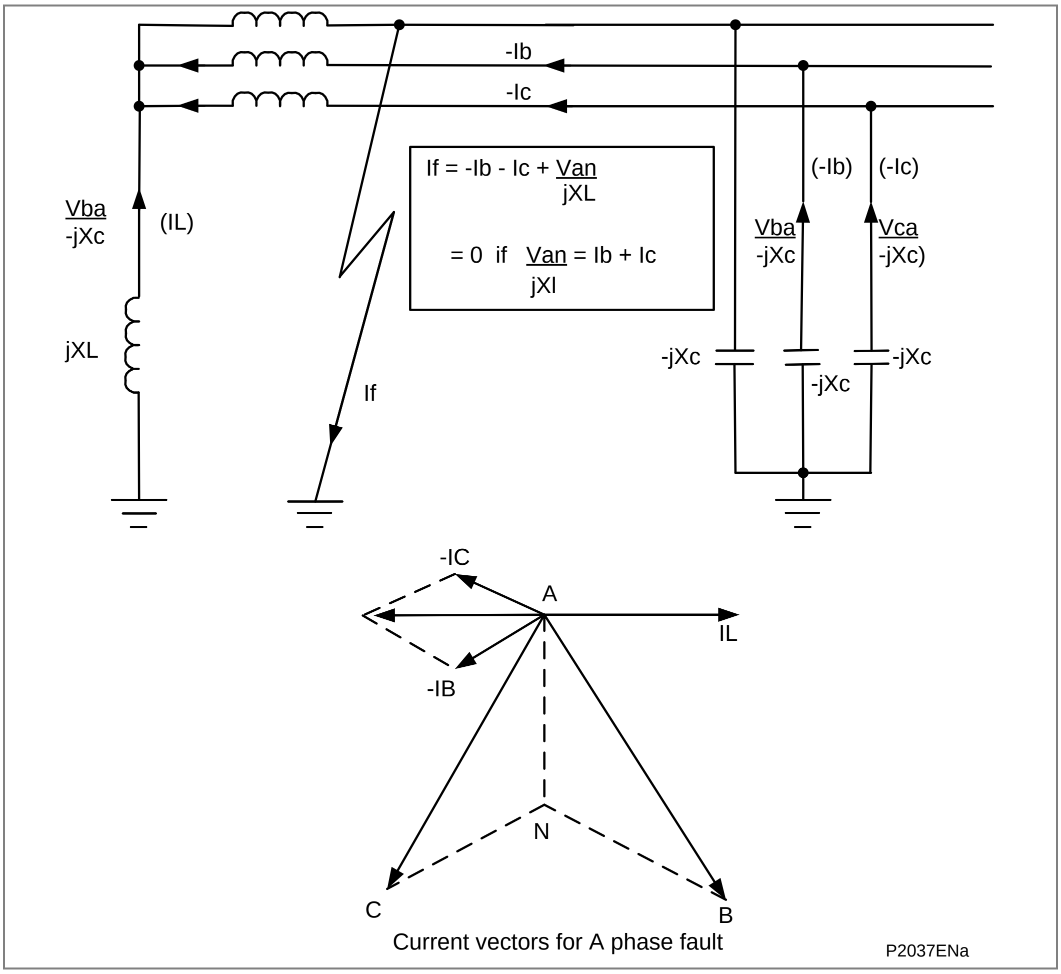


Figure 9 - Current distribution in Petersen Coil earthed system

The *Current distribution in Petersen Coil earthed system* diagram shows a radial distribution system having a source that is earthed via a Petersen Coil. Three outgoing feeders are present, the lower of which has a phase to earth fault applied on the C phase.

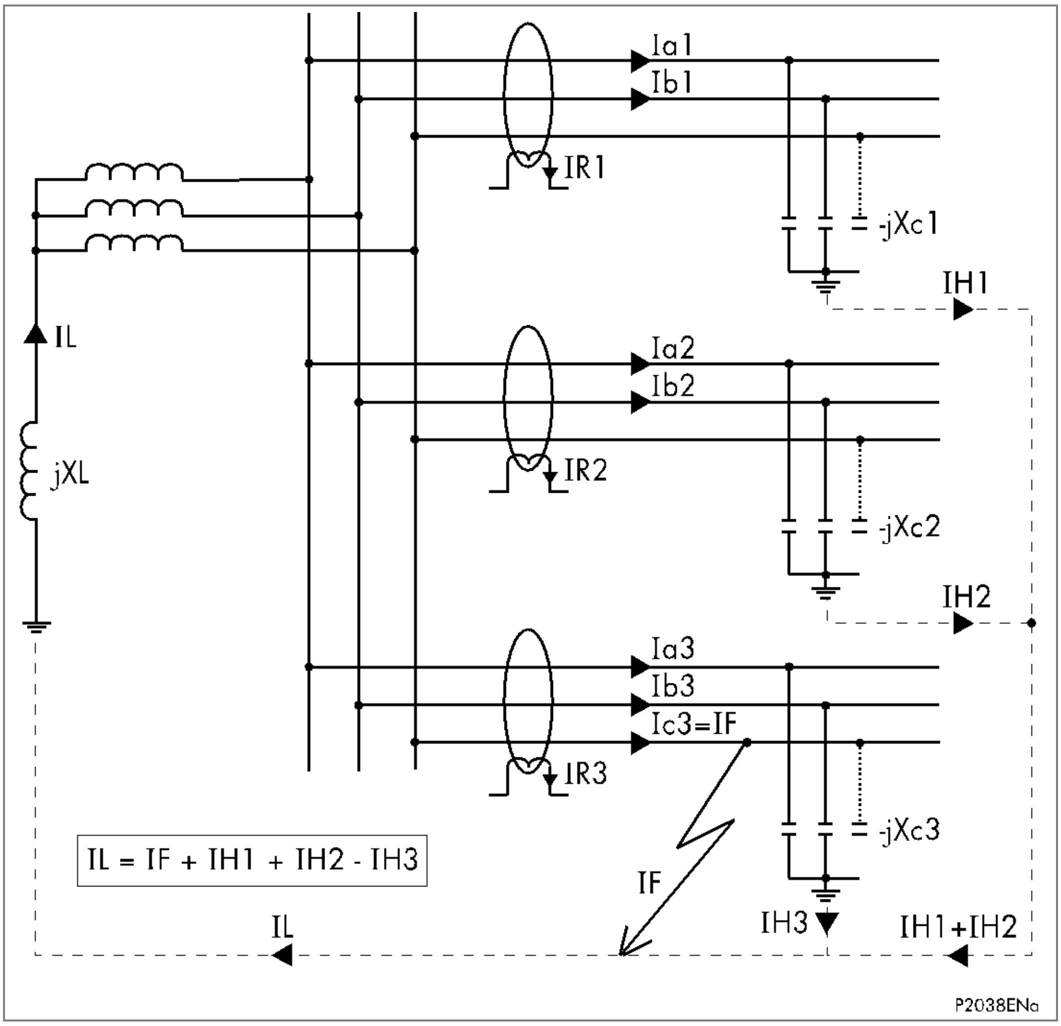


Figure 10 - Distribution of currents during a C phase to earth fault

The *Theoretical case - no resistance present in XL or XC* diagram (parts a, b and c) show vector diagrams for the previous system, assuming that it is fully compensated (i.e. coil reactance fully tuned to system capacitance), in addition to assuming a theoretical situation where no resistance is present either in the earthing coil or in the feeder cables.

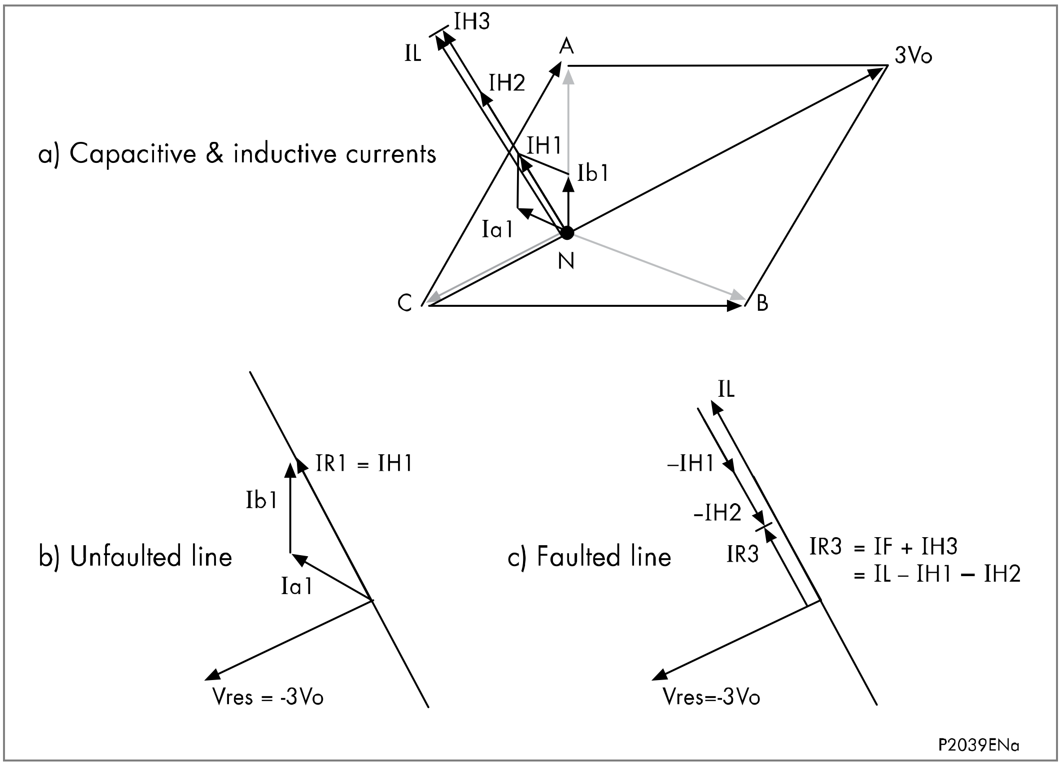


Figure 11 - Theoretical case - no resistance present in XL or XC

Referring to *Theoretical case - no resistance present in XL or XC* diagram (parts a), it can be seen that the C phase to earth fault causes the voltages on the healthy phases to rise by a factor of √3. The A phase charging currents (Ia1, Ia2 and Ia3), are then shown to be leading the resultant A phase voltage by 90° and likewise for the B phase charging currents with respect to the resultant Vb.

The unbalance current detected by a core balance current transformer on the healthy feeders can be seen to be a simple vector addition of Ia1 and Ib1, giving a residual current which lies at exactly 90° lagging the residual voltage (as shown in The *Theoretical case - no resistance present in XL or XC* diagram (part b). Clearly, as the healthy phase voltages have risen by a factor of √3, the charging currents on these phases will also be √3 times larger than their steady state values. Therefore, the magnitude of residual current, IR1, is equal to 3 x the steady state per phase charging current.

Note	*The actual residual voltage used as a reference signal for directional earth fault relays is phase shifted by 180° and is therefore shown as –3Vo in the vector diagrams. This phase shift is automatically introduced within the P145 relays.*

Note	*On the faulted feeder, the residual current is the addition of the charging current on the healthy phases (IH3) plus the fault current (IF). The net unbalance is therefore equal to IL-IH1-IH2, as shown in The* Theoretical case - no resistance present in XL or XC *diagram (part c).*

Note	*This situation may be more readily observed by considering the zero sequence network for this fault condition. This is depicted in the* ***Zero sequence network showing residual currents*** *diagram.*

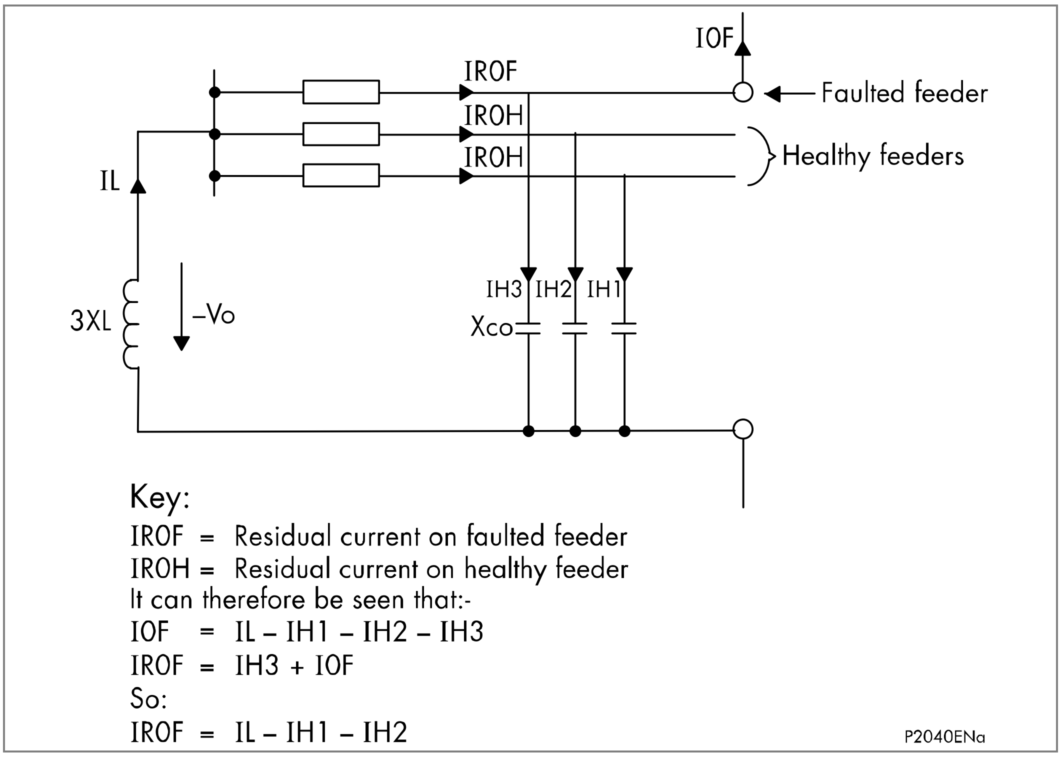


Figure 12 - Zero sequence network showing residual currents

In comparing the residual currents occurring on the healthy and on the faulted feeders (the *Theoretical case - no resistance present in XL or XC* diagram (part b and c), it can be seen that the currents would be similar in both magnitude and phase; hence it would not be possible to apply a relay which could provide discrimination.

However, as previously stated, the scenario of no resistance being present in the coil or feeder cables is purely theoretical. Further consideration therefore needs to be given to a practical application in which the resistive component is no longer ignored - consider the *Practical case - resistance present in XL and Xc* diagram.

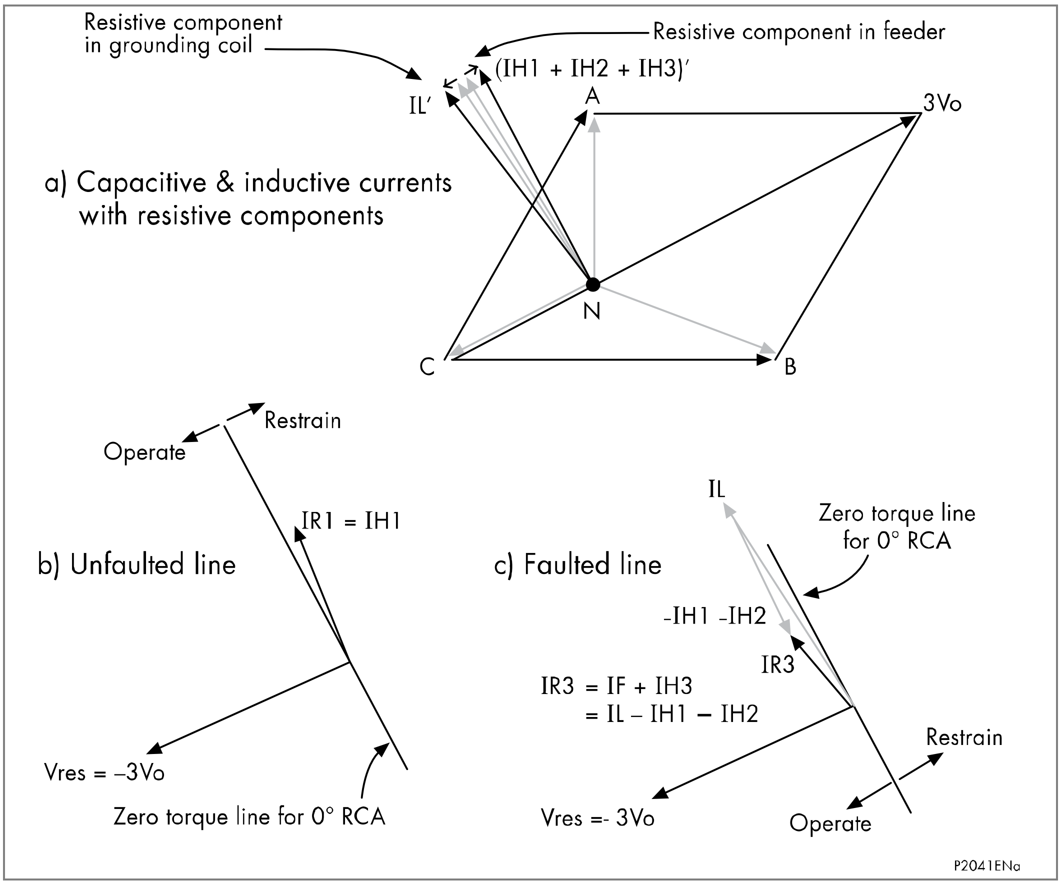


Figure 13 - Practical case - resistance present in XL and Xc

The *Practical case - resistance present in XL and Xc* part a again shows the relationship between the capacitive currents, coil current and residual voltage. It can now be seen that due to the presence of resistance in the feeders, the healthy phase charging currents are now leading their respective phase voltages by less than 90°. In a similar manner, the resistance present in the earthing coil has the effect of shifting the current, IL, to an angle less than 90° lagging. The result of these slight shifts in angles can be seen in *Practical case - resistance present in XL and Xc* part b and *Practical case - resistance present in XL and Xc* part c.

The residual current now appears at an angle in excess of 90° from the polarizing voltage for the unfaulted feeder and less than 90° on the faulted feeder. Hence, a directional relay having a characteristic angle setting of 0° (with respect to the polarizing signal of -3Vo) could be applied to provide discrimination. i.e. the healthy feeder residual current would appear within the restrain section of the characteristic but the residual current on the faulted feeder would lie within the operate region - as shown in *Zero sequence network showing residual currents* part b and part c.

In practical systems, it may be found that a value of resistance is purposely inserted in parallel with the earthing coil. This serves two purposes; one is to actually increase the level of earth fault current to a more practically detectable level and the second is to increase the angular difference between the residual signals; again to aid in the application of discriminating protection.

2.5.4 Applications to Compensated Networks

2.5.4.1 Required Relay Current and Voltage Connections

Referring to the relevant application diagram for the P145/P341 Relay, it should be applied such that it’s direction for forward operation is looking down into the protected feeder (away from the busbar), with a 0° RCA setting.

2.5.4.2 Calculation of Required Relay Settings

As has been previously shown, for a fully compensated system, the residual current detected by the relay on the faulted feeder is equal to the coil current minus the sum of the charging currents flowing from the rest of the system. Further, as stated in the previous section, the addition of the two healthy phase charging currents on each feeder gives a total charging current which has a magnitude of three times the steady state per phase value. Therefore, for a fully compensated system, the total unbalance current detected by the relay is equal to three times the per phase charging current of the faulted circuit. A typical relay setting may therefore be in the order of 30% of this value, i.e. equal to the per phase charging current of the faulted circuit. Practically though, the required setting may well be determined on site, where system faults can be applied and suitable settings can be adopted based upon practically obtained results.

It should be noted that in most situations, the system will not be fully compensated and consequently a small level of steady state fault current will be allowed to flow. The residual current seen by the relay on the faulted feeder may thus be a larger value, which further emphasizes the fact that relay settings should be based upon practical current levels, wherever possible.

The above also holds true regarding the required Relay Characteristic Angle (RCA) setting. As has been shown earlier, a nominal RCA setting of 0º is required. However, fine-tuning of this setting will require to be carried out on site in order to obtain the optimum setting in accordance with the levels of coil and feeder resistances present. The loading and performance of the CT will also have an effect in this regard. The effect of CT magnetizing current will be to create phase lead of current. Whilst this would assist with operation of faulted feeder relays it would reduce the stability margin of healthy feeder relays. A compromise can therefore be reached through fine adjustment of the RCA. This is adjustable in 1° steps on the P145 relays.

2.6 Restricted Earth Fault (REF) Protection

Earth faults occurring on a transformer winding or terminal may be of limited magnitude, either due to the impedance present in the earth path or by the percentage of transformer winding that is involved in the fault. It is common to apply standby earth fault protection fed from a single CT in the transformer earth connection - this provides time-delayed protection for a transformer winding or terminal fault. In general, particularly as the size of the transformer increases, it becomes unacceptable to rely on time delayed protection to clear winding or terminal faults as this would lead to an increased amount of damage to the transformer. A common requirement is therefore to provide instantaneous phase and earth fault protection. Applying differential protection across the transformer may fulfill these requirements. However, an earth fault occurring on the LV winding, particularly if it is of a limited level, may not be detected by the differential relay, as it is only measuring the corresponding HV current. Therefore, instantaneous protection that is restricted to operating for transformer earth faults only is applied. This is referred to as Restricted Earth Fault (REF) Protection.

It can also be referred to as Restricted, or Balanced, Earth Fault (REF or BEF) Protection. The BEF terminology is usually used when the protection is applied to a delta winding.

When applying differential protection such as REF, some suitable means must be employed to give the protection stability under external fault conditions, therefore ensuring that relay operation only occurs for faults on the transformer winding / connections.

Two methods are commonly used; bias or high impedance. The biasing technique operates by measuring the level of through current flowing and altering the relay sensitivity accordingly. The high impedance technique ensures that the relay circuit is of sufficiently high impedance such that the differential voltage that may occur under external fault conditions is less than that required to drive setting current through the relay.

The REF protection in the relays can be configured to operate as high impedance element. Following sections describe the application of the relay for high impedance element.

Note	*The high impedance REF element of the relay shares the same CT input as the SEF protection. Hence, only one of these elements may be selected.*

Note	*The low impedance REF element does not use the SEF input and so may be selected at the same time.*
Note	*CT requirements for REF protection are included in the Current Transformer (CT) Requirements section.*

2.6.1 Biased Differential Protection

The Relay connections for biased REF protection diagram shows the appropriate relay connections for the P145 relay applied for biased REF protection.

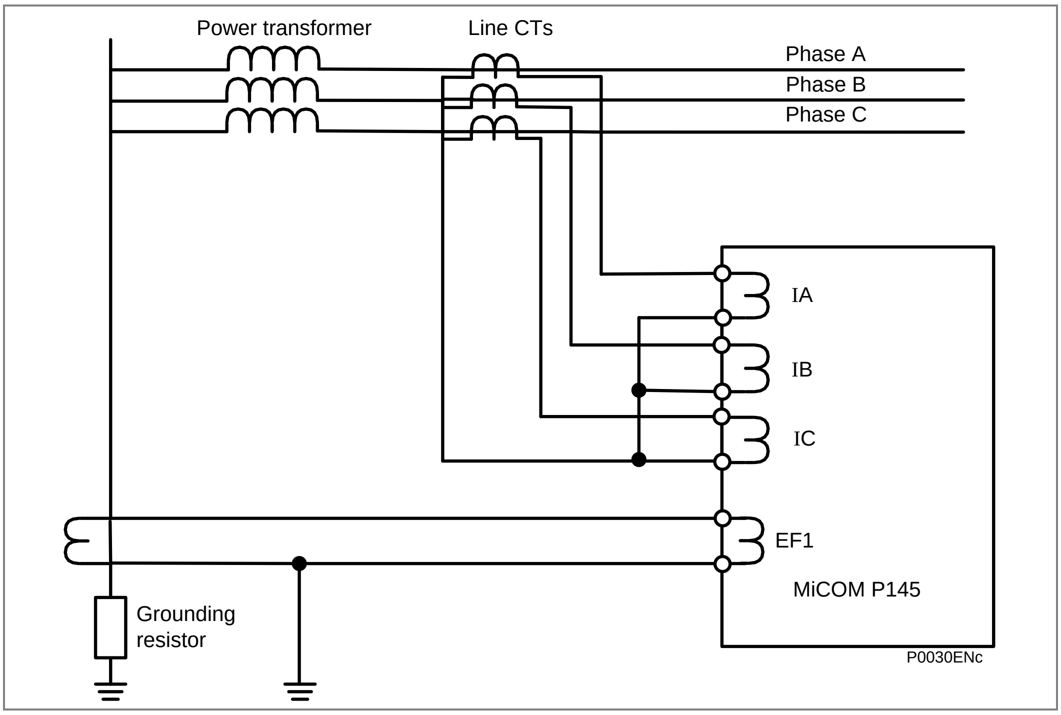


Figure 14 - Relay connections for biased REF protection

As can be seen in the *Relay connections for biased REF protection* diagram, the three line CTs are connected to the three-phase CTs in the normal manner. The neutral CT is then connected to the EF1 CT input. These currents are then used internally to derive both a bias and a differential current quantity for use by the low impedance REF protection. The advantage of this mode of connection is that the line and neutral CT's are not differentially connected and so the neutral CT can also be used to drive the EF1 protection to provide Standby Earth Fault Protection. Also, no external equipment such as stabilizing resistors or metrosils is required, as is the case with high impedance protection.

2.6.2 Setting Guidelines for Biased REF Protection

As can be seen from the Operation section (P14x/EN OP), two bias settings are provided in the REF characteristic of the P145. The k1 level of bias is applied up to through currents of Is2, which is normally set to the rated current of the transformer. k1 should normally be set to 0% to give optimum sensitivity for internal faults. However, if any CT mismatch is present under normal conditions, then k1 may be increased accordingly, to compensate.

k2 bias is applied for through currents above Is2 and would typically be set to 150%.

2.6.3 Setting Guidelines for High Impedance REF

From the **SEF/REF options** cell, **Hi Z REF** must be selected to enable this protection. The only setting cell then visible is **IREF>Is**, which may be programmed with the required differential current setting. This would typically be set to give a primary operating current of either 30% of the minimum earth fault level for a resistance earthed system or between 10 and 60% of rated current for a solidly earthed system.

The primary operating current (Iop) will be a function of the current transformer ratio, the relay operating current (IREF>Is1), the number of current transformers in parallel with a relay element (n) and the magnetizing current of each current transformer (Ie) at the stability voltage (Vs). This relationship can be expressed in three ways:

To determine the maximum current transformer magnetizing current to achieve a specific primary operating current with a particular relay operating current.

$$I_e < \frac{1}{n} \times \left(\frac{I_{op}}{\text{CT ratio}} - I\ REF > I_s \right)$$

To determine the minimum relay current setting to achieve a specific primary operating current with a given current transformer magnetizing current.

$$I\ REF > I_s < \left(\frac{I_{op}}{\text{CT ratio}} - nI_e \right)$$

To express the protection primary operating current for a particular relay operating current and with a particular level of magnetizing current.

$$I_{op} = (\text{CT ratio}) \times (IREF > Is + nI_c)$$

To achieve the required primary operating current with the current transformers that are used, a current setting (IREF>Is) must be selected for the high impedance element, as detailed in expression (ii) above. The setting of the Stabilizing Resistor (RST) must be calculated in the following manner, where the setting is a function of the required stability voltage setting (Vs) and the relay current setting (IREF>Is).

$$R_{st} = \frac{V_s}{I_{REF} > I_s} = \frac{I_F\ (R_{CT} + 2_{RL})}{I_{REF} > I_s}$$

Note	*The above formula assumes negligible relay burden.*

The stabilizing resistor that can be supplied is continuously adjustable up to its maximum declared resistance.

2.6.4 Use of METROSIL Non-Linear Resistors

Metrosils are used to limit the peak voltage developed by the current transformers under internal fault conditions, to a value below the insulation level of the current transformers, relay and interconnecting leads, which are normally able to withstand 3000 V peak.

The following formulae should be used to estimate the peak transient voltage that can be produced for an internal fault. The peak voltage produced during an internal fault will be a function of the current transformer kneepoint voltage and the prospective voltage that would be produced for an internal fault if current transformer saturation did not occur.

$$Vp = 2\sqrt{2V_k (V_f - V_k)}$$

V_f = $I'f (R_{ct} + 2R_L + R_{ST})$

Where:

V_p = Peak voltage developed by the CT under internal fault conditions
V_k = Current transformer kneepoint voltage
V_f = Maximum voltage that would be produced if CT saturation did not occur
I'_f = Maximum internal secondary fault current
R_{ct} = Current transformer secondary winding resistance
R_L = Maximum lead burden from current transformer to relay
R_{ST} = Relay stabilizing resistor

When the value given by the formulae is greater than 3000 V peak, Metrosils should be applied. They are connected across the relay circuit and serve the purpose of shunting the secondary current output of the current transformer from the relay to prevent very high secondary voltages.

Metrosils are externally mounted and take the form of annular discs. Their operating characteristics follow the expression:

$V = CI^{0.25}$

Where:

V = Instantaneous voltage applied to the non-linear resistor (Metrosil)
C = Constant of the non-linear resistor (Metrosil)
I = Instantaneous current through the non-linear resistor (Metrosil)

With a sinusoidal voltage applied across the Metrosil, the RMS current would be approximately 0.52 x the peak current. This current value can be calculated as follows:

$$I(rms) = 0.52\left(\frac{Vs\ (rms) \times \sqrt{2}}{C}\right)^4$$

Where:

Vs(rms) = rms value of the sinusoidal voltage applied across the metrosil.

This is because the current waveform through the Metrosil is not sinusoidal but appreciably distorted.

For satisfactory application of a non-linear resistor (Metrosil), it's characteristic should be such that it complies with these requirements:

- At the relay voltage setting, the non-linear resistor (Metrosil) current should be as low as possible, but no greater than approximately 30 mA rms for 1 A current transformers and approximately 100 mA rms for 5 A current transformers.
- At the maximum secondary current, the non-linear resistor (Metrosil) should limit the voltage to 1500V rms or 2120V peak for 0.25 second. At higher relay voltage settings, it is not always possible to limit the fault voltage to 1500V rms, so higher fault voltages may have to be tolerated.

The following tables show the typical Metrosil types that will be required, depending on relay current rating, REF voltage setting etc.

2.6.4.1 Metrosil Units for Relays with a 1 Amp CT

Metrosil Units for IEDs with a 1 Amp CT

The Metrosil units with 1 Amp CTs have been designed to comply with these restrictions:

- At the relay voltage setting, the Metrosil current should be less than 30mA rms.
- At the maximum secondary internal fault current the Metrosil unit should limit the voltage to 1500V rms if possible.

The Metrosil units normally recommended for use with 1Amp CT's are as shown below:

Relay voltage setting	Nominal characteristic		Recommended Metrosil type	
	C	β	Single pole relay	Triple pole relay
Up to 125 V rms 125 to 300 V rms	450 900	0.25 0.25	600 A/S1/S256 600 A/S1/S1088	600 A/S3/1/S802 600 A/S3/1/S1195

Note *Single pole Metrosil units are normally supplied without mounting brackets unless otherwise specified by the customer.*

2.6.4.2 Metrosil Units for Relays with a 5 Amp CT

Metrosil units for relays with a 5 amp CT

These Metrosil units have been designed to comply with these requirements:

- At the relay voltage setting, the Metrosil current should be less than 100 mA rms (the actual maximum currents passed by the units shown below their type description.
- At the maximum secondary internal fault current the Metrosil unit should limit the voltage to 1500 V rms for 0.25 secs. At the higher relay settings, it is not possible to limit the fault voltage to 1500 V rms hence higher fault voltages have to be tolerated (indicated by *, **, ***).

The Metrosil units normally recommended for use with 5 Amp CTs and single pole relays are as shown in the following table:

Secondary internal fault current	Recommended Metrosil type			
	Relay voltage setting			
Amps rms	Up to 200 V rms	250 V rms	275 V rms	300 V rms
50 A	600 A/S1/S1213 C = 540/640 35 mA rms	600 A/S1/S1214 C = 670/800 40 mA rms	600 A/S1/S1214 C =670/800 50 mA rms	600 A/S1/S1223 C = 740/870* 50 mA rms
100 A	600 A/S2/P/S1217 C = 470/540 70 mA rms	600 A/S2/P/S1215 C = 570/670 75 mA rms	600 A/S2/P/S1215 C =570/670 100 mA rms	600 A/S2/P/S1196 C =620/740* 100 mA rms
150 A	600 A/S3/P/S1219 C = 430/500 100 mA rms	600 A/S3/P/S1220 C = 520/620 100 mA rms	600 A/S3/P/S1221 C = 570/670** 100 mA rms	600 A/S3/P/S1222 C =620/740*** 100 mA rms
Note:			**2200 V peak	*2400 V peak ***2600 V peak

In some cases, single disc assemblies may be acceptable, contact Schneider Electric for detailed applications.

Note 1 *The Metrosil units recommended for use with 5 Amp CTs can also be applied for use with triple pole relays and consist of three single-pole units mounted on the same central stud but electrically insulated from each other. To order these units please specify "Triple-pole Metrosil type", followed by the single-pole type reference.*

Note 2 *Metrosil units for higher relay voltage settings and fault currents can be supplied if required.*

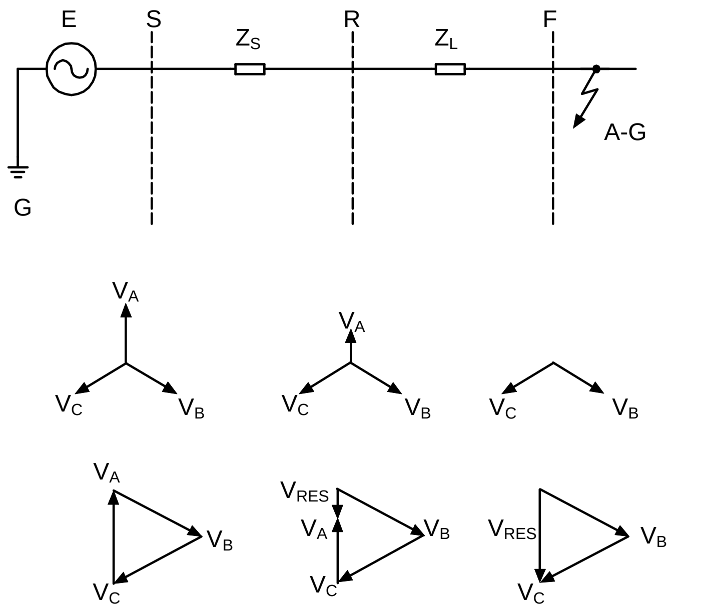
2.7 Residual Overvoltage (Neutral Displacement) Protection

On a healthy 3-phase power system, the addition of each of the 3-phase to earth voltages is nominally zero, as it is the vector addition of three balanced vectors at 120° to one another. However, when an earth fault occurs on the primary system this balance is upset and a 'residual' voltage is produced. This could be measured, for example, at the secondary terminals of a voltage transformer having a "broken delta" secondary connection. Hence, a residual voltage-measuring relay can be used to offer earth fault protection on such a system.

Note	*This condition causes a rise in the neutral voltage with respect to earth that is commonly referred to as "neutral voltage displacement" or NVD.*

The following figure shows the residual voltages that are produced during earth fault conditions occurring on a solid earthed power system.

As shown in below the residual voltage measured by a relay for an earth fault on a solidly earthed system is solely dependent upon the ratio of source impedance behind the relay to line impedance in front of the relay, up to the point of fault. For a remote fault, the Zs/Zl ratio will be small, resulting in a correspondingly small residual voltage. As such, depending upon the relay setting, such a relay would only operate for faults up to a certain distance along the system. The value of residual voltage generated for an earth fault condition is given by the general formula shown.



Residual voltage at R (relay point) is dependant upon Z_S/Z_L ratio.

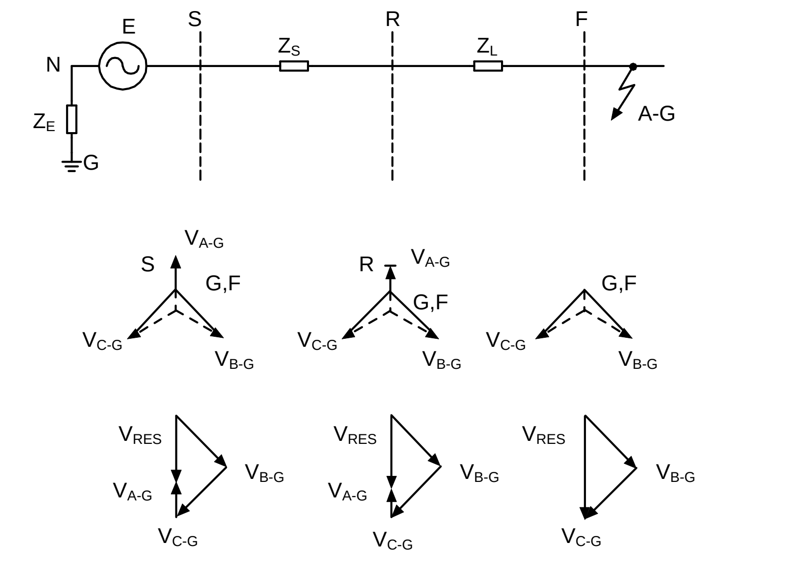
$$V_{RES} = \frac{Z_{S0}}{2Z_{S1} + Z_{S0} + 2Z_{L1} + Z_{L0}} \times 3E$$

P0117ENa

Figure 15 - Residual voltage, solidly earthed system

The following figure shows the residual voltages that are produced during earth fault conditions occurring on an impedance earthed power system.

This shows that a resistance earthed system will always generate a relatively large degree of residual voltage, as the zero sequence source impedance now includes the earthing impedance. It follows then, that the residual voltage generated by an earth fault on an insulated system will be the highest possible value (3 x phase-neutral voltage), as the zero sequence source impedance is infinite.



$$V_{RES} = \frac{Z_{S0} + 3Z_E}{2Z_{S1} + Z_{S0} + 2Z_{L1} + Z_{L0} + 3Z_E} \times 3E$$

Figure 16 - Residual voltage, resistance earthed system

The detection of a residual overvoltage condition is an alternative means of earth fault detection, which does not require any measurement of current. This may be particularly advantageous in high impedance earthed or insulated systems, where the provision of core balance CTs on each feeder may be either impractical, or uneconomic.

It must be noted that where residual overvoltage protection is applied, such a voltage will be generated for a fault occurring anywhere on that section of the system and hence the NVD protection must co-ordinate with other earth fault protections.

The P145/P341 relay internally derives this voltage from the three-phase voltage input that must be supplied from either a 5-limb or three single-phase VTs. These types of VT design allow the passage of residual flux and consequently permit the relay to derive the required residual voltage. In addition, the primary star point of the VT must be earthed. A three limb VT has no path for residual flux and is therefore unsuitable to supply the relay.

2.7.1 Setting Guidelines

The voltage setting applied to the elements depends on the magnitude of residual voltage that is expected to occur during the earth fault condition. This in turn is dependent on the method of system earthing employed and may be calculated by using the formulae previously given in the previous diagrams. It must also be ensured that the relay is set above any standing level of residual voltage that is present on the system.

Note	*IDMT characteristics are selectable on the first stage of NVD so that elements located at various points on the system may be time graded with one another.*

2.8 Undervoltage Protection

Undervoltage conditions may occur on a power system for a variety of reasons, some of which are outlined below:

- Increased system loading. Generally, some corrective action would be taken by voltage regulating equipment such as AVRs or On Load Tap Changers, in order to bring the system voltage back to it’s nominal value. If the regulating equipment is unsuccessful in restoring healthy system voltage, then tripping by means of an undervoltage relay will be required following a suitable time delay.

- Faults occurring on the power system result in a reduction in voltage of the phases involved in the fault. The proportion by which the voltage decreases is directly dependent upon the type of fault, method of system earthing and it's location with respect to the relaying point. Consequently, co-ordination with other voltage and current-based protection devices is essential in order to achieve correct discrimination.
- Complete loss of busbar voltage. This may occur due to fault conditions present on the incomer or busbar itself, resulting in total isolation of the incoming power supply. For this condition, it may be a requirement for each of the outgoing circuits to be isolated, such that when supply voltage is restored, the load is not connected. Hence, the automatic tripping of a feeder upon detection of complete loss of voltage may be required. This may be achieved by a three-phase undervoltage element.
- Where outgoing feeders from a busbar are supplying induction motor loads, excessive dips in the supply may cause the connected motors to stall, and should be tripped for voltage reductions which last longer than a pre-determined time.

Both the under and overvoltage protection functions can be found in the relay menu "Volt Protection". The following table shows the undervoltage section of this menu along with the available setting ranges and factory defaults.

2.8.1 Setting Guidelines

In most applications, undervoltage protection is not required to operate during system earth fault conditions. If this is the case, the element should be selected in the menu to operate from a phase to phase voltage measurement, as this quantity is less affected by single-phase voltage depressions due to earth faults.

The voltage threshold setting for the undervoltage protection should be set at some value below the voltage excursions that may be expected under normal system operating conditions. This threshold is dependent upon the system in question but typical healthy system voltage excursions may be in the order of -10% of nominal value.

Similar comments apply regarding a time setting for this element, i.e. the required time delay is dependent upon the time for which the system is able to withstand a depressed voltage. As mentioned earlier, if motor loads are connected, then a typical time setting may be in the order of 0.5 seconds.

2.9 Overvoltage Protection

As previously discussed, undervoltage conditions are relatively common, as they are related to fault conditions. However, overvoltage conditions are also a possibility and are generally related to loss of load conditions.

- Under conditions of load rejection, the supply voltage will increase in magnitude. This situation would normally be rectified by voltage regulating equipment such as AVRs or on-load tap changers. However, failure of this equipment to bring the system voltage back within prescribed limits leaves the system with an overvoltage condition which must be cleared to preserve the life of the system insulation. Hence, overvoltage protection that is suitably time-delayed to allow for normal regulator action may be applied.
- Also, during earth fault conditions on a power system, there may be an increase in the healthy phase voltages. Ideally the system should be designed to withstand such overvoltages for a defined period.

2.9.1 Setting Guidelines

The inclusion of the two stages and their respective operating characteristics allows for a number of possible applications:

- Use of the IDMT characteristic gives the option of a longer time delay if the overvoltage condition is only slight but results in a fast trip for a severe overvoltage. As the voltage settings for both of the stages are independent, the second stage could then be set lower than the first to provide a time delayed alarm stage if required .
- Alternatively, if preferred, both stages could be set to definite time and configured to provide the required alarm and trip stages.
- If only one stage of overvoltage protection is required, or if the element is required to provide an alarm only, the remaining stage may be disabled within the relay menu.

This type of protection must be co-ordinated with any other overvoltage relays at other locations on the system. This should be carried out in a similar manner to that used for grading current operated devices.

2.10 Negative Phase Sequence (NPS) Overvoltage Protection

Where an incoming feeder is supplying a switchboard which is feeding rotating plant (e.g. induction motors), correct phasing and balance of the ac supply is essential. Incorrect phase rotation will result in any connected motors rotating in the wrong direction. For directionally sensitive applications, such as elevators and conveyor belts, it may be unacceptable to allow this to happen.

Any unbalanced condition occurring on the incoming supply will result in the presence of Negative Phase Sequence (NPS) components of voltage. In the event of incorrect phase rotation, the supply voltage would effectively consist of 100% NPS voltage only.

2.10.1 Setting Guidelines

As the primary concern is the detection of incorrect phase rotation (rather than small unbalances), a sensitive setting is not required. You must ensure that the setting is above any standing NPS voltage that may be present due to imbalances in the measuring VT, relay tolerances etc. A setting of approximately 15% of rated voltage may be typical.

Note	*Standing levels of NPS voltage (V2) are displayed in "Measurements 1" column of the relay menu, labeled "V2 Magnitude".*

Hence, if more sensitive settings are required, they may be determined during the commissioning stage by viewing the actual level that is present.

The operation time of the element is highly dependent on the application. A typical setting would be in the region of 5 s. If the NPS overvoltage element is used to provide an additional check for the voltage controlled overcurrent element, set the time delay to 0 s.

2.11 Negative Phase Sequence (NPS) Overcurrent Protection

When applying traditional phase overcurrent protection, the overcurrent elements must be set higher than maximum load current, thereby limiting the element’s sensitivity. Most protection schemes also use an earth fault element operating from residual current, which improves sensitivity for earth faults. However, certain faults may arise which can remain undetected by such schemes.

Any unbalanced fault condition will produce negative sequence current of some magnitude. Thus, a Negative Phase Sequence (NPS) overcurrent element can operate for both phase-to-phase and phase-to-earth faults.

- NPS overcurrent elements give greater sensitivity to resistive phase-to-phase faults, where phase overcurrent elements may not operate
- In certain applications, residual current may not be detected by an earth fault relay due to the system configuration. For example, an earth fault relay applied on the delta side of a delta-star transformer is unable to detect earth faults on the star side. However, negative sequence current will be present on both sides of the transformer for any fault condition, irrespective of the transformer configuration. Therefore, a NPS overcurrent element may be employed to provide time-delayed back-up protection for any uncleared asymmetrical faults downstream
- Where rotating machines are protected by fuses, loss of a fuse produces a large amount of negative sequence current. This is a dangerous condition for the machine due to the heating effects of NPS current and hence an upstream NPS overcurrent element may be applied to provide back-up protection for dedicated motor protection relays
- It may be required to simply alarm for the presence of NPS currents on the system. Operators may then investigate the cause of the unbalance

2.11.1 Setting Guidelines

2.11.1.1 Negative Phase Sequence Current Threshold, 'I2> Current Set'

The current pick-up threshold must be set higher than the NPS current due to the maximum normal load unbalance on the system. This can be set practically at the commissioning stage, making use of the relay measurement function to display the standing NPS current, and setting at least 20% above this figure.

Where the NPS element is required to operate for specific uncleared asymmetric faults, a precise threshold setting would have to be based upon an individual fault analysis for that particular system due to the complexities involved. However, to ensure operation of the protection, the current pick-up setting must be set approximately 20% below the lowest calculated NPS fault current contribution to a specific remote fault condition.

2.11.1.2 Time delay for the Negative Phase Sequence Overcurrent Element, 'I2> Time Delay'

As stated above, correct setting of the time delay for this function is vital. It should also be noted that this element is applied primarily to provide back-up protection to other protective devices or to provide an alarm. Hence, in practice, it would be associated with a long time delay.

It must be ensured that the time delay is set greater than the operating time of any other protective device (at minimum fault level) on the system which may respond to unbalanced faults.

- Phase overcurrent elements
- Earth fault elements
- Broken conductor elements
- Negative phase sequence influenced thermal elements

2.11.1.3 Directionalizing the Negative Phase Sequence Overcurrent Element

Where NPS current may flow in either direction through a relay location, such as parallel lines, directional control of the element should be employed. Directionality is achieved by comparison of the angle between the NPS voltage and the NPS current and the element may be selected to operate in either the forward or reverse direction. A suitable relay characteristic angle setting (I2> Char Angle) is chosen to provide optimum performance. This setting should be set equal to the phase angle of the negative sequence current with respect to the inverted negative sequence voltage (– V2), in order to be at the center of the directional characteristic.

The angle that occurs between V2 and I2 under fault conditions is directly dependent upon the negative sequence source impedance of the system. However, typical settings for the element are as follows;

- For a transmission system the RCA should be set equal to -60°
- For a distribution system the RCA should be set equal to -45°

For the NPS directional elements to operate, the relay must detect a polarizing voltage above a minimum threshold, **I2> V2pol Set**. This must be set in excess of any steady state NPS voltage. This may be determined during the commissioning stage by viewing the NPS measurements in the relay.

2.12 Voltage Controlled Overcurrent (VCO) Protection (51V)

As described in the *Overcurrent Protection* section, overcurrent relays are co-ordinated throughout a system such that cascade operation is achieved. This means that the failure of a downstream circuit breaker to trip for a fault condition, whether due to the failure of a protective device, or of the breaker itself, should result in time graded tripping of the next upstream circuit breaker.

However, where long feeders are protected by overcurrent relays, the detection of remote phase-to-phase faults may prove difficult. This is due to the fact that the current pick up of phase overcurrent elements must be set above the maximum load current, thereby limiting the elements minimum sensitivity. If the current seen by a local relay for a remote fault condition is below it's overcurrent setting, a Voltage Controlled Overcurrent (VCO) element may be used to increase the relay sensitivity to such faults. In this case, a reduction in system voltage will occur; this may then be used to reduce the pick up level of the overcurrent protection.

Note	*Voltage dependent overcurrent relays are more often applied in generator protection applications to give adequate overcurrent relay sensitivity for close-up fault conditions. The fault characteristic of this protection must then co-ordinate with any of the downstream overcurrent relays that are responsive to the current decrement condition. It therefore follows that if the P145 relay is to be applied on an outgoing feeder from a generator station, the use of voltage controlled overcurrent protection in the feeder relay may allow better co-ordination with the VCO relay on the generator. The settings in such an application will be directly dependent upon those employed for the generator relay.*

2.12.1 Setting Guidelines

The "VCO k Setting" should be set low enough to allow operation for remote phase to phase faults, typically:

$$k = \frac{I_F}{I > \times 1.2}$$

Where:

If = Minimum fault current expected for the remote fault

I> = Phase current setting for the element to have VCO control

e.g. If the overcurrent relay has a setting of 160% In, but the minimum fault current for the remote fault condition is only 80% In, then the required k factor is given by:

$$k = \frac{0.8}{1.6 \times 1.2} = 0.42$$

The voltage threshold, "VCO V< Setting", would be set below the lowest system voltage that may occur under normal system operating conditions, whilst ensuring correct detection of the remote fault.

2.13 Circuit Breaker Fail (CBF) Protection

Following inception of a fault one or more main protection devices will operate and issue a trip output to the circuit breaker(s) associated with the faulted circuit. Operation of the circuit breaker is essential to isolate the fault, and prevent damage / further damage to the power system. For transmission/sub-transmission systems, slow fault clearance can also threaten system stability. It is therefore common practice to install Circuit Breaker Failure (CBF) protection, which monitors that the circuit breaker has opened within a reasonable time. If the fault current has not been interrupted following a set time delay from circuit breaker trip initiation, CBF protection will operate.

CBF operation can be used to backtrip upstream circuit breakers to ensure that the fault is isolated correctly. CBF operation can also reset all start output contacts, ensuring that any blocks asserted on upstream protection are removed.

2.13.1 Reset Mechanisms for Breaker Fail Timers

It is common practice to use low set undercurrent elements in protection relays to indicate that Circuit Breaker (CB) poles have interrupted the fault or load current, as required. This covers the following situations:

- Where CB auxiliary contacts are defective, or cannot be relied on to definitely indicate that the CB has tripped.
- Where a CB has started to open but has become jammed. This may result in continued arcing at the primary contacts, with an additional arcing resistance in the fault current path. Should this resistance severely limit fault current, the initiating protection element may reset. Therefore reset of the element may not give a reliable indication that the CB has opened fully.

For any protection function requiring current to operate, the relay uses operation of undercurrent elements (I<) to detect that the necessary circuit breaker poles have tripped and reset the CB fail timers. However, the undercurrent elements may not be reliable methods of resetting circuit breaker fail in all applications. For example:

- Where non-current operated protection, such as under/overvoltage or under/overfrequency, derives measurements from a line connected voltage transformer. Here, I< only gives a reliable reset method if the protected circuit would always have load current flowing. Detecting drop-off of the initiating protection element might be a more reliable method.
- Where non-current operated protection, such as under/overvoltage or under/overfrequency, derives measurements from a busbar connected voltage transformer. Again, using I< would rely on the feeder normally being loaded. Also, tripping the circuit breaker may not remove the initiating condition from the busbar, so drop-off of the protection element may not occur. In such cases, the position of the circuit breaker auxiliary contacts may give the best reset method.

CBF protection monitors whether the circuit breaker has opened in reasonable amount of time when protection devices issues trip command in fault situation. This should happen to prevent further damage in power system and isolate the fault in transmission or sub-transmission systems. If a false short pulse energized to opto input connected in PSL to DDB227 “External Trip 3ph” which may not enough for normal trip but because of CB failure logic this signal goes to SET-RESET gate and causes protection trip after 200ms.

2.13.2 Typical Settings

2.13.2.1 Breaker Fail Timer Settings

Typical timer settings to use are as follows:

CB fail reset mechanism	tBF time delay	Typical delay for 2 ½ cycle circuit breaker
Initiating element reset	CB interrupting time + element reset time (max.) + error in tBF timer + safety margin	50 + 45 + 10 + 50 = 155 ms
CB open	CB auxiliary contacts opening/closing time (max.) + error in tBF timer + safety margin	50 + 10 + 50 = 110 ms
Undercurrent elements	CB interrupting time + undercurrent element (max.) + safety margin	50 + 25 + 50 = 125 ms

Note *All CB Fail resetting involves the operation of the undercurrent elements. Where element reset or CB open resetting is used the undercurrent time setting should still be used if this proves to be the worst case.*

The examples above consider direct tripping of a 2½ cycle circuit breaker.

Note *Where auxiliary tripping relays are used, an additional 10-15 ms must be added to allow for trip relay operation.*

2.13.2.2 Breaker Fail Undercurrent Settings

The phase undercurrent settings (I<) must be set less than load current, to ensure that I< operation indicates that the circuit breaker pole is open. A typical setting for overhead line or cable circuits is 20% In, reduced to 10% or 5% where the infeed has a high SIR ratio (e.g. at a spur terminal with embedded generation infeed).

The sensitive earth fault protection (SEF) undercurrent element must be set less than the respective trip setting, typically as follows:

ISEF< = (ISEF> trip) / 2

IN< = (IN> trip)/2

2.14 Broken Conductor Detection

The majority of faults on a power system occur between one phase and ground or two phases and ground. These are known as shunt faults and arise from lightning discharges and other overvoltages which initiate flashovers. Alternatively, they may arise from other causes such as birds on overhead lines or mechanical damage to cables etc. Such faults result in an appreciable increase in current and hence in the majority of applications are easily detectable.

Another type of unbalanced fault that can occur on the system is the series or open circuit fault. These can arise from broken conductors, maloperation of single phase switchgear, or single-phasing of fuses. Series faults will not cause an increase in phase current on the system and hence are not readily detectable by standard protection. However, they will produce an unbalance and a resultant level of negative phase sequence current, which can be detected.

It is possible to apply a negative phase sequence overcurrent relay to detect the above condition. However, on a lightly loaded line, the negative sequence current resulting from a series fault condition may be very close to, or less than, the full load steady state unbalance arising from CT errors, load unbalance etc. A negative sequence element therefore would not operate at low load levels.

2.14.1 Setting Guidelines

For a broken conductor affecting a single point earthed power system, there will be little zero sequence current flow and the ratio of I2/I1 that flows in the protected circuit will approach 100%. In the case of a multiple earthed power system (assuming equal impedance's in each sequence network), the ratio I2/I1 will be 50%.

In practice, the levels of standing negative phase sequence current present on the system govern this minimum setting. This can be determined from a system study, or by making use of the relay measurement facilities at the commissioning stage. If the latter method is adopted, it is important to take the measurements during maximum system load conditions, to ensure that all single-phase loads are accounted for.

Note	*A minimum value of 8% negative phase sequence current is required for successful relay operation.*

As sensitive settings have been employed, it can be expected that the element will operate for any unbalance condition occurring on the system (for example, during a single pole auto-reclose cycle). Hence, a long time delay is needed to ensure co-ordination with other protective devices. A 60 second time delay setting may be typical.

For example, this information was recorded by the relay during commissioning;

Ifull load = 500 A
I2 = 50 A

Therefore, the quiescent I2/I1 ratio is given by:

I2/I1 = 50/500 = 0.1

To allow for tolerances and load variations a setting of 20% of this value may be typical: Therefore, set I2/I1 = 0.2

In a double circuit (parallel line) application, using a 40% setting will ensure that the broken conductor protection will operate only for the circuit that is affected. Setting 0.4 results in no pick-up for the parallel healthy circuit.

Set I2/I1 Time Delay = 60 s to allow adequate time for short circuit fault clearance by time delayed protections.

2.15 Cold-Load Pick-Up (CLP) Logic

When a feeder circuit breaker is closed in order to energize a load, the current levels that flow for a period of time following energization may differ greatly from the normal load levels. Consequently, overcurrent settings that have been applied to give short circuit protection may not be suitable during the period of energization, as they may give incorrect operation.

The Cold Load Pick-Up (CLP) logic included within the P14x relays serves to either inhibit one or more stages of the overcurrent protection for a set duration or, alternatively, to raise the settings of selected stages. This, therefore, allows the protection settings to be set closer to the load profile by automatically increasing them following circuit energization. The CLP logic thus provides stability, whilst maintaining protection during starting.

2.15.1 Air Conditioning/Resistive Heating Loads

Where a feeder is being used to supply air conditioning or resistive heating loads there may be a conflict between the 'steady state' overcurrent settings and those required following energization. This is due to the temporary increase in load current that may arise during this period. The CLP logic can be used to alter the applied settings during this time.

In this situation, "Enable" should be selected (from the "I> status" option) and the temporary current and time settings can then be programmed. These settings would be chosen in accordance with the expected load profile. Where it is not necessary to alter the setting of a particular stage, the CLP settings should be set to the required overcurrent settings.

It may not be necessary to alter the protection settings following a short supply interruption. In this case a suitable tcold timer setting can be used.

It should be noted that it is not possible to alter any of the directional settings in the CLP logic.

2.15.2 Motor Feeders

In general, a dedicated motor protection device from the MiCOM range would protect feeders supplying motor loads. However, if no specific protection has been applied (possibly due to economic reasons) then the CLP logic in the P14x may be used to modify the overcurrent settings accordingly during starting.

Depending upon the magnitude and duration of the motor starting current, it may be sufficient to simply block operation of instantaneous elements or, if the start duration is long, the time delayed protection settings may also need to be raised. Hence, a combination of both blocking and raising of settings of the relevant overcurrent stages may be adopted. The CLP overcurrent settings in this case must be chosen with regard to the motor starting characteristic.

As previously described, the CLP logic includes the option of either blocking or raising the settings of the first stage of the standard earth fault protection. This may be useful where instantaneous earth fault protection is required to be applied to the motor. During conditions of motor starting, it is likely that incorrect operation of the earth fault element would occur due to asymmetric CT saturation. This is a result of the high level of starting current causing saturation of one or more of the line CT's feeding the overcurrent/earth fault protection. The resultant transient imbalance in the secondary line current quantities is thus detected by the residually connected earth fault element. For this reason, it is normal to either apply a nominal time delay to the element, or to utilize a series stabilizing resistor.

The CLP logic may be utilized to allow reduced operating times or current settings to be applied to the earth fault element under normal running conditions. These settings could then be raised prior to motor starting, via the logic.

2.15.3 Switch On To Fault (SOTF) Protection

In some feeder applications, fast tripping may be required if a fault is present on the feeder when it is energized. Such faults may be due to a fault condition not having been removed from the feeder, or due to earthing clamps having been left on following maintenance. In either case, it may be desirable to clear the fault condition in an accelerated time, rather than waiting for the time delay associated with IDMT overcurrent protection.

The above situation may be catered for by the CLP logic. Selected overcurrent/earth fault stages could be set to instantaneous operation for a defined period following circuit breaker closure (typically 200ms). Hence, instantaneous fault clearance would be achieved for a SOTF condition.

2.16 Blocked Overcurrent Protection

Blocked overcurrent protection involves the use of start contacts from downstream relays wired onto blocking inputs of upstream relays. This allows identical current and time settings to be employed on each of the relays involved in the scheme, as the relay nearest to the fault does not receive a blocking signal and hence trips discriminatively. This type of scheme therefore reduces the amount of required grading stages and consequently fault clearance times.

The principle of blocked overcurrent protection may be extended by setting fast-acting overcurrent elements on the incoming feeders to a substation which are then arranged to be blocked by start contacts from the relays protecting the outgoing feeders. The fast-acting element is thus allowed to trip for a fault condition on the busbar but is stable for external feeder faults by means of the blocking signal. This type of scheme provides much reduced fault clearance times for busbar faults than would be the case with conventional time graded overcurrent protection. The availability of multiple overcurrent and earth fault stages means that back-up time graded overcurrent protection is also provided. This is shown in the *Simple busbar blocking scheme (single incomer)* diagram and the *Simple busbar blocking scheme (single incomer)* diagram.

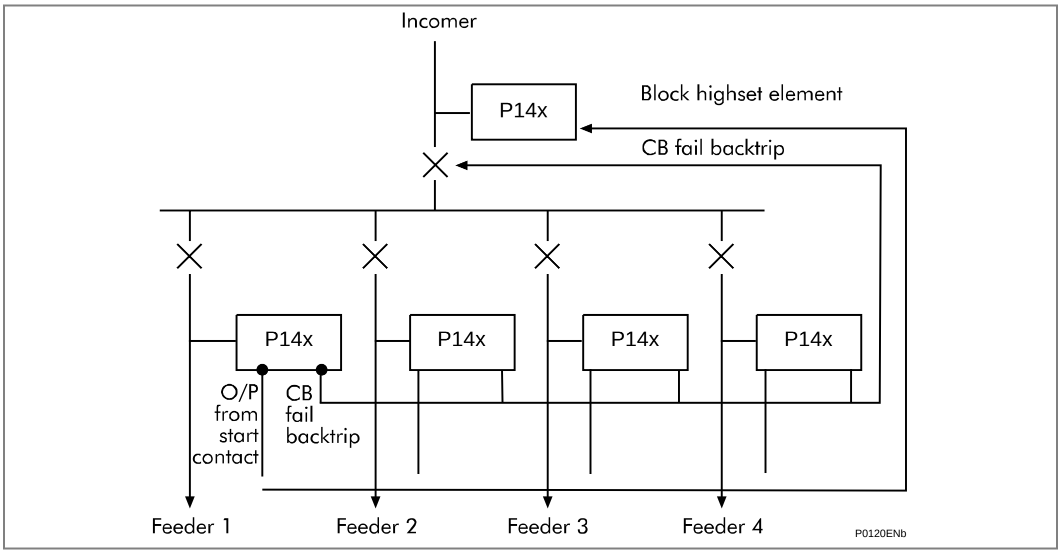


Figure 17 - Simple busbar blocking scheme (single incomer)

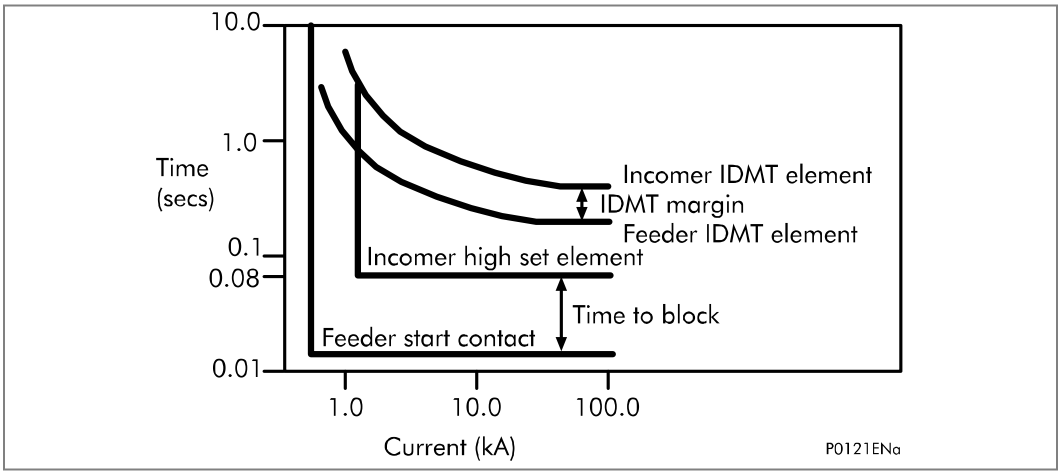


Figure 18 - Simple busbar blocking scheme (single incomer)

For guidance on the use of blocked overcurrent schemes refer to Schneider Electric.

2.17 Advanced Underfrequency Protection ‘f+t’ [81U]

Frequency variations on a power system are an indication that the power balance between generation and load has been lost. In particular, under-frequency implies that the net load is in excess of the available generation. Such a condition can arise, when an interconnected system splits, and the load left connected to one of the subsystems is in excess of the capacity of the generators in that particular subsystem. Industrial plants that are dependent on utilities to supply part of their loads will experience under-frequency conditions when the incoming lines are lost.

An underfrequency condition at nominal voltage can result in over-fluxing of generators and transformers and many types of industrial loads have limited tolerances on the operating frequency and running speeds e.g. synchronous motors. Sustained underfrequency has implications on the stability of the system, whereby any subsequent disturbance may lead to damage to frequency sensitive equipment and even blackouts, if the underfrequency condition is not corrected sufficiently fast.

The underfrequency protection settings are found in the “f+t [81U/81O]” relay menu column.

2.17.1 Setting Guidelines

In order to minimize the effects of underfrequency on a system, a multi stage load shedding scheme may be used with the plant loads prioritized and grouped. During an underfrequency condition, the load groups are disconnected sequentially depending on the level of underfrequency, with the highest priority group being the last one to be disconnected.

The effectiveness of each stage of load shedding depends on what proportion of the power deficiency it represents. If the load shedding stage is too small compared to the prevailing generation deficiency, then the improvement in frequency may be non-existent. This aspect should be taken into account when forming the load groups.

Time delays should be sufficient to override any transient dips in frequency, as well as to provide time for the frequency controls in the system to respond. This should be balanced against the system survival requirement since excessive time delays may jeopardize system stability. Time delay settings of 5 - 20s are typical.

An example of a four-stage load shedding scheme for 50Hz systems is shown below:

Stage	Element	Frequency Setting (Hz)	Time Setting (Sec)
1	Stage 1(f+t)	49.0	20s
2	Stage 2(f+t)	48.6	20s
3	Stage 3(f+t)	48.2	10s
4	Stage 4(f+t)	47.8	10s

Table 1 - Four-stage load shedding scheme example

The relatively long time delays are intended to provide time for the system controls to respond and will work well in a situation where the decline of system frequency is slow. For situations where rapid decline of frequency is expected, the load shedding scheme above should be supplemented by rate of change of frequency protection elements.

It may be noted that the protection package for generators at site may include underfrequency relays. The settings made on the P140 should be co-ordinated with the generator protection frequency relays.

2.18 Advanced Overfrequency Protection ‘f+t’ [81O]

Over frequency running of a generator arises when the mechanical power input to the machine exceeds the electrical output. This could happen, for instance, when there is a sudden loss of load due to tripping of an outgoing feeder from the plant to a load center. Under such over speed conditions, the governor should respond quickly so as to obtain a balance between the mechanical input and electrical output, thereby restoring normal frequency. Over frequency protection is required as a back-up to cater for slow response of frequency control equipment.

The overfrequency protection settings are found in the “f+t [81U/81O]” relay menu column.

2.18.1 Setting Guidelines

Following faults on the network, or other operational requirements, it is possible that various subsystems will be formed within the power network and it is likely that each of these subsystems will suffer from a generation to load imbalance. The “islands” where generation exceeds the existing load will be subject to over frequency conditions, the level of frequency being a function of the percentage of excess generation. Severe over frequency conditions may be unacceptable to many industrial loads, since running speeds of motors will be affected. The “f+t” element of the MiCOM P140 can be suitably set to sense this contingency.

An example of two-stage over frequency protection is shown below using stages 5 and 6 of the “f+t” element. However, it should be considered that settings for a real system will depend upon the maximum frequency that equipment can tolerate for a given period of time.

Stage	Element	Frequency Setting (Hz)	Time Setting (Sec.)
1	Stage 5(f+t)	50.5	30
2	Stage 6(f+t)	51.0	20

Table 2 - Two-stage over frequency protection

The relatively long time delays are intended to provide time for the system controls to respond and will work well in a situation where the increase of system frequency is slow.

For situations where rapid increase of frequency is expected, the protection scheme above could be supplemented by rate of change of frequency protection elements, possibly utilized to split the system further. For example, in the system shown in the *Power system segregation based upon frequency measurements* diagram the generation in the MV bus is sized according to the loads on that bus, whereas the generators linked to the HV bus produce energy for export to utility. If the links to the grid are lost, the IPP generation will cause the system frequency to rise. This rate of rise can be used to isolate the MV bus from the HV system, if operationally acceptable.

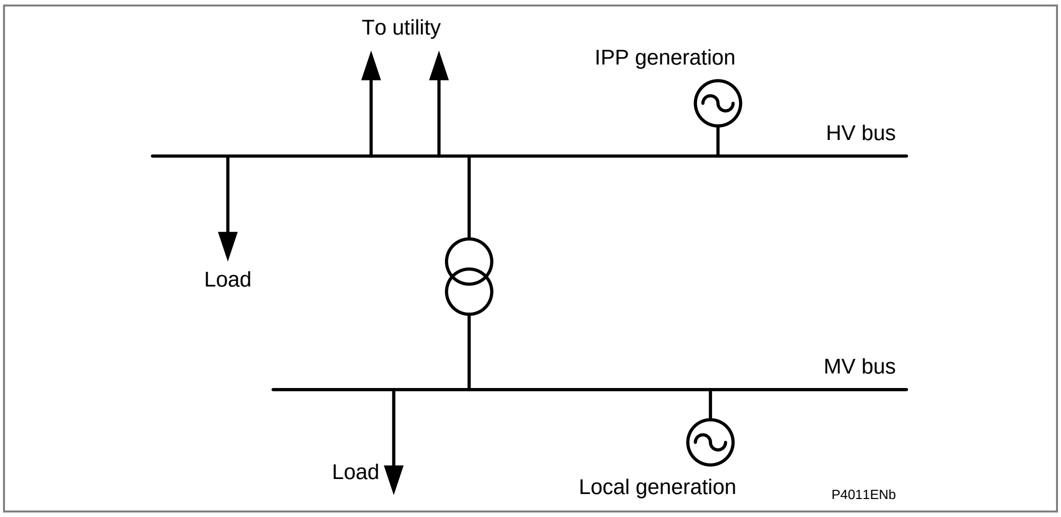


Figure 19 - Power system segregation based upon frequency measurements

The following tables give possible settings that could be used to speed up the process of segregating the system as outlined above, in conjunction with the overfrequency element:

Stage	Frequency "f+t [81U/81O]" Elements		Frequency Supervised Rate of Change of Frequency "f+df/dt dt [81RF]" Elements	
	Frequency Setting (Hz)	Time Setting (Sec.)	Frequency Setting (Hz)	Rate of Change of Frequency Setting (Hz/Sec)
1	50.5	30	50.5	1.0
2	51	20	51	1.0

Table 3 - Typical settings for over frequency with frequency supervised rate of change of frequency

Stage	Frequency "f+t [81U/81O]" Elements		Average Rate of Change of Frequency "f+Df/Dt [81RAV]" Elements		
	Frequency Setting (Hz)	Time Setting (Sec.)	Frequency Setting (Hz)	Frequency Difference Setting, Df (Hz)	Time Period, Dt (Sec.)
1	50.5	30	50.5	0.5	0.5
2	51	20	51	0.5	0.5

Table 4 - Overfrequency protection with average rate of change of frequency

Stage	Frequency "f+t [81U/81O]" Elements		Rate of Change of Frequency "df/dt+t [81R]" Elements	
	Frequency Setting (Hz)	Time Setting (Sec.)	Rate of Change of Frequency Setting (Hz/Sec.)	Time Setting (Sec.)
1	50.5	30	3.0	0.5
2	51	20	2.0	0.5

Table 5 - Overfrequency protection with independent rate of change of frequency

It may be noted that the protection package for generators at site may include overfrequency relays. The settings made on the P140 should be co-ordinated with the generator protection frequency relays.

2.19 Advanced Frequency Supervised Rate of Change of Frequency Protection 'f+df/dt' [81RF]

Conditions may arise in an electrical network where the load to generation imbalance is considerable and this may result in relatively rapid changes of the system frequency. In such a case, maintaining the system stability is an onerous task, and calls for quick corrective action.

High speed load shedding cannot be achieved by monitoring the system frequency alone and the rate of change of system frequency becomes an equally critical parameter to use.

In the load shedding scheme below, it is assumed under falling frequency conditions that by shedding a stage of load, the system can be stabilized at frequency f2. For slow rates of decay, this can be achieved using the underfrequency protection element set at frequency f1 with a suitable time delay. However, if the generation deficit is substantial, the frequency will rapidly decrease and it is possible that the time delay imposed by the underfrequency protection will not allow for frequency stabilization. In this case, the chance of system recovery will be enhanced by disconnecting the load stage based upon a measurement of rate of change of frequency and bypassing the time delay.

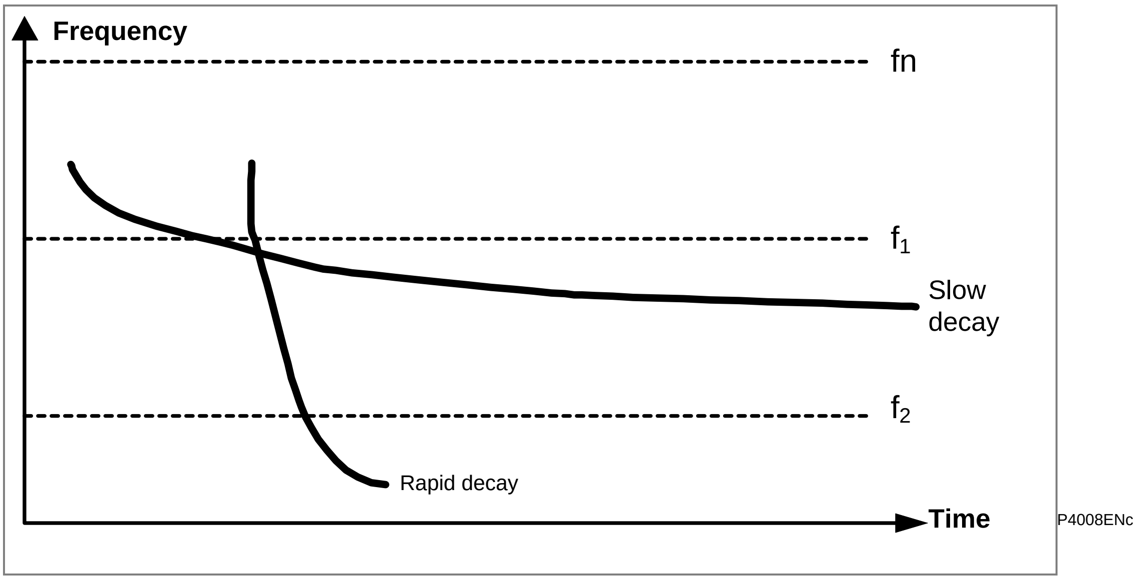


Figure 20 - Advanced frequency supervised rate of change of frequency protection

With the frequency supervised rate of change of frequency element, the basic rate of change of frequency measurement is supervised by an additional frequency measurement. As such, the rate of change of frequency AND the frequency must exceed the set thresholds before an output can be given.

The frequency supervised rate of change of frequency protection settings may be found in the "f+df/dt [81RF]" relay menu column.

2.19.1 Setting Guidelines

It is recommended that the frequency supervised rate of change of frequency protection (f+df/dt) element be used in conjunction with the time delayed frequency protection (f+t) elements.

A four stage high speed load shedding scheme may be configured as shown in the *Four-stage high-speed load shedding scheme* table and the *Improved four-stage high-speed load shedding scheme* table, noting that in each stage, both the "f+t" and the "f+df/dt" elements are enabled.

Stage	Frequency “f+t [81U/81O]” Elements		Frequency Supervised Rate of Change of Frequency “f+df/dt [81RF]” Elements	
	Frequency Setting (Hz)	Time Setting (Sec.)	Frequency Setting (Hz)	Rate of Change of Frequency Setting (Hz/sec.)
1	49	20	49	1.0
2	48.6	20	48.6	1.0
3	48.2	10	48.2	1.0
4	47.8	10	47.8	1.0

Table 6 - Four-stage high-speed load shedding scheme

It may be possible to further improve the speed of load shedding in critical cases by changing the frequency setting on the frequency supervised rate of change of frequency element. In the settings shown in the *Improved four-stage high-speed load shedding scheme* table, the frequency settings for the “f+df/dt” element have been set slightly higher than the frequency settings for the “f+t” element. This difference will allow for the measuring time of the relay, assuming the set rate of frequency change and default frequency averaging cycles, and will result in the tripping of the two elements at approximately the same frequency value. Thus, with this scheme, the slow frequency decline and fast frequency decline scenarios are independently monitored and optimized without sacrificing system security.

Stage	Frequency “f+t [81U/81O]” Elements		Frequency Supervised Rate of Change of Frequency “f+df/dt [81RF]” Elements	
	Frequency Setting (Hz)	Time Setting (Sec.)	Frequency Setting (Hz)	Rate of Change of Frequency Setting (Hz/sec.)
1	49	20	49.2	1.0
2	48.6	20	48.8	1.0
3	48.2	10	48.4	1.0
4	47.8	10	48.0	1.0

Table 7 - Improved four-stage high-speed load shedding scheme

2.20 Advanced Independent Rate of Change of Frequency Protection 'df/dt+t' [81R]

This element is a plain rate of change of frequency monitoring element, and is not supervised by a frequency setting as per the "f+df/dt" element. However, a timer is included to provide a time delayed operation. The element can be utilized to provide extra flexibility to a load shedding scheme in dealing with severe load to generation imbalances.

As mentioned in other sections, conditions involving very large load - generation imbalances may occur, accompanied by rapid decline in system frequency. Shedding of one or two stages of load is unlikely to stop the decline in frequency, if the discrepancy is still large. In such a situation, it is advantageous to have an element that identifies the high rate of decline of frequency, and adapts the load shedding scheme accordingly.

Since the rate of change monitoring is independent of frequency, the element can identify frequency variations occurring close to nominal frequency and thus provide early warning to the operator on a developing frequency problem. Additionally, the element could also be used as an alarm to warn operators of unusually high system frequency variations.

The rate of change of frequency protection settings may be found in the "df/dt+t [81R]" relay menu column.

2.20.1 Setting Guidelines

Considerable care should be taken when setting this element because it is not supervised by a frequency setting. Setting of the time delay or increasing the number of df/dt averaging cycles will lead to a more stable element but this should be considered against the loss of fast tripping capability as the tripping time is extended.

It is likely that this element would be used in conjunction with other frequency based protection elements to provide a scheme that accounts for severe frequency fluctuations. An example scheme is shown in the *Improved setting guidelines* table:

Stage	Frequency "f+t [81U/81O]" Elements		Frequency Supervised Rate of Change of Frequency "f+df/dt [81RF]" Elements	
	Frequency Setting (Hz)	Time Setting (Sec.)	Frequency Setting (Hz)	Rate of Change of Frequency Setting (Hz/Sec.)
1	49	20	49.2	1.0
2	48.6	20	48.8	1.0
3	48.2	10	48.4	1.0
4	47.8	10	48.0	1.0
5	-	-	-	-

Stage	Rate of Change of Frequency "df/dt+t [81R]" Elements	
	Rate of Change of Frequency Setting (Hz/Sec.)	Time Setting (Sec.)
1	-	-
2	-	-
3	-3.0	0.5
4	-3.0	0.5
5	-3.0	0.1

Table 8 - Improved setting guidelines

In the above scheme, tripping of the last two stages is accelerated by using the independent rate of change of frequency element. If the frequency starts falling at a high rate (> 3Hz/s in this example), then stages 3 & 4 are shed at around 48.5Hz, with the objective of a better chance of system stability. Stage 5 serves as an alarm and gives operators advance warning that the situation is critical and if it persists, there is the likelihood for all stages of load being shed.

2.21 Advanced Average Rate of Change of Frequency Protection ‘f+Df/Dt’ [81RAV]

Owing to the complex dynamics of power systems, variations in frequency during times of generation - load imbalance do not follow any regular patterns and are highly non-linear. Oscillations will occur as the system seeks to address the imbalance, resulting in frequency oscillations typically in the order of 0.1Hz to 1Hz, in addition to the basic change in frequency.

The rate of change of frequency elements discussed in the ***Thermal Overload Protection*** section and the ***Earth Fault (EF) Protection*** section both use an “instantaneous” measurement of “df/dt” based upon a 3 cycle, filtered, “rolling” average technique. Due to the oscillatory nature of frequency excursions, this instantaneous value can sometimes be misleading, either causing unexpected operation or excessive stability. For this reason, the P140 relays also provide an element for monitoring the longer term frequency trend, thereby reducing the effects of non-linearity’s in the system and providing increased security to the rate of change of frequency decision.

Using the average rate of change of frequency element “f+Df/Dt”, when the measured frequency crosses the supervising frequency threshold a timer is initiated. At the end of this time period, Δt, the frequency difference, Δf, is evaluated and if this exceeds the setting, a trip output is given.

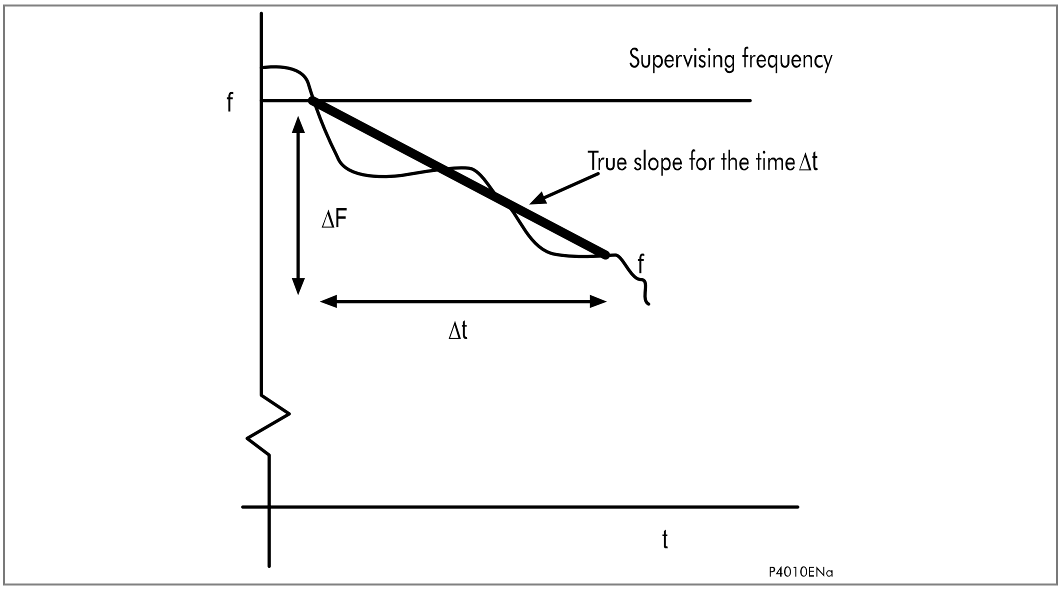


Figure 21 - Advanced average rate of change of frequency protection

After time Δt, regardless of the outcome of the comparison, the element is blocked from further operation until the frequency recovers to a value above the supervising frequency threshold (or below in the case where the element is configured for overfrequency operation).

The average rate of change of frequency protection settings may be found in the “f+Df/Dt [81RAV]” relay menu column.

2.21.1 Setting Guidelines

As for the other rate of change of frequency elements, it is recommended that the “f+Df/Dt” element be used in conjunction with the “f+t” element. The average rate of change of frequency element can be set to measure the rate of change over a short period as low as 20ms (1 cycle @ 50Hz) or a relatively long period up to 2s (100 cycles @ 50Hz). With a time setting, Dt, towards the lower end of this range, the element becomes similar to the frequency supervised rate of change function, “f+df/dt”. With high Dt settings, the element acts as a frequency trend monitor.

Although the element has a wide range of setting possibilities, it is recommended that the Dt setting is set greater than 100ms to ensure the accuracy of the element as described in P14x/EN TD.

A possible four stage load shedding scheme using the average rate of change frequency element is shown in the *Four-stage load shedding scheme (average rate of change of frequency)* table:

Stage	Frequency “f+t [81U/81O]” Elements		Average Rate of Change of Frequency “f+Df/Dt [81RAV]” Elements		
	(f+t) f Frequency Setting (Hz)	(f+t) t Time Setting (Sec.)	(f+Df/Dt) f Frequency Setting (Hz)	(f+Df/Dt) Df Frequency Diff Setting, (Hz)	(f+Df/Dt) Dt Time Period, (Sec.)
1	49	20	49	0.5	0.5
2	48.6	20	48.6	0.5	0.5
3	48.2	10	48.2	0.5	0.5
4	47.8	10	47.8	0.5	0.5

Table 9 - Four-stage load shedding scheme (average rate of change of frequency)

In the above scheme, the faster load shed decisions are made by monitoring the frequency change over 500ms. Hence tripping takes place slower than in schemes employing the frequency supervised rate of change element (f+df/dt [81RF]), but the difference is not very much at this setting. If the delay is unacceptable for system stability, then the scheme can be improved by increasing the independent “f” setting of the element. Depending upon how much this value is increased, the frequency at which the “f+Df/Dt” element will trip also increases and hence reduces the time delay to load shedding under more severe frequency fluctuations. For example, with the settings shown in the *Improved four-stage load shedding system* table and assuming the set average rate of frequency decline, the first stage of load shedding would be tripped approximately 300msecs after 49.0Hz had been reached and at a frequency of approximately 48.7Hz.

Stage	Frequency “f+t [81U/81O]” Elements		Average Rate of Change of Frequency “f+Df/Dt [81RAV]” Elements		
	(f+t) f Frequency Setting (Hz)	(f+t) t Time Setting (Sec)	(f+Df/Dt) f Frequency Setting (Hz)	(f+Df/Dt) Df Frequency Diff Setting (Hz)	(f+Df/Dt) Dt Time Period, (Sec.)
1	49	20	49.2	0.5	0.5 s
2	48.6	20	48.8	0.5	0.5 s
3	48.2	10	48.4	0.5	0.5 s
4	47.8	10	48.0	0.5	0.5 s

Table 10 - Improved four-stage load shedding system

2.22 Advanced Load Restoration

It is the goal of load shedding to stabilize the frequency on a system and to re-establish the load to generation imbalance that initially caused the frequency to decline. As the system stabilizes and the generation capability improves, the system frequency will recover to near normal levels and after some time delay it is possible to consider the restoration of load onto the healthy system. However, load restoration needs to be performed carefully and systematically so that system stability is not jeopardized again. A careful balance needs to be sought to minimize the length of time that the loads are disconnected but at the same time, not re-connect loads that will cause the problem to immediately re-occur.
In the case of industrial plants with captive generation, restoration should be linked to the available generation since connecting additional load when the generation is still inadequate, will only result in declining frequency and consequent load shedding. If the in-plant generation is insufficient to meet the load requirements, then load restoration should be interlocked with recovery of the utility supply.

The load restoration settings may be found in the “Load Restoration” relay menu column.

2.22.1 Setting Guidelines

A four stage, single frequency load restoration scheme is shown in the Restoration guidelines table. The frequency setting has been chosen such that there is sufficient separation between the highest load shed frequency (49.0 Hz from the underfrequency protection elements - see the *Transformer Magnetizing Inrush* section) and the restoration frequency to prevent any possible hunting. A restoration frequency setting closer to nominal frequency may be chosen if an operating frequency of 49.3 Hz is unacceptable.

Stage	Restoration Frequency Setting (Hz)	Restoration Time Delay (secs)	Holding Time Delay (secs)
1	49.3Hz	240 sec	20 sec
2	49.3Hz	180 sec	20 sec
3	49.3Hz	120 sec	20 sec
4	49.3Hz	60 sec	20 sec

Table 11 - Restoration guidelines

In this scheme, the time delays ensure that the most critical loads are reconnected first assuming that the higher stages refer to more important loads. By sequentially restoring the load, it is also hoped that system stability is maintained and that the frequency problems are not re-instated. These time settings are system dependent; higher or lower settings may be required depending on the particular application.

It is possible to set up restoration schemes involving multiple frequencies. This allows faster restoration of loads, but the possibility of continuous system operation at frequencies far removed from the nominal must be considered in this case. A typical scheme using two frequencies is shown in the *Typical scheme using two frequencies* table:

Stage	Restore Freq. Restoration Frequency Setting (Hz)	Restore Delay Restoration Time Delay (S)	Holding Time Delay (S)
1	49.5Hz	120 sec	20 sec
2	49.5Hz	60 sec	20 sec
3	49.0Hz	120 sec	20 sec
4	49.0Hz	60 sec	20 sec

Table 12 - Typical scheme using two frequencies

Staggered time settings may be used in this scheme as well, but the time separation among the restoration of stages will be a function of the frequency recovery pattern. Time co-ordinated restoration can only be guaranteed for those stages with a common restoration frequency setting.

2.23 EIA(RS)232 InterMiCOM ("MODEM InterMiCOM")

The settings needed for the implementation of MODEM InterMiCOM are stored in two columns of the menu structure. The first column entitled **INTERMICOM COMMS** contains all the information to configure the communication channel and also contains the channel statistics and diagnostic facilities. The second column entitled **INTERMICOM CONF** selects the format of each signal and its fallback operation mode.

The settings needed for the InterMiCOM signaling are largely dependant on whether a direct or indirect (modem/multiplexed) connection between the scheme ends is used.

Direct connections will either be short metallic or dedicated fiber optic based (by means of suitable EIA(RS)232 to optical fiber converters) and hence can be set to have the highest signaling speed of 19200b/s. Due to this high signaling rate, the difference in operating speed between the direct, permissive and blocking type signals is so small that the most secure signaling (direct intertrip) can be selected without any significant loss of speed. In turn, since the direct intertrip signaling requires the full checking of the message frame structure and CRC checks, it would seem prudent that the **IM# Fallback Mode** be set to Default with a minimal intentional delay by setting **IM# FrameSyncTim** to 10 msecs. In other words, whenever two consecutive messages have an invalid structure, the relay will immediately revert to the default value until a new valid message is received.

For indirect connections, the settings that can be applied will become more application and communication media dependent. As for the direct connections, consider only the fastest baud rate but this will usually increase the cost of the necessary modem/multiplexer. In addition, devices operating at these high baud rates may suffer from **data jams** during periods of interference and in the event of communication interruptions, may require longer re-synchronization periods. Both of these factors will reduce the effective communication speed thereby leading to a recommended baud rate setting of 9.6 kbit/s. As the baud rate decreases, the communications will become more robust with fewer interruptions, but the overall signaling times will increase.

Since it is likely that slower baud rates will be selected, the choice of signaling mode becomes significant. However, once the signaling mode has been chosen it is necessary to consider what should happen during periods of noise when message structure and content can be lost. If **Blocking** mode is selected, only a small amount of the total message is actually used to provide the signal, which means that in a noisy environment there is still a good likelihood of receiving a valid message. In this case, it is recommended that the **IM# Fallback Mode** is set to **Default** with a reasonably long **IM# FrameSyncTim**. A typical default selection of Default = 1 (blocking received substitute) would generally apply as the failsafe assignment for blocking schemes.

If <u>**Direct Intertrip**</u> mode is selected, the whole message structure must be valid and checked to provide the signal, which means that in a very noisy environment the chances of receiving a valid message are quite small. In this case, it is recommended that the **IM# Fallback Mode** is set to **Default** with a minimum **IM# FrameSyncTim** setting i.e. whenever a non-valid message is received, InterMiCOM will use the set default value. A typical default selection of Default = 0 (intertrip NOT received substitute) would generally apply as the failsafe assignment for intertripping schemes.

If <u>**Permissive**</u> mode is selected, the chances of receiving a valid message is between that of the **Blocking** and **Direct Intertrip** modes. In this case, it is possible that the **IM# Fallback Mode** is set to **Latched**. The table below highlights the recommended **IM# FrameSyncTim** settings for the different signaling modes and baud rates:

Baud rate	Minimum recommended "IM# FrameSyncTim" Setting		Minimum setting (ms)	Maximum setting (ms)
	Direct intertrip mode	Blocking mode		
600	100	250	100	1500
1200	50	130	50	1500
2400	30	70	30	1500
4800	20	40	20	1500
9600	10	20	10	1500
19200	10	10	10	1500

Note *No recommended setting is given for the Permissive mode since it is anticipated that* ***Latched*** *operation will be selected. If* ***Default mode*** *is selected, the* ***IM# FrameSyncTim*** *setting should be set greater than the minimum settings listed above. If the* ***IM# FrameSyncTim*** *setting is set lower than the minimum setting listed above, there is a danger that the relay will monitor a correct change in message as a corrupted message.*

A setting of 25% is recommended for the communications failure alarm.

Table 13 - Recommended IM# FrameSyncTim settings

2.24 Sensitive Power Protection

The Sensitive Power is a single phase power element using A phase current and voltage. This protection provides all the required functionality - Low Forward Power, Reverse Power and Over Power with timer and pole-dead inhibit.

For both reverse and low forward power protection function settings greater than 3% Pn, the phase angle errors of suitable protection class current transformers will not result in any risk of mal-operation or failure to operate. However, for the sensitive power protection if settings less than 3% are used, it is recommended that the current input is driven by a correctly loaded metering class current transformer.

The sensitive power protection has a minimum setting accuracy of 0.5% Pn using the In sensitive CT to calculate single phase active power. It also provides phase compensation to remove errors introduced by the primary input transformers.

2.25 Phase Segregated Power Protection

2.25.1 Low Forward Power Protection

When the machine is generating and the CB connecting the generator to the system is tripped, the electrical load on the generator is cut. This could lead to generator over-speed if the mechanical input power is not reduced quickly. Turbo-alternators with low-inertia rotor designs, do not have a high over speed tolerance. Trapped steam in the turbine, downstream of a valve that has just closed, can rapidly lead to over speed. To reduce the risk of over speed damage to such sets, it is sometimes chosen to interlock non-urgent tripping of the generator breaker and the excitation system with a low forward power check. This ensures that the generator set circuit breaker is opened only when the output power is sufficiently low that over speeding is unlikely. The delay in electrical tripping, until prime mover input power has been removed, may be deemed acceptable for ‘non-urgent’ protection trips. For ‘urgent’ trips, the low forward power interlock should not be used. With the low probability of ‘urgent’ trips, the risk of over speed and possible consequences must be accepted.

The low forward power protection can be arranged to interlock ‘non-urgent’ protection tripping using the relay scheme logic. It can also be arranged to provide a contact for external interlocking of manual tripping, if desired. To prevent unwanted relay alarms and flags, a low forward power protection element can be disabled when the circuit breaker is opened via ‘poledead’ logic. The low forward power protection can also be used to provide loss of load protection when a machine is motoring. It can be used for example to protect a machine which is pumping from becoming unprimed or to stop a motor in the event of a failure in the mechanical transmission. A typical application would be for pump storage generators operating in the motoring mode, where there is a need to prevent the machine becoming unprimed which can cause blade and runner cavitation.

2.25.2 Reverse Power Protection

A generator is expected to supply power to the connected system in normal operation. If the generator prime mover fails, a generator that is connected in parallel with another source of electrical supply will begin to ‘motor’. This reversal of power flow due to loss of prime mover can be detected by the reverse power element. The consequences of generator motoring and the level of power drawn from the power system will be dependent on the type of prime mover.

In some applications, the level of reverse power in the case of prime mover failure may fluctuate. This may be the case for a failed diesel engine. To prevent cyclic initiation and reset of the main trip timer, and consequent failure to trip, an adjustable reset time delay is provided. This delay would need to be set longer than the period for which the reverse power could fall below the power setting. This setting needs to be taken into account when setting the main trip time delay. It should also be noted that a delay on reset in excess of half the period of any system power swings could result in operation of the reverse power protection during swings. Reverse power protection may also be used to interlock the opening of the generator set circuit breaker for ‘non-urgent’ tripping. Reverse power interlocks are preferred over low forward power interlocks by some utilities.

2.25.3 Over Power Protection

The overpower protection can be used as overload indication, as a back-up protection for failure of governor and control equipment, and would be set above the maximum power rating of the machine.

3 APPLICATION OF NON-PROTECTION FUNCTIONS

3.1 Three-Phase Auto-Reclosing

An analysis of faults on any overhead line network has shown that 80 - 90% are transient in nature.

A transient fault, such as an insulator flashover, is a self-clearing ‘non-damage’ fault. This type of fault can be cleared by the immediate tripping of one or more circuit breakers to isolate the fault, and does not recur when the line is re-energized. Lightning is the most common cause of transient faults, other possible causes being clashing conductors and wind blown debris. The remaining 10 - 20% of faults are either semi-permanent or permanent.

A small tree branch falling on the line could cause a semi-permanent fault. Here the cause of the fault would not be removed by the immediate tripping of the circuit, but could be burnt away during a time-delayed trip.

Permanent faults could be broken conductors, transformer faults, cable faults or machine faults that must be located and repaired before the supply can be restored.

In the majority of fault incidents, if the faulty line is immediately tripped out, and time is allowed for the fault arc to de-ionize, re-closure of the circuit breakers will result in the line being successfully re-energized. Auto-reclose schemes are employed to automatically re-close a switching device a set time after it has been opened due to operation of protection where transient and semi-permanent faults are prevalent.

On HV/MV distribution networks, auto-reclosing is applied mainly to radial feeders where system stability problems do not generally arise. The main advantages to be derived from using auto-reclose can be summarized as follows:

- Minimizes interruptions in supply to the consumer
- Reduces operating costs - less man-hours in repairing fault damage and the possibility of running substations unattended. With auto-reclose instantaneous protection can be used which means shorter fault duration’s which gives rise to less fault damage and fewer permanent faults

The introduction of auto-reclosing gives an important benefit on circuits using time graded protection, in that it allows the use of instantaneous protection to give a high speed first trip. With fast tripping, the duration of the power arc resulting from an overhead line fault is reduced to a minimum, thus lessening the chance of damage to the line, which might otherwise cause a transient fault to develop into a permanent fault. Using instantaneous protection also prevents blowing of fuses in teed circuits and reduces circuit breaker maintenance by eliminating pre-arc heating when clearing transient faults.

It should be noted that when instantaneous protection is used with auto-reclosing, the scheme is normally arranged to block the instantaneous protection after the first trip. Therefore, if the fault persists after re-closure, the time graded protection will give discriminative tripping with fuses or other protection devices, resulting in the isolation of the faulted section. However, for certain applications, where the majority of the faults are likely to be transient, it is not uncommon to allow more than one instantaneous trip before the instantaneous protection is blocked.

Some schemes allow a number of re-closures and time graded trips after the first instantaneous trip, which may result in the burning out and clearance of semi-permanent faults. Such a scheme may also be used to allow fuses to operate in teed feeders where the fault current is low.

When considering feeders that are partly overhead line and partly underground cable, any decision to install auto-reclosing would be influenced by any data known on the frequency of transient faults. When a significant proportion of the faults are permanent, the advantages of auto-reclosing are small, particularly since re-closing on to a faulty cable is likely to aggravate the damage.

3.1.1 Setting Guidelines

3.1.1.1 Number of Shots

There are no clear-cut rules for defining the number of shots for a particular application. Generally medium voltage systems utilize only two or three shot auto-reclose schemes. However, in certain countries, for specific applications, four shots is not uncommon. Four shots have the advantage that the final dead time can be set sufficiently long to allow any thunderstorms to pass before re-closing for the final time. This arrangement will prevent unnecessary lockout for consecutive transient faults.

Typically, the first trip, and sometimes the second, will result from instantaneous protection - since 80% of faults are transient, the subsequent trips will be time delayed, all with increasing dead times to clear semi-permanent faults.

In order to determine the required number of shots the following factors must be taken into account:

- An important consideration is the ability of the circuit breaker to perform several trip-close operations in quick succession and the effect of these operations on the maintenance period.
- On EHV transmission circuits with high fault levels, only one re-closure is normally applied, because of the damage that could be caused by multiple re-closures if the fault is permanent.

3.1.1.2 Dead Timer Setting

The choice of dead time is, very much, system dependent. The main factors that can influence the choice of dead time are:

- Stability and synchronism requirements
- Operational convenience
- Load
- The type of circuit breaker
- Fault de-ionizing time
- The protection reset time

3.1.1.3 Stability and Synchronism Requirements

If the power transfer level on a specific feeder is such that the systems at either end of the feeder could quickly fall out of synchronism if the feeder is opened, it is usually required to re-close the feeder as quickly as possible, to prevent loss of synchronism. This is called High Speed Auto-Reclosing (HSAR). In this situation, the dead time setting should be adjusted to the minimum time necessary to allow complete de-ionization of the fault path and restoration of the full voltage withstand level, and comply with the “minimum dead time” limitations imposed by the circuit breaker and protection (see below). Typical HSAR dead time values are between 0.3 and 0.5 seconds.

On a closely interconnected transmission system, where alternative power transfer paths usually hold the overall system in synchronism even when a specific feeder opens, or on a radial supply system where there are no stability implications, it is often preferred to leave a feeder open for a few seconds after fault clearance. This allows the system to stabilize, and reduces the shock to the system on re-closure. This is called slow or Delayed Auto-Reclosing (DAR). The dead time setting for DAR is usually selected for operational convenience (see below).

3.1.1.3.1 Operational Convenience

When HSAR is not required, the dead time chosen for the first re-closure (shot) following a fault trip is not critical. It should be long enough to allow any transients resulting from the fault and trip to decay, but not so long as to cause major inconvenience to consumers who are affected by the loss of the feeder. The setting chosen often depends on service experience with the specific feeder.

Typical first shot dead time settings on 11 kV distribution systems are 5 to 10 seconds. In situations where two parallel circuits from one substation are carried on the same towers, it is often arranged for the dead times on the two circuits to be staggered, e.g. one at 5 seconds and the other at 10 seconds, so that the two circuit breakers do not re-close simultaneously following a fault affecting both circuits.

For multi-shot auto-reclose cycles, the second and subsequent shot dead times are usually longer than the first shot, to allow time for “semi-permanent” faults to burn clear, and to allow for the CB rated duty cycle and spring charging time. Typical second and third shot dead time settings are 30 seconds and 60 seconds respectively.

3.1.1.3.2 Load Requirements

Some types of electrical load might have specific requirements for minimum and/or maximum dead time, to prevent damage and ensure minimum disruption. For example, synchronous motors are only capable of tolerating extremely short interruptions of supply without loss of synchronism. In practice it is desirable to disconnect the motor from the supply in the event of a fault; the dead time would normally be sufficient to allow the motor no-volt device to operate. Induction motors, on the other hand, can withstand supply interruptions up to typically 0.5 seconds and re-accelerate successfully.

3.1.1.3.3 Circuit Breaker

For high speed auto-reclose the minimum dead time of the power system will depend on the minimum time delays imposed by the circuit breaker during a tripping and re-closing operation.

After tripping, time must be allowed for the mechanism to reset before applying a closing pulse; otherwise, the circuit breaker might fail to close correctly. This resetting time will vary depending on the circuit breaker, but is typically 0.1 seconds.

Once the mechanism has reset, a CB Close signal can be applied. The time interval between the energization of the closing mechanism and the making of the contacts is termed the closing time. Owing to the time constant of a solenoid closing mechanism and the inertia of the plunger, a solenoid closing mechanism may take 0.3s. A spring operated breaker, on the other hand, can close in less than 0.1 seconds.

Where high speed re-closing is required, for the majority of medium voltage applications, the circuit breaker mechanism reset time itself dictates the minimum dead time. The minimum system dead time only considering the CB is the mechanism reset time plus the CB closing time. Thus, a solenoid mechanism will not be suitable for high speed auto-reclose as the closing time is generally too long.

For most circuit breakers, after one re-closure, it is necessary to recharge the closing mechanism energy source, (spring, gas pressure etc.) before a further re-closure can take place. Therefore the dead time for second and subsequent shots in a multi-shot sequence must be set longer than the spring or gas pressure recharge time.

3.1.1.3.4 Fault De-Ionizing Time

For high speed auto-reclose the fault de-ionizing time may be the most important factor when considering the dead time. This is the time required for ionized air to disperse around the fault position so that the insulation level of the air is restored. It cannot be accurately predicted. However, it can be approximated from the following formula, based on extensive experience on many transmission and distribution systems throughout the world:

De-ionizing time = (10.5 + ((system voltage in kV)/34.5))/frequency
For 66 kV = 0.25s (50Hz)
For 132 kV = 0.29s (50 Hz)

3.1.1.3.5 Protection Reset

It is essential that any time graded protection fully resets during the dead time, so that correct time discrimination will be maintained after re-closure on to a fault. For high speed auto-reclose, instantaneous reset of protection is required. However at distribution level, where the protection is predominantly made up of overcurrent and earthfault relays, the protection reset time may not be instantaneous (e.g. induction disk relays). In the event that the circuit breaker re-closes on to a fault and the protection has not fully reset, discrimination may be lost with the downstream protection. To avoid this condition the dead time must be set in excess of the slowest reset time of either the local relay or any downstream protection.

Typical 11/33kV dead time settings in the UK are as follows:
1st dead time = 5 - 10 seconds
2nd dead time = 30 seconds
3rd dead time = 60 - 180 seconds
4th dead time (uncommon in the UK, however used in South Africa) = 1 - 30 minutes

3.1.1.4 Reclaim Timer Setting

A number of factors influence the choice of the reclaim timer, such as:

- Supply continuity - Large reclaim times can result in unnecessary lockout for transient faults
- Fault incidence/Past experience - Small reclaim times may be required where there is a high incidence of lightning strikes to prevent unnecessary lockout for transient faults
- Spring charging time - For high speed auto-reclose the reclaim time may be set longer than the spring charging time to ensure there is sufficient energy in the circuit breaker to perform a trip-close-trip cycle. For delayed auto-reclose there is no need as the dead time can be extended by an extra CB healthy check window time if there is insufficient energy in the CB. If there is insufficient energy after the check window time the relay will lockout
- Switchgear maintenance - Excessive operation resulting from short reclaim times can mean shorter maintenance periods. A minimum reclaim time of >5s may be needed to allow the CB time to recover after a trip and close before it can perform another trip-close-trip cycle. This time will depend on the duty (rating) of the CB

The reclaim time must be long enough to allow any time delayed protection initiating auto-reclose to operate. Failure to do so would result in premature resetting of the auto-reclose scheme and re-enabling of instantaneous protection. If this condition arose, a permanent fault would effectively look like a number of transient faults, resulting in continuous auto-reclosing unless additional measures were taken to overcome this such as excessive fault frequency lockout protection.

Sensitive earth fault protection is applied to detect high resistance earth faults and usually has a long time delay, typically 10 - 15s. This longer time may have to be taken into consideration, if auto-reclosing from SEF protection, when deciding on a reclaim time, if the reclaim time is not blocked by an SEF protection start signal. High resistance earth faults, for example, a broken overhead conductor in contact with dry ground or a wood fence, is rarely transient and may be a danger to the public. It is therefore common practice to block auto-reclose by operation of sensitive earth fault protection and lockout the circuit breaker.

A typical 11/33kV reclaim time in the UK is 5 - 10 seconds, this prevents unnecessary lockout during thunderstorms. However, times up to 60 - 180 seconds may be used elsewhere in the world.

3.2 Function Keys

The following default PSL logic illustrates the programming of function keys to enable/disable the commissioning mode functionality.

Please note the auto-reclose functionality should be enabled in the Configuration column for this feature to work.

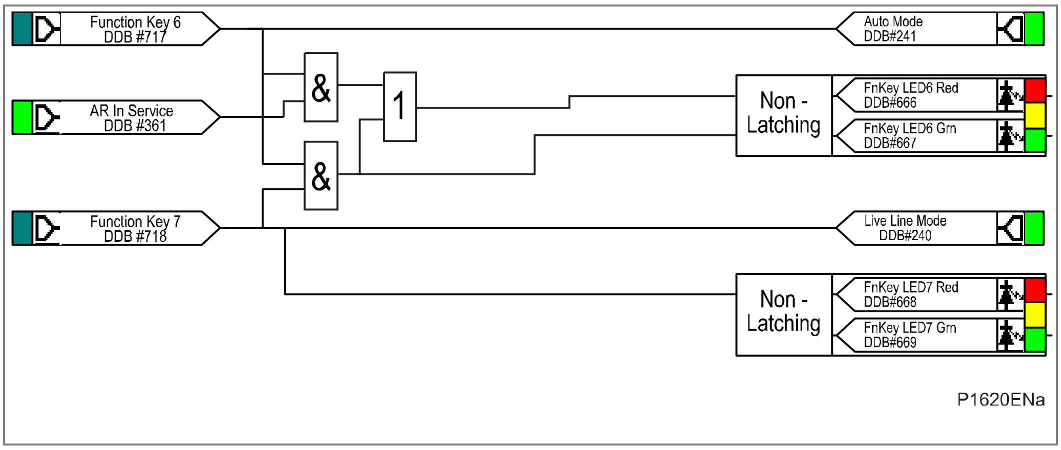


Figure 22 - Auto-reclose default PSL

Note	*Energizing two inputs to an LED conditioner creates a YELLOW illumination.*

Function Key 6 is set to ‘Toggle’ mode and on activation of the key, the auto-reclose function will be in service as long as the auto-reclose function has been enabled in the “Configuration” menu. The associated LED will indicate the state of the ARC function in service as RED. The LED indication will show YELLOW should the ‘Live Line mode’ be activated whilst the ARC in service function key is active.

Function Key 7 is set to ‘Toggle’ mode and on activation of the key, the auto-reclose function will be set to the ‘Live Line Mode’ with the auto-reclose enabled in the “Configuration” menu. The associated LED will indicate the state of the ARC function in ‘Live Line’ as RED.

3.3 Current Transformer Supervision (CTS)

The Current Transformer Supervision (CTS) feature is used to detect failure of one or more of the ac phase current inputs to the relay. Failure of a phase CT or an open circuit of the interconnecting wiring can result in incorrect operation of any current operated element. Additionally, interruption in the ac current circuits risks dangerous CT secondary voltages being generated.

3.3.1 Setting the CT Supervision Element

The residual voltage setting, **CTS Vn< Inhibit** and the residual current setting, **CTS In> set**, should be set to avoid unwanted operation during healthy system conditions. For example **CTS Vn< Inhibit** should be set to at least 120% of the maximum steady state residual voltage. The **CTS In> set** will typically be set below minimum load current. The time-delayed alarm, **CTS Time Delay**, is generally set to 5 seconds.

Where the magnitude of residual voltage during a ground/earth fault is unpredictable, the element can be disabled to prevent protection elements being blocked during fault conditions.

3.4 Circuit Breaker Condition Monitoring

Periodic maintenance of circuit breakers is necessary to ensure that the trip circuit and mechanism operate correctly and also that the interrupting capability has not been compromised due to previous fault interruptions. Generally, such maintenance is based on a fixed time interval, or a fixed number of fault current interruptions. These methods of monitoring circuit breaker condition give a rough guide only and can lead to excessive maintenance.

The relays record various statistics related to each circuit breaker trip operation, allowing a more accurate assessment of the circuit breaker condition to be determined. These monitoring features are discussed in the following section.

3.4.1 Setting Guidelines

3.4.1.1 Setting the Σ I^ Thresholds

Where overhead lines are prone to frequent faults and are protected by Oil Circuit Breakers (OCBs), oil changes account for a large proportion of the life cycle cost of the switchgear. Generally, oil changes are performed at a fixed interval of circuit breaker fault operations. However, this may result in premature maintenance where fault currents tend to be low, and hence oil degradation is slower than expected. The Σ I^ counter monitors the cumulative severity of the duty placed on the interrupter allowing a more accurate assessment of the circuit breaker condition to be made.

For OCBs, the dielectric withstand of the oil generally decreases as a function of ΣI^2t. This is where ‘I’ is the fault current broken, and ‘t’ is the arcing time within the interrupter tank (not the interrupting time). As the arcing time cannot be determined accurately, the relay would normally be set to monitor the sum of the broken current squared, by setting ‘Broken I^’ = 2.

For other types of circuit breaker, especially those operating on higher voltage systems, practical evidence suggests that the value of ‘**Broken I^**’ = 2 may be inappropriate. In such applications ‘**Broken I^**’ may be set lower, typically 1.4 or 1.5. An alarm in this instance may be indicative of the need for gas/vacuum interrupter HV pressure testing, for example. The setting range for ‘**Broken I^**’ is variable between 1.0 and 2.0 in 0.1 steps. It is imperative that any maintenance program must be fully compliant with the switchgear manufacturer’s instructions.

3.4.1.2 Setting the Number of Operations Thresholds

Every operation of a circuit breaker results in some degree of wear for its components. Therefore, routine maintenance, such as oiling of mechanisms, may be based upon the number of operations. Suitable setting of the maintenance threshold will allow an alarm to be raised, indicating when preventative maintenance is due. Should maintenance not be carried out, the relay can be set to lockout the auto-reclose function on reaching a second operations threshold. This prevents further reclosure when the circuit breaker has not been maintained to the standard demanded by the switchgear manufacturer’s maintenance instructions.

Certain circuit breakers, such as Oil Circuit Breakers (OCBs) can only perform a certain number of fault interruptions before requiring maintenance attention. This is because each fault interruption causes carbonizing of the oil, degrading its dielectric properties. The maintenance alarm threshold **No CB Ops. Maint.** may be set to indicate the requirement for oil sampling for dielectric testing, or for more comprehensive maintenance. Again, the lockout threshold **No CB Ops. Lock** may be set to disable auto-reclosure when repeated further fault interruptions could not be guaranteed. This minimizes the risk of oil fires or explosion.

3.4.1.3 Setting the Operating Time Thresholds

Slow CB operation is also indicative of the need for mechanism maintenance. Therefore, alarm and lockout thresholds (CB Time Maint./CB Time Lockout) are provided and are settable in the range of 5 to 500 ms. This time is set in relation to the specified interrupting time of the circuit breaker.

3.4.1.4 Setting the Excessive Fault Frequency Thresholds

Persistent faults will generally cause auto-reclose lockout, with subsequent maintenance attention. Intermittent faults such as clashing vegetation may repeat outside of any reclaim time, and the common cause might never be investigated. For this reason it is possible to set a frequent operations counter on the relay which allows the number of operations **Fault Freq. Count** over a set time period **Fault Freq. Time** to be monitored. A separate alarm and lockout threshold can be set.

3.5 Calculating the Rate of Change of Frequency for Load Shedding

In the event of severe system overload or loss of generation conditions, the system frequency will decline exponentially and theoretically stabilize at a steady state level somewhere below the nominal frequency. The time constant of the exponential decay as well as the steady state level is governed by certain parameters such as the system inertia constant, system damping constant etc. The following is an available theory for calculating the rate of change of frequency for a particular system contingency.

Assuming that the load and generation remain constant as the frequency changes, the instantaneous rate of change of frequency at the time of an overload is given by:

Equation 1 - Instantaneous rate of change of frequency:

$$\frac{df}{dt} = \frac{\Delta P.fn}{2H}$$

Where:

$$\Delta P = \text{overload in per unit} = \frac{\text{Connected Load – Available Generation}}{\text{Available Generation}}$$

f_n = nominal system frequency (in Hz)

H = combined inertia constant of the power system (MWsec/MVA)

$$H = \left(\frac{H_1 MVA_1 + ... + H_n MVA_n}{MVA_1 + ... + MVA_n} \right)$$

Where n subscripts 1, 2, …, n refer to individual generating units

The inertia constant used in in the previous equation, is essentially a measure of the kinetic energy in a generator rotor. For some types of large steam generator sets, the inertia constant can have a value of 10 but a figure of less than 5 is more prevalent especially when considering other generator types. Lower values tend to dominate with smaller rotor masses e.g. wind turbines, and can make the power system more prone to serious frequency disturbances for sudden load changes. Typically values between 2 and 5 may be used if no other knowledge is available.

Real loads, particularly motor loads, do vary with frequency and have a tendency to decrease as frequency reduces. This will have some beneficial effect on system stability and will reduce the effects of the overload condition. Taking this load reduction factor into account, the frequency deviation from nominal is given by:

Equation 2 - Frequency deviation from nominal:

$$\Delta f = \frac{\Delta P.f_n}{d}\left(1 - e^{-\left(\frac{t.d}{2H}\right)}\right)$$

Where:

d = load reduction (or damping) factor

$$d = \frac{\text{Percentage change in load}}{\text{Percentage change in frequency}}$$

The above equations are a result of vast simplifications. The actual frequency change will be influenced by governor droop characteristics, load dynamics, interconnections between various generators, system stabilizers etc. However the frequency deviations calculated in the formulae described may be a good measure of the rate of change of frequency for the purpose of setting the relay.

Warning	**The frequency profile is system and situation specific. A good knowledge of the system behavior under a variety of conditions is essential so you can decide on suitable settings for the frequency protection.**

3.5.1 Example of Frequency Behavior During Overload Conditions

Using the theoretical formulae given in the *Three-Phase Auto-Reclosing* section, it is possible to calculate the theoretical behavior of a simple network, shown below:

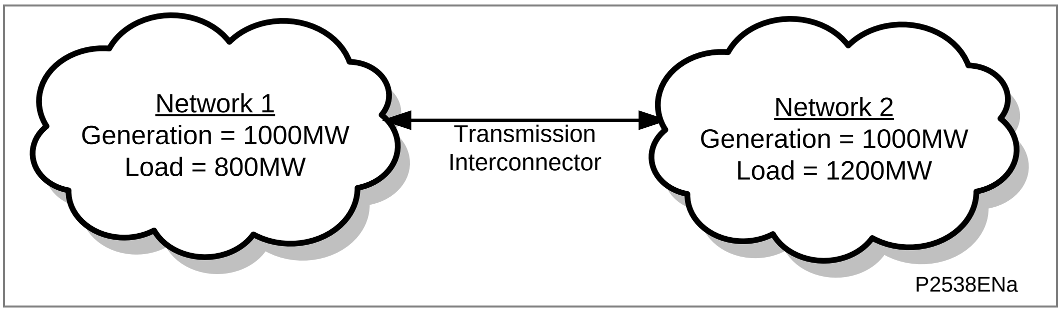


Figure 23 - Simple interconnected system to highlight frequency behavior calculations

In the simple network shown in the *Simple interconnected system to highlight frequency behavior calculations* diagram, it can be easily seen that Network 2 has a generation deficit of 200MW which is normally supplied from Network 1 through the transmission interconnector. In the event of loss of this interconnection, and assuming that the System Inertia Constant (H) of Network 2 is equal to 4, we can calculate that the rate of change of frequency at the time of the overload using the “Instantaneous rate of change of frequency “ Equation.

Equation 3 - Instantaneous rate of change of frequency - example:

$$\frac{df}{dt} = \frac{\Delta P.f_n}{2H} = \left(\frac{\left(\frac{1200 - 1000}{1000}\right).50}{8}\right) = -1.25 \text{ Hz/s}$$

It is clear from this calculation that if the inertia constant reduces, the rate of change will increase. For example if H=1, then df/dt = -5Hz/s.

We can also introduce the concept of damping factor that assumes that as the frequency reduces, there is a corresponding load reduction, by using the previous equation (Instantaneous rate of change of frequency - example). If we assume that there is a 1% change in load for every 1% change in frequency, we have a damping factor of 1, and the frequency deviation after 1s will be:

Equation 4 - Frequency deviation from nominal - example:

$$\Delta f = \frac{\Delta P.f_n}{d}\left(1 - e^{-\left(\frac{t.d}{2H}\right)}\right) = \frac{0.2x50}{1}\left(1 - e^{-\left(\frac{1}{8}\right)}\right) = 1.175Hz$$

In other words, if the system was originally operating at 50Hz, after 1s the system frequency would have dropped to 48.825Hz. Here we notice the effects of the damping factor since the first calculation assumed an initial rate of change of frequency of -1.25Hz/s, which in turn would lead us to consider a system frequency of 48.75Hz after 1s of overload.

The *Frequency profile of the example system for various overload conditions* diagram shows a set of curves highlighting the frequency of the example system assuming different overload levels and inertia constants for 35s after onset of the overload condition. The damping factor, d, in all cases is 1.

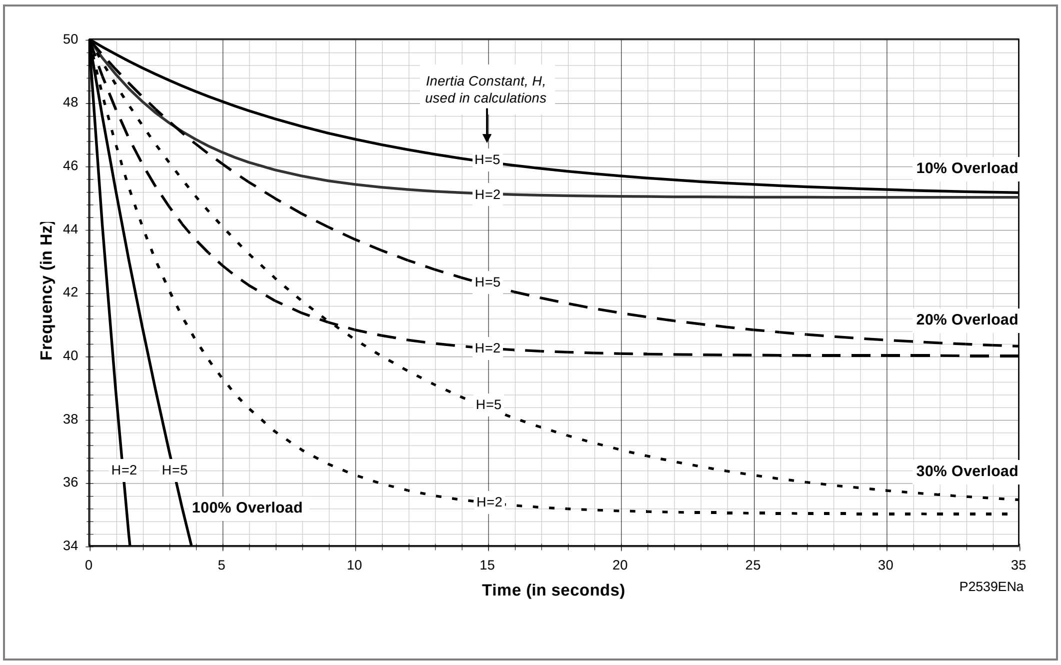


Figure 24 - Frequency profile of the example system for various overload conditions

3.6 Effect of Averaging Cycles

The P140 relays use a 1-cycle Discrete Fourier transform (DFT) in order to track the system frequency and maintain the sampling rate (see P14x/EN PD). Two times per cycle, a new frequency measurement is made available to the frequency protection algorithms. However, in order to assist stability of the measurement, various averaging techniques are used and their effects are discussed in the following two sections.

3.6.1 Frequency Averaging Cycles

Two times per cycle, a new “raw” frequency measurement is made available by the DFT and placed into the frequency averaging buffer. The size of this buffer is user-selectable up to 48 cycles for software version 43. It is the output of this buffer that is checked against any frequency setting to establish whether the element should start operation or not. The purpose of this averaging process is to smooth the frequency measurement since real frequency excursions are highly oscillatory, but as a consequence the operating and reset times will extend depending upon the exact system conditions and relay settings.

Due to the techniques used and the myriad of different frequency conditions that can be exposed to the relay, it is difficult to provide an exact formula to calculate the extension of times associated with the number of frequency averaging cycles. However, as a result of extensive relay testing, it is possible to give the following graphs that indicate typical additional times. These values must be added to the operation time for the relay with a frequency averaging cycle setting of zero (see P14x/EN TD).

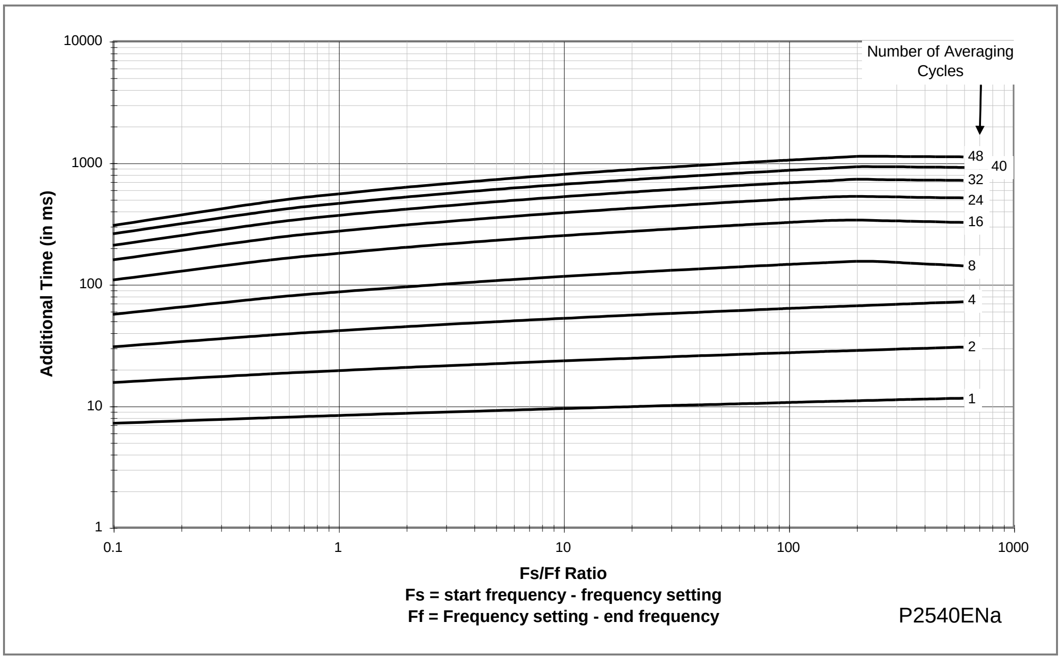


Figure 25 - Additional operating time for underfrequency thresholds

In the *Additional operating time for underfrequency thresholds* diagram, the Fs/Ff ratio is related to a test scenario where the start frequency is above the underfrequency setting and the end frequency is below the frequency setting.

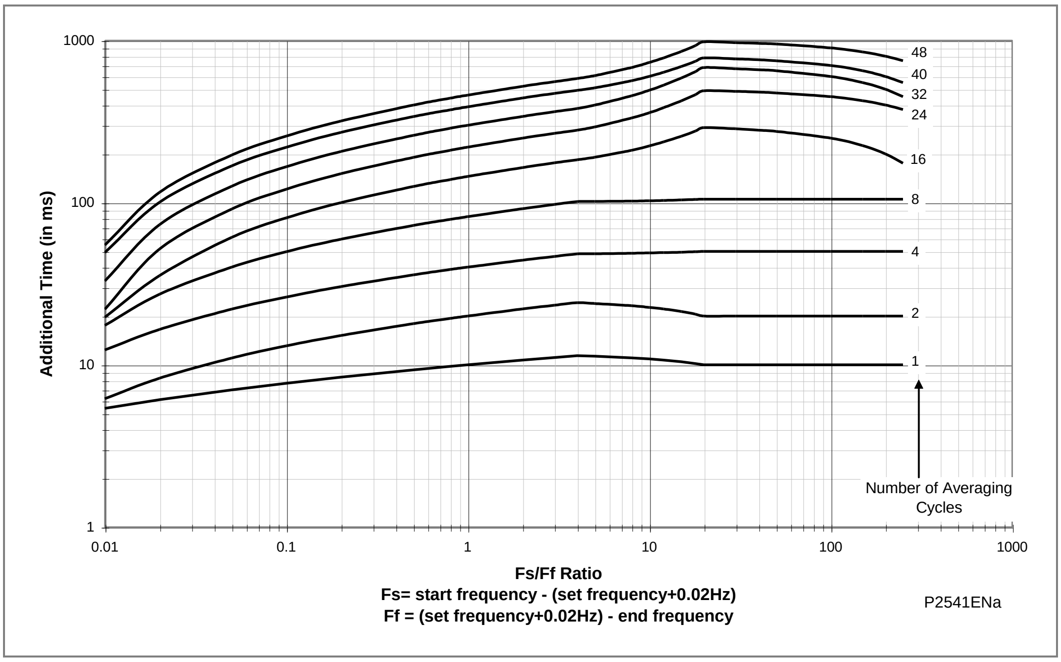


Figure 26 - Additional reset time for underfrequency thresholds

In the *Additional reset time for underfrequency thresholds* diagram, the Fs/Ff ratio is related to a test scenario where the start frequency is below the underfrequency setting and the end frequency is above the frequency setting.

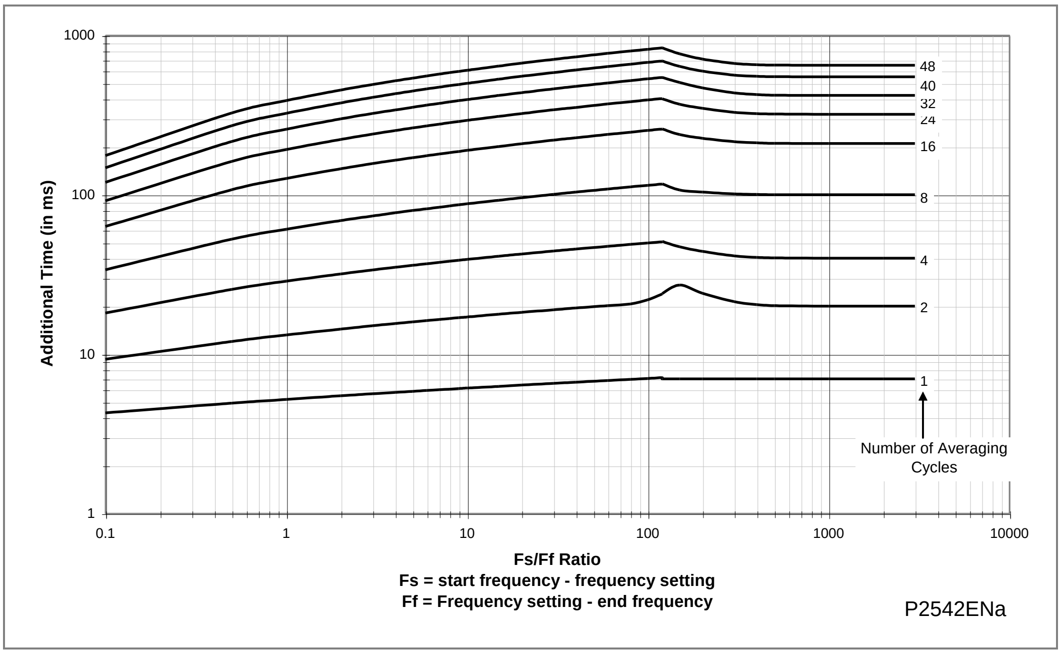


Figure 27 - Additional operating time for overfrequency thresholds

In the *Additional operating time for overfrequency thresholds* diagram, the Fs/Ff ratio is related to a test scenario where the start frequency is below the overfrequency setting and the end frequency is above the frequency setting.

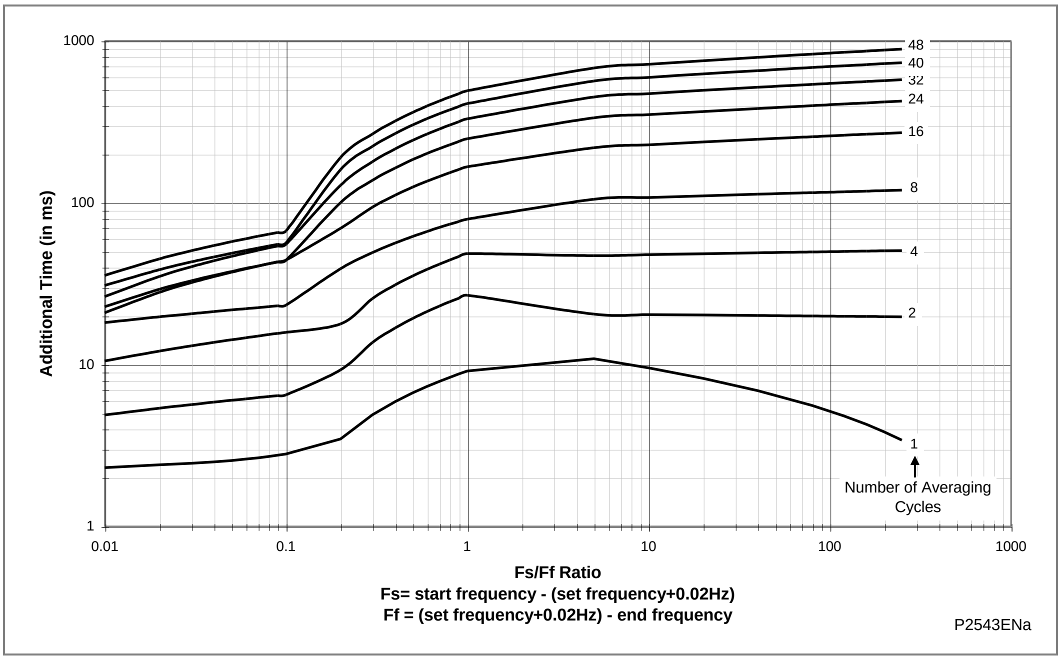


Figure 28 - Additional reset time for overfrequency thresholds

In the *Additional reset time for overfrequency thresholds* diagram, the Fs/Ff ratio is related to a test scenario where the start frequency is above the overfrequency setting and the end frequency is below the frequency setting.

All frequency settings are affected by the selection of frequency averaging cycles. In other words, the f+t [81O/81U], the f+df/dt [81RF], the f+Df/Dt [81RAV], load restoration and generator abnormal protection [81AB] will all use the averaged frequency measurements.

3.6.2 df/dt Averaging Cycles

As for the frequency measurements, two times per cycle a new “raw” df/dt measurement is passed into the df/dt averaging buffer. The size of this buffer is user-selectable up to 48 cycles for software version 43. It is the output of this buffer that is checked against any df/dt setting to establish whether the element should start operation or not. The purpose of this averaging process is to smooth the df/dt measurement since real frequency excursions are highly oscillatory, but as a consequence the operating and reset times will extend depending upon the exact system conditions and relay settings.

Due to the techniques used and the myriad of different conditions that can be exposed to the relay, it is difficult to provide an exact formula to calculate the extension of times associated with the number of df/dt averaging cycles. However, as a result of extensive relay testing, it is possible to give the following graphs that indicate typical additional times. These values must be added to the operation time for the relay with a df/dt averaging cycle setting of zero (see P14x/EN TD).

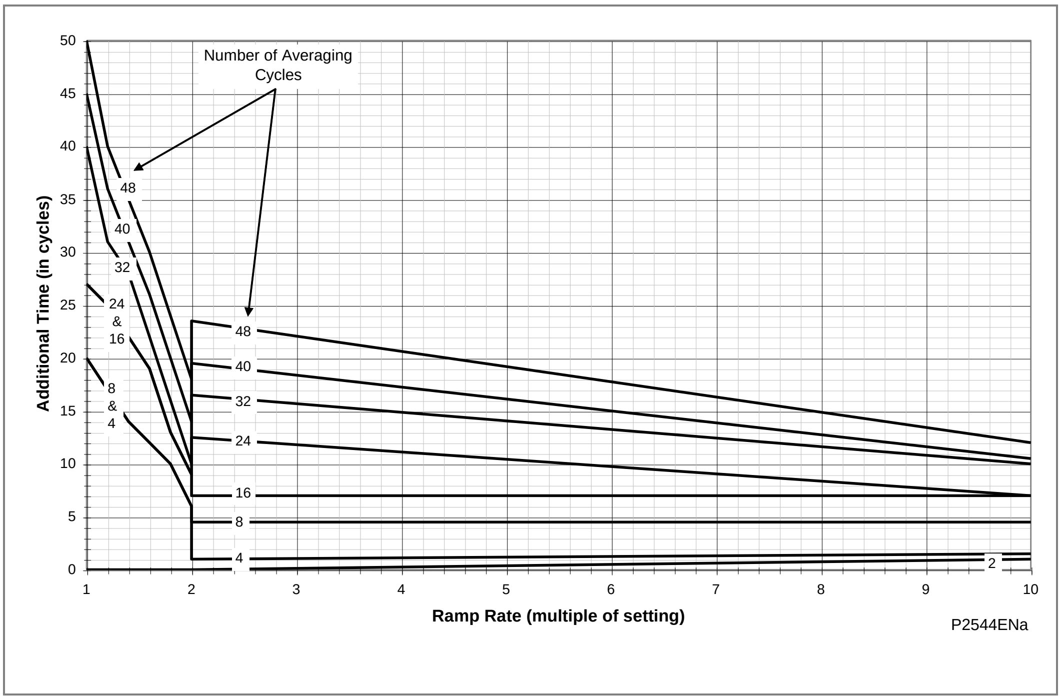


Figure 29 - Additional operating time for falling frequency conditions

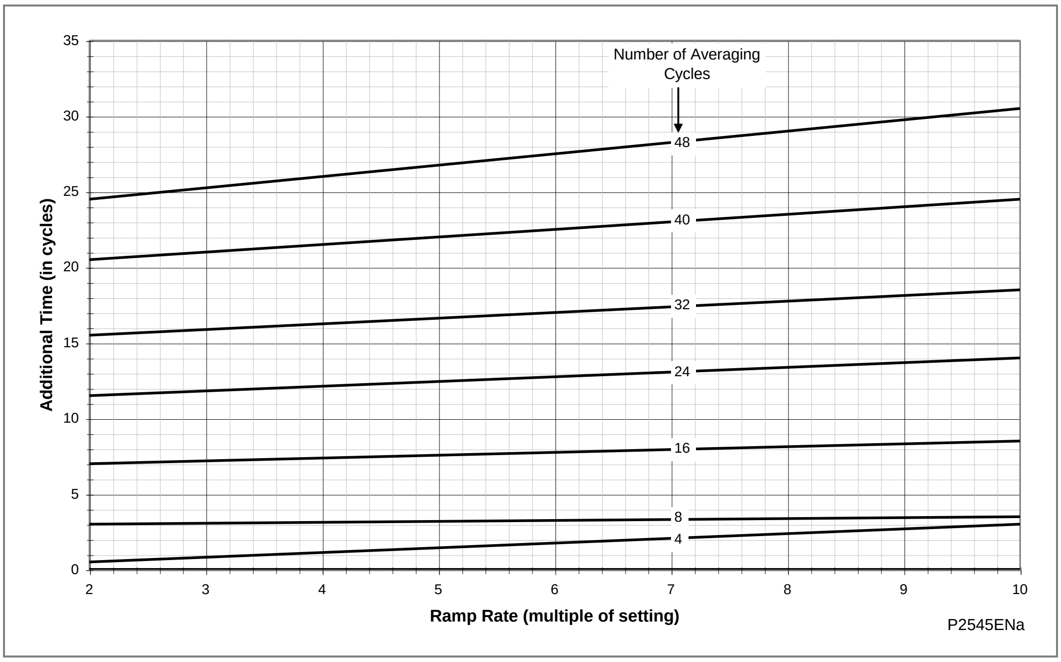


Figure 30 - Additional reset time for falling frequency conditions

In the *Additional reset time for falling frequency conditions* diagram, the ramp rate refers to the rate of rise of frequency as a multiple of the df/dt setting.

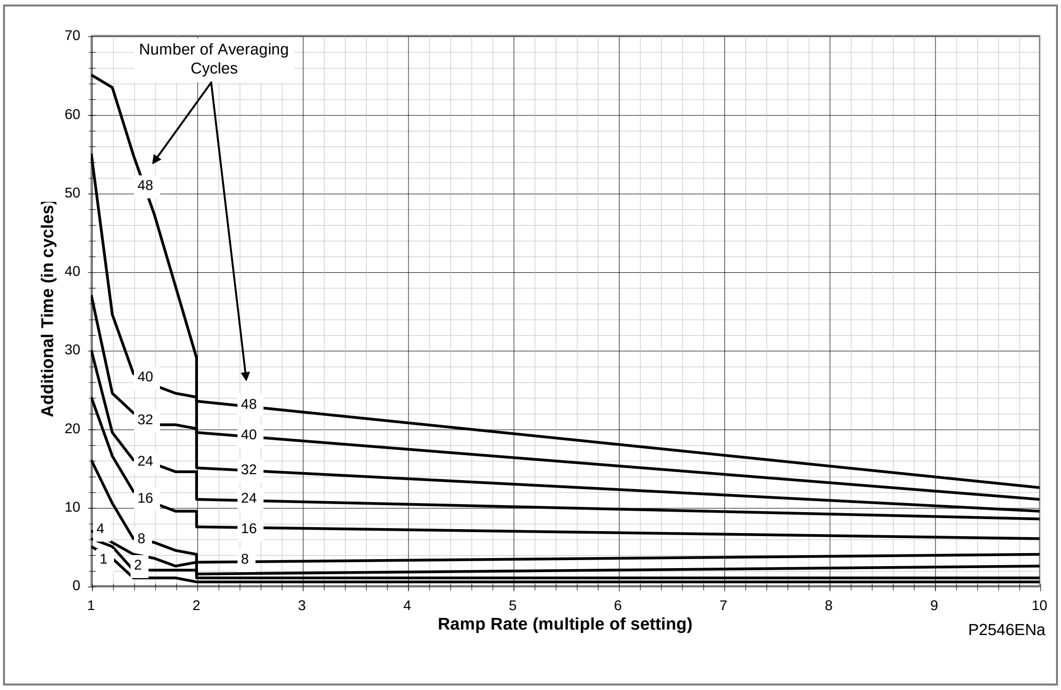


Figure 31 - Additional operating time for rising frequency conditions

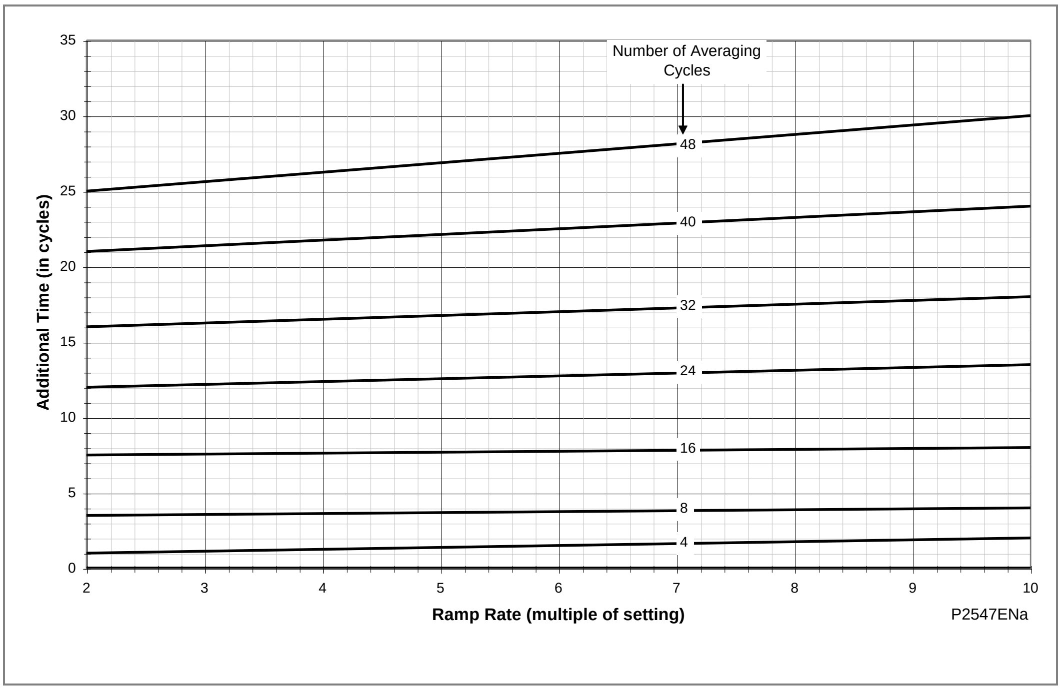


Figure 32 - Additional reset time for rising frequency conditions

In the *Additional reset time for rising frequency conditions* diagram, the ramp rate refers to the rate of fall of frequency as a multiple of the df/dt setting.

All instantaneous rate of change of frequency settings are affected by the selection of df/dt averaging cycles. In other words, the df/dt+t [81R] and the f+df/dt [81RF] will both use the averaged df/dt measurements. The f+Df/Dt[81RAV] is unaffected by the df/dt averaging cycles setting as both the frequency and average rate of change of frequency measurements are based upon actual frequency measurements which are controlled by the frequency averaging cycles setting.

3.6.3 Setting Recommendation for df/dt Averaging Cycles

One of the enhancements in version 43 software was the reduction of the lower setting limit of the df/dt threshold to 0.01Hz/s. This sensitive setting range makes the relay prone to “chatter” as a result of the oscillations that will be present during the frequency excursion, and therefore it is necessary to stabilize the relay using the averaging cycles setting and/or time delays. The *Additional reset time for rising frequency conditions* diagram shows the minimum recommended df/dt averaging cycles that should be used if no intentional time delays are set for the element.

Figure 33 - Additional reset time for rising frequency conditions

3.7 Trip Circuit Supervision (TCS)

The trip circuit, in most protective schemes, extends beyond the relay enclosure and passes through components such as fuses, links, relay contacts, auxiliary switches and other terminal boards. This complex arrangement, coupled with the importance of the trip circuit, has led to dedicated schemes for its supervision.

Several Trip Circuit Supervision (TCS) schemes with various features can be produced with the P14x range. Although there are no dedicated settings for TCS, in the P14x, the following schemes can be produced using the Programmable Scheme Logic (PSL). A user alarm is used in the PSL to issue an alarm message on the relay front display. If necessary, the user alarm can be re-named using the menu text editor to indicate that there is a fault with the trip circuit.

3.7.1 TCS Scheme 1

3.7.1.1 Scheme Description

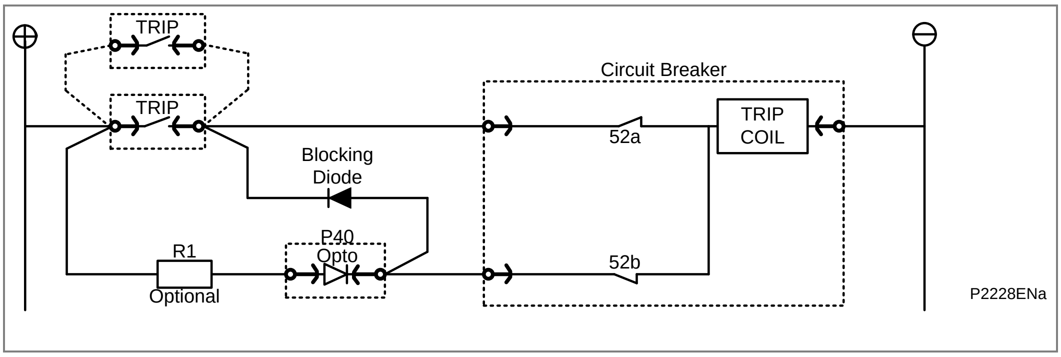


Figure 34 - TCS scheme 1

This scheme provides supervision of the trip coil with the breaker open or closed, however, pre-closing supervision is not provided. This scheme is also incompatible with latched trip contacts, as a latched contact will short out the opto for greater than the recommended DDO timer setting of 400ms. If breaker status monitoring is required a further 1 or 2 opto inputs must be used.

Note	*A 52a CB auxiliary contact follows the CB position and a 52b contact is the opposite.*

When the breaker is closed, supervision current passes through the opto input, blocking diode and trip coil. When the breaker is open current still flows through the opto input and into the trip coil via the 52b auxiliary contact. Hence, no supervision of the trip path is provided whilst the breaker is open. Any fault in the trip path will only be detected on CB closing, after a 400ms delay.

Resistor R1 is an optional resistor that can be fitted to prevent maloperation of the circuit breaker if the opto input is inadvertently shorted, by limiting the current to <60mA. The resistor should not be fitted for auxiliary voltage ranges of 30/34 volts or less, as satisfactory operation can no longer be guaranteed. The table below shows the appropriate resistor value and voltage setting (**Opto Config.** menu) for this scheme.

This TCS scheme will function correctly even without resistor R1, since the opto input automatically limits the supervision current to less that 10mA. However, if the opto is accidentally shorted the circuit breaker may trip.

Auxiliary Voltage (Vx)	Resistor R1 (ohms)	Opto Voltage Setting with R1 Fitted
24/27	-	-
30/34	-	-
48/54	1.2k	24/27
110/250	2.5k	48/54
220/250	5.0k	110/125

Note *When R1 is not fitted the opto voltage setting must be set equal to supply voltage of the supervision circuit.*

3.7.2 Scheme 1 PSL

The next figure shows the scheme logic diagram for the TCS scheme 1. Any of the available opto inputs can be used to show whether or not the trip circuit is healthy. The delay on drop off timer operates as soon as the opto is energized, but will take 400ms to drop off/reset in the event of a trip circuit failure. The 400ms delay prevents a false alarm due to voltage dips caused by faults in other circuits or during normal tripping operation when the opto input is shorted by a self-reset trip contact. When the timer is operated the NC (normally closed) output relay opens and the LED and user alarms are reset.

The 50ms delay on pick-up timer prevents false LED and user alarm indications during the relay power up time, following an auxiliary supply interruption.

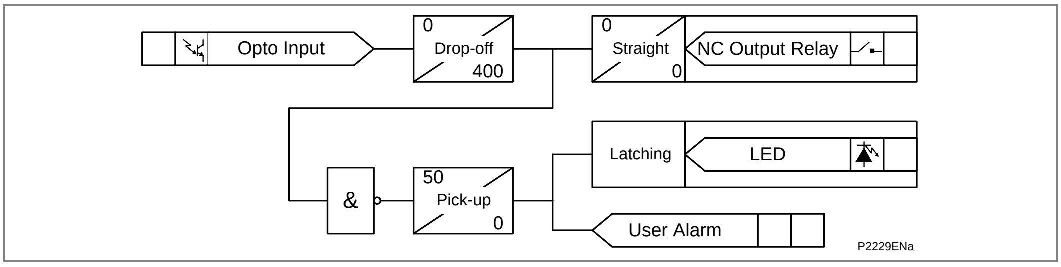


Figure 35 - PSL for TCS schemes 1 and 3

3.7.3 TCS Scheme 2

3.7.3.1 Scheme Description

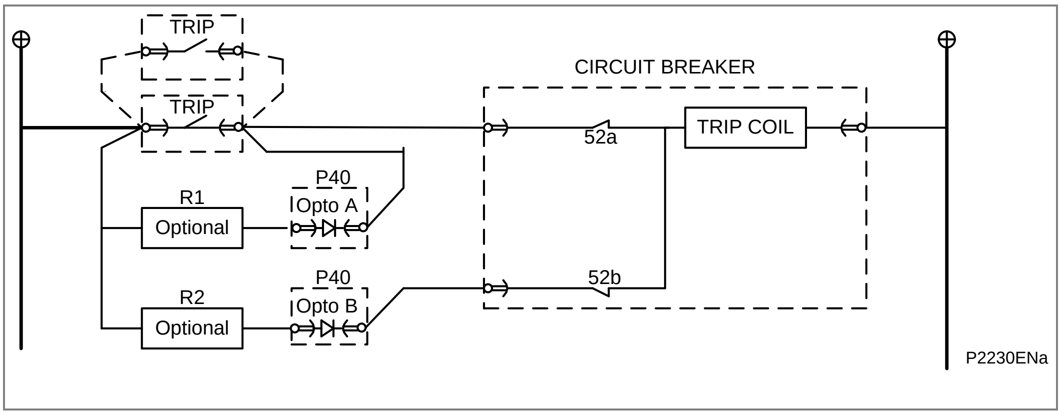


Figure 36 - TCS scheme 2

Much like scheme 1, this scheme provides supervision of the trip coil with the breaker open or closed and also does not provide pre-closing supervision. However, using two opto inputs allows the relay to correctly monitor the circuit breaker status since they are connected in series with the CB auxiliary contacts. This is achieved by assigning Opto A to the 52a contact and Opto B to the 52b contact. Provided the **Circuit Breaker Status** is set to **52a and 52b** (CB CONTROL column) the relay will correctly monitor the status of the breaker. This scheme is also fully compatible with latched contacts as the supervision current will be maintained through the 52b contact when the trip contact is closed.

When the breaker is closed, supervision current passes through opto input A and the trip coil. When the breaker is open current flows through opto input B and the trip coil. As with scheme 1, no supervision of the trip path is provided whilst the breaker is open. Any fault in the trip path will only be detected on CB closing, after a 400 ms delay.

As with scheme 1, optional resistors R1 and R2 can be added to prevent tripping of the CB if either opto is shorted. The resistor values of R1 and R2 are equal and can be set the same as R1 in scheme 1.

3.7.4 Scheme 2 PSL

The PSL for this scheme is practically the same as that of scheme 1. The main difference being that both opto inputs must be off before a trip circuit fail alarm is given.

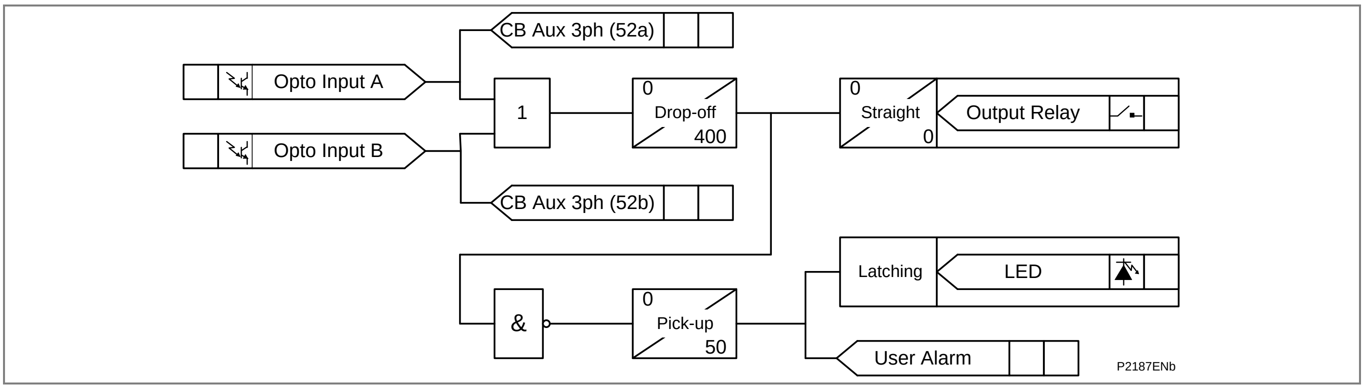


Figure 37 – PSL for TCS scheme 2

3.7.5 TCS Scheme 3

3.7.5.1 Scheme Description

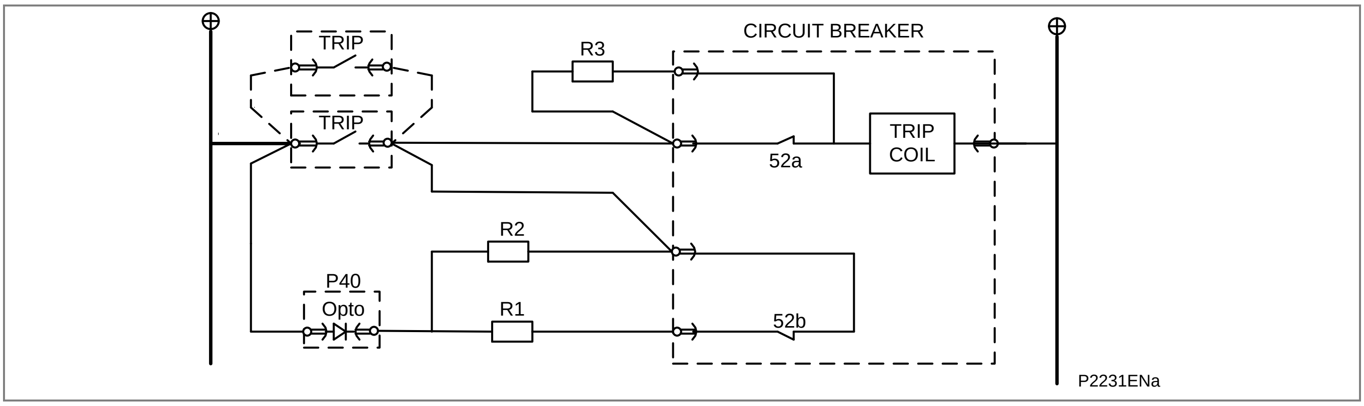


Figure 38 – TCS scheme 3

Scheme 3 is designed to provide supervision of the trip coil with the breaker open or closed, but unlike schemes 1 and 2, it also provides pre-closing supervision. Since only one opto input is used, this scheme is not compatible with latched trip contacts. If circuit breaker status monitoring is required a further 1 or 2 opto inputs must be used.

When the breaker is closed, supervision current passes through the opto input, resistor R2 and the trip coil. When the breaker is open current flows through the opto input, resistors R1 and R2 (in parallel), resistor R3 and the trip coil. Unlike schemes 1 and 2, supervision current is maintained through the trip path with the breaker in either state, thus giving pre-closing supervision.

As with schemes 1 and 2, resistors R1 and R2 are used to prevent false tripping, if the opto-input is accidentally shorted. However, unlike the other two schemes, this scheme is dependent upon the position and value of these resistors. Removing them would result in incomplete trip circuit monitoring. The table below shows the resistor values and voltage settings required for satisfactory operation.

Auxiliary Voltage (Vx)	Resistor R1 & R2 (ohms)	Resistor R3 (ohms)	Opto Voltage Setting
24/27	-	-	-
30/34	-	-	-
48/54	1.2k	0.6k	24/27
110/250	2.5k	1.2k	48/54
220/250	5.0k	2.5k	110/125

Note *Scheme 3 is not compatible with auxiliary supply voltages of 30/34 volts and below.*

3.7.6 Scheme 3 PSL

The PSL for scheme 3 is identical to that of scheme 1.

3.8 Fault Locator

Fault location is part of the data included within the relay fault record and therefore the fault locator is triggered whenever a fault record is generated. This is controlled by DDB 144: Fault REC TRIG; in the default PSL this signal is energized from operation of any protection trip.

3.8.1 Setting Example

Assuming the following data for the protected line:

230kV transmission line

CT ratio	=	1200/5
VT ratio	=	230,000/115
Line length	=	10km

Positive sequence line impedance	ZL1	=	0.089+j0.476 Ohms/km
Zero sequence line impedance	ZL0	=	0.34+j1.03 ohms/km
Zero sequence mutual impedance	ZM0	=	0.1068+j0.5712 Ohms/km

The line length can be set in either meters or miles.

Therefore for this example set line length = 10km.

The line impedance magnitude and angle settings are calculated as follows:

Ratio of secondary to primary impedance	=	CT ratio/VT ratio = 0.12
Positive sequence line impedance ZL1	=	$0.12 \times 10(0.484\angle 79.4°)$
	=	$0.58 \angle 79.4°$
Therefore set line length	=	0.58
Line angle	=	79°

The residual impedance compensation magnitude and angle are calculated using the following formula:

Equation 5 – Residual Impedance Compensation Magnitude and Angle:

$$KZn = \frac{ZL0 - ZL1}{3\ ZL1}$$

$$KZn = \frac{(0.34 + j1.03) - (0.089 + j0.476)}{3 \times (0.484 \angle 79.4°)}$$

$$KZn = \frac{0.6 \angle 65.2°}{1.45 \angle 79.4°}$$

$$KZn = 0.41 \angle -14.2°$$

Therefore set kZn Residual	=	0.41
kZn Res. Angle	=	$\angle$-14°

3.9 VT Connections

3.9.1 Open Delta (Vee Connected) VT's

MiCOM relays can be used with V-connected VTs by connecting the VT secondaries to:

- C19, C20 and C21 input terminals, with the C22 input left unconnected for P14x, P341, P342, P343, P344, P345, P443, P445, P543, P544 and P841A
- D19, D20 and D21 input terminals, with the D22 input left unconnected for P446, P545, P546, P547 and P841B
- C2, C4 and E2 input terminals, with the Vn input left unconnected for P64x (P642, P643 & P645)

For more details, see the see the *Connection Diagrams* chapter.

This type of VT arrangement cannot pass zero-sequence (residual) voltage to the relay, or provide any phase to neutral voltage quantities. Therefore any protection that is dependent upon phase to neutral voltage measurements should be disabled.

The under and over voltage protection can be set as phase to phase measurement with vee connected VTs. The voltage dependent overcurrent use phase-phase voltages anyway, therefore the accuracy should not be affected. Directional earth fault and sensitive directional earth fault protection should be disabled as the neutral voltage will always be zero, even in the event of an earth fault. CT supervision should also be disabled, as this is also dependent upon the measurement of zero sequence voltage.

The accuracy of the single-phase voltage measurements can be impaired when using vee connected VT's. The relay attempts to derive the phase to neutral voltages from the phase to phase voltage vectors. If the impedance of the voltage inputs were perfectly matched the phase to neutral voltage measurements would be correct, provided the phase to phase voltage vectors were balanced. However, in practice there are small differences in the impedance of the voltage inputs, which can cause small errors in the phase to neutral voltage measurements. This may give rise to an apparent residual voltage. This problem also extends to single-phase power measurements that are also dependent upon their respective single-phase voltages.

The phase to neutral voltage measurement accuracy can be improved by connecting three, well-matched, load resistors between the relevant phase voltage inputs and neutral thus creating a 'virtual' neutral point. The load resistor values must be chosen so that their power consumption is within the limits of the VT. It is recommended that 10 kΩ ±1% (6 W) resistors are used for the 110 V (Vn) rated relay, assuming the VT can supply this burden.

The connections are as follows for different MiCOM relays:

Phase Voltage Inputs	Neutral	MiCOM IEDs
C19, C20, C21	C22	P14x, P341, P342, P343, P344, P345, P443, P445, P446, P543, P544, P841A
D19, D20, D21	D22	P545, P546, P841B

3.9.2 VT Single Point Earthing

The MiCOM P14x/P341/P34x/P391/P443/P445/P446/P54x/P547/P64x/P841 will function correctly with conventional 3-phase VTs earthed at any one point on the VT secondary circuit. Typical earthing examples being neutral earthing, or B-phase (UK: "**yellow phase**" earthing).

3.10 Read Only Mode

With IEC 61850 and Ethernet/Internet communication capabilities, security has become a pressing issue. The Px40 IED provides a facility to allow the user to enable or disable the change in configuration remotely.

Read Only mode can be enabled/disabled for the following rear ports:

- Rear Port 1 - IEC 60870-5-103 and Courier protocols
- Rear Port 2 (if fitted) - Courier protocol
- Ethernet Port (if fitted) - IEC61850 and Courier protocol (**tunnelled**)

4 CURRENT TRANSFORMER (CT) REQUIREMENTS

The Current Transformer (CT) requirements are based on a maximum prospective fault current of 50 times the relay rated current (In) and the relay having an instantaneous setting of 25 times rated current (In). The CT requirements are designed to provide operation of all protection elements.

Where the criteria for a specific application are in excess of those detailed above, or the actual lead resistance exceeds the limiting value quoted, the CT requirements may need to be increased according to the formulae in the following sections:

Nominal rating	Nominal output	Accuracy class	Accuracy limited factor	Limiting lead resistance
1 A	2.5 VA	10P	20	1.3 ohms
5 A	7.5 VA	10P	20	0.11 ohms

Table 14 - CT Requirements

Separate requirements for Restricted Earth Fault are given in the *Low Impedance Restricted Earth Fault Protection* sections.

4.1 Abbreviations

Abbreviations used in these formulae are explained below:

Icn = Maximum prospective secondary earth fault current or 31 times I> setting (whichever is lower) (amps)
Icp = Maximum prospective secondary phase fault current or 31 times I> setting (whichever is lower) (amps)
If = Maximum secondary through fault current level (amps) or Maximum through fault current level (amps)
Ifn = Maximum prospective secondary earth fault current (amps)
Ifp = Maximum prospective secondary phase fault current (amps)
In = rated secondary current (amps)
IS = Current setting of REF element (amps), (IREF>Is)
Isn = Stage 2 & 3 earth fault setting (amps)
Isp = Stage 2 and 3 setting (amps)
RCT = Resistance of current transformer secondary winding (ohms)
RL = Resistance of a single lead from relay to current transformer (ohms)
Rrn = Impedance of the relay neutral current input at 30In (ohms)
Rrp = Impedance of relay phase current input at 30In (ohms)
Rst = Value of stabilizing resistor (ohms)
VK = Required CT knee-point voltage (volts)

4.2 Non-Directional Definite Time/IDMT Overcurrent & Earth Fault Protection

Equation 6 – Time-Delayed Phase Overcurrent Elements

$$VK \geq Icp/2 * (RCT + RL + Rrp)$$

Equation 7 – Time-Delayed Earth Fault Overcurrent Elements

$$VK \geq Icn/2 * (RCT + 2RL + Rrp + Rrn)$$

4.3 Non-Directional Instantaneous Overcurrent & Earth Fault Protection

Equation 8 – CT Requirements for Instantaneous Phase Overcurrent Elements

$$VK \geq Isp \times (RCT + RL + Rrp)$$

Equation 9 – CT Requirements for Instantaneous Earth Fault Overcurrent Elements

$$VK \geq Isn \times (RCT + 2RL + Rrp + Rrn)$$

4.4 Directional Definite Time/IDMT Overcurrent & Earth Fault Protection

Equation 10 – Time-Delayed Phase Overcurrent Elements

VK ≥ Icp/2 * (RCT + RL + Rrp)

Equation 11 – Time-Delayed Earth Fault Overcurrent Elements

VK ≥ Icn/2 * (RCT + 2RL + Rrp + Rrn)

4.5 Directional Instantaneous Overcurrent & Earth Fault Protection

Equation 12 – CT Requirements for Instantaneous Phase Overcurrent Elements

VK ≥ Ifp/2 * (RCT + RL + Rrp)

Equation 13 – CT Requirements for Instantaneous Earth Fault Overcurrent Elements

VK ≥ Ifn/2 * (RCT + 2RL + Rrp + Rrn)

4.6 Non-Directional/Directional Definite Time/IDMT Sensitive Earth Fault (SEF) Protection

Equation 14 – Non-Directional Time Delayed SEF Protection (Residually Connected)

VK ≥ Icn/2 * (RCT + 2RL + Rrp + Rrn)

Equation 15 – Non-Directional Instantaneous SEF Protection (Residually Connected)

VK ≥ Isn x (RCT + 2RL + Rrp + Rrn)

Equation 16 – Directional Time Delayed SEF protection (Residually Connected)

VK ≥ Icn/2 x (RCT + 2RL + Rrp + Rrn)

Equation 17 – Directional Instantaneous SEF Protection (Residually connected)

VK ≥ Ifn/2 * (RCT + 2RL + Rrp + Rrn)

4.6.1 SEF Protection - as fed from a Core-Balance CT

Core balance current transformers of metering class accuracy are required and should have a limiting secondary voltage satisfying the formulae given below:

Equation 18 – Directional/non-directional time delayed element:

VK ≥ Icn/2 * (RCT + 2RL + Rrn)

Equation 19 – Directional instantaneous element:

VK ≥ Ifn/2 * (RCT + 2RL + Rrn)

Equation 20 – Non-directional element:

VK ≥ Isn x (RCT + 2RL + Rrn)

Note	In addition, it should be ensured that the phase error of the applied core balance current transformer is less than 90 minutes at 10% of rated current and less than 150 minutes at 1% of rated current.

4.7 Low Impedance Restricted Earth Fault Protection

Equation 21 – Low Impedance Restricted Earth Fault

VK ≥ 24 * In * (RCT + 2RL) for X/R < 40 and if < 15In

VK ≥ 48 * In * (RCT + 2RL) for X/R < 40,
15In < If < 40In and 40 <X/R
< 120, If < 15In

Where:

If = Maximum through fault current level (amps)

Note	Class PX or Class 5P CTs should be used for low impedance restricted earth fault applications.

4.8 High Impedance Restricted Earth Fault Protection

The high impedance restricted earth fault element shall maintain stability for through faults and operate in less than 40ms for internal faults provided the following equations are met:

Equation 22 – High Impedance Restricted Earth Fault Protection

$$R_{st} = \frac{I_F (R_{CT} + 2_{RL})}{I_s}$$

VK ≥ 4 * Is * Rst

Where:

If = Maximum secondary through fault current level (amps)

> *Note* *Class PX CTs should be used for high impedance restricted earth fault applications.*

4.9 Use of ANSI/IEEE "C" Class CTs

Where American/IEEE standards are used to specify CTs, the C class voltage rating can be checked to determine the equivalent Vk (knee point voltage according to IEC). The equivalence formula is:

Equation 23 – Knee Point Voltage

Vk = [(C rating in volts) x 1.05] + [100 x RCT]

5 AUXILIARY SUPPLY FUSE RATING

In the Safety Information part of this manual, the maximum allowable fuse rating of 16A is quoted. To allow time grading with fuses upstream, a lower fuselink current rating is often preferable. Use of standard ratings of between 6A and 16A is recommended. Low voltage fuselinks, rated at 250V minimum and compliant with IEC60269-2 general application type gG are acceptable, with high rupturing capacity. This gives equivalent characteristics to HRC "red spot" fuses type NIT/TIA often specified historically.

The table below recommends advisory limits on relays connected per fused spur. This applies to MiCOM Px40 series devices with hardware suffix C and higher, as these have inrush current limitation on switch-on, to conserve the fuse-link.

Maximum Number of MiCOM Px40 Relays Recommended Per Fuse				
Battery Nominal Voltage	**6A**	**10A Fuse**	**15 or 16A Fuse**	**Fuse Rating > 16A**
24 to 54V	2	4	6	Not permitted
60 to 125V	4	8	12	Not permitted
138 to 250V	6	10	16	Not permitted
Alternatively, Miniature Circuit Breakers (MCBs) may be used to protect the auxiliary supply circuits.				

USING THE PSL EDITOR

CHAPTER 7

Date:	08/2017	
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.	
Hardware Suffix:	All MiCOM Px4x products	
Software Version:	All MiCOM Px4x products	
Connection Diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P341: 10P341xx (xx = 01 to 12) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P445: 10P445xx (xx = 01 to 04) P44x: 10P44101 (SH 1 & 2) 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)	P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 01 to 10) 10P643xx (xx = 01 to 06) 10P645xx (xx = 01 to 09) P74x: 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)

CONTENTS

FIGURES

TABLES

Notes:

1 OVERVIEW

The purpose of the Programmable Scheme Logic (PSL) is to allow the relay user to configure an individual protection scheme to suit their own particular application. This is achieved through the use of programmable logic gates and delay timers.

The input to the PSL is any combination of the status of opto inputs. It is also used to assign the mapping of functions to the opto inputs and output contacts, the outputs of the protection elements, e.g. protection starts and trips, and the outputs of the fixed protection scheme logic. The fixed scheme logic provides the relay’s standard protection schemes.

The PSL itself consists of software logic gates and timers. The logic gates can be programmed to perform a range of different logic functions and can accept any number of inputs. The timers are used either to create a programmable delay, and/or to condition the logic outputs, e.g. to create a pulse of fixed duration on the output regardless of the length of the pulse on the input. The outputs of the PSL are the LEDs on the front panel of the relay and the output contacts at the rear.

The execution of the PSL logic is event driven; the logic is processed whenever any of its inputs change, for example as a result of a change in one of the digital input signals or a trip output from a protection element. Also, only the part of the PSL logic that is affected by the particular input change that has occurred is processed. This reduces the amount of processing time that is used by the PSL; even with large, complex PSL schemes the relay trip time will not lengthen.

This system provides flexibility for the user to create their own scheme logic design. However, it also means that the PSL can be configured into a very complex system; hence setting of the PSL is implemented through the PC support package Easergy Studio.

Note	*MiCOM S1 Studio has been renamed as Easergy Studio.*

2 EASERGY STUDIO PSL EDITOR

Note	MiCOM S1 Studio has been renamed as Easergy Studio.

The PSL Editor can be used inside Easergy Studio or directly.
This chapter assumes that you are using the PSL Editor from within Easergy Studio.
If you use it from Easergy Studio, the Studio software will be locked whilst you are using the PSL editor software. The Studio software will be unlocked when you close the PSL Editor software.
The Easergy Studio product is updated periodically. These updates provide support for new features (such as allowing you to manage new MiCOM products, as well as using new software releases and hardware suffixes). The updates may also include fixes.
Accordingly, we strongly advise customers to use the latest Schneider Electric version of Easergy Studio.
If you need more information regarding bug fixes, please contact your **Schneider Electric** local support.

2.1 How to Obtain Easergy Studio Software

Easergy Studio is available from the Schneider Electric website:

- www.schneider-electric.com

2.2 To Start Easergy Studio

To Start the Easergy Studio software, click the **Start** > **All apps** > **Schneider Electric** > **Easergy Studio** menu option.

2.3 To Open a Pre-Existing System

Within Easergy Studio, click the **File** + **Open System** menu option.
Navigate to where the scheme is stored, then double-click to open the scheme.

2.4 To Start the PSL Editor

The PSL editor lets you connect to any MiCOM device front port, retrieve and edit its PSL files and send the modified file back to a suitable MiCOM device.
Px30 and Px40 products are edited using different versions of the PSL Editor. There is one link to the Px30 editor and one link to the Px40 editor.
To start the PSL editor for Px40 products:

Highlight the PSL file you wish to edit, and then either:

Double-click the highlighted PSL file,

Click the open icon or

In the Easergy Studio main menu, select Tools > PSL PSL editor (Px40) menu.

The PSL Editor will then start, and show you the relevant PSL Diagram(s) for the file you have opened. An example of such a PSL diagram is shown in the *Example of a PSL editor module* diagram.

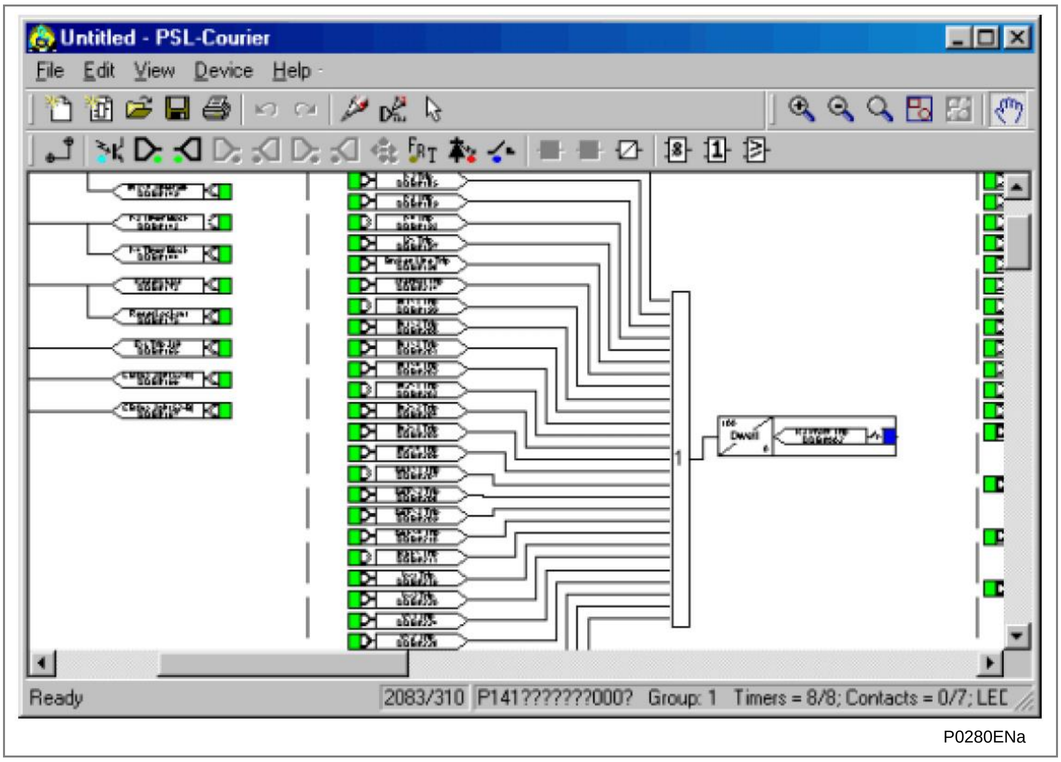


Figure 1 - Example of a PSL editor module

2.5 How to use MiCOM PSL Editor

The MiCOM PSL editor lets you:

- Start a new PSL diagram
- Extract a PSL file from a MiCOM Px40 IED
- Open a diagram from a PSL file
- Add logic components to a PSL file
- Move components in a PSL file
- Edit link of a PSL file
- Add link to a PSL file
- Highlight path in a PSL file
- Use a conditioner output to control logic
- Download PSL file to a MiCOM Px40 IED
- Print PSL files

For a detailed discussion on how to use these functions, please refer to the Easergy Studio online help.

2.6 Warnings

Before the scheme is sent to the relay checks are done. Various warning messages may be displayed as a result of these checks.

The Editor first reads in the model number of the connected relay, then compares it with the stored model number. A "wildcard" comparison is used. If a model mismatch occurs, a warning is generated before sending starts. Both the stored model number and the number read from the relay are displayed with the warning. However, the user must decide if the settings to be sent are compatible with the relay that is connected. Ignoring the warning could lead to undesired behavior of the relay.

If there are any potential problems of an obvious nature then a list will be generated. The types of potential problems that the program attempts to detect are:

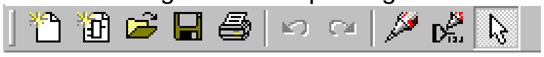
- One or more gates, LED signals, contact signals, and/or timers have their outputs linked directly back to their inputs. An erroneous link of this sort could lock up the relay, or cause other more subtle problems to arise.
- Inputs to Trigger (ITT) exceeds the number of inputs. If a programmable gate has its ITT value set to greater than the number of actual inputs; the gate can never activate. There is no lower ITT value check. A 0-value does not generate a warning.
- Too many gates. There is a theoretical upper limit of 256 gates in a scheme, but the practical limit is determined by the complexity of the logic. In practice the scheme would have to be very complex, and this error is unlikely to occur.
- Too many links. There is no fixed upper limit to the number of links in a scheme. However, as with the maximum number of gates, the practical limit is determined by the complexity of the logic. In practice the scheme would have to be very complex, and this error is unlikely to occur.

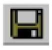
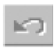
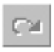
3 TOOLBAR AND COMMANDS

There are a number of toolbars available for easy navigation and editing of PSL.

3.1 Standard Tools

For file management and printing.

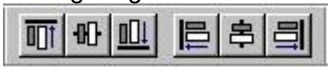


	Blank Scheme	Create a blank scheme based on a relay model.
	Default Configuration	Create a default scheme based on a relay model.
	Open	Open an existing diagram.
	Save	Save the active diagram.
	Print	Display the Windows Print dialog, enabling you to print the current diagram.
	Undo	Undo the last action.
	Redo	Redo the previously undone action.
	Redraw	Redraw the diagram.
	No of DDBs	Display the DDB numbers of the links.
	Calculate CRC	Calculate unique number based on both the function and layout of the logic.
	Compare Files	Compare current file with another stored on disk.
	Select	Enable the select function. While this button is active, the mouse pointer is displayed as an arrow. This is the default mouse pointer. It is sometimes referred to as the selection pointer.

Point to a component and click the left mouse button to select it. Several components may be selected by clicking the left mouse button on the diagram and dragging the pointer to create a rectangular selection area.

3.2 Alignment Tools

To align logic elements horizontally or vertically into groups.



 **Align Top** Align all selected components so the top of each is level with the others.

 **Align Middle** Align all selected components so the middle of each is level with the others.

 **Align Bottom** Align all selected components so the bottom of each is level with the others.

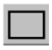
 **Align Left** Align all selected components so the leftmost point of each is level with the others.

 **Align Centre** Align all selected components so the centre of each is level with the others.

 **Align Right** Align all selected components so the rightmost point of each is level with the others.

3.3 Drawing Tools

To add text comments and other annotations, for easier reading of PSL schemes.

 **Rectangle** When selected, move the mouse pointer to where you want one of the corners to be hold down the left mouse button and move it to where you want the diagonally opposite corner to be. Release the button. To draw a square hold down the SHIFT key to ensure height and width remain the same.

 **Ellipse** When selected, move the mouse pointer to where you want one of the corners to be hold down the left mouse button and move until the ellipse is the size you want it to be. Release the button. To draw a circle hold down the SHIFT key to ensure height and width remain the same.

 **Line** When selected, move the mouse pointer to where you want the line to start, hold down left mouse, move to the position of the end of the line and release button. To draw horizontal or vertical lines only hold down the SHIFT key.

 **Polyline** When selected, move the mouse pointer to where you want the polyline to start and click the left mouse button. Now move to the next point on the line and click the left button. Double click to indicate the final point in the polyline.

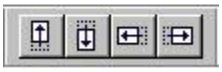
 **Curve** When selected, move the mouse pointer to where you want the polycurve to start and click the left mouse button. Each time you click the button after this a line will be drawn, each line bisects its associated curve. Double click to end. The straight lines will disappear leaving the polycurve.
Note: whilst drawing the lines associated with the polycurve, a curve will not be displayed until either three lines in succession have been drawn or the polycurve line is complete.

 **Text** When selected, move the mouse pointer to where you want the text to begin and click the left mouse button. To change the font, size or colour, or text attributes select Properties from the right mouse button menu.

 **Image** When selected, the Open dialog is displayed, enabling you to select a bitmap or icon file. Click Open, position the mouse pointer where you want the image to be and click the left mouse button.

3.4 Nudge Tools

To move logic elements.

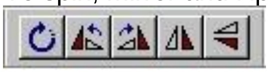


The nudge tool buttons enable you to shift a selected component a single unit in the selected direction, or five pixels if the SHIFT key is held down.
As well as using the tool buttons, single unit nudge actions on the selected components can be achieved using the arrow keys on the keyboard.

	Nudge Up	Shift the selected component(s) upwards by one unit. Holding down the SHIFT key while clicking on this button will shift the component five units upwards.
	Nudge Down	Shift the selected component(s) downwards by one unit. Holding down the SHIFT key while clicking on this button will shift the component five units downwards.
	Nudge Left	Shift the selected component(s) to the left by one unit. Holding down the SHIFT key while clicking on this button will shift the component five units to the left.
	Nudge Right	Shift the selected component(s) to the right by one unit. Holding down the SHIFT key while clicking on this button will shift the component five units to the right.

3.5 Rotation Tools

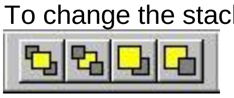
To spin, mirror and flip.

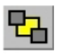


	Free Rotate	Enable the rotation function. While rotation is active components may be rotated as required. Press the ESC key or click on the diagram to disable the function.
	Rotate Left	Rotate the selected component 90 degrees to the left.
	Rotate Right	Rotate the selected component 90 degrees to the right.
	Flip Horizontal	Flip the component horizontally.
	Flip Vertical	Flip the component vertically.

3.6 Structure Tools

To change the stacking order of logic components.



	Bring to Front	Bring the selected components in front of all other components.
	Send to Back	Bring the selected components behind all other components.
	Bring Forward	Bring the selected component forward one layer.
	Send Backward	Send the selected component backwards one layer.

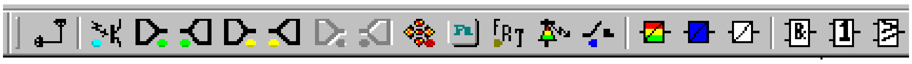
3.7 Zoom and Pan Tools

For scaling the displayed screen size, viewing the entire PSL, or zooming to a selection.

	Zoom In	Increases the Zoom magnification by 25%.
	Zoom Out	Decreases the Zoom magnification by 25%.
	Zoom	Enable the zoom function. While this button is active, the mouse pointer is displayed as a magnifying glass. Right-clicking will zoom out and left-clicking will zoom in. Press the ESC key to return to the selection pointer. Click and drag to zoom in to an area.
	Zoom to Fit	Display at the highest magnification that will show all the diagram's components.
	Zoom to Selection	Display at the highest magnification that will show the selected component(s).
	Pan	Enable the pan function. While this button is active, the mouse pointer is displayed as a hand. Hold down the left mouse button and drag the pointer across the diagram to pan. Press the ESC key to return to the selection pointer.

3.8 Logic Symbols

This toolbar provides icons to place each type of logic element into the scheme diagram. Not all elements are available in all devices. Icons will only be displayed for those elements available in the selected device. Depending on the device, the toolbar may not include Function key or coloured LED conditioner/signal or Contact conditioner or SR Gate icons.



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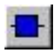
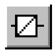
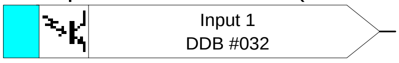
Link Create a link between two logic symbols.	
Opto Signal Create an opto signal.	
Input Signal Create an input signal.	
Output Signal Create an output signal.	
GOOSE In Create an input signal to logic to receive a UCA2.0 or IEC 61850 GOOSE message transmitted from another IED.	
GOOSE Out Create an output signal from logic to transmit a UCA2.0 or IEC 61850 GOOSE message to another IED.	
Control In Create an input signal to logic that can be operated from an external command.	
Integral Intertripping In/InterMiCOM In Create an input signal to logic to receive a MiCOM command transmitted from another IED. InterMiCOM is not available for all products.	
Integral Intertripping Out/InterMiCOM OutCreate an output signal from logic to transmit a MiCOM command to another IED. InterMiCOM is not available for all products.	

Function Key Create a function key input signal.	
Trigger Signal Create a fault record trigger.	
LED Signal Create an LED input signal that repeats the status of the LED. The icon colour shows whether the product uses mono-colour or tri-color LEDs.	
Contact Signal Create a contact signal.	
LED Conditioner Create a LED conditioner. The icon colour shows whether the product uses mono-colour or tri-color LEDs.	
Contact Conditioner Create a contact conditioner. Contact conditioning is not available for all products.	
Timer Create a timer.	
AND Gate Create an AND Gate.	
OR Gate Create an OR Gate.	
Programmable Gate Create a programmable gate.	
SR gate Create an SR gate.	

4 PSL LOGIC SIGNALS PROPERTIES

The logic signal toolbar is used for the selection of logic signals.
This allows you to link signals together to program the PSL. A number of different properties are associated with each signal. In the following sections, these are characterized by the use of an icon from the toolbar; together with a signal name and a DDB number. The name and DDB number are shown in a pointed rectangular block, which includes a colour code, the icon, the name, DDB No and a directional pointer. One example of such a block (for P54x for Opto Signal 1 DDB No #032) is shown below:



More examples of these are shown in the following properties sections.

Important	**The DDB Numbers vary according to the particular product and the particular name, so that Opto Signal 1 may not be DDB No #032 for all products. The various names and DDB numbers illustrated below are provided as an example.** **You need to look up the DDB numbers for the signal and the specific MiCOM product you are working on in the relevant DDB table for your chosen product.** **Available functions will depend on model/firmware version.**

4.1 Signal Properties Menu

The logic signal toolbar is used for the selection of logic signals. To use this:

- Use the logic toolbar to select logic signals.
  This is enabled by default but to hide or show it, select **View** > **Logic Toolbar**.
- Zoom in or out of a logic diagram using the toolbar icon or select **View** > **Zoom Percent**.
- Right-click any logic signal and a context-sensitive menu appears.
- Certain logic elements show the **Properties…** option. Select this and a **Component Properties** window appears. The Component Properties window and the signals listed vary depending on the logic symbol selected.

The following subsections describe each of the available logic symbols.

4.2 Link Properties

Links form the logical link between the output of a signal, gate or condition and the input to any element.
Any link that is connected to the input of a gate can be inverted. Right-click the input and select **Properties…**. The **Link Properties** window appears.

Figure 2 - Link properties

4.2.1 Rules for Linking Symbols

An inverted link is shown with a small circle on the input to a gate. A link must be connected to the input of a gate to be inverted.
Links can only be started from the output of a signal, gate, or conditioner, and can only be ended at an input to any element.

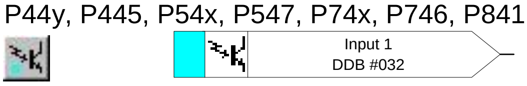
Signals can only be an input or an output. To follow the convention for gates and conditioners, input signals are connected from the left and output signals to the right. The Editor automatically enforces this convention.
A link is refused for the following reasons:

- An attempt to connect to a signal that is already driven. The reason for the refusal may not be obvious because the signal symbol may appear elsewhere in the diagram.

  Right-click the link and select Highlight to find the other signal. Click anywhere on the diagram to disable the highlight.
- An attempt is made to repeat a link between two symbols. The reason for the refusal may not be obvious because the existing link may be represented elsewhere in the diagram.

4.3 Opto Signal Properties

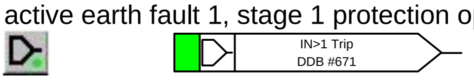
Each opto input can be selected and used for programming in PSL. Activation of the opto input drives an associated DDB signal.
For example, activating opto Input L1 asserts DDB 032 in the PSL for the P14x, P34x, P44y, P445, P54x, P547, P74x, P746, P841, P849 products.



DDB Nos	*“Input 1 DDB #064” applies to: P24x, P64x.* *“Opto Label DDB #064” applies to: P44x.*

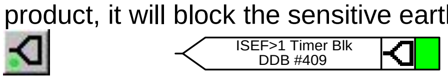
4.4 Input Signal Properties

Relay logic functions provide logic output signals that can be used for programming in PSL. Depending on the relay functionality, operation of an active relay function drives an associated DDB signal in PSL.
For example, DDB 671 is asserted in the PSL for the P44y, P547 & P841 product if the active earth fault 1, stage 1 protection operate/trip.



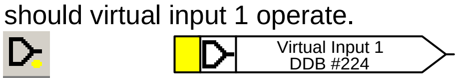
4.5 Output Signal Properties

Relay logic functions provide logic input signals that can be used for programming in PSL. Depending on the relay functionality, activation of the output signal will drive an associated DDB signal in PSL and cause an associated response to the relay function.
For example, if DDB 409 is asserted in the PSL for the P44y, P54x, P547 and P841 product, it will block the sensitive earth function stage 1 timer.



4.6 GOOSE Input Signal Properties

The PSL interfaces with the GOOSE Scheme Logic using virtual inputs. The Virtual Inputs can be used in much the same way as the Opto Input signals.
The logic that drives each of the Virtual Inputs is contained within the relay’s GOOSE Scheme Logic file. It is possible to map any number of bit-pairs, from any enrolled device, using logic gates onto a Virtual Input (see Easergy Studio (MiCOM S1 Studio) User Manual for more details). The number of available GOOSE virtual inputs is shown in the *Programmable Logic* chapter.
For example DDB 224 will be asserted in PSL for the P44y, P54x, P547 & P841 product should virtual input 1 operate.



4.7 GOOSE Output Signal Properties

The PSL interfaces with the GOOSE Scheme Logic using 32 virtual outputs. Virtual outputs can be mapped to bit-pairs for transmitting to any enrolled devices.

For example if DDB 256 is asserted in PSL for the P44y, P54x, P547 and P841 product, Virtual Output 32 and its associated mappings will operate.

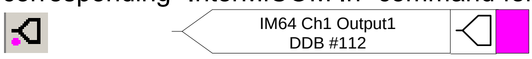
4.8 Control In Signal Properties

There are 32 control inputs which can be activated via the relay menu, ‘hotkeys’ or via rear communications. Depending on the programmed setting i.e. latched or pulsed, an associated DDB signal will be activated in PSL when a control input is operated

For example, when operated control input 1 will assert DDB 192 in the PSL for the P44y, P54x, P547 and P841 products.

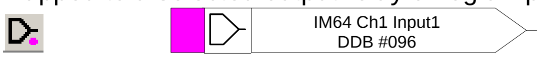
4.9 InterMiCOM Output Commands Properties

There are 16 InterMiCOM outputs that could be selected and use for teleprotection, remote commands, etc. “InterMiCOM Out” is a send command to a remote end that could be mapped to any logic output or opto input. This will be transmitted to the remote end as corresponding “InterMiCOM In” command for the P14x, P44y, P445 & P54x products.



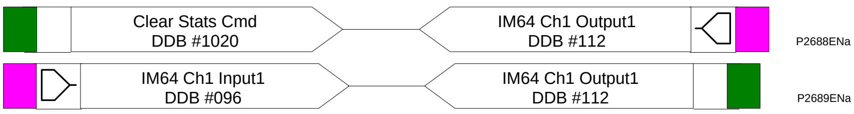
4.10 InterMiCOM Input Commands Properties

There are 16 InterMiCOM inputs that could be selected and use for teleprotection, remote commands, etc. “InterMiCOM In” is a received signal from remote end that could be mapped to a selected output relay or logic input.



Example:

Relay End A	At end A, InterMiCOM Output 1 is mapped to the command indication “Clear Statistics” (issued at end A).
Relay End B	At end B, InterMiCOM Input 1 is mapped to the command “Clear Statistics”.
	Upon receive of IM64 1 from relay at end A, the relay at end B will reset its statistics.



4.11 Function Key Properties

Each function key can be selected and used for programming in PSL. Activation of the function key will drive an associated DDB signal and the DDB signal will remain active depending on the programmed setting i.e. toggled or normal. Toggled mode means the DDB signal will remain latched or unlatched on key press and normal means the DDB will only be active for the duration of the key press.

For example, operate function key 1 to assert DDB 1096 in the PSL for the P44y, P54x, P547 or P841 products.

4.12 Fault Recorder Trigger Properties

The fault recording facility can be activated by driving the fault recorder trigger DDB signal.
For example assert DDB 702 to activate the fault recording in the PSL for the P44y, P54x, P547 or P841 product.


4.13 LED Signal Properties

All programmable LEDs will drive associated DDB signal when the LED is activated.
For example DDB 1036 will be asserted when LED 7 is activated for the P44y, P54x, P547 or P841 product.


4.14 Contact Signal Properties

All relay output contacts will drive associated DDB signal when the output contact is activated.
For example, DDB 009 will be asserted when output R10 is activated for all products.


4.15 LED Conditioner Properties

1. Select the **LED name** from the list (only shown when inserting a new symbol).
2. Configure the LED output to be Red, Yellow or Green.
   Configure a Green LED by driving the Green DDB input.
   Configure a RED LED by driving the RED DDB input.
   Configure a Yellow LED by driving the RED and GREEN DDB inputs simultaneously.

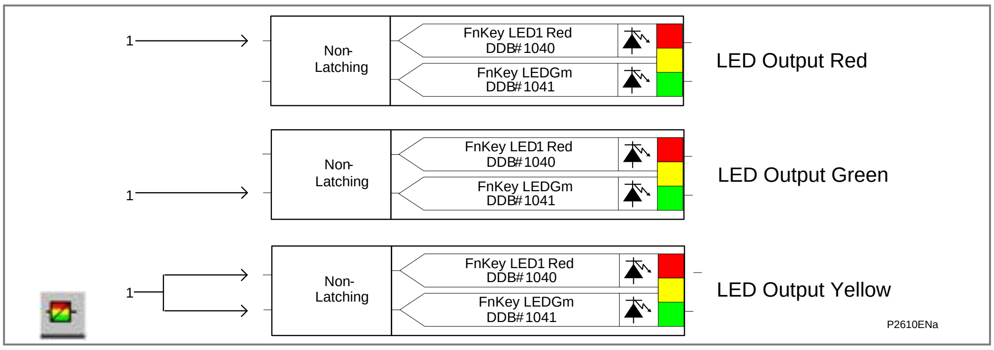


Figure 3 - Red, green and yellow LED outputs

3. Configure the LED output to be latching or non-latching.

DDB #642 and DDB #643 applies to these products: P14x, P44x, P74x, P746 and P849.
DDB #1040 and DDB #1041 applies to these products: P24x, P34x, P44y, P54x, P547, P64x and P841.

4.16 Contact Conditioner Properties

Each contact can be conditioned with an associated timer that can be selected for pick up, drop off, dwell, pulse, pick-up/drop-off, straight-through, or latching operation. **Straight-through** means it is not conditioned in any way whereas **Latching** is used to create a sealed-in or lockout type function.

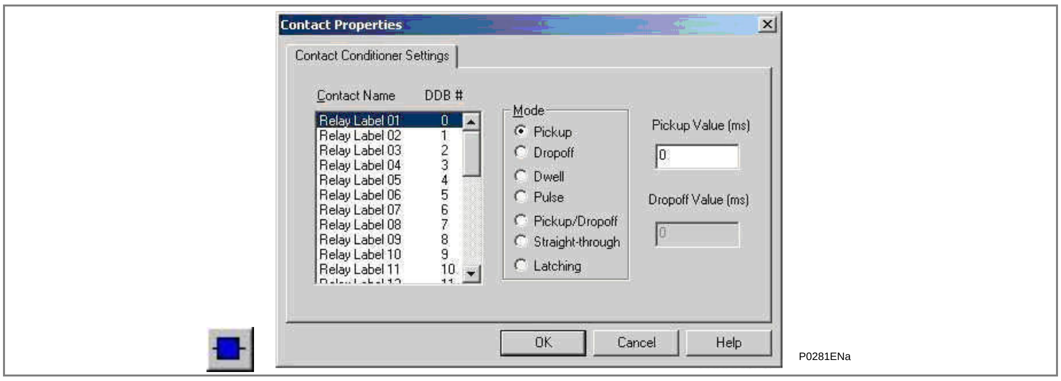


Figure 4 - Contact conditioner settings

1. Select the contact **name** from the **Contact Name** list (only shown when inserting a new symbol).
2. Choose the conditioner type required in the **Mode** tick list.
3. Set the **Pick-up** Time (in milliseconds), if required.
4. Set the **Drop-off** Time (in milliseconds), if required.

4.17 Timer Properties

Each timer can be selected for pick up, drop off, dwell, pulse or pick-up/drop-off operation.

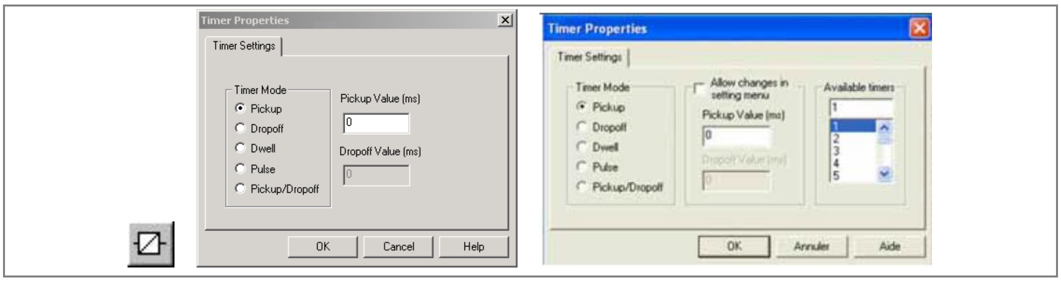


Figure 5 - Timer settings

1. Choose the operation mode from the **Timer Mode** tick list.
2. Set the Pick-up Time (in milliseconds), if required.
3. Set the Drop-off Time (in milliseconds), if required.

4.18 Gate Properties

A Gate may be an AND, OR, or programmable gate.

	An **AND** gate requires that all inputs are TRUE for the output to be TRUE.
	An **OR** gate requires that one or more input is TRUE for the output to be TRUE.
	A **Programmable** gate requires that the number of inputs that are TRUE is equal to or greater than its 'Inputs to Trigger' setting for the output to be TRUE.

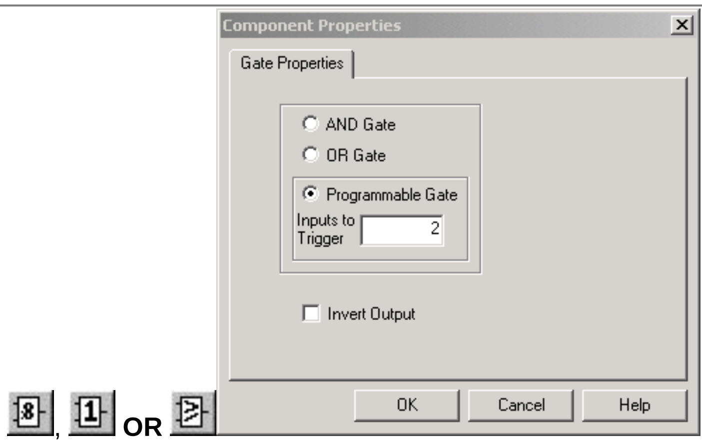


Figure 6 - Gate properties

1. Select the Gate type AND, OR, or Programmable.
2. Set the number of inputs to trigger when Programmable is selected.
3. Select if the output of the gate should be inverted using the Invert Output check box. An inverted output is indicated with a "bubble" on the gate output.

4.19 SR Programmable Gate Properties

For many products a number of programmable SR Latches are added. They are configured by an appropriate version of PSL Editor (S1v2.14 version 5.0.0 or greater) where an SRQ icon features on the toolbar.

Each SR latch has a Q output. The Q output may be inverted in the PSL Editor under the SR Latch component properties window. The SR Latches may be configured as Standard (no input dominant), Set Dominant or Reset Dominant in the PSL Editor under the SR Latch component properties window. The truth table for the SR Latches is given below.

A **Programmable** SR gate can be selected to operate with these latch properties:

S input	R input	O - Standard	O – Set input dominant	O – Reset input dominant
0	0	0	0	0
0	1	0	0	0
1	0	1	1	1
1	1	0	1	0

Table 1 - SR programmable gate properties

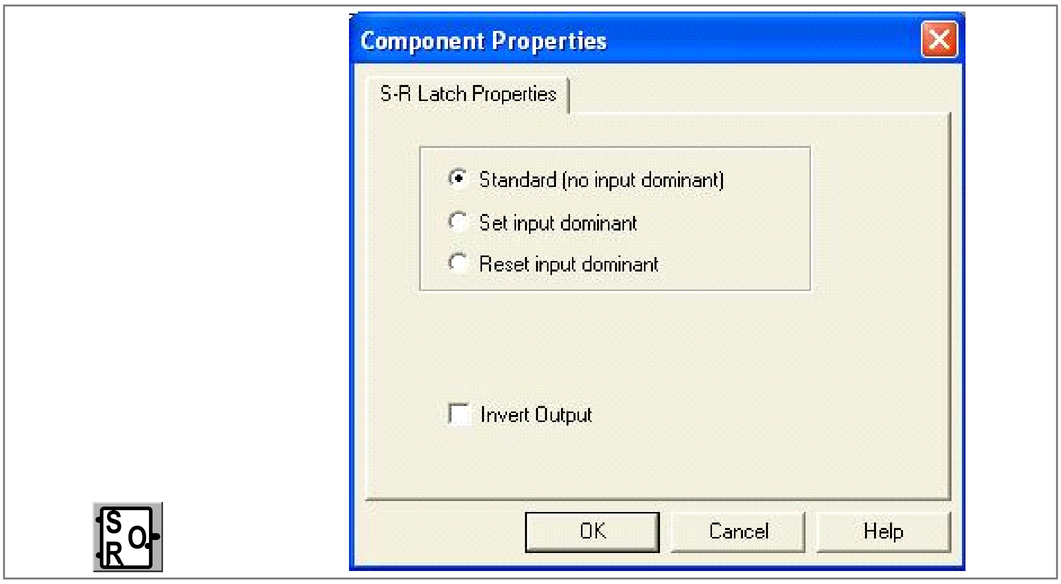


Figure 7 - SR latch component properties

Select if the output of the gate should be inverted using the Invert Output check box. An inverted output is indicated with a "bubble" on the gate output.

4.20 PSL Signal Grouping Modes

PSL Signal Grouping Nodes

For Software Version D1a and later, these DDB "Group" Nodes can be mapped to individual or multiple DDBs in the PSL:

PSL Group Sig 1
PSL Group Sig 2
PSL Group Sig 3
PSL Group Sig 4

There are now four additional ***DDB Group Sig x*** Nodes that can be mapped to individual or multiple DDBs in the PSL. These can then be set to trigger the DR via the DISTURBANCE RECORD menu.

These "Nodes" are general and can also be used to group signals together in the PSL for any other reason. These four nodes are available in each of the four PSL setting groups.

Number	PSL Group Sig
992	PSL Group Sig 1
993	PSL Group Sig 2
994	PSL Group Sig 3
995	PSL Group Sig 4

1. For a control input, the DR can be triggered directly by triggering directly from the Individual Control Input (e.g. Low to High (L to H) change)
2. For an input that cannot be triggered directly, or where any one of a number of DDBs are required to trigger a DR, map the DDBs to the new PSL Group sig n and then trigger the DR on this.

e.g. in the PSL:

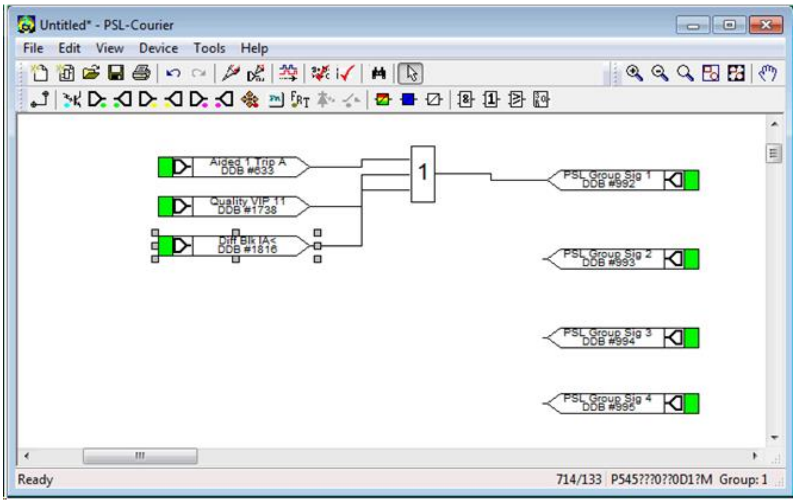


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Figure 8 - PSL diagram

In the DR Settings:

- Digital Input 1 is triggered by the PSL Group Sig 1 (L to H)
- Digital Input 2 is triggered by Control Input 1 (L to H)

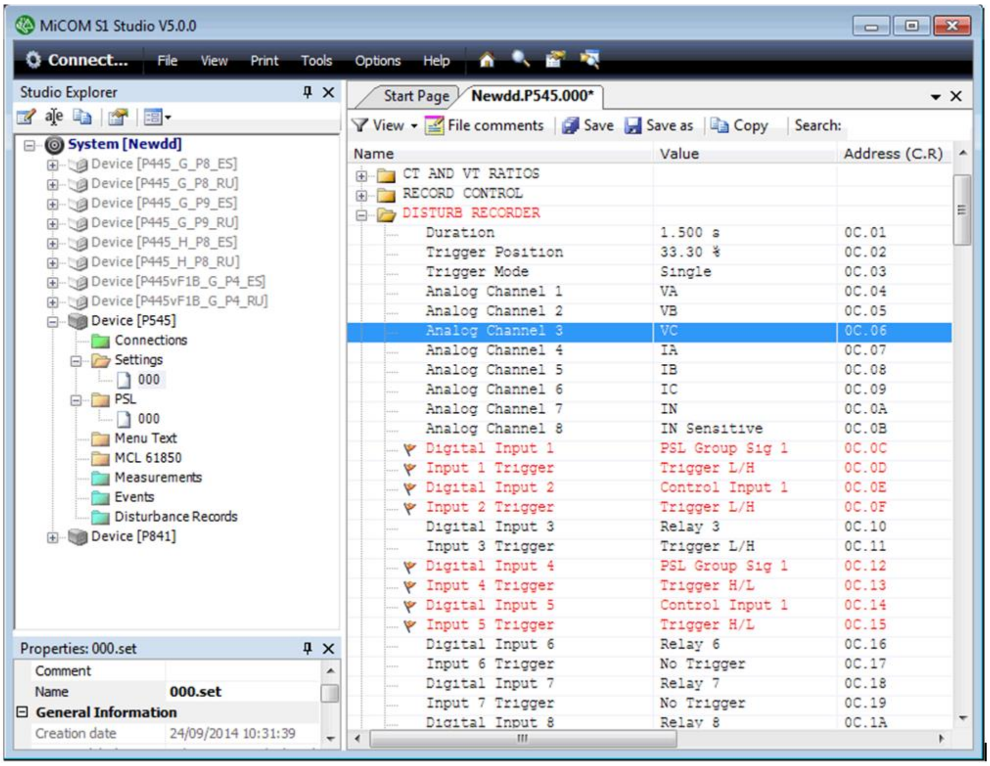

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Figure 9 – Easergy Studio (MiCOM S1 Studio) Disturb Recorder table diagram

If triggering on both edges is required map another DR channel to the H/L as well

Digital Input 4 is triggered by the PSL Group Sig 1 (H to L)

Digital Input 5 is triggered by Control Input 1 (H to L)

5 SPECIFIC TASKS

Note	*MiCOM S1 Studio has been renamed as Easergy Studio.*

5.1 DR Digital Input Label Operation (P44y, P54x, P445 & P841 only)

The digital input labels can be modified via the MiCOM Px40 user interface or Easergy Studio (MiCOM S1 Studio). The following example is using S1 Studio Version 5.0.0. The digital input labels are available in the “DR CHAN LABELS” folder in the settings file as shown below:

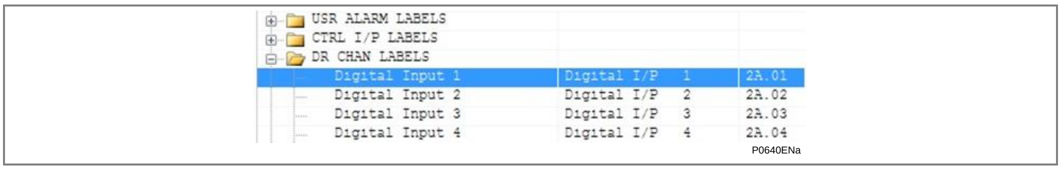


Figure 10 - DR Chan Labels tree

Easergy Studio (MiCOM S1 Studio) removes leading spaces from the value field so making the ‘D’ look as if it’s the 1st character in the label. The default values above in fact have a leading space which is used to switch off the use of the label as show below in the change settings view.

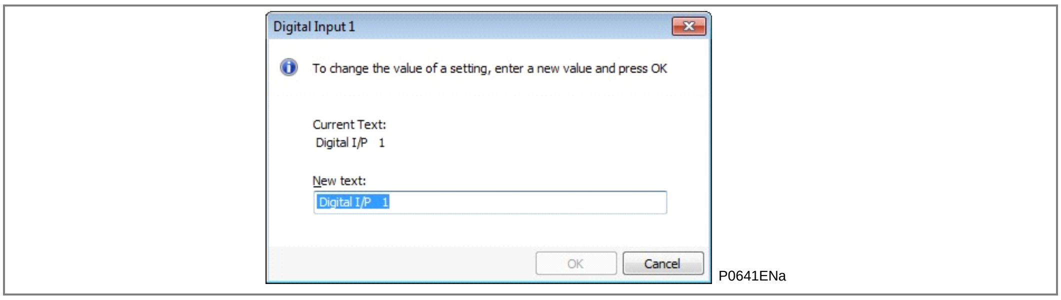


Figure 11 - Digital Input 1 dialog box

Pressing OK will save the setting and return to the settings page as follows:

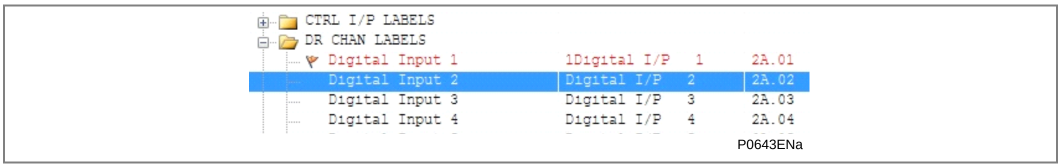


Figure 12 - DR Chan Labels tree

Digital Input 1 label will now be used in the Disturbance Record when the settings file is downloaded to the relay.

5.2 Virtual Input Label Operation

The Virtual Input labels can be modified via the MiCOM Px40 user interface or Easergy Studio.

The default labels are available in the “VIR I/P LABELS” (or “VIRT I/P LABELS”) folder in the settings file as shown below:

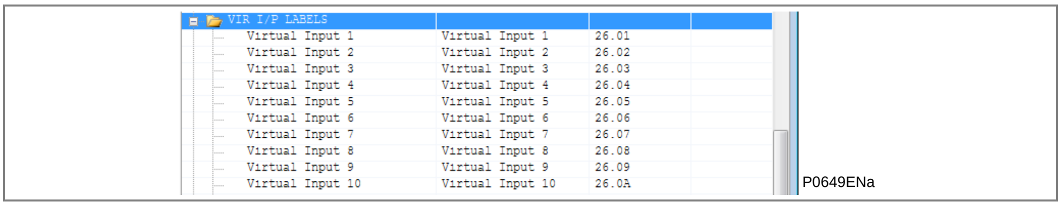


Figure 13 - Easergy Studio VIR I/P Labels Tree

The default “Virtual Input” labels can be changed to customer requirements. For example, to change default text from “Virtual Input 1” to “Customer Func 1” open the ***Virtual Input 1*** box, and change “Virtual Input 1” in the ***New Text:*** box to “Customer Func 1”:

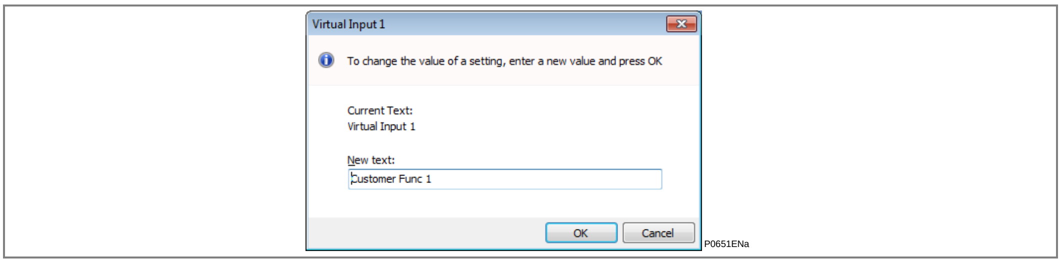


Figure 14 - Virtual Input 1 dialog box

Pressing OK will save the setting and return to the settings page as follows:

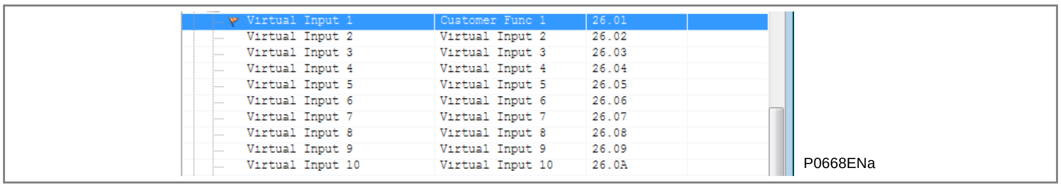


Figure 15 - Easergy Studio VIR I/P Labels Tree

The above “Customer Func 1” label text will now be used in place of “Virtual Input 1” in the Disturbance / Event Records after the settings file is downloaded to the relay.

5.3 Virtual Output Label Operation

The Virtual Output labels can be modified via the relay user interface or Easergy Studio.

The virtual Output labels are available in the “VIR O/P LABELS” ” (or “VIRT O/P LABELS”) folder in the settings file as shown below:

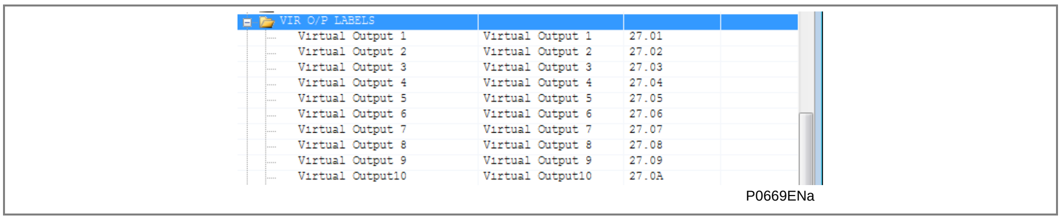


Figure 16 - Easergy Studio VIR O/P Labels Tree

The default “Virtual Output Labels” can be changed to suit the customer requirements. The process is identical to the previously described procedure for the Virtual Input Labels.

5.4 SR/MR User Alarm Label Operation

The SR/MR User Alarm input labels can be modified via the MiCOM Px40 user interface or Easergy Studio.

The default labels are available in the "USR ALARM LABELS" folder in the settings file as shown below:

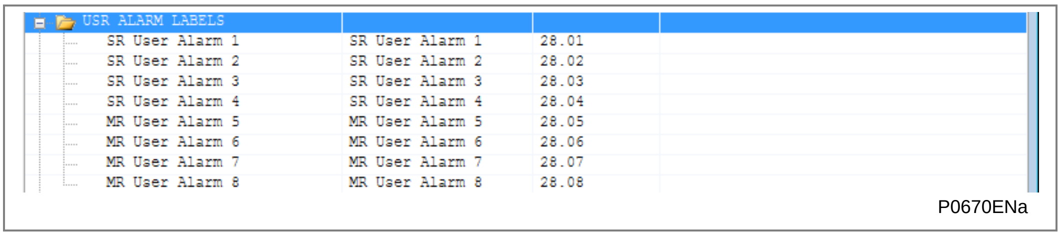


Figure 17 - Easergy Studio USR Labels Tree

The default "SR User Alarm" and "MR User Alarm" labels can be changed to suit the customer requirements. For example, to change default text from "SR User Alarm 1" to "Customer Alarm 1" open the ***SR User Alarm 1*** dialog box and change "SR User Alarm 1" in the ***New Text:*** Text box to be "Customer Alarm 1".

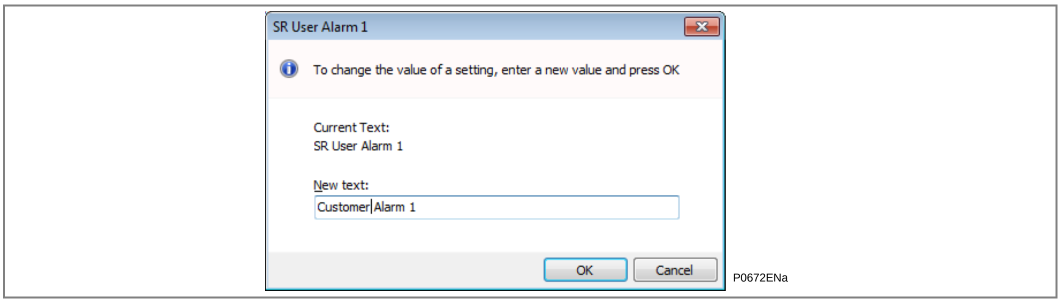


Figure 18 – User Alarm dialog box

Pressing OK will save the setting and return to the settings page as follows:

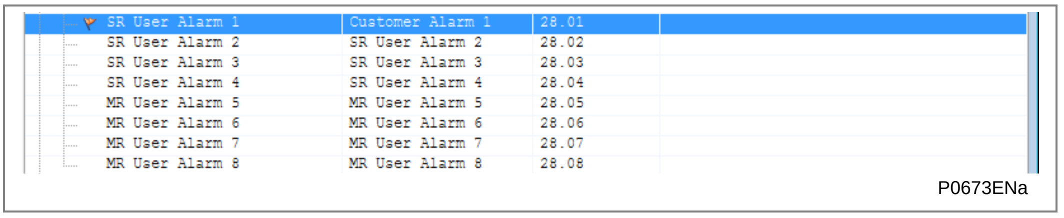


Figure 19 - Virtual Input 1 settings

The above "Customer Alarm 1" label text will now be used in place of "SR User Alarm 1" in the Disturbance / Event Records after the settings file is downloaded to the relay.

5.5 Settable Control Input Operation (P14x, P44y, P54x, P445 & P841 only)

The settings should be applied to all relays in the current differential protection scheme. As from Software Versions C1/D1/F1/G4/H4/J4, there are now 32 Standard Control Inputs and 16 additional Settable Control Inputs available. These are settable via the “CONTROL INPUTS” folder and are located after the standard “Control Input” labels in the relevant settings file.

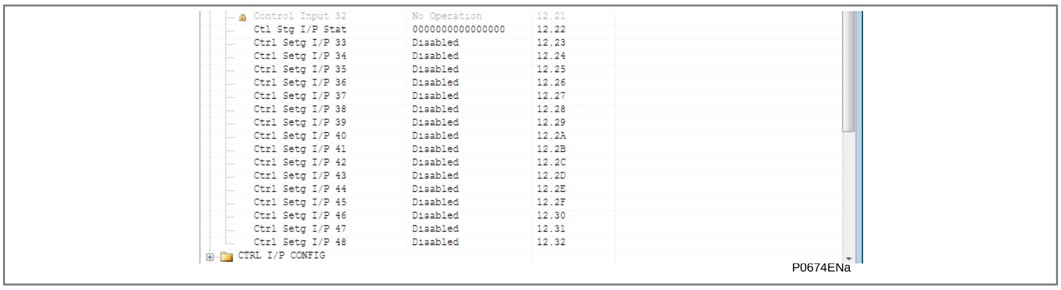


Figure 20 - Easergy Studio Control Inputs tree

Each Settable control Input “Ctrl Setg I/P xx” can be controlled using Enable / Disable settings. To change from (the default) Disabled to Enabled, open the ***Ctrl Setg I/P xx*** dialog box, then change Disabled to Enabled in the ***New Setting*** drop-down list box:

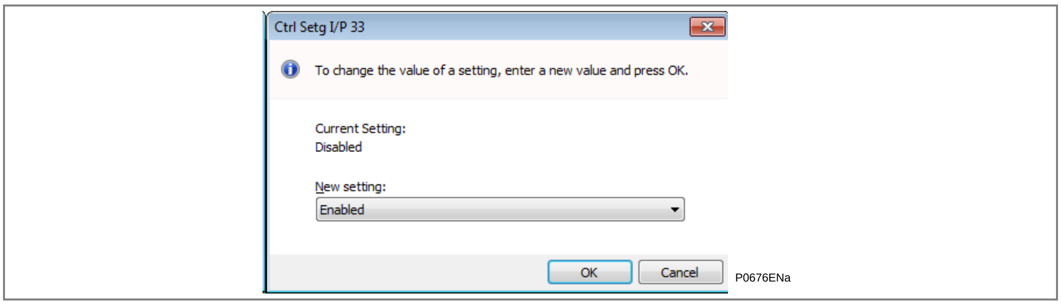


Figure 21 – Ctrl Setg I/P 33 dialog box

Pressing OK will save the setting and return to the settings page as follows:

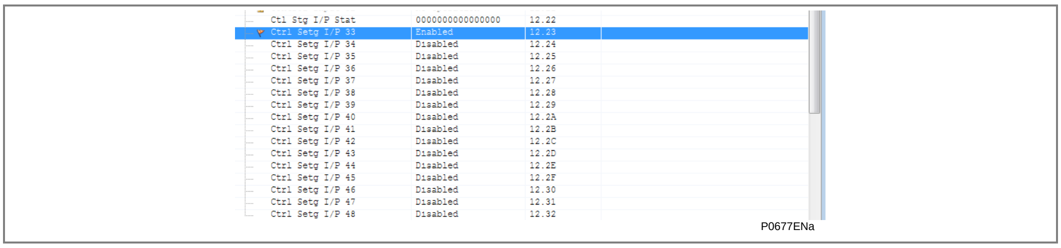


Figure 22 - Easergy Studio Control Inputs (Ctl Setg I/P 33) tree

The setting “Ctl Stg I/P Stat” can be used to control multiple “Ctrl Setg I/P” at the same time, e.g. clear Ctrl Setg I/P 33 and set Ctrl Setg I/P 34 to 38, but please note that the status will not be reflected in the individual inputs settings or vice versa.

This cell may be hidden in the Easergy Studio files.

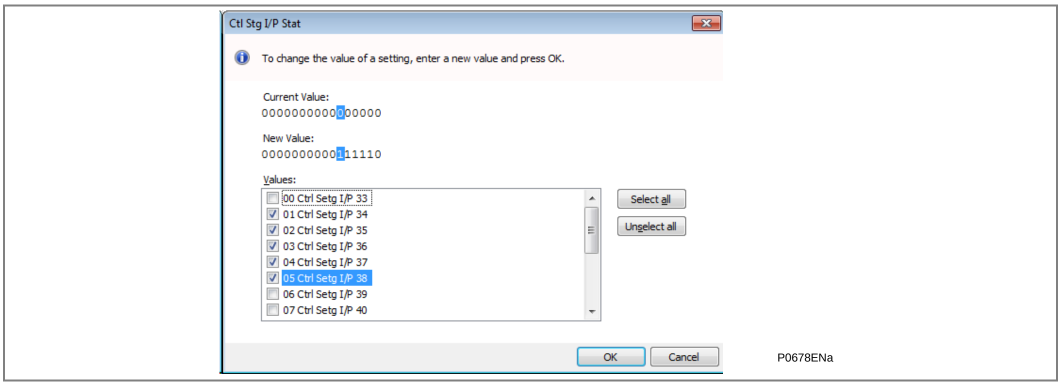


Figure 23 – Ctrl Stg I/P Stat dialog box

5.6 Settable Control Setg I/P Label Operation (P14x, P44y, P54x, P445 & P841 only)

The default labels are available in the “CTRL I/P LABELS” folder and are located after the standard “Control Input” labels in the settings file as shown below:

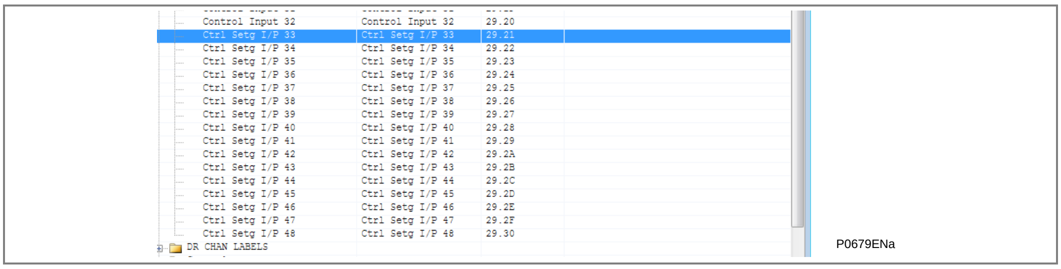


Figure 24 - Easergy Studio Control I/P Labels (Ctl Setg I/P 33) tree

The default “Ctrl Setg I/P” labels can be changed to suit the customer requirements using the same procedure as for the standard “Control Inputs”. For example to change the default text from “Ctrl Setg I/P 33” to “Custom Ctrl Sg 1” open the ***Ctrl Setg I/P 33*** dialog box, then change “Ctrl Setg I/P 33” in the ***New Text:*** box to be “Custom Ctrl Sg 1”.

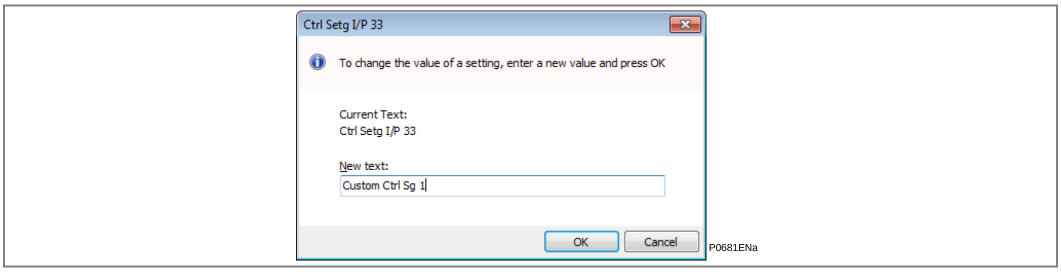


Figure 25 – Ctrl Setg I/P 33 dialog box

Pressing OK will save the setting and return to the settings page as follows:

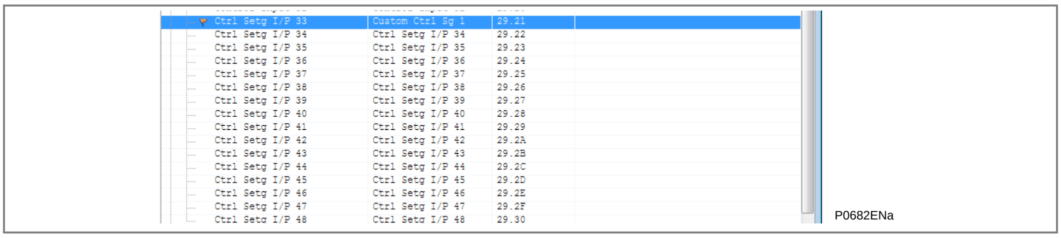


Figure 26 - Easergy Studio Control I/P Labels (Ctl Setg I/P 33) tree

The above “Custom Ctrl Sg 1” label text will now be used in place of “Ctrl Setg I/P 33” in the Disturbance / Event Records after the settings file is downloaded to the relay.

6 MAKING A RECORD OF MICOM PX40 DEVICE SETTINGS

6.1 Using Easergy Studio to Manage Device Settings

An engineer often needs to create a record of what settings have been applied to a device. In the past, they could have used paper printouts of all the available settings, and mark up the ones they had used. Keeping such a paper-based Settings Records could be time-consuming and prone to error (e.g. due to being settings written down incorrectly). The Easergy Studio software lets you read from or write to MiCOM devices.

- **Extract** lets you download all the settings from a MiCOM Px40 device. A summary is given in the ***Extract Settings from a MiCOM Px40 Device*** section.
- **Send** lets you send the settings you currently have open in Easergy Studio. A summary is given in the ***Send Settings to a MiCOM Px40 Device*** section.

In most cases, it will be quicker and less error prone to extract settings electronically and store them in a settings file on a memory stick. In this way, there will be a digital record which is certain to be accurate. It is also possible to archive these settings files in a repository; so they can be used again or adapted for another use.

Full details of how to do this is provided in the Easergy Studio help.

A quick summary of the main steps is here. In each case, you need to make sure that:

- Your computer includes the Easergy Studio software.
- Your computer and the MiCOM device are powered on.
- You have used a suitable cable to connect your computer to the MiCOM device (Front Port, Rear Port, Ethernet port or Modem as available).

6.2 Extract Settings from a MiCOM Px40 Device

Full details of how to do this is provided in the Easergy Studio help.

As a quick guide, you need to do the following:

1. In Easergy Studio, click the Quick Connect… button.
2. Select the relevant Device Type in the Quick Connect dialog box.
3. Click the relevant port in the Port Selection dialog box.
4. Enter the relevant connection parameters in the Connection Parameters dialog box and click the Finish button
5. Studio will try to communicate with the Px40 device. It will display a connected message if the connection attempt is successful.
6. The device will appear in the Studio Explorer pane on the top-left hand side of the interface.
7. Click the + button to expand the options for the device, then click on the Settings folder.
8. Right-click on Settings and select the Extract Settings link to read the settings on the device and store them on your computer or a memory stick attached to your computer.
9. After retrieving the settings file, close the dialog box by clicking the Close button.

6.3 Send Settings to a MiCOM Px40 Device

Full details of how to do this is provided in the Easergy Studio help.

As a quick guide, you need to do the following:

1. In Easergy Studio, click the Quick Connect… button.
2. Select the relevant Device Type in the Quick Connect dialog box.
3. Click the relevant port in the Port Selection dialog box.
4. Enter the relevant connection parameters in the Connection Parameters dialog box and click the Finish button
5. Studio will try to communicate with the Px40 device. It will display a connected message if the connection attempt is successful.
6. The device will appear in the Studio Explorer pane on the top-left hand side of the interface.
7. Click the + button to expand the options for the device, then click on the Settings link.
8. Right-click on the device name and select the Send link.

Note	*When you send settings to a MiCOM Px40 device, the data is stored in a temporary location at first. This temporary data is tested to make sure it is complete. If the temporary data is complete, it will be programmed into the MiCOM Px40 device. This avoids the risk of a device being programmed with incomplete or corrupt settings.*

9. In the Send To dialog box, select the settings file(s) you wish to send, then click the Send button.
10. Close the Send To dialog box by clicking the Close button.

PROGRAMMABLE LOGIC

CHAPTER 8

Date:	07/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142 & P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

CONTENTS

TABLES

1 OVERVIEW

The purpose of the Programmable Scheme Logic (PSL) is to allow the user to configure an individual protection scheme to suit their own particular application. This is achieved through the use of programmable logic gates and delay timers.

The input to the PSL is any combination of the status of opto inputs. It is also used to assign the mapping of functions to the opto inputs and output contacts, the outputs of the protection elements, e.g. protection starts and trips, and the outputs of the fixed protection scheme logic. The fixed scheme logic provides the relay's standard protection schemes.

The PSL itself consists of software logic gates and timers. The logic gates can be programmed to perform a range of different logic functions and can accept any number of inputs. The timers are used either to create a programmable delay, and/or to condition the logic outputs, e.g. to create a pulse of fixed duration on the output regardless of the length of the pulse on the input. The outputs of the PSL are the LEDs on the front panel of the relay and the output contacts at the rear.

The execution of the PSL logic is event driven; the logic is processed whenever any of its inputs change, for example as a result of a change in one of the digital input signals. Also, only the part of the PSL logic that is affected by the particular input change that has occurred is processed. This reduces the amount of processing time that is used by the PSL. This means that even with large, complex PSL schemes the device trip time will not lengthen.

This system provides flexibility for the user to create their own scheme logic design. It also means that the PSL can be configured into a very complex system, hence setting of the PSL is implemented through the PC support package MiCOM S1 Studio.

How to edit the PSL schemes is described in the "Using the PSL Editor" chapter.

This chapter contains details of the logic nodes which are specific to this product, together with any PSL diagrams which we have published for this product.

2 DESCRIPTION OF LOGIC NODES

DDB No	Source	Element Name	Description	English Text
0	SW	DDB_OUTPUT_RELAY_1	see [4B 01]	
1	SW	DDB_OUTPUT_RELAY_2	see [4B 02]	
2	SW	DDB_OUTPUT_RELAY_3	see [4B 03]	
3	SW	DDB_OUTPUT_RELAY_4	see [4B 04]	
4	SW	DDB_OUTPUT_RELAY_5	see [4B 05]	
5	SW	DDB_OUTPUT_RELAY_6	see [4B 06]	
6	SW	DDB_OUTPUT_RELAY_7	see [4B 07]	
7	SW	DDB_OUTPUT_RELAY_8	see [4B 08]	
8	SW	DDB_OUTPUT_RELAY_9	see [4B 09]	
9	SW	DDB_OUTPUT_RELAY_10	see [4B 0A]	
10	SW	DDB_OUTPUT_RELAY_11	see [4B 0B]	
11	SW	DDB_OUTPUT_RELAY_12	see [4B 0C]	
12	SW	DDB_OUTPUT_RELAY_13	see [4B 0D]	
13	SW	DDB_OUTPUT_RELAY_14	see [4B 0E]	
14	SW	DDB_OUTPUT_RELAY_15	see [4B 0F]	
15	SW	DDB_OUTPUT_RELAY_16	see [4B 10]	
16	SW	DDB_OUTPUT_RELAY_17	see [4B 11]	
17	SW	DDB_OUTPUT_RELAY_18	see [4B 12]	
18	SW	DDB_OUTPUT_RELAY_19	see [4B 13]	
19	SW	DDB_OUTPUT_RELAY_20	see [4B 14]	
20	SW	DDB_OUTPUT_RELAY_21	see [4B 15]	
21	SW	DDB_OUTPUT_RELAY_22	see [4B 16]	
22	SW	DDB_OUTPUT_RELAY_23	see [4B 17]	
23	SW	DDB_OUTPUT_RELAY_24	see [4B 18]	
24	SW	DDB_OUTPUT_RELAY_25	see [4B 19]	
25	SW	DDB_OUTPUT_RELAY_26	see [4B 1A]	
26	SW	DDB_OUTPUT_RELAY_27	see [4B 1B]	
27	SW	DDB_OUTPUT_RELAY_28	see [4B 1C]	
28	SW	DDB_OUTPUT_RELAY_29	see [4B 1D]	
29	SW	DDB_OUTPUT_RELAY_30	see [4B 1E]	
30	SW	DDB_OUTPUT_RELAY_31	see [4B 1F]	
31	SW	DDB_OUTPUT_RELAY_32	see [4B 20]	
32	SW	DDB_OPTO_ISOLATOR_1	see [4A 01]	
33	SW	DDB_OPTO_ISOLATOR_2	see [4A 02]	
34	SW	DDB_OPTO_ISOLATOR_3	see [4A 03]	
35	SW	DDB_OPTO_ISOLATOR_4	see [4A 04]	
36	SW	DDB_OPTO_ISOLATOR_5	see [4A 05]	
37	SW	DDB_OPTO_ISOLATOR_6	see [4A 06]	
38	SW	DDB_OPTO_ISOLATOR_7	see [4A 07]	
39	SW	DDB_OPTO_ISOLATOR_8	see [4A 08]	
40	SW	DDB_OPTO_ISOLATOR_9	see [4A 09]	
41	SW	DDB_OPTO_ISOLATOR_10	see [4A 0A]	

DDB No	Source	Element Name	Description	English Text
42	SW	DDB_OPTO_ISOLATOR_11	see [4A 0B]	
43	SW	DDB_OPTO_ISOLATOR_12	see [4A 0C]	
44	SW	DDB_OPTO_ISOLATOR_13	see [4A 0D]	
45	SW	DDB_OPTO_ISOLATOR_14	see [4A 0E]	
46	SW	DDB_OPTO_ISOLATOR_15	see [4A 0F]	
47	SW	DDB_OPTO_ISOLATOR_16	see [4A 10]	
48	SW	DDB_OPTO_ISOLATOR_17	see [4A 11]	
49	SW	DDB_OPTO_ISOLATOR_18	see [4A 12]	
50	SW	DDB_OPTO_ISOLATOR_19	see [4A 13]	
51	SW	DDB_OPTO_ISOLATOR_20	see [4A 14]	
52	SW	DDB_OPTO_ISOLATOR_21	see [4A 15]	
53	SW	DDB_OPTO_ISOLATOR_22	see [4A 16]	
54	SW	DDB_OPTO_ISOLATOR_23	see [4A 17]	
55	SW	DDB_OPTO_ISOLATOR_24	see [4A 18]	
56	SW	DDB_OPTO_ISOLATOR_25	see [4A 19]	
57	SW	DDB_OPTO_ISOLATOR_26	see [4A 1A]	
58	SW	DDB_OPTO_ISOLATOR_27	see [4A 1B]	
59	SW	DDB_OPTO_ISOLATOR_28	see [4A 1C]	
60	SW	DDB_OPTO_ISOLATOR_29	see [4A 1D]	
61	SW	DDB_OPTO_ISOLATOR_30	see [4A 1E]	
62	SW	DDB_OPTO_ISOLATOR_31	see [4A 1F]	
63	SW	DDB_OPTO_ISOLATOR_32	see [4A 20]	
64	SW	DDB_OUTPUT_LED_1		LED 1
65	SW	DDB_OUTPUT_LED_2		LED 2
66	SW	DDB_OUTPUT_LED_3		LED 3
67	SW	DDB_OUTPUT_LED_4		LED 4
68	SW	DDB_OUTPUT_LED_5		LED 5
69	SW	DDB_OUTPUT_LED_6		LED 6
70	SW	DDB_OUTPUT_LED_7		LED 7
71	SW	DDB_OUTPUT_LED_8		LED 8
72	PSL	DDB_OUTPUT_CON_1		Relay Cond 1
73	PSL	DDB_OUTPUT_CON_2		Relay Cond 2
74	PSL	DDB_OUTPUT_CON_3		Relay Cond 3
75	PSL	DDB_OUTPUT_CON_4		Relay Cond 4
76	PSL	DDB_OUTPUT_CON_5		Relay Cond 5
77	PSL	DDB_OUTPUT_CON_6		Relay Cond 6
78	PSL	DDB_OUTPUT_CON_7		Relay Cond 7
79	PSL	DDB_OUTPUT_CON_8		Relay Cond 8
80	PSL	DDB_OUTPUT_CON_9		Relay Cond 9
81	PSL	DDB_OUTPUT_CON_10		Relay Cond 10
82	PSL	DDB_OUTPUT_CON_11		Relay Cond 11
83	PSL	DDB_OUTPUT_CON_12		Relay Cond 12
84	PSL	DDB_OUTPUT_CON_13		Relay Cond 13
85	PSL	DDB_OUTPUT_CON_14		Relay Cond 14

DDB No	Source	Element Name	Description	English Text
86	PSL	DDB_OUTPUT_CON_15		Relay Cond 15
87	PSL	DDB_OUTPUT_CON_16		Relay Cond 16
88	PSL	DDB_OUTPUT_CON_17		Relay Cond 17
89	PSL	DDB_OUTPUT_CON_18		Relay Cond 18
90	PSL	DDB_OUTPUT_CON_19		Relay Cond 19
91	PSL	DDB_OUTPUT_CON_20		Relay Cond 20
92	PSL	DDB_OUTPUT_CON_21		Relay Cond 21
93	PSL	DDB_OUTPUT_CON_22		Relay Cond 22
94	PSL	DDB_OUTPUT_CON_23		Relay Cond 23
95	PSL	DDB_OUTPUT_CON_24		Relay Cond 24
96	PSL	DDB_OUTPUT_CON_25		Relay Cond 25
97	PSL	DDB_OUTPUT_CON_26		Relay Cond 26
98	PSL	DDB_OUTPUT_CON_27		Relay Cond 27
99	PSL	DDB_OUTPUT_CON_28		Relay Cond 28
100	PSL	DDB_OUTPUT_CON_29		Relay Cond 29
101	PSL	DDB_OUTPUT_CON_30		Relay Cond 30
102	PSL	DDB_OUTPUT_CON_31		Relay Cond 31
103	PSL	DDB_OUTPUT_CON_32		Relay Cond 32
104	PSL	DDB_LED_CON_1		LED Cond IN 1
105	PSL	DDB_LED_CON_2		LED Cond IN 2
106	PSL	DDB_LED_CON_3		LED Cond IN 3
107	PSL	DDB_LED_CON_4		LED Cond IN 4
108	PSL	DDB_LED_CON_5		LED Cond IN 5
109	PSL	DDB_LED_CON_6		LED Cond IN 6
110	PSL	DDB_LED_CON_7		LED Cond IN 7
111	PSL	DDB_LED_CON_8		LED Cond IN 8
112	PSL	DDB_TIMERIN_1		Timer in 1
113	PSL	DDB_TIMERIN_2		Timer in 2
114	PSL	DDB_TIMERIN_3		Timer in 3
115	PSL	DDB_TIMERIN_4		Timer in 4
116	PSL	DDB_TIMERIN_5		Timer in 5
117	PSL	DDB_TIMERIN_6		Timer in 6
118	PSL	DDB_TIMERIN_7		Timer in 7
119	PSL	DDB_TIMERIN_8		Timer in 8
120	PSL	DDB_TIMERIN_9		Timer in 9
121	PSL	DDB_TIMERIN_10		Timer in 10
122	PSL	DDB_TIMERIN_11		Timer in 11
123	PSL	DDB_TIMERIN_12		Timer in 12
124	PSL	DDB_TIMERIN_13		Timer in 13
125	PSL	DDB_TIMERIN_14		Timer in 14
126	PSL	DDB_TIMERIN_15		Timer in 15
127	PSL	DDB_TIMERIN_16		Timer in 16
128	SW	DDB_TIMEROUT_1		Timer out 1
129	SW	DDB_TIMEROUT_2		Timer out 2

DDB No	Source	Element Name	Description	English Text
130	SW	DDB_TIMEROUT_3		Timer out 3
131	SW	DDB_TIMEROUT_4		Timer out 4
132	SW	DDB_TIMEROUT_5		Timer out 5
133	SW	DDB_TIMEROUT_6		Timer out 6
134	SW	DDB_TIMEROUT_7		Timer out 7
135	SW	DDB_TIMEROUT_8		Timer out 8
136	SW	DDB_TIMEROUT_9		Timer out 9
137	SW	DDB_TIMEROUT_10		Timer out 10
138	SW	DDB_TIMEROUT_11		Timer out 11
139	SW	DDB_TIMEROUT_12		Timer out 12
140	SW	DDB_TIMEROUT_13		Timer out 13
141	SW	DDB_TIMEROUT_14		Timer out 14
142	SW	DDB_TIMEROUT_15		Timer out 15
143	SW	DDB_TIMEROUT_16		Timer out 16
144	PSL	DDB_FAULT_RECORDER_START		Fault REC TRIG
145	SW	DDB_ILLEGAL_OPTO_SETTINGS_GROUP	Setting Group via opto invalid	SG-opto Invalid
146	SW	DDB_OOS_ALARM	Test Mode Enabled	Prot'n Disabled
147	FL	DDB_FREQ_ALARM	Frequency out of range	F out of Range
148	SW	DDB_VTS_INDICATION	VTS Indication	VT Fail Alarm
149	SW	DDB_CTS_INDICATION	CTS Indication	CT Fail Alarm
150	SW	DDB_BREAKER_FAIL_ALARM	Breaker Fail Any Trip	CB Fail Alarm
151	SW	DDB_BROKEN_CURRENT_ALARM	Broken Current Maintenance Alarm	I^ Maint Alarm
152	SW	DDB_BROKEN_CURRENT_LOCKOUT	Broken Current Lockout Alarm	I^ Lockout Alarm
153	SW	DDB_MAINTENANCE_ALARM	No of CB Ops Maintenance Alarm	CB Ops Maint
154	SW	DDB_MAINTENANCE_LOCKOUT	No of CB Ops Maintenance Lockout	CB Ops Lockout
155	SW	DDB_EXCESSIVE_OP_TIME_ALARM	Excessive CB Op Time Maintenance Alarm	CB Op Time Maint
156	SW	DDB_EXCESSIVE_OP_TIME_LOCKOUT	Excessive CB Op Time Lockout Alarm	CB Op Time Lock
157	SW	DDB_EFF_LOCKOUT	EFF Lockout Alarm	Fault Freq Lock
158	SW	DDB_CB_STATUS_ALARM	CB Status Alarm	CB Status Alarm
159	SW	DDB_CB_FAILED_TO_TRIP	CB Failed to Trip	Man CB Trip Fail
160	SW	DDB_CB_FAILED_TO_CLOSE	CB Failed to Close	CB Cls Fail
161	SW	DDB_CONTROL_CB_UNHEALTHY	Control CB Unhealthy	Man CB Unhealthy
162	SW	DDB_CONTROL_NO_CHECK_SYNC	Control No Check Sync	Man No Checksync
163	SW	DDB_AR_LOCKOUT	Autoclose Lockout/RLY BAR	AR Lockout
164	SW	DDB_AR_CB_UNHEALTHY	AR CB Unhealthy	AR CB Unhealthy
165	SW	DDB_AR_NO_SYS_CHECK	A/R No Sys Check	AR No Sys Check
166	SW	DDB_SYSTEM_SPLIT_ALARM	System Split Alarm	System Split
167	SW	DDB_UNDERVOLTAGE_BLOCK	Blocks advanced frequency load shedding	UV Block
168	PSL	DDB_USER_ALARM_1	User definable Self Reset Alarm 1	SR User Alarm 1
169	PSL	DDB_USER_ALARM_2	User definable Self Reset Alarm 2	SR User Alarm 2
170	PSL	DDB_USER_ALARM_3	User definable Self Reset Alarm 3	SR User Alarm 3
171	PSL	DDB_USER_ALARM_4	User definable Self Reset Alarm 4	SR User Alarm 4
172	PSL	DDB_USER_ALARM_5	User definable Self Reset Alarm 5	SR User Alarm 5
173	PSL	DDB_USER_ALARM_6	User definable Self Reset Alarm 6	SR User Alarm 6

DDB No	Source	Element Name	Description	English Text
174	PSL	DDB_USER_ALARM_7	User definable Self Reset Alarm 7	SR User Alarm 7
175	PSL	DDB_USER_ALARM_8	User definable Self Reset Alarm 8	SR User Alarm 8
176	PSL	DDB_USER_ALARM_9	User definable Self Reset Alarm 9	SR User Alarm 9
177	PSL	DDB_USER_ALARM_10	User definable Self Reset Alarm 10	SR User Alarm 10
178	PSL	DDB_USER_ALARM_11	User definable Self Reset Alarm 11	SR User Alarm 11
179	PSL	DDB_USER_ALARM_12	User definable Self Reset Alarm 12	SR User Alarm 12
180	PSL	DDB_USER_ALARM_13	User definable Self Reset Alarm 13	SR User Alarm 13
181	PSL	DDB_USER_ALARM_14	User definable Self Reset Alarm 14	SR User Alarm 14
182	PSL	DDB_USER_ALARM_15	User definable Self Reset Alarm 15	SR User Alarm 15
183	PSL	DDB_USER_ALARM_16	User definable Self Reset Alarm 16	SR User Alarm 16
184	PSL	DDB_USER_ALARM_17	User definable Self Reset Alarm 17	SR User Alarm 17
185	PSL	DDB_USER_ALARM_18	User definable Manual Reset Alarm 18	MR User Alarm 18
186	PSL	DDB_USER_ALARM_19	User definable Manual Reset Alarm 19	MR User Alarm 19
187	PSL	DDB_USER_ALARM_20	User definable Manual Reset Alarm 20	MR User Alarm 20
188	PSL	DDB_USER_ALARM_21	User definable Manual Reset Alarm 21	MR User Alarm 21
189	PSL	DDB_USER_ALARM_22	User definable Manual Reset Alarm 22	MR User Alarm 22
190	PSL	DDB_USER_ALARM_23	User definable Manual Reset Alarm 23	MR User Alarm 23
191	PSL	DDB_USER_ALARM_24	User definable Manual Reset Alarm 24	MR User Alarm 24
192	PSL	DDB_USER_ALARM_25	User definable Manual Reset Alarm 25	MR User Alarm 25
193	PSL	DDB_USER_ALARM_26	User definable Manual Reset Alarm 26	MR User Alarm 26
194	PSL	DDB_USER_ALARM_27	User definable Manual Reset Alarm 27	MR User Alarm 27
195	PSL	DDB_USER_ALARM_28	User definable Manual Reset Alarm 28	MR User Alarm 28
196	PSL	DDB_USER_ALARM_29	User definable Manual Reset Alarm 29	MR User Alarm 29
197	PSL	DDB_USER_ALARM_30	User definable Manual Reset Alarm 30	MR User Alarm 30
198	PSL	DDB_USER_ALARM_31	User definable Manual Reset Alarm 31	MR User Alarm 31
199	PSL	DDB_USER_ALARM_32	User definable Manual Reset Alarm 32	MR User Alarm 32
200	PSL	DDB_USER_ALARM_33	User definable Manual Reset Alarm 33	MR User Alarm 33
201	PSL	DDB_USER_ALARM_34	User definable Manual Reset Alarm 34	MR User Alarm 34
202	PSL	DDB_USER_ALARM_35	User definable Manual Reset Alarm 35	MR User Alarm 35
203	PSL	DDB_POC_1_TIMER_BLOCK	Block Phase Overcurrent Stage 1 time delay	I>1 Timer Block
204	PSL	DDB_POC_2_TIMER_BLOCK	Block Phase Overcurrent Stage 2 time delay	I>2 Timer Block
205	PSL	DDB_POC_3_TIMER_BLOCK	Block Phase Overcurrent Stage 3 time delay	I>3 Timer Block
206	PSL	DDB_POC_4_TIMER_BLOCK	Block Phase Overcurrent Stage 4 time delay	I>4 Timer Block
207	PSL	DDB_INHIBIT_CBF	Inhibit CBF	Inhibit CBF
208	PSL	DDB_EF1_1_TIMER_BLOCK	Block Earth Fault #1 Stage 1 time delay	IN1>1 Timer Blk
209	PSL	DDB_EF1_2_TIMER_BLOCK	Block Earth Fault #1 Stage 2 time delay	IN1>2 Timer Blk
210	PSL	DDB_EF1_3_TIMER_BLOCK	Block Earth Fault #1 Stage 3 time delay	IN1>3 Timer Blk
211	PSL	DDB_EF1_4_TIMER_BLOCK	Block Earth Fault #1 Stage 4 time delay	IN1>4 Timer Blk
212	PSL	DDB_EF2_1_TIMER_BLOCK	Block Earth Fault #2 Stage 1 time delay	IN2>1 Timer Blk
213	PSL	DDB_EF2_2_TIMER_BLOCK	Block Earth Fault #2 Stage 2 time delay	IN2>2 Timer Blk
214	PSL	DDB_EF2_3_TIMER_BLOCK	Block Earth Fault #2 Stage 3 time delay	IN2>3 Timer Blk
215	PSL	DDB_EF2_4_TIMER_BLOCK	Block Earth Fault #2 Stage 4 time delay	IN2>4 Timer Blk
216	PSL	DDB_SEF_1_TIMER_BLOCK	Block SEF Stage 1 time delay	ISEF>1 Timer Blk
217	PSL	DDB_SEF_2_TIMER_BLOCK	Block SEF Stage 2 time delay	ISEF>2 Timer Blk

DDB No	Source	Element Name	Description	English Text
218	PSL	DDB_SEF_3_TIMER_BLOCK	Block SEF Stage 3 time delay	ISEF>3 Timer Blk
219	PSL	DDB_SEF_4_TIMER_BLOCK	Block SEF Stage 4 time delay	ISEF>4 Timer Blk
220	PSL	DDB_RESOV_1_TIMER_BLOCK	Block Residual Overvoltage Stage 1 time delay	VN>1 Timer Blk
221	PSL	DDB_RESOV_2_TIMER_BLOCK	Block Residual Overvoltage Stage 2 time delay	VN>2 Timer Blk
222	PSL	DDB_PUV_1_TIMER_BLOCK	Block Phase Undervoltage Stage 1 time delay	V<1 Timer Block
223	PSL	DDB_PUV_2_TIMER_BLOCK	Block Phase Undervoltage Stage 2 time delay	V<2 Timer Block
224	PSL	DDB_POV_1_TIMER_BLOCK	Block Phase Overvoltage Stage 1 time delay	V>1 Timer Block
225	PSL	DDB_POV_2_TIMER_BLOCK	Block Phase Overvoltage Stage 4 time delay	V>2 Timer Block
226	PSL	DDB_CLP_INITIATE	CLP Initiate	CLP Initiate
227	PSL	DDB_EXTERNAL_TRIP_3PH	External Trip 3ph	Ext. Trip 3ph
228	PSL	DDB_CB_THREE_PHASE_52A	52-A (3 phase)	CB Aux 3ph(52-A)
229	PSL	DDB_CB_THREE_PHASE_52B	52-B (3 phase)	CB Aux 3ph(52-B)
230	PSL	DDB_CB_HEALTHY	CB Healthy	CB Healthy
231	PSL	DDB_VTS_MCB_OPTO	MCB/VTS opto	MCB/VTS
232	PSL	DDB_LOGIC_INPUT_TRIP	Logic Input Trip	Init Trip CB
233	PSL	DDB_LOGIC_INPUT_CLOSE	Logic Input Close	Init Close CB
234	PSL	DDB_RESET_CB_CLOSE_DELAY	Reset Manual CB Close Time Delay	Reset Close Dly
235	PSL	DDB_RESET_RELAYS_LEDS	Reset Latched Relays & LED’s	Reset Relays/LED
236	PSL	DDB_RESET_THERMAL	Reset Thermal State	Reset Thermal
237	PSL	DDB_RESET_LOCKOUT	Reset Lockout Opto Input	Reset Lockout
238	PSL	DDB_RESET_ALL_VALUES	Reset CB Maintenance Values	Reset CB Data
239	PSL	DDB_BLOCK_AR	Block Autoreclose / BAR	Block AR
240	PSL	DDB_LIVE_LINE_MODE	Live Line Operation	Live Line Mode
241	PSL	DDB_AUTO_MODE	Auto Mode Operation	Auto Mode
242	PSL	DDB_TELECONTROL_MODE	Telecontrol Mode Operation	Telecontrol Mode
243	SW	DDB_POC_1_3PH_TRIP	1st Stage O/C Trip 3ph	I>1 Trip
244	SW	DDB_POC_1_PH_A_TRIP	1st Stage O/C Trip A	I>1 Trip A
245	SW	DDB_POC_1_PH_B_TRIP	1st Stage O/C Trip B	I>1 Trip B
246	SW	DDB_POC_1_PH_C_TRIP	1st Stage O/C Trip C	I>1 Trip C
247	SW	DDB_POC_2_3PH_TRIP	2nd Stage O/C Trip 3ph	I>2 Trip
248	SW	DDB_POC_2_PH_A_TRIP	2nd Stage O/C Trip A	I>2 Trip A
249	SW	DDB_POC_2_PH_B_TRIP	2nd Stage O/C Trip B	I>2 Trip B
250	SW	DDB_POC_2_PH_C_TRIP	2nd Stage O/C Trip C	I>2 Trip C
251	SW	DDB_POC_3_3PH_TRIP	3rd Stage O/C Trip 3ph	I>3 Trip
252	SW	DDB_POC_3_PH_A_TRIP	3rd Stage O/C Trip A	I>3 Trip A
253	SW	DDB_POC_3_PH_B_TRIP	3rd Stage O/C Trip B	I>3 Trip B
254	SW	DDB_POC_3_PH_C_TRIP	3rd Stage O/C Trip C	I>3 Trip C
255	SW	DDB_POC_4_3PH_TRIP	4th Stage O/C Trip 3ph	I>4 Trip
256	SW	DDB_POC_4_PH_A_TRIP	4th Stage O/C Trip A	I>4 Trip A
257	SW	DDB_POC_4_PH_B_TRIP	4th Stage O/C Trip B	I>4 Trip B
258	SW	DDB_POC_4_PH_C_TRIP	4th Stage O/C Trip C	I>4 Trip C
259	SW	DDB_DST_STATUS	If this location DST is in effect now	DST status
260	SW	DDB_BROKEN_CONDUCTOR_TRIP	Broken Conductor Trip	Broken Line Trip
261	SW	DDB_EF1_1_TRIP	1st Stage EF#1 Trip	IN1>1 Trip

DDB No	Source	Element Name	Description	English Text
262	SW	DDB_EF1_2_TRIP	2nd Stage EF#1 Trip	IN1>2 Trip
263	SW	DDB_EF1_3_TRIP	3rd Stage EF#1 Trip	IN1>3 Trip
264	SW	DDB_EF1_4_TRIP	4th Stage EF#1 Trip	IN1>4 Trip
265	SW	DDB_EF2_1_TRIP	1st Stage EF#2 Trip	IN2>1 Trip
266	SW	DDB_EF2_2_TRIP	2nd Stage EF#2 Trip	IN2>2 Trip
267	SW	DDB_EF2_3_TRIP	3rd Stage EF#2 Trip	IN2>3 Trip
268	SW	DDB_EF2_4_TRIP	4th Stage EF#2 Trip	IN2>4 Trip
269	SW	DDB_SEF_1_TRIP	1st Stage SEF Trip	ISEF>1 Trip
270	SW	DDB_SEF_2_TRIP	2nd Stage SEF Trip	ISEF>2 Trip
271	SW	DDB_SEF_3_TRIP	3rd Stage SEF Trip	ISEF>3 Trip
272	SW	DDB_SEF_4_TRIP	4th Stage SEF Trip	ISEF>4 Trip
273	SW	DDB_REF_TRIP	REF Trip	IREF> Trip
274	SW	DDB_RESOV_1_TRIP	1st Stage Residual O/V Trip	VN>1 Trip
275	SW	DDB_RESOV_2_TRIP	2nd Stage Residual O/V Trip	VN>2 Trip
276	SW	DDB_THERMAL_TRIP	Thermal Overload Trip	Thermal Trip
277	SW	DDB_NEGSEQOV_TRIP	Negative Sequence O/V Trip	V2> Trip
278	SW	DDB_PUV_1_3PH_TRIP	1st Stage Phase U/V Trip 3ph	V<1 Trip
279	SW	DDB_PUV_1_PH_A_TRIP	1st Stage Phase U/V Trip A/AB	V<1 Trip A/AB
280	SW	DDB_PUV_1_PH_B_TRIP	1st Stage Phase U/V Trip B/BC	V<1 Trip B/BC
281	SW	DDB_PUV_1_PH_C_TRIP	1st Stage Phase U/V Trip C/CA	V<1 Trip C/CA
282	SW	DDB_PUV_2_3PH_TRIP	2nd Stage Phase U/V Trip 3ph	V<2 Trip
283	SW	DDB_PUV_2_PH_A_TRIP	2nd Stage Phase U/V Trip A/AB	V<2 Trip A/AB
284	SW	DDB_PUV_2_PH_B_TRIP	2nd Stage Phase U/V Trip B/BC	V<2 Trip B/BC
285	SW	DDB_PUV_2_PH_C_TRIP	2nd Stage Phase U/V Trip C/CA	V<2 Trip C/CA
286	SW	DDB_POV_1_3PH_TRIP	1st Stage Phase O/V Trip 3ph	V>1 Trip
287	SW	DDB_POV_1_PH_A_TRIP	1st Stage Phase O/V Trip A/AB	V>1 Trip A/AB
288	SW	DDB_POV_1_PH_B_TRIP	1st Stage Phase O/V Trip B/BC	V>1 Trip B/BC
289	SW	DDB_POV_1_PH_C_TRIP	1st Stage Phase O/V Trip C/CA	V>1 Trip C/CA
290	SW	DDB_POV_2_3PH_TRIP	2nd Stage Phase O/V Trip 3ph	V>2 Trip
291	SW	DDB_POV_2_PH_A_TRIP	2nd Stage Phase O/V Trip A/AB	V>2 Trip A/AB
292	SW	DDB_POV_2_PH_B_TRIP	2nd Stage Phase O/V Trip B/BC	V>2 Trip B/BC
293	SW	DDB_POV_2_PH_C_TRIP	2nd Stage Phase O/V Trip C/CA	V>2 Trip C/CA
294	FL	DDB_ANY_START	Any Start	Any Start
295	SW	DDB_POC_1_3PH_START	1st Stage O/C Start 3ph	I>1 Start
296	SW	DDB_POC_1_PH_A_START	1st Stage O/C Start A	I>1 Start A
297	SW	DDB_POC_1_PH_B_START	1st Stage O/C Start B	I>1 Start B
298	SW	DDB_POC_1_PH_C_START	1st Stage O/C Start C	I>1 Start C
299	SW	DDB_POC_2_3PH_START	2nd Stage O/C Start 3ph	I>2 Start
300	SW	DDB_POC_2_PH_A_START	2nd Stage O/C Start A	I>2 Start A
301	SW	DDB_POC_2_PH_B_START	2nd Stage O/C Start B	I>2 Start B
302	SW	DDB_POC_2_PH_C_START	2nd Stage O/C Start C	I>2 Start C
303	SW	DDB_POC_3_3PH_START	3rd Stage O/C Start 3ph	I>3 Start
304	SW	DDB_POC_3_PH_A_START	3rd Stage O/C Start A	I>3 Start A
305	SW	DDB_POC_3_PH_B_START	3rd Stage O/C Start B	I>3 Start B

DDB No	Source	Element Name	Description	English Text
306	SW	DDB_POC_3_PH_C_START	3rd Stage O/C Start C	I>3 Start C
307	SW	DDB_POC_4_3PH_START	4th Stage O/C Start 3ph	I>4 Start
308	SW	DDB_POC_4_PH_A_START	4th Stage O/C Start A	I>4 Start A
309	SW	DDB_POC_4_PH_B_START	4th Stage O/C Start B	I>4 Start B
310	SW	DDB_POC_4_PH_C_START	4th Stage O/C Start C	I>4 Start C
311	SW	DDB_VCO_PH_AB_START	Voltage Controlled O/C Start AB	VDep OC Start AB
312	SW	DDB_VCO_PH_BC_START	Voltage Controlled O/C Start BC	VDep OC Start BC
313	SW	DDB_VCO_PH_CA_START	Voltage Controlled O/C Start CA	VDep OC Start CA
314	SW	DDB_ACEPT_SIMULATED_ALM	IEC 61850 accept simulated GOOSE and SV alarm	Sim.Signal Alm
315	SW	DDB_EF1_1_START	1st Stage EF#1 Start	IN1>1 Start
316	SW	DDB_EF1_2_START	2nd Stage EF#1 Start	IN1>2 Start
317	SW	DDB_EF1_3_START	3rd Stage EF#1 Start	IN1>3 Start
318	SW	DDB_EF1_4_START	4th Stage EF#1 Start	IN1>4 Start
319	SW	DDB_EF2_1_START	1st Stage EF#2 Start	IN2>1 Start
320	SW	DDB_EF2_2_START	2nd Stage EF#2 Start	IN2>2 Start
321	SW	DDB_EF2_3_START	3rd Stage EF#2 Start	IN2>3 Start
322	SW	DDB_EF2_4_START	4th Stage EF#2 Start	IN2>4 Start
323	SW	DDB_SEF_1_START	1st Stage SEF Start	ISEF>1 Start
324	SW	DDB_SEF_2_START	2nd Stage SEF Start	ISEF>2 Start
325	SW	DDB_SEF_3_START	3rd Stage SEF Start	ISEF>3 Start
326	SW	DDB_SEF_4_START	4th Stage SEF Start	ISEF>4 Start
327	SW	DDB_RESOV_1_START	1st Stage Residual O/V Start	VN>1 Start
328	SW	DDB_RESOV_2_START	2nd Stage Residual O/V Start	VN>2 Start
329	SW	DDB_THERMAL_ALARM	Thermal Overload Alarm	Thermal Alarm
330	SW	DDB_NEGSEQOV_START	Negative Sequence O/V Start	V2> Start
331	SW	DDB_PUV_1_3PH_START	1st Stage Phase U/V Start 3ph	V<1 Start
332	SW	DDB_PUV_1_PH_A_START	1st Stage Phase U/V Start A/AB	V<1 Start A/AB
333	SW	DDB_PUV_1_PH_B_START	1st Stage Phase U/V Start B/BC	V<1 Start B/BC
334	SW	DDB_PUV_1_PH_C_START	1st Stage Phase U/V Start C/CA	V<1 Start C/CA
335	SW	DDB_PUV_2_3PH_START	2nd Stage Phase U/V Start 3ph	V<2 Start
336	SW	DDB_PUV_2_PH_A_START	2nd Stage Phase U/V Start A/AB	V<2 Start A/AB
337	SW	DDB_PUV_2_PH_B_START	2nd Stage Phase U/V Start B/BC	V<2 Start B/BC
338	SW	DDB_PUV_2_PH_C_START	2nd Stage Phase U/V Start C/CA	V<2 Start C/CA
339	SW	DDB_POV_1_3PH_START	1st Stage Phase O/V Start 3ph	V>1 Start
340	SW	DDB_POV_1_PH_A_START	1st Stage Phase O/V Start A/AB	V>1 Start A/AB
341	SW	DDB_POV_1_PH_B_START	1st Stage Phase O/V Start B/BC	V>1 Start B/BC
342	SW	DDB_POV_1_PH_C_START	1st Stage Phase O/V Start C/CA	V>1 Start C/CA
343	SW	DDB_POV_2_3PH_START	2nd Stage Phase O/V Start 3ph	V>2 Start
344	SW	DDB_POV_2_PH_A_START	2nd Stage Phase O/V Start A/AB	V>2 Start A/AB
345	SW	DDB_POV_2_PH_B_START	2nd Stage Phase O/V Start B/BC	V>2 Start B/BC
346	SW	DDB_POV_2_PH_C_START	2nd Stage Phase O/V Start C/CA	V>2 Start C/CA
347	SW	DDB_CLP_OPERATION	Cold Load Pickup Operation	CLP Operation
348	SW	DDB_PH_BLOCKED_OC_START	I> Blocked O/C Start	I> BlockStart
349	SW	DDB_N_BLOCKED_OC_START	IN/ISEF> Blocked O/C Start	IN/SEF>Blk Start

DDB No	Source	Element Name	Description	English Text
350	SW	DDB_VTS_FAST_BLOCK	VTS Fast Block	VTS Fast Block
351	SW	DDB_VTS_SLOW_BLOCK	VTS Slow Block	VTS Slow Block
352	SW	DDB_CTS_BLOCK	CTS Block	CTS Block
353	SW	DDB_CBF1_TRIP_3PH	tBF1 Trip 3Ph	Bfail1 Trip 3ph
354	SW	DDB_CBF2_TRIP_3PH	tBF2 Trip 3Ph	Bfail2 Trip 3ph
355	SW	DDB_CONTROL_TRIP	Control Trip	Control Trip
356	SW	DDB_CONTROL_CLOSE	Control Close	Control Close
357	SW	DDB_CONTROL_CLOSE_IN_PROGRESS	Control Close in Progress	Close in Prog
358	SW	DDB_AR_BLOCK_MAIN_PROTECTION	AR Block Main Protection	Block Main Prot
359	SW	DDB_AR_BLOCK_SEF_PROTECTION	AR Block SEF Protection	Block SEF Prot
360	SW	DDB_AR_3_POLE_IN_PROGRESS	Autoreclose In Progress	AR In Progress
361	SW	DDB_AR_IN_SERVICE	Autoreclose In/Out of service	AR In Service
362	SW	DDB_SEQ_COUNT_0	Seq Counter = 0	Seq Counter = 0
363	SW	DDB_SEQ_COUNT_1	Seq Counter = 1	Seq Counter = 1
364	SW	DDB_SEQ_COUNT_2	Seq Counter = 2	Seq Counter = 2
365	SW	DDB_SEQ_COUNT_3	Seq Counter = 3	Seq Counter = 3
366	SW	DDB_SEQ_COUNT_4	Seq Counter = 4	Seq Counter = 4
367	SW	DDB_AR_SUCCESSFUL_RECLOSE	Successful Reclosure	Successful Close
368	SW	DDB_DEAD_TIME_IN_PROGRESS	Dead Time in Progress	Dead T in Prog
369	SW	DDB_AR_PROTECTION_LOCKOUT	Protection Lockout of AR	Protection Lockt
370	SW	DDB_AR_RESET_LOCKOUT_ALARM	AR Reset Lockout Alarm	Reset Lckout Alm
371	SW	DDB_AUTO_CLOSE	Auto Close/ AR Close	Auto Close
372	SW	DDB_AR_TRIP_TEST	Autoreclose trip test	AR Trip Test
373	SW	DDB_PHASE_A_UNDERCURRENT	IA< operate	IA< Start
374	SW	DDB_PHASE_B_UNDERCURRENT	IB< operate	IB< Start
375	SW	DDB_PHASE_C_UNDERCURRENT	IC< operate	IC< Start
376	SW	DDB_EF_UNDERCURRENT	IN< operate	IN< Start
377	SW	DDB_SEF_UNDERCURRENT	ISEF< operate	ISEF< Start
378	SW	DDB_CB_OPEN	3 ph CB Open	CB Open 3 ph
379	SW	DDB_CB_CLOSED	3 ph CB Closed	CB Closed 3 ph
380	SW	DDB_ALL_POLEDEAD	All Poles Dead	All Poles Dead
381	SW	DDB_ANY_POLEDEAD	Any Pole Dead	Any Pole Dead
382	SW	DDB_PHASE_A_POLEDEAD	Phase A Pole Dead	Pole Dead A
383	SW	DDB_PHASE_B_POLEDEAD	Phase B Pole Dead	Pole Dead B
384	SW	DDB_PHASE_C_POLEDEAD	Phase C Pole Dead	Pole Dead C
385	FL	DDB_VTS_ACCELERATE_INPUT	Accelerate Ind	VTS Acc Ind
386	FL	DDB_VTS_ANY_VOLTAGE_DEP_FN	Any Voltage Dependent	VTS Volt Dep
387	SW	DDB_VTS_IA_OPERATED	Ia over threshold	VTS IA>
388	SW	DDB_VTS_IB_OPERATED	Ib over threshold	VTS IB>
389	SW	DDB_VTS_IC_OPERATED	Ic over threshold	VTS IC>
390	SW	DDB_VTS_VA_OPERATED	Va over threshold	VTS VA>
391	SW	DDB_VTS_VB_OPERATED	Vb over threshold	VTS VB>
392	SW	DDB_VTS_VC_OPERATED	Vc over threshold	VTS VC>
393	SW	DDB_VTS_I2_OPERATED	I2 over threshold	VTS I2>

DDB No	Source	Element Name	Description	English Text
394	SW	DDB_VTS_V2_OPERATED	V2 over threshold	VTS V2>
395	SW	DDB_VTS_DELTA_IA_OPERATED	Superimposed Ia over threshold	VTS IA delta>
396	SW	DDB_VTS_DELTA_IB_OPERATED	Superimposed Ib over threshold	VTS IB delta>
397	SW	DDB_VTS_DELTA_IC_OPERATED	Superimposed Ic over threshold	VTS IC delta>
398	FL	DDB_CURRENT_PROT_SEF_TRIP	CBF Current Prot SEF Trip	CBF SEF Trip
399	FL	DDB_CBF_NON_CURRENT_PROT_TRIP	CBF Non Current Prot Trip	CBF Non I Trip
400	FL	DDB_CBF_SEF_STAGE_TRIP	Fixed Logic CBF SEF Stage Trip	CBF SEF Trip-1
401	FL	DDB_CBF_NON_CURRENT_STAGE_TRIP	Fixed Logic CBF Non Current Protection Stage Trip	CBF Non I Trip-1
402	PSL	DDB_SYNC_CTRL_SYS_CHECK_OK	Control System Checks OK	Man Check Synch
403	PSL	DDB_SYNC_AR_SYS_CHECK_OK	AR System Checks OK	AR Sys Checks OK
404	SW	DDB_CB_LOCKOUT_ALARM	Composite Lockout Alarm	Lockout Alarm
405	SW	DDB_CB_PRE_LOCKOUT	Pre-Lockout	Pre-Lockout
406	SW	DDB_FREQ_ABOVE_RANGE_LIMIT	Freq High	Freq High
407	SW	DDB_FREQ_BELOW_RANGE_LIMIT	Freq Low	Freq Low
408	FL	DDB_FREQ_STOP_TRACK	Stop Freq Track	Stop Freq Track
409	FL	DDB_EF_START	Composite EF Start	Start N
410	SW	DDB_FIELD_VOLTS_FAIL	Field Voltage Failure	Field volts fail
411	SW	DDB_FREQ_NOT_FOUND	Freq Not Found	Freq Not Found
412	PSL	DDB_UFREQ_1_TIMER_BLOCK	Block Underfrequency Stage 1 Timer	F<1 Timer Block
413	PSL	DDB_UFREQ_2_TIMER_BLOCK	Block Underfrequency Stage 2 Timer	F<2 Timer Block
414	PSL	DDB_UFREQ_3_TIMER_BLOCK	Block Underfrequency Stage 3 Timer	F<3 Timer Block
415	PSL	DDB_UFREQ_4_TIMER_BLOCK	Block Underfrequency Stage 4 Timer	F<4 Timer Block
416	PSL	DDB_OFREQ_1_TIMER_BLOCK	Block Overfrequency Stage 1 Timer	F>1 Timer Block
417	PSL	DDB_OFREQ_2_TIMER_BLOCK	Block Overfrequency Stage 2 Timer	F>2 Timer Block
418	SW	DDB_UFREQ_1_START	Under frequency Stage 1 START	F<1 Start
419	SW	DDB_UFREQ_2_START	Under frequency Stage 2 START	F<2 Start
420	SW	DDB_UFREQ_3_START	Under frequency Stage 3 START	F<3 Start
421	SW	DDB_UFREQ_4_START	Under frequency Stage 4 START	F<4 Start
422	SW	DDB_OFREQ_1_START	Over frequency Stage 1 START	F>1 Start
423	SW	DDB_OFREQ_2_START	Over frequency Stage 2 START	F>2 Start
424	SW	DDB_UFREQ_1_TRIP	Under frequency Stage 1 trip	F<1 Trip
425	SW	DDB_UFREQ_2_TRIP	Under frequency Stage 2 trip	F<2 Trip
426	SW	DDB_UFREQ_3_TRIP	Under frequency Stage 3 trip	F<3 Trip
427	SW	DDB_UFREQ_4_TRIP	Under frequency Stage 4 trip	F<4 Trip
428	SW	DDB_OFREQ_1_TRIP	Over frequency Stage 1 Trip	F>1 Trip
429	SW	DDB_OFREQ_2_TRIP	Over frequency Stage 2 Trip	F>2 Trip
430	PSL	DDB_YN_TIMER_BLOCK	Block Overadmittance Timer	YN> Timer Block
431	PSL	DDB_GN_TIMER_BLOCK	Block Overconductance Timer	GN> Timer Block
432	PSL	DDB_BN_TIMER_BLOCK	Block Oversusceptance Timer	BN> Timer Block
433	SW	DDB_YN_START	Overadmittance Start	YN> Start
434	SW	DDB_GN_START	Overconductance Start	GN> Start
435	SW	DDB_BN_START	Oversusceptance Start	BN> Start
436	SW	DDB_YN_TRIP	Overadmittance Trip	YN> Trip
437	SW	DDB_GN_TRIP	Overconductance Trip	GN> Trip

DDB No	Source	Element Name	Description	English Text
438	SW	DDB_BN_TRIP	Oversusceptance Trip	BN> Trip
439	PSL	DDB_EXT_AR_PROT_TRIP	External Initiate AR Protection Trip	Ext AR Prot Trip
440	PSL	DDB_EXT_AR_PROT_START	External Initiate AR Protection Start	Ext AR Prot Strt
441	PSL	DDB_TEST_MODE	Initiate Test Mode	Test Mode
442	PSL	DDB_SEF_INHIBIT	Inhibit SEF	Inhibit SEF
443	SW	DDB_SYSCHECKS_LINE_LIVE	Live Line	Live Line
444	SW	DDB_SYSCHECKS_LINE_DEAD	Dead Line	Dead Line
445	SW	DDB_SYSCHECKS_BUS_LIVE	Live Line	Live Bus
446	SW	DDB_SYSCHECKS_BUS_DEAD	Dead Line	Dead Bus
447	SW	DDB_CHECKSYNC_1_OK	Check Sync 1 OK	Check Sync 1 OK
448	SW	DDB_CHECKSYNC_2_OK	Check Sync 2 OK	Check Sync 2 OK
449	SW	DDB_SYSCHECKS_INACTIVE	SysChks Inactive	SysChks Inactive
450	PSL	DDB_CHECKSYNC_1_ENABLED	CS1 Enabled	CS1 Enabled
451	PSL	DDB_CHECKSYNC_2_ENABLED	CS2 Enabled	CS2 Enabled
452	PSL	DDB_SYSTEM_SPLIT_ENABLED	SysSplit Enabled	SysSplit Enabled
453	PSL	DDB_DAR_COMPLETE	DAR Complete	DAR Complete
454	PSL	DDB_CB_IN_SERVICE	CB in Service	CB in Service
455	PSL	DDB_AR_RESTART	AR Restart	AR Restart
456	SW	DDB_AR_IP_1	AR In Progress 1	AR In Progress 1
457	PSL	DDB_DEADTIME_ENABLE	DeadTime Enabled	DeadTime Enabled
458	PSL	DDB_DEADTIME_OK_TO_START	DT OK To Start	DT OK To Start
459	SW	DDB_DEADTIME_COMPLETE	DT Complete	DT Complete
460	SW	DDB_ARCHECKS_IN_PROGRESS	Reclose Checks In Progress	Reclose Checks
461	PSL	DDB_AR_LIVEDEAD_CCTS_OK	Live/Dead Circuits OK	Circuits OK
462	SW	DDB_AR_SYNC_CHECK	AR Sync Check	AR Sync Check
463	SW	DDB_AR_SYSTEMCHECKS_OK	AR SysChecks OK	AR SysChecks OK
464	PSL	DDB_INIT_AR_TRIP_TEST	AR Init TripTest	AR Init TripTest
465	PSL	DDB_MONITOR_BLOCKING	Monitor Block	103 MonitorBlock
466	PSL	DDB_COMMAND_BLOCKING	Command Block	103 CommandBlock
467	SW	DDB_SEF_1_START_2	1st Stage SEF Start 2	ISEF>1 Start 2
468	SW	DDB_SEF_2_START_2	2nd Stage SEF Start 2	ISEF>2 Start 2
469	SW	DDB_SEF_3_START_2	3rd Stage SEF Start 2	ISEF>3 Start 2
470	SW	DDB_SEF_4_START_2	4th Stage SEF Start 2	ISEF>4 Start 2
471	SW	DDB_CS1_SLIP_ABOVE_SETTING	Check Synch 1 Slip > Setting	CS1 Slipfreq>
472	SW	DDB_CS1_SLIP_BELOW_SETTING	Check Synch 1 Slip < Setting	CS1 Slipfreq<
473	SW	DDB_CS2_SLIP_ABOVE_SETTING	Check Synch 2 Slip > Setting	CS2 Slipfreq>
474	SW	DDB_CS2_SLIP_BELOW_SETTING	Check Synch 2 Slip < Setting	CS2 Slipfreq<
475	PSL	DDB_TIME_SYNCH	Perform basic time synchronisation	Time Synch
476	PSL	DDB_DFDT_INHIBIT	Inhibit df/dt protection	df/dt> Inhibit
477	PSL	DDB_DFDT_1_TIMER_BLOCK	Block ROCOF Stage 1 Timer	df/dt>1 Tmr Blk
478	PSL	DDB_DFDT_2_TIMER_BLOCK	Block ROCOF Stage 2 Timer	df/dt>2 Tmr Blk
479	PSL	DDB_DFDT_3_TIMER_BLOCK	Block ROCOF Stage 3 Timer	df/dt>3 Tmr Blk
480	PSL	DDB_DFDT_4_TIMER_BLOCK	Block ROCOF Stage 4 Timer	df/dt>4 Tmr Blk

DDB No	Source	Element Name	Description	English Text
481	SW	DDB_DFDT_1_START	ROCOF Stage 1 Start	df/dt>1 Start
482	SW	DDB_DFDT_2_START	ROCOF Stage 2 Start	df/dt>2 Start
483	SW	DDB_DFDT_3_START	ROCOF Stage 3 Start	df/dt>3 Start
484	SW	DDB_DFDT_4_START	ROCOF Stage 4 Start	df/dt>4 Start
485	SW	DDB_DFDT_1_TRIP	ROCOF Stage 1 Trip	df/dt>1 Trip
486	SW	DDB_DFDT_2_TRIP	ROCOF Stage 2 Trip	df/dt>2 Trip
487	SW	DDB_DFDT_3_TRIP	ROCOF Stage 3 Trip	df/dt>3 Trip
488	SW	DDB_DFDT_4_TRIP	ROCOF Stage 4 Trip	df/dt>4 Trip
489	SW	DDB_SYSCHECKS_VLINE_UV	Line volts less than CS undervoltage setting	CS Vline<
490	SW	DDB_SYSCHECKS_VBUS_UV	Bus volts less than CS undervoltage setting	CS Vbus<
491	SW	DDB_SYSCHECKS_VLINE_OV	Line volts greater than CS overvoltage setting	CS Vline>
492	SW	DDB_SYSCHECKS_VBUS_OV	Bus volts greater than CS overvoltage setting	CS Vbus>
493	SW	DDB_SYSCHECKS_VLINE_DIFF_HIGH	Line volts greater than (bus volts + CS diff voltage setting)	CS Vline>Vbus
494	SW	DDB_SYSCHECKS_VBUS_DIFF_HIGH	Bus volts greater than (line volts + CS diff voltage setting)	CS Vline<Vbus
495	SW	DDB_CS1_LINE_FREQ_GT_BUS_FREQ	Line freq greater than (bus freq + CS1 slip freq setting)	CS1 Fline>Fbus
496	SW	DDB_CS1_LINE_FREQ_LT_BUS_FREQ	Bus freq greater than (line freq + CS1 slip freq setting)	CS1 Fline<Fbus
497	SW	DDB_CS1_ANG_NOT_OK_POS	Line angle in range (CS1 ang setting to +180 deg)	CS1 Ang Not OK +
498	SW	DDB_CS1_ANG_NOT_OK_NEG	Line angle in range (-CS1 ang setting to -180 deg)	CS1 Ang Not OK -
499	PSL	DDB_EXTERNAL_TRIP_A	External A Phase Trip initiates CB Fail	External Trip A
500	PSL	DDB_EXTERNAL_TRIP_B	External B Phase Trip initiates CB Fail	External Trip B
501	PSL	DDB_EXTERNAL_TRIP_C	External C Phase Trip initiates CB Fail	External Trip C
502	PSL	DDB_EXTERNAL_TRIP_EF	External EF Trip initiates CB Fail	External Trip EF
503	PSL	DDB_EXTERNAL_TRIP_SEF	External SEF Trip initiates CB Fail	External TripSEF
504	PSL	DDB_NPSOC_INHIBIT	Inhibit I2> protection	I2> Inhibit
505	PSL	DDB_NPSOC_1_TIMER_BLOCK	Block I2> Stage 1 Timer	I2>1 Tmr Blk
506	PSL	DDB_NPSOC_2_TIMER_BLOCK	Block I2> Stage 2 Timer	I2>2 Tmr Blk
507	PSL	DDB_NPSOC_3_TIMER_BLOCK	Block I2> Stage 3 Timer	I2>3 Tmr Blk
508	PSL	DDB_NPSOC_4_TIMER_BLOCK	Block I2> Stage 4 Timer	I2>4 Tmr Blk
509	SW	DDB_NPSOC_1_START	I2> Stage 1 Start	I2>1 Start
510	SW	DDB_NPSOC_2_START	I2> Stage 2 Start	I2>2 Start
511	SW	DDB_NPSOC_3_START	I2> Stage 3 Start	I2>3 Start
512	SW	DDB_NPSOC_4_START	I2> Stage 4 Start	I2>4 Start
513	SW	DDB_NPSOC_1_TRIP	I2> Stage 1 Trip	I2>1 Trip
514	SW	DDB_NPSOC_2_TRIP	I2> Stage 2 Trip	I2>2 Trip
515	SW	DDB_NPSOC_3_TRIP	I2> Stage 3 Trip	I2>3 Trip
516	SW	DDB_NPSOC_4_TRIP	I2> Stage 4 Trip	I2>4 Trip
517	PSL	DDB_ACCELERATE_NPSOV	Accelerate V2>	V2> Accelerate
518	PSL	DDB_TRIP_LED_TRIGGER	Trip LED Trigger	Trip LED Trigger
519	SW	DDB_CS2_LINE_FREQ_GT_BUS_FREQ	Line freq greater than (bus freq + CS2 slip freq setting)	CS2 Fline>Fbus
520	SW	DDB_CS2_LINE_FREQ_LT_BUS_FREQ	Bus freq greater than (line freq + CS2 slip freq setting)	CS2 Fline<Fbus
521	SW	DDB_CS2_ANG_NOT_OK_POS	Line angle in range (CS2 angle setting to +180 deg)	CS2 Ang Not OK +
522	SW	DDB_CS2_ANG_NOT_OK_NEG	Line angle in range (-CS2 angle setting to -180 deg)	CS2 Ang Not OK -
523	SW	DDB_SYSCHECKS_ANG_ACW	Line/Bus phase angle is rotating anti-clockwise	CS Ang Rot ACW

DDB No	Source	Element Name	Description	English Text
524	SW	DDB_SYSCHECKS_ANG_CW	Line/Bus phase angle is rotating clockwise	CS Ang Rot CW
525	PSL	DDB_BLOCK_REMOTE_CB_OPS	Blocks remote CB Trip/Close commands when asserted	Blk Rmt. CB Ops
526	PSL	DDB_SG_SELECTOR_X1	Binary coded setting group selector 1	SG Select x1
527	PSL	DDB_SG_SELECTOR_1X	Binary coded setting group selector 2	SG Select 1x
528	PSL	DDB_EF1_INHIBIT	Inhibit IN1> (Earth Fault 1) protection	IN1> Inhibit
529	PSL	DDB_EF2_INHIBIT	Inhibit IN2> (Earth Fault 2) protection	IN2> Inhibit
530	PSL	DDB_AR_SKIP_SHOT_1	Forces AR to skip shot 1 of a reclose sequence	AR Skip Shot 1
531	SW	DDB_LOGIC_0	Logic 0 for use in PSL (Never changes state!)	Logic 0 Ref.
532	PSL	DDB_AR_INHIBIT_RECLAIM_TIME	Inhibit AR Reclaim Timer	Inh Reclaim Time
533	SW	DDB_AR_RECLAIM_IN_PROGRESS	AR Reclaim Time In Progress	Reclaim In Prog
534	SW	DDB_AR_RECLAIM_TIME_COMPLETE	AR Reclaim Time Complete	Reclaim Complete
535	SW	DDB_BROKEN_CONDUCTOR_START	Broken Conductor Start	BrokenLine Start
536	PSL	DDB_ANY_TRIP	Trip Command initiated by DDB_TRIP_INITIATE	Trip Command In
537	FL	DDB_TRIP_INITIATE	Initiate Trip	Trip Command Out
538	SW	DDB_2ND_HARMONIC_IA	2nd Harmonic over threshold in IA	IA2H Start
539	SW	DDB_2ND_HARMONIC_IB	2nd Harmonic over threshold in IB	IB2H Start
540	SW	DDB_2ND_HARMONIC_IC	2nd Harmonic over threshold in IC	IC2H Start
541	SW	DDB_2ND_HARMONIC	2nd Harmonic over threshold in any of IA, IB or IC	I2H Any Start
542	PSL	DDB_RP1_READ_ONLY	Remote Read Only 1 DDB	RP1 Read Only
543	PSL	DDB_RP2_READ_ONLY	Remote Read Only 2 DDB	RP2 Read Only
544	PSL	DDB_NIC_READ_ONLY	Remote Read Only NIC DDB	NIC Read Only
545	SW	DDB_DVDT_1_PH_A_START	Stage 1:Phase A or AB Start	dv/dt1 StartA/AB
546	SW	DDB_DVDT_1_PH_B_START	Stage 1:Phase B or BC Start	dv/dt1 StartB/BC
547	SW	DDB_DVDT_1_PH_C_START	Stage 1:Phase C or CA Start	dv/dt1 StartC/CA
548	SW	DDB_DVDT_1_START	Stage 1:General Start can be any phase or three phase (changes by setting)	dv/dt1 Start
549	SW	DDB_DVDT_2_PH_A_START	Stage 2:Phase A or AB Start	dv/dt2 StartA/AB
550	SW	DDB_DVDT_2_PH_B_START	Stage 2:Phase B or BC Start	dv/dt2 StartB/BC
551	SW	DDB_DVDT_2_PH_C_START	Stage 2:Phase C or CA Start	dv/dt2 StartC/CA
552	SW	DDB_DVDT_2_START	Stage 2:General Start can be any phase or three phase (changes by setting)	dv/dt2 Start
553	SW	DDB_DVDT_1_PH_A_TRIP	Stage 1:Phase A or AB Trip	dv/dt1 Trip A/AB
554	SW	DDB_DVDT_1_PH_B_TRIP	Stage 1:Phase B or BC Trip	dv/dt1 Trip B/BC
555	SW	DDB_DVDT_1_PH_C_TRIP	Stage 1:Phase C or CA Trip	dv/dt1 Trip C/CA
556	SW	DDB_DVDT_1_TRIP	Stage 1:General Trip can be any phase or three phase (changes by setting)	dv/dt1 Trip
557	SW	DDB_DVDT_2_PH_A_TRIP	Stage 2:Phase A or AB Trip	dv/dt2 Trip A/AB
558	SW	DDB_DVDT_2_PH_B_TRIP	Stage 2:Phase B or BC Trip	dv/dt2 Trip B/BC
559	SW	DDB_DVDT_2_PH_C_TRIP	Stage 2:Phase C or CA Trip	dv/dt2 Trip C/CA
560	SW	DDB_DVDT_2_TRIP	Stage 2:General Trip can be any phase or three phase (changes by setting)	dv/dt2 Trip
561	PSL	DDB_DVDT_1_BLOCK	Stage1 block signal from PSL	dv/dt1 Blocking
562	PSL	DDB_DVDT_2_BLOCK	Stage2 block signal from PSL	dv/dt2 Blocking
563	SW	DDB_PHASE_A_ZCD	Zero crossing undercurrent phA	ZCD IA<
564	SW	DDB_PHASE_B_ZCD	Zero crossing undercurrent phB	ZCD IB<

DDB No	Source	Element Name	Description	English Text
565	SW	DDB_PHASE_C_ZCD	Zero crossing undercurrent phC	ZCD IC<
566	SW	DDB_EF_ZCD	Zero crossing undercurrent EF	ZCD IN<
567	PSL	DDB_POC_5_TIMER_BLOCK	Block Phase Overcurrent Stage 5 time delay	I>5 Timer Block
568	PSL	DDB_POC_6_TIMER_BLOCK	Block Phase Overcurrent Stage 6 time delay	I>6 Timer Block
569	SW	DDB_SEF_ZCD	Zero crossing undercurrent SEF	ZCD ISEF<
570	SW	DDB_POC_5_3PH_TRIP	5th Stage O/C Trip 3ph	I>5 Trip
571	SW	DDB_POC_5_PH_A_TRIP	5th Stage O/C Trip A	I>5 Trip A
572	SW	DDB_POC_5_PH_B_TRIP	5th Stage O/C Trip B	I>5 Trip B
573	SW	DDB_POC_5_PH_C_TRIP	5th Stage O/C Trip C	I>5 Trip C
574	SW	DDB_POC_6_3PH_TRIP	6th Stage O/C Trip 3ph	I>6 Trip
575	SW	DDB_POC_6_PH_A_TRIP	6th Stage O/C Trip A	I>6 Trip A
576	SW	DDB_POC_6_PH_B_TRIP	6th Stage O/C Trip B	I>6 Trip B
577	SW	DDB_POC_6_PH_C_TRIP	6th Stage O/C Trip C	I>6 Trip C
578	SW	DDB_INVALID_CONFIG_ALARM	Invalid IEC 61850 Configuration Alarm	Invalid Config.
579	SW	DDB_POC_5_3PH_START	5th Stage O/C Start 3ph	I>5 Start
580	SW	DDB_POC_5_PH_A_START	5th Stage O/C Start A	I>5 Start A
581	SW	DDB_POC_5_PH_B_START	5th Stage O/C Start B	I>5 Start B
582	SW	DDB_POC_5_PH_C_START	5th Stage O/C Start C	I>5 Start C
583	SW	DDB_POC_6_3PH_START	6th Stage O/C Start 3ph	I>6 Start
584	SW	DDB_POC_6_PH_A_START	6th Stage O/C Start A	I>6 Start A
585	SW	DDB_POC_6_PH_B_START	6th Stage O/C Start B	I>6 Start B
586	SW	DDB_POC_6_PH_C_START	6th Stage O/C Start C	I>6 Start C
587	SW	DDB_TEST_MODE_ALARM	Test Mode Activated Alarm	Test Mode Alm
588	SW	DDB_CONT_BLK_ALARM	Contacts Blocked Alarm	Contacts Blk Alm
589	SW	DDB_MONITOR1	Monitor bit 1	Monitor bit 1
590	SW	DDB_MONITOR2	Monitor bit 2	Monitor bit 2
591	SW	DDB_MONITOR3	Monitor bit 3	Monitor bit 3
592	SW	DDB_MONITOR4	Monitor bit 4	Monitor bit 4
593	SW	DDB_MONITOR5	Monitor bit 5	Monitor bit 5
594	SW	DDB_MONITOR6	Monitor bit 6	Monitor bit 6
595	SW	DDB_MONITOR7	Monitor bit 7	Monitor bit 7
596	SW	DDB_MONITOR8	Monitor bit 8	Monitor bit 8
597	SW	DDB_INVALID_DNPOE_IP_ALARM	Invalid DNPoE IP Configuration Alarm	Invalid DNPoE IP
598	SW	DDB_UNUSED_598		
599	SW	DDB_UNUSED_599		
600	SW	DDB_UNUSED_600		
601	SW	DDB_UNUSED_601		
602	SW	DDB_UNUSED_602		
603	SW	DDB_UNUSED_603		
604	SW	DDB_UNUSED_604		
605	SW	DDB_UNUSED_605		
606	SW	DDB_UNUSED_606		
607	SW	DDB_UNUSED_607		

DDB No	Source	Element Name	Description	English Text
608	SW	DDB_UNUSED_608		
609	SW	DDB_UNUSED_609		
610	SW	DDB_IRIGB_SIGNAL_VALID	IRIG-B Status Signal Valid	IRIG-B Valid
611	SW	DDB_UNUSED_611		
612	SW	DDB_UNUSED_612		
613	SW	DDB_UNUSED_613		
614	SW	DDB_UNUSED_614		
615	SW	DDB_UNUSED_615		
616	SW	DDB_UNUSED_616		
617	SW	DDB_UNUSED_617		
618	SW	DDB_UNUSED_618		
619	SW	DDB_UNUSED_619		
620	SW	DDB_UNUSED_620		
621	SW	DDB_UNUSED_621		
622	SW	DDB_UNUSED_622		
623	SW	DDB_UNUSED_623		
624	SW	DDB_UNUSED_624		
625	SW	DDB_UNUSED_625		
626	SW	DDB_UNUSED_626		
627	PSL	DDB_POC_LOAD_BLINDER_INHIBIT		Blinder Inhibit
628	SW	DDB_POC_LOAD_BLINDER_Z_FWD_PH_A		A FWD Blinder
629	SW	DDB_POC_LOAD_BLINDER_Z_REV_PH_A		A REV Blinder
630	SW	DDB_POC_LOAD_BLINDER_Z_PH_A		A LoadBlinder
631	SW	DDB_POC_LOAD_BLINDER_Z_FWD_PH_B		B FWD Blinder
632	SW	DDB_POC_LOAD_BLINDER_Z_REV_PH_B		B REV Blinder
633	SW	DDB_POC_LOAD_BLINDER_Z_PH_B		B LoadBlinder
634	SW	DDB_POC_LOAD_BLINDER_Z_FWD_PH_C		C FWD Blinder
635	SW	DDB_POC_LOAD_BLINDER_Z_REV_PH_C		C REV Blinder
636	SW	DDB_POC_LOAD_BLINDER_Z_PH_C		C LoadBlinder
637	SW	DDB_POC_LOAD_BLINDER_Z1_FWD		Z1 FWD Blinder
638	SW	DDB_POC_LOAD_BLINDER_Z1_REV		Z1 REV Blinder
639	SW	DDB_POC_LOAD_BLINDER_Z1		Z1 LoadBlinder
640	SW	DDB_OUTPUT_TRI_LED_1_RED		LED1 Red
641	SW	DDB_OUTPUT_TRI_LED_1_GRN		LED1 Grn
642	SW	DDB_OUTPUT_TRI_LED_2_RED		LED2 Red
643	SW	DDB_OUTPUT_TRI_LED_2_GRN		LED2 Grn
644	SW	DDB_OUTPUT_TRI_LED_3_RED		LED3 Red
645	SW	DDB_OUTPUT_TRI_LED_3_GRN		LED3 Grn
646	SW	DDB_OUTPUT_TRI_LED_4_RED		LED4 Red
647	SW	DDB_OUTPUT_TRI_LED_4_GRN		LED4 Grn
648	SW	DDB_OUTPUT_TRI_LED_5_RED		LED5 Red
649	SW	DDB_OUTPUT_TRI_LED_5_GRN		LED5 Grn
650	SW	DDB_OUTPUT_TRI_LED_6_RED		LED6 Red
651	SW	DDB_OUTPUT_TRI_LED_6_GRN		LED6 Grn

DDB No	Source	Element Name	Description	English Text
652	SW	DDB_OUTPUT_TRI_LED_7_RED		LED7 Red
653	SW	DDB_OUTPUT_TRI_LED_7_GRN		LED7 Grn
654	SW	DDB_OUTPUT_TRI_LED_8_RED		LED8 Red
655	SW	DDB_OUTPUT_TRI_LED_8_GRN		LED8 Grn
656	SW	DDB_OUTPUT_TRI_LED_9_RED		FnKey LED1 Red
657	SW	DDB_OUTPUT_TRI_LED_9_GRN		FnKey LED1 Grn
658	SW	DDB_OUTPUT_TRI_LED_10_RED		FnKey LED2 Red
659	SW	DDB_OUTPUT_TRI_LED_10_GRN		FnKey LED2 Grn
660	SW	DDB_OUTPUT_TRI_LED_11_RED		FnKey LED3 Red
661	SW	DDB_OUTPUT_TRI_LED_11_GRN		FnKey LED3 Grn
662	SW	DDB_OUTPUT_TRI_LED_12_RED		FnKey LED4 Red
663	SW	DDB_OUTPUT_TRI_LED_12_GRN		FnKey LED4 Grn
664	SW	DDB_OUTPUT_TRI_LED_13_RED		FnKey LED5 Red
665	SW	DDB_OUTPUT_TRI_LED_13_GRN		FnKey LED5 Grn
666	SW	DDB_OUTPUT_TRI_LED_14_RED		FnKey LED6 Red
667	SW	DDB_OUTPUT_TRI_LED_14_GRN		FnKey LED6 Grn
668	SW	DDB_OUTPUT_TRI_LED_15_RED		FnKey LED7 Red
669	SW	DDB_OUTPUT_TRI_LED_15_GRN		FnKey LED7 Grn
670	SW	DDB_OUTPUT_TRI_LED_16_RED		FnKey LED8 Red
671	SW	DDB_OUTPUT_TRI_LED_16_GRN		FnKey LED8 Grn
672	SW	DDB_OUTPUT_TRI_LED_17_RED		FnKey LED9 Red
673	SW	DDB_OUTPUT_TRI_LED_17_GRN		FnKey LED9 Grn
674	SW	DDB_OUTPUT_TRI_LED_18_RED		FnKey LED10 Red
675	SW	DDB_OUTPUT_TRI_LED_18_GRN		FnKey LED10 Grn
676	PSL	DDB_TRI_LED_RED_CON_1		LED1 Con R
677	PSL	DDB_TRI_LED_GRN_CON_1		LED1 Con G
678	PSL	DDB_TRI_LED_RED_CON_2		LED2 Con R
679	PSL	DDB_TRI_LED_GRN_CON_2		LED2 Con G
680	PSL	DDB_TRI_LED_RED_CON_3		LED3 Con R
681	PSL	DDB_TRI_LED_GRN_CON_3		LED3 Con G
682	PSL	DDB_TRI_LED_RED_CON_4		LED4 Con R
683	PSL	DDB_TRI_LED_GRN_CON_4		LED4 Con G
684	PSL	DDB_TRI_LED_RED_CON_5		LED5 Con R
685	PSL	DDB_TRI_LED_GRN_CON_5		LED5 Con G
686	PSL	DDB_TRI_LED_RED_CON_6		LED6 Con R
687	PSL	DDB_TRI_LED_GRN_CON_6		LED6 Con G
688	PSL	DDB_TRI_LED_RED_CON_7		LED7 Con R
689	PSL	DDB_TRI_LED_GRN_CON_7		LED7 Con G
690	PSL	DDB_TRI_LED_RED_CON_8		LED8 Con R
691	PSL	DDB_TRI_LED_GRN_CON_8		LED8 Con G
692	PSL	DDB_TRI_LED_RED_CON_9		FnKey LED1 ConR
693	PSL	DDB_TRI_LED_GRN_CON_9		FnKey LED1 ConG

DDB No	Source	Element Name	Description	English Text
694	PSL	DDB_TRI_LED_RED_CON_10		FnKey LED2 ConR
695	PSL	DDB_TRI_LED_GRN_CON_10		FnKey LED2 ConG
696	PSL	DDB_TRI_LED_RED_CON_11		FnKey LED3 ConR
697	PSL	DDB_TRI_LED_GRN_CON_11		FnKey LED3 ConG
698	PSL	DDB_TRI_LED_RED_CON_12		FnKey LED4 ConR
699	PSL	DDB_TRI_LED_GRN_CON_12		FnKey LED4 ConG
700	PSL	DDB_TRI_LED_RED_CON_13		FnKey LED5 ConR
701	PSL	DDB_TRI_LED_GRN_CON_13		FnKey LED5 ConG
702	PSL	DDB_TRI_LED_RED_CON_14		FnKey LED6 ConR
703	PSL	DDB_TRI_LED_GRN_CON_14		FnKey LED6 ConG
704	PSL	DDB_TRI_LED_RED_CON_15		FnKey LED7 ConR
705	PSL	DDB_TRI_LED_GRN_CON_15		FnKey LED7 ConG
706	PSL	DDB_TRI_LED_RED_CON_16		FnKey LED8 ConR
707	PSL	DDB_TRI_LED_GRN_CON_16		FnKey LED8 ConG
708	PSL	DDB_TRI_LED_RED_CON_17		FnKey LED9 ConR
709	PSL	DDB_TRI_LED_GRN_CON_17		FnKey LED9 ConG
710	PSL	DDB_TRI_LED_RED_CON_18		FnKey LED10 ConR
711	PSL	DDB_TRI_LED_GRN_CON_18		FnKey LED10 ConG
712	SW	DDB_FN_KEY_1		Function Key 1
713	SW	DDB_FN_KEY_2		Function Key 2
714	SW	DDB_FN_KEY_3		Function Key 3
715	SW	DDB_FN_KEY_4		Function Key 4
716	SW	DDB_FN_KEY_5		Function Key 5
717	SW	DDB_FN_KEY_6		Function Key 6
718	SW	DDB_FN_KEY_7		Function Key 7
719	SW	DDB_FN_KEY_8		Function Key 8
720	SW	DDB_FN_KEY_9		Function Key 9
721	SW	DDB_FN_KEY_10		Function Key 10
722	SW	DDB_OVER_POWER_1_3PH_START		Power>1 3PhStart
723	SW	DDB_OVER_POWER_1_A_PH_START		Power>1 A Start
724	SW	DDB_OVER_POWER_1_B_PH_START		Power>1 B Start
725	SW	DDB_OVER_POWER_1_C_PH_START		Power>1 C Start

DDB No	Source	Element Name	Description	English Text
726	SW	DDB_OVER_POWER_2_3PH_START		Power>2 3PhStart
727	SW	DDB_OVER_POWER_2_A_PH_START		Power>2 A Start
728	SW	DDB_OVER_POWER_2_B_PH_START		Power>2 B Start
729	SW	DDB_OVER_POWER_2_C_PH_START		Power>2 C Start
730	SW	DDB_UNDER_POWER_1_3PH_START		Power<1 3PhStart
731	SW	DDB_UNDER_POWER_1_A_PH_START		Power<1 A Start
732	SW	DDB_UNDER_POWER_1_B_PH_START		Power<1 B Start
733	SW	DDB_UNDER_POWER_1_C_PH_START		Power<1 C Start
734	SW	DDB_UNDER_POWER_2_3PH_START		Power<2 3PhStart
735	SW	DDB_UNDER_POWER_2_A_PH_START		Power<2 A Start
736	SW	DDB_UNDER_POWER_2_B_PH_START		Power<2 B Start
737	SW	DDB_UNDER_POWER_2_C_PH_START		Power<2 C Start
738	SW	DDB_OVER_POWER_1_3PH_TRIP		Power>1 3Ph Trip
739	SW	DDB_OVER_POWER_1_A_PH_TRIP		Power>1 A Trip
740	SW	DDB_OVER_POWER_1_B_PH_TRIP		Power>1 B Trip
741	SW	DDB_OVER_POWER_1_C_PH_TRIP		Power>1 C Trip
742	SW	DDB_OVER_POWER_2_3PH_TRIP		Power>2 3Ph Trip
743	SW	DDB_OVER_POWER_2_A_PH_TRIP		Power>2 A Trip
744	SW	DDB_OVER_POWER_2_B_PH_TRIP		Power>2 B Trip
745	SW	DDB_OVER_POWER_2_C_PH_TRIP		Power>2 C Trip
746	SW	DDB_UNDER_POWER_1_3PH_TRIP		Power<1 3Ph Trip
747	SW	DDB_UNDER_POWER_1_A_PH_TRIP		Power<1 A Trip
748	SW	DDB_UNDER_POWER_1_B_PH_TRIP		Power<1 B Trip
749	SW	DDB_UNDER_POWER_1_C_PH_TRIP		Power<1 C Trip
750	SW	DDB_UNDER_POWER_2_3PH_TRIP		Power<2 3Ph Trip
751	SW	DDB_UNDER_POWER_2_A_PH_TRIP		Power<2 A Trip
752	SW	DDB_UNDER_POWER_2_B_PH_TRIP		Power<2 B Trip
753	SW	DDB_UNDER_POWER_2_C_PH_TRIP		Power<2 C Trip
754	PSL	DDB_OVER_POWER_1_BLOCK		Power>1 Block
755	PSL	DDB_OVER_POWER_2_BLOCK		Power>2 Block
756	PSL	DDB_UNDER_POWER_1_BLOCK		Power<1 Block
757	PSL	DDB_UNDER_POWER_2_BLOCK		Power<2 Block
758	SW	DDB_SPOWER_1_START	Sensitive A Phase Power Stage 1 Start	SensP1 Start A
759	SW	DDB_SPOWER_2_START	Sensitive A Phase Power Stage 2 Start	SensP2 Start A
760	SW	DDB_SPOWER_1_TRIP	Sensitive A Phase Power Stage 1 Trip	SensP1 Trip A
761	SW	DDB_SPOWER_2_TRIP	Sensitive A Phase Power Stage 2 Trip	SensP2 Trip A
762	SW	DDB_UNUSED_762		
763	SW	DDB_UNUSED_763		
764	SW	DDB_UNUSED_764		
765	SW	DDB_UNUSED_765		
766	SW	DDB_UNUSED_766		
767	SW	DDB_UNUSED_767		
768	SW	DDB_UNUSED_768		
769	SW	DDB_BATTERY_FAIL_ALARM	Battery Failure Alarm	Battery Fail

DDB No	Source	Element Name	Description	English Text
770	SW	DDB_REAR_COMMS_FAIL	Rear Comms Failed	Rear Comm 2 Fail
771	SW	DDB_GOOSE_MISSING_IED_ALARM	GOOSE IED Absent Alarm	GOOSE IED Absent
772	SW	DDB_ECARD_NOT_FITTED_ALARM	Ethernet card not fitted Alarm	NIC Not Fitted
773	SW	DDB_NIC_NOT_RESPONDING_ALARM	Ethernet card not responding Alarm	NIC No Response
774	SW	DDB_NIC_FATAL_ERROR_ALARM	Ethernet card fatal error Alarm	NIC Fatal Error
775	SW	DDB_NIC_SOFTWARE_RELOAD_ALARM	Ethernet card software reload Alarm	NIC Soft. Reload
776	SW	DDB_INVALID_TCP_IP_CONFIG_ALARM	Bad TCP/IP Configuration Alarm	Bad TCP/IP Cfg.
777	SW	DDB_INVALID_OSI_CONFIG_ALARM	Bad OSI Configuration Alarm	Bad OSI Config.
778	SW	DDB_MU_OOS_ALARM	MU OOS Alarm	MU OOS Alarm
779	SW	DDB_SW_MISMATCH_ALARM	Main card/Ethernet card software mismatch Alarm	NIC SW Mis-Match
780	SW	DDB_IP_ADDRESS_CONFLICT_ALARM	IP Address conflict Alarm	IP Addr Conflict
781	SW	DDB_INTERMICOM_LOOPBACK_ALARM	InterMiCOM Loopback Fail	IM Loopback
782	SW	DDB_INTERMICOM_MESSAGE_ALARM	InterMiCOM Message Fail	IM Msg Fail
783	SW	DDB_INTERMICOM_DCD_ALARM	InterMiCOM Data CD Fail	IM DCD Fail
784	SW	DDB_INTERMICOM_CHANNEL_ALARM	InterMiCOM Channel Fail	IM Chan Fail
785	SW	DDB_BACKUP_SETTINGS_ALARM	Backup settings in use' Alarm	Backup Setting
786	SW	DDB_BACKUP_USR_CRV_ALARM	Backup' User Curve in use Alarm	Backup Usr Curve
787	SW	DDB_NIC_LINK_1_FAIL	Network Interface Card link 1 fail indication	ETH Link 1 Fail
788	SW	DDB_NIC_LINK_2_FAIL	Network Interface Card link 2 fail indication	ETH Link 2 Fail
789	SW	DDB_NIC_LINK_3_FAIL	Network Interface Card link 3 fail indication	ETH Link 3 Fail
790	SW	DDB_HW_MISMATCH_ALARM	Main card/Ethernet card hw option mismatch Alarm	NIC HW Mis-Match
791	SW	DDB_IEC61850_VER_MISMATCH_ALARM	Main card/Ethernet card IEC61850 ver mismatch Alarm	NIC Ed Mis-Match
792	SW	DDB_INVALID_SV_CONFIG_ALARM	Invalid IEC 61850 Configuration Alarm for PB	Invalid SV conf.
793	SW	DDB_SV_ABSENCE_ALARM	SV Absence Alm	SV Absence Alm
794	SW	DDB_SV_SMPSYNCH_ALARM	SV SmpSynch alarm	SV SmpSynch Alm
795	SW	DDB_SV_TEST_ALARM	SV Test alarm	SV Test Alm
796	SW	DDB_SV_INVALID_ALARM	SV Invalid alarm	SV Invalid Alm
797	SW	DDB_SV_QUESTIONABLE_ALARM	SV Questionable alarm	SV Quest Alm
798	SW	DDB_1588_STATUS	IEEE1588 Status Signal Valid	1588 Status
799	SW	DDB_UNUSED_799		
800	SW	DDB_CONTROL_1		Control Input 1
801	SW	DDB_CONTROL_2		Control Input 2
802	SW	DDB_CONTROL_3		Control Input 3
803	SW	DDB_CONTROL_4		Control Input 4
804	SW	DDB_CONTROL_5		Control Input 5
805	SW	DDB_CONTROL_6		Control Input 6
806	SW	DDB_CONTROL_7		Control Input 7
807	SW	DDB_CONTROL_8		Control Input 8
808	SW	DDB_CONTROL_9		Control Input 9
809	SW	DDB_CONTROL_10		Control Input 10
810	SW	DDB_CONTROL_11		Control Input 11
811	SW	DDB_CONTROL_12		Control Input 12

DDB No	Source	Element Name	Description	English Text
812	SW	DDB_CONTROL_13		Control Input 13
813	SW	DDB_CONTROL_14		Control Input 14
814	SW	DDB_CONTROL_15		Control Input 15
815	SW	DDB_CONTROL_16		Control Input 16
816	SW	DDB_CONTROL_17		Control Input 17
817	SW	DDB_CONTROL_18		Control Input 18
818	SW	DDB_CONTROL_19		Control Input 19
819	SW	DDB_CONTROL_20		Control Input 20
820	SW	DDB_CONTROL_21		Control Input 21
821	SW	DDB_CONTROL_22		Control Input 22
822	SW	DDB_CONTROL_23		Control Input 23
823	SW	DDB_CONTROL_24		Control Input 24
824	SW	DDB_CONTROL_25		Control Input 25
825	SW	DDB_CONTROL_26		Control Input 26
826	SW	DDB_CONTROL_27		Control Input 27
827	SW	DDB_CONTROL_28		Control Input 28
828	SW	DDB_CONTROL_29		Control Input 29
829	SW	DDB_CONTROL_30		Control Input 30
830	SW	DDB_CONTROL_31		Control Input 31
831	SW	DDB_CONTROL_32		Control Input 32
832	SW	DDB_GOOSEIN_1		Virtual Input 1
833	SW	DDB_GOOSEIN_2		Virtual Input 2
834	SW	DDB_GOOSEIN_3		Virtual Input 3
835	SW	DDB_GOOSEIN_4		Virtual Input 4
836	SW	DDB_GOOSEIN_5		Virtual Input 5
837	SW	DDB_GOOSEIN_6		Virtual Input 6
838	SW	DDB_GOOSEIN_7		Virtual Input 7
839	SW	DDB_GOOSEIN_8		Virtual Input 8
840	SW	DDB_GOOSEIN_9		Virtual Input 9
841	SW	DDB_GOOSEIN_10		Virtual Input 10
842	SW	DDB_GOOSEIN_11		Virtual Input 11
843	SW	DDB_GOOSEIN_12		Virtual Input 12
844	SW	DDB_GOOSEIN_13		Virtual Input 13
845	SW	DDB_GOOSEIN_14		Virtual Input 14
846	SW	DDB_GOOSEIN_15		Virtual Input 15
847	SW	DDB_GOOSEIN_16		Virtual Input 16
848	SW	DDB_GOOSEIN_17		Virtual Input 17
849	SW	DDB_GOOSEIN_18		Virtual Input 18
850	SW	DDB_GOOSEIN_19		Virtual Input 19
851	SW	DDB_GOOSEIN_20		Virtual Input 20
852	SW	DDB_GOOSEIN_21		Virtual Input 21
853	SW	DDB_GOOSEIN_22		Virtual Input 22
854	SW	DDB_GOOSEIN_23		Virtual Input 23
855	SW	DDB_GOOSEIN_24		Virtual Input 24

DDB No	Source	Element Name	Description	English Text
856	SW	DDB_GOOSEIN_25		Virtual Input 25
857	SW	DDB_GOOSEIN_26		Virtual Input 26
858	SW	DDB_GOOSEIN_27		Virtual Input 27
859	SW	DDB_GOOSEIN_28		Virtual Input 28
860	SW	DDB_GOOSEIN_29		Virtual Input 29
861	SW	DDB_GOOSEIN_30		Virtual Input 30
862	SW	DDB_GOOSEIN_31		Virtual Input 31
863	SW	DDB_GOOSEIN_32		Virtual Input 32
864	SW	DDB_GOOSEIN_33		Virtual Input 33
865	SW	DDB_GOOSEIN_34		Virtual Input 34
866	SW	DDB_GOOSEIN_35		Virtual Input 35
867	SW	DDB_GOOSEIN_36		Virtual Input 36
868	SW	DDB_GOOSEIN_37		Virtual Input 37
869	SW	DDB_GOOSEIN_38		Virtual Input 38
870	SW	DDB_GOOSEIN_39		Virtual Input 39
871	SW	DDB_GOOSEIN_40		Virtual Input 40
872	SW	DDB_GOOSEIN_41		Virtual Input 41
873	SW	DDB_GOOSEIN_42		Virtual Input 42
874	SW	DDB_GOOSEIN_43		Virtual Input 43
875	SW	DDB_GOOSEIN_44		Virtual Input 44
876	SW	DDB_GOOSEIN_45		Virtual Input 45
877	SW	DDB_GOOSEIN_46		Virtual Input 46
878	SW	DDB_GOOSEIN_47		Virtual Input 47
879	SW	DDB_GOOSEIN_48		Virtual Input 48
880	SW	DDB_GOOSEIN_49		Virtual Input 49
881	SW	DDB_GOOSEIN_50		Virtual Input 50
882	SW	DDB_GOOSEIN_51		Virtual Input 51
883	SW	DDB_GOOSEIN_52		Virtual Input 52
884	SW	DDB_GOOSEIN_53		Virtual Input 53
885	SW	DDB_GOOSEIN_54		Virtual Input 54
886	SW	DDB_GOOSEIN_55		Virtual Input 55
887	SW	DDB_GOOSEIN_56		Virtual Input 56
888	SW	DDB_GOOSEIN_57		Virtual Input 57
889	SW	DDB_GOOSEIN_58		Virtual Input 58
890	SW	DDB_GOOSEIN_59		Virtual Input 59
891	SW	DDB_GOOSEIN_60		Virtual Input 60
892	SW	DDB_GOOSEIN_61		Virtual Input 61
893	SW	DDB_GOOSEIN_62		Virtual Input 62
894	SW	DDB_GOOSEIN_63		Virtual Input 63
895	SW	DDB_GOOSEIN_64		Virtual Input 64
896	SW	DDB_INTERIN_1	InterMiCOM in 1	InterMiCOM in 1
897	SW	DDB_INTERIN_2	InterMiCOM in 2	InterMiCOM in 2
898	SW	DDB_INTERIN_3	InterMiCOM in 3	InterMiCOM in 3
899	SW	DDB_INTERIN_4	InterMiCOM in 4	InterMiCOM in 4

DDB No	Source	Element Name	Description	English Text
900	SW	DDB_INTERIN_5	InterMiCOM in 5	InterMiCOM in 5
901	SW	DDB_INTERIN_6	InterMiCOM in 6	InterMiCOM in 6
902	SW	DDB_INTERIN_7	InterMiCOM in 7	InterMiCOM in 7
903	SW	DDB_INTERIN_8	InterMiCOM in 8	InterMiCOM in 8
904	PSL	DDB_INTEROUT_1	InterMiCOM out 1	InterMiCOM out 1
905	PSL	DDB_INTEROUT_2	InterMiCOM out 2	InterMiCOM out 2
906	PSL	DDB_INTEROUT_3	InterMiCOM out 3	InterMiCOM out 3
907	PSL	DDB_INTEROUT_4	InterMiCOM out 4	InterMiCOM out 4
908	PSL	DDB_INTEROUT_5	InterMiCOM out 5	InterMiCOM out 5
909	PSL	DDB_INTEROUT_6	InterMiCOM out 6	InterMiCOM out 6
910	PSL	DDB_INTEROUT_7	InterMiCOM out 7	InterMiCOM out 7
911	PSL	DDB_INTEROUT_8	InterMiCOM out 8	InterMiCOM out 8
912	SW	DDB_UNUSED_912		
913	SW	DDB_UNUSED_913		
914	SW	DDB_UNUSED_914		
915	SW	DDB_UNUSED_915		
916	SW	DDB_UNUSED_916		
917	SW	DDB_UNUSED_917		
918	SW	DDB_UNUSED_918		
919	SW	DDB_UNUSED_919		
920	SW	DDB_UNUSED_920		
921	SW	DDB_UNUSED_921		
922	SW	DDB_UNUSED_DR	Provides the "Unused" selection in G32	
923	PSL	DDB_PSLINT_1		
924	PSL	DDB_PSLINT_2		
925	PSL	DDB_PSLINT_3		
926	PSL	DDB_PSLINT_4		
927	PSL	DDB_PSLINT_5		
928	PSL	DDB_PSLINT_6		
929	PSL	DDB_PSLINT_7		
930	PSL	DDB_PSLINT_8		
931	PSL	DDB_PSLINT_9		
932	PSL	DDB_PSLINT_10		
933	PSL	DDB_PSLINT_11		
934	PSL	DDB_PSLINT_12		
935	PSL	DDB_PSLINT_13		
936	PSL	DDB_PSLINT_14		
937	PSL	DDB_PSLINT_15		
938	PSL	DDB_PSLINT_16		
939	PSL	DDB_PSLINT_17		
940	PSL	DDB_PSLINT_18		
941	PSL	DDB_PSLINT_19		
942	PSL	DDB_PSLINT_20		
943	PSL	DDB_PSLINT_21		

DDB No	Source	Element Name	Description	English Text
944	PSL	DDB_PSLINT_22		
945	PSL	DDB_PSLINT_23		
946	PSL	DDB_PSLINT_24		
947	PSL	DDB_PSLINT_25		
948	PSL	DDB_PSLINT_26		
949	PSL	DDB_PSLINT_27		
950	PSL	DDB_PSLINT_28		
951	PSL	DDB_PSLINT_29		
952	PSL	DDB_PSLINT_30		
953	PSL	DDB_PSLINT_31		
954	PSL	DDB_PSLINT_32		
955	PSL	DDB_PSLINT_33		
956	PSL	DDB_PSLINT_34		
957	PSL	DDB_PSLINT_35		
958	PSL	DDB_PSLINT_36		
959	PSL	DDB_PSLINT_37		
960	PSL	DDB_PSLINT_38		
961	PSL	DDB_PSLINT_39		
962	PSL	DDB_PSLINT_40		
963	PSL	DDB_PSLINT_41		
964	PSL	DDB_PSLINT_42		
965	PSL	DDB_PSLINT_43		
966	PSL	DDB_PSLINT_44		
967	PSL	DDB_PSLINT_45		
968	PSL	DDB_PSLINT_46		
969	PSL	DDB_PSLINT_47		
970	PSL	DDB_PSLINT_48		
971	PSL	DDB_PSLINT_49		
972	PSL	DDB_PSLINT_50		
973	PSL	DDB_PSLINT_51		
974	PSL	DDB_PSLINT_52		
975	PSL	DDB_PSLINT_53		
976	PSL	DDB_PSLINT_54		
977	PSL	DDB_PSLINT_55		
978	PSL	DDB_PSLINT_56		
979	PSL	DDB_PSLINT_57		
980	PSL	DDB_PSLINT_58		
981	PSL	DDB_PSLINT_59		
982	PSL	DDB_PSLINT_60		
983	PSL	DDB_PSLINT_61		
984	PSL	DDB_PSLINT_62		
985	PSL	DDB_PSLINT_63		
986	PSL	DDB_PSLINT_64		
987	PSL	DDB_PSLINT_65		

DDB No	Source	Element Name	Description	English Text
988	PSL	DDB_PSLINT_66		
989	PSL	DDB_PSLINT_67		
990	PSL	DDB_PSLINT_68		
991	PSL	DDB_PSLINT_69		
992	PSL	DDB_PSLINT_70		
993	PSL	DDB_PSLINT_71		
994	PSL	DDB_PSLINT_72		
995	PSL	DDB_PSLINT_73		
996	PSL	DDB_PSLINT_74		
997	PSL	DDB_PSLINT_75		
998	PSL	DDB_PSLINT_76		
999	PSL	DDB_PSLINT_77		
1000	PSL	DDB_PSLINT_78		
1001	PSL	DDB_PSLINT_79		
1002	PSL	DDB_PSLINT_80		
1003	PSL	DDB_PSLINT_81		
1004	PSL	DDB_PSLINT_82		
1005	PSL	DDB_PSLINT_83		
1006	PSL	DDB_PSLINT_84		
1007	PSL	DDB_PSLINT_85		
1008	PSL	DDB_PSLINT_86		
1009	PSL	DDB_PSLINT_87		
1010	PSL	DDB_PSLINT_88		
1011	PSL	DDB_PSLINT_89		
1012	PSL	DDB_PSLINT_90		
1013	PSL	DDB_PSLINT_91		
1014	PSL	DDB_PSLINT_92		
1015	PSL	DDB_PSLINT_93		
1016	PSL	DDB_PSLINT_94		
1017	PSL	DDB_PSLINT_95		
1018	PSL	DDB_PSLINT_96		
1019	PSL	DDB_PSLINT_97		
1020	PSL	DDB_PSLINT_98		
1021	PSL	DDB_PSLINT_99		
1022	PSL	DDB_PSLINT_100		
1023	SW	DDB_UNUSED_1023		
1024	PSL	DDB_GOOSEOUT_1		Virtual Output 1
1025	PSL	DDB_GOOSEOUT_2		Virtual Output 2
1026	PSL	DDB_GOOSEOUT_3		Virtual Output 3
1027	PSL	DDB_GOOSEOUT_4		Virtual Output 4
1028	PSL	DDB_GOOSEOUT_5		Virtual Output 5
1029	PSL	DDB_GOOSEOUT_6		Virtual Output 6
1030	PSL	DDB_GOOSEOUT_7		Virtual Output 7
1031	PSL	DDB_GOOSEOUT_8		Virtual Output 8

DDB No	Source	Element Name	Description	English Text
1032	PSL	DDB_GOOSEOUT_9		Virtual Output 9
1033	PSL	DDB_GOOSEOUT_10		Virtual Output10
1034	PSL	DDB_GOOSEOUT_11		Virtual Output11
1035	PSL	DDB_GOOSEOUT_12		Virtual Output12
1036	PSL	DDB_GOOSEOUT_13		Virtual Output13
1037	PSL	DDB_GOOSEOUT_14		Virtual Output14
1038	PSL	DDB_GOOSEOUT_15		Virtual Output15
1039	PSL	DDB_GOOSEOUT_16		Virtual Output16
1040	PSL	DDB_GOOSEOUT_17		Virtual Output17
1041	PSL	DDB_GOOSEOUT_18		Virtual Output18
1042	PSL	DDB_GOOSEOUT_19		Virtual Output19
1043	PSL	DDB_GOOSEOUT_20		Virtual Output20
1044	PSL	DDB_GOOSEOUT_21		Virtual Output21
1045	PSL	DDB_GOOSEOUT_22		Virtual Output22
1046	PSL	DDB_GOOSEOUT_23		Virtual Output23
1047	PSL	DDB_GOOSEOUT_24		Virtual Output24
1048	PSL	DDB_GOOSEOUT_25		Virtual Output25
1049	PSL	DDB_GOOSEOUT_26		Virtual Output26
1050	PSL	DDB_GOOSEOUT_27		Virtual Output27
1051	PSL	DDB_GOOSEOUT_28		Virtual Output28
1052	PSL	DDB_GOOSEOUT_29		Virtual Output29
1053	PSL	DDB_GOOSEOUT_30		Virtual Output30
1054	PSL	DDB_GOOSEOUT_31		Virtual Output31
1055	PSL	DDB_GOOSEOUT_32		Virtual Output32
1056	SW	DDB_VIP_QUALITY_1	GOOSE Virtual input 1 Quality bit	Quality VIP 1
1057	SW	DDB_VIP_QUALITY_2	GOOSE Virtual input 2 Quality bit	Quality VIP 2
1058	SW	DDB_VIP_QUALITY_3	GOOSE Virtual input 3 Quality bit	Quality VIP 3
1059	SW	DDB_VIP_QUALITY_4	GOOSE Virtual input 4 Quality bit	Quality VIP 4
1060	SW	DDB_VIP_QUALITY_5	GOOSE Virtual input 5 Quality bit	Quality VIP 5
1061	SW	DDB_VIP_QUALITY_6	GOOSE Virtual input 6 Quality bit	Quality VIP 6
1062	SW	DDB_VIP_QUALITY_7	GOOSE Virtual input 7 Quality bit	Quality VIP 7
1063	SW	DDB_VIP_QUALITY_8	GOOSE Virtual input 8 Quality bit	Quality VIP 8
1064	SW	DDB_VIP_QUALITY_9	GOOSE Virtual input 9 Quality bit	Quality VIP 9
1065	SW	DDB_VIP_QUALITY_10	GOOSE Virtual input 10 Quality bit	Quality VIP 10
1066	SW	DDB_VIP_QUALITY_11	GOOSE Virtual input 11 Quality bit	Quality VIP 11
1067	SW	DDB_VIP_QUALITY_12	GOOSE Virtual input 12 Quality bit	Quality VIP 12
1068	SW	DDB_VIP_QUALITY_13	GOOSE Virtual input 13 Quality bit	Quality VIP 13
1069	SW	DDB_VIP_QUALITY_14	GOOSE Virtual input 14 Quality bit	Quality VIP 14
1070	SW	DDB_VIP_QUALITY_15	GOOSE Virtual input 15 Quality bit	Quality VIP 15
1071	SW	DDB_VIP_QUALITY_16	GOOSE Virtual input 16 Quality bit	Quality VIP 16
1072	SW	DDB_VIP_QUALITY_17	GOOSE Virtual input 17 Quality bit	Quality VIP 17
1073	SW	DDB_VIP_QUALITY_18	GOOSE Virtual input 18 Quality bit	Quality VIP 18
1074	SW	DDB_VIP_QUALITY_19	GOOSE Virtual input 19 Quality bit	Quality VIP 19
1075	SW	DDB_VIP_QUALITY_20	GOOSE Virtual input 20 Quality bit	Quality VIP 20

DDB No	Source	Element Name	Description	English Text
1076	SW	DDB_VIP_QUALITY_21	GOOSE Virtual input 21 Quality bit	Quality VIP 21
1077	SW	DDB_VIP_QUALITY_22	GOOSE Virtual input 22 Quality bit	Quality VIP 22
1078	SW	DDB_VIP_QUALITY_23	GOOSE Virtual input 23 Quality bit	Quality VIP 23
1079	SW	DDB_VIP_QUALITY_24	GOOSE Virtual input 24 Quality bit	Quality VIP 24
1080	SW	DDB_VIP_QUALITY_25	GOOSE Virtual input 25 Quality bit	Quality VIP 25
1081	SW	DDB_VIP_QUALITY_26	GOOSE Virtual input 26 Quality bit	Quality VIP 26
1082	SW	DDB_VIP_QUALITY_27	GOOSE Virtual input 27 Quality bit	Quality VIP 27
1083	SW	DDB_VIP_QUALITY_28	GOOSE Virtual input 28 Quality bit	Quality VIP 28
1084	SW	DDB_VIP_QUALITY_29	GOOSE Virtual input 29 Quality bit	Quality VIP 29
1085	SW	DDB_VIP_QUALITY_30	GOOSE Virtual input 30 Quality bit	Quality VIP 30
1086	SW	DDB_VIP_QUALITY_31	GOOSE Virtual input 31 Quality bit	Quality VIP 31
1087	SW	DDB_VIP_QUALITY_32	GOOSE Virtual input 32 Quality bit	Quality VIP 32
1088	SW	DDB_VIP_QUALITY_33	GOOSE Virtual input 33 Quality bit	Quality VIP 33
1089	SW	DDB_VIP_QUALITY_34	GOOSE Virtual input 34 Quality bit	Quality VIP 34
1090	SW	DDB_VIP_QUALITY_35	GOOSE Virtual input 35 Quality bit	Quality VIP 35
1091	SW	DDB_VIP_QUALITY_36	GOOSE Virtual input 36 Quality bit	Quality VIP 36
1092	SW	DDB_VIP_QUALITY_37	GOOSE Virtual input 37 Quality bit	Quality VIP 37
1093	SW	DDB_VIP_QUALITY_38	GOOSE Virtual input 38 Quality bit	Quality VIP 38
1094	SW	DDB_VIP_QUALITY_39	GOOSE Virtual input 39 Quality bit	Quality VIP 39
1095	SW	DDB_VIP_QUALITY_40	GOOSE Virtual input 40 Quality bit	Quality VIP 40
1096	SW	DDB_VIP_QUALITY_41	GOOSE Virtual input 41 Quality bit	Quality VIP 41
1097	SW	DDB_VIP_QUALITY_42	GOOSE Virtual input 42 Quality bit	Quality VIP 42
1098	SW	DDB_VIP_QUALITY_43	GOOSE Virtual input 43 Quality bit	Quality VIP 43
1099	SW	DDB_VIP_QUALITY_44	GOOSE Virtual input 44 Quality bit	Quality VIP 44
1100	SW	DDB_VIP_QUALITY_45	GOOSE Virtual input 45 Quality bit	Quality VIP 45
1101	SW	DDB_VIP_QUALITY_46	GOOSE Virtual input 46 Quality bit	Quality VIP 46
1102	SW	DDB_VIP_QUALITY_47	GOOSE Virtual input 47 Quality bit	Quality VIP 47
1103	SW	DDB_VIP_QUALITY_48	GOOSE Virtual input 48 Quality bit	Quality VIP 48
1104	SW	DDB_VIP_QUALITY_49	GOOSE Virtual input 49 Quality bit	Quality VIP 49
1105	SW	DDB_VIP_QUALITY_50	GOOSE Virtual input 50 Quality bit	Quality VIP 50
1106	SW	DDB_VIP_QUALITY_51	GOOSE Virtual input 51 Quality bit	Quality VIP 51
1107	SW	DDB_VIP_QUALITY_52	GOOSE Virtual input 52 Quality bit	Quality VIP 52
1108	SW	DDB_VIP_QUALITY_53	GOOSE Virtual input 53 Quality bit	Quality VIP 53
1109	SW	DDB_VIP_QUALITY_54	GOOSE Virtual input 54 Quality bit	Quality VIP 54
1110	SW	DDB_VIP_QUALITY_55	GOOSE Virtual input 55 Quality bit	Quality VIP 55
1111	SW	DDB_VIP_QUALITY_56	GOOSE Virtual input 56 Quality bit	Quality VIP 56
1112	SW	DDB_VIP_QUALITY_57	GOOSE Virtual input 57 Quality bit	Quality VIP 57
1113	SW	DDB_VIP_QUALITY_58	GOOSE Virtual input 58 Quality bit	Quality VIP 58
1114	SW	DDB_VIP_QUALITY_59	GOOSE Virtual input 59 Quality bit	Quality VIP 59
1115	SW	DDB_VIP_QUALITY_60	GOOSE Virtual input 60 Quality bit	Quality VIP 60
1116	SW	DDB_VIP_QUALITY_61	GOOSE Virtual input 61 Quality bit	Quality VIP 61
1117	SW	DDB_VIP_QUALITY_62	GOOSE Virtual input 62 Quality bit	Quality VIP 62
1118	SW	DDB_VIP_QUALITY_63	GOOSE Virtual input 63 Quality bit	Quality VIP 63
1119	SW	DDB_VIP_QUALITY_64	GOOSE Virtual input 64 Quality bit	Quality VIP 64

DDB No	Source	Element Name	Description	English Text
1120	SW	DDB_VIP_PUB_PRES_1	GOOSE Virtual input 1 publisher bit	PubPres VIP 1
1121	SW	DDB_VIP_PUB_PRES_2	GOOSE Virtual input 2 publisher bit	PubPres VIP 2
1122	SW	DDB_VIP_PUB_PRES_3	GOOSE Virtual input 3 publisher bit	PubPres VIP 3
1123	SW	DDB_VIP_PUB_PRES_4	GOOSE Virtual input 4 publisher bit	PubPres VIP 4
1124	SW	DDB_VIP_PUB_PRES_5	GOOSE Virtual input 5 publisher bit	PubPres VIP 5
1125	SW	DDB_VIP_PUB_PRES_6	GOOSE Virtual input 6 publisher bit	PubPres VIP 6
1126	SW	DDB_VIP_PUB_PRES_7	GOOSE Virtual input 7 publisher bit	PubPres VIP 7
1127	SW	DDB_VIP_PUB_PRES_8	GOOSE Virtual input 8 publisher bit	PubPres VIP 8
1128	SW	DDB_VIP_PUB_PRES_9	GOOSE Virtual input 9 publisher bit	PubPres VIP 9
1129	SW	DDB_VIP_PUB_PRES_10	GOOSE Virtual input 10 publisher bit	PubPres VIP 10
1130	SW	DDB_VIP_PUB_PRES_11	GOOSE Virtual input 11 publisher bit	PubPres VIP 11
1131	SW	DDB_VIP_PUB_PRES_12	GOOSE Virtual input 12 publisher bit	PubPres VIP 12
1132	SW	DDB_VIP_PUB_PRES_13	GOOSE Virtual input 13 publisher bit	PubPres VIP 13
1133	SW	DDB_VIP_PUB_PRES_14	GOOSE Virtual input 14 publisher bit	PubPres VIP 14
1134	SW	DDB_VIP_PUB_PRES_15	GOOSE Virtual input 15 publisher bit	PubPres VIP 15
1135	SW	DDB_VIP_PUB_PRES_16	GOOSE Virtual input 16 publisher bit	PubPres VIP 16
1136	SW	DDB_VIP_PUB_PRES_17	GOOSE Virtual input 17 publisher bit	PubPres VIP 17
1137	SW	DDB_VIP_PUB_PRES_18	GOOSE Virtual input 18 publisher bit	PubPres VIP 18
1138	SW	DDB_VIP_PUB_PRES_19	GOOSE Virtual input 19 publisher bit	PubPres VIP 19
1139	SW	DDB_VIP_PUB_PRES_20	GOOSE Virtual input 20 publisher bit	PubPres VIP 20
1140	SW	DDB_VIP_PUB_PRES_21	GOOSE Virtual input 21 publisher bit	PubPres VIP 21
1141	SW	DDB_VIP_PUB_PRES_22	GOOSE Virtual input 22 publisher bit	PubPres VIP 22
1142	SW	DDB_VIP_PUB_PRES_23	GOOSE Virtual input 23 publisher bit	PubPres VIP 23
1143	SW	DDB_VIP_PUB_PRES_24	GOOSE Virtual input 24 publisher bit	PubPres VIP 24
1144	SW	DDB_VIP_PUB_PRES_25	GOOSE Virtual input 25 publisher bit	PubPres VIP 25
1145	SW	DDB_VIP_PUB_PRES_26	GOOSE Virtual input 26 publisher bit	PubPres VIP 26
1146	SW	DDB_VIP_PUB_PRES_27	GOOSE Virtual input 27 publisher bit	PubPres VIP 27
1147	SW	DDB_VIP_PUB_PRES_28	GOOSE Virtual input 28 publisher bit	PubPres VIP 28
1148	SW	DDB_VIP_PUB_PRES_29	GOOSE Virtual input 29 publisher bit	PubPres VIP 29
1149	SW	DDB_VIP_PUB_PRES_30	GOOSE Virtual input 30 publisher bit	PubPres VIP 30
1150	SW	DDB_VIP_PUB_PRES_31	GOOSE Virtual input 31 publisher bit	PubPres VIP 31
1151	SW	DDB_VIP_PUB_PRES_32	GOOSE Virtual input 32 publisher bit	PubPres VIP 32
1152	SW	DDB_VIP_PUB_PRES_33	GOOSE Virtual input 33 publisher bit	PubPres VIP 33
1153	SW	DDB_VIP_PUB_PRES_34	GOOSE Virtual input 34 publisher bit	PubPres VIP 34
1154	SW	DDB_VIP_PUB_PRES_35	GOOSE Virtual input 35 publisher bit	PubPres VIP 35
1155	SW	DDB_VIP_PUB_PRES_36	GOOSE Virtual input 36 publisher bit	PubPres VIP 36
1156	SW	DDB_VIP_PUB_PRES_37	GOOSE Virtual input 37 publisher bit	PubPres VIP 37
1157	SW	DDB_VIP_PUB_PRES_38	GOOSE Virtual input 38 publisher bit	PubPres VIP 38
1158	SW	DDB_VIP_PUB_PRES_39	GOOSE Virtual input 39 publisher bit	PubPres VIP 39
1159	SW	DDB_VIP_PUB_PRES_40	GOOSE Virtual input 40 publisher bit	PubPres VIP 40
1160	SW	DDB_VIP_PUB_PRES_41	GOOSE Virtual input 41 publisher bit	PubPres VIP 41
1161	SW	DDB_VIP_PUB_PRES_42	GOOSE Virtual input 42 publisher bit	PubPres VIP 42
1162	SW	DDB_VIP_PUB_PRES_43	GOOSE Virtual input 43 publisher bit	PubPres VIP 43
1163	SW	DDB_VIP_PUB_PRES_44	GOOSE Virtual input 44 publisher bit	PubPres VIP 44

DDB No	Source	Element Name	Description	English Text
1164	SW	DDB_VIP_PUB_PRES_45	GOOSE Virtual input 45 publisher bit	PubPres VIP 45
1165	SW	DDB_VIP_PUB_PRES_46	GOOSE Virtual input 46 publisher bit	PubPres VIP 46
1166	SW	DDB_VIP_PUB_PRES_47	GOOSE Virtual input 47 publisher bit	PubPres VIP 47
1167	SW	DDB_VIP_PUB_PRES_48	GOOSE Virtual input 48 publisher bit	PubPres VIP 48
1168	SW	DDB_VIP_PUB_PRES_49	GOOSE Virtual input 49 publisher bit	PubPres VIP 49
1169	SW	DDB_VIP_PUB_PRES_50	GOOSE Virtual input 50 publisher bit	PubPres VIP 50
1170	SW	DDB_VIP_PUB_PRES_51	GOOSE Virtual input 51 publisher bit	PubPres VIP 51
1171	SW	DDB_VIP_PUB_PRES_52	GOOSE Virtual input 52 publisher bit	PubPres VIP 52
1172	SW	DDB_VIP_PUB_PRES_53	GOOSE Virtual input 53 publisher bit	PubPres VIP 53
1173	SW	DDB_VIP_PUB_PRES_54	GOOSE Virtual input 54 publisher bit	PubPres VIP 54
1174	SW	DDB_VIP_PUB_PRES_55	GOOSE Virtual input 55 publisher bit	PubPres VIP 55
1175	SW	DDB_VIP_PUB_PRES_56	GOOSE Virtual input 56 publisher bit	PubPres VIP 56
1176	SW	DDB_VIP_PUB_PRES_57	GOOSE Virtual input 57 publisher bit	PubPres VIP 57
1177	SW	DDB_VIP_PUB_PRES_58	GOOSE Virtual input 58 publisher bit	PubPres VIP 58
1178	SW	DDB_VIP_PUB_PRES_59	GOOSE Virtual input 59 publisher bit	PubPres VIP 59
1179	SW	DDB_VIP_PUB_PRES_60	GOOSE Virtual input 60 publisher bit	PubPres VIP 60
1180	SW	DDB_VIP_PUB_PRES_61	GOOSE Virtual input 61 publisher bit	PubPres VIP 61
1181	SW	DDB_VIP_PUB_PRES_62	GOOSE Virtual input 62 publisher bit	PubPres VIP 62
1182	SW	DDB_VIP_PUB_PRES_63	GOOSE Virtual input 63 publisher bit	PubPres VIP 63
1183	SW	DDB_VIP_PUB_PRES_64	GOOSE Virtual input 64 publisher bit	PubPres VIP 64
1184	SW	DDB_UI_LOGGEDIN	User logged into UI	Logged into UI
1185	SW	DDB_FCUR_LOGGEDIN	User logged into front port courier	Logged into FP
1186	SW	DDB_RP1_LOGGEDIN	User logged into Rear Port1 courier	Logged into RP1
1187	SW	DDB_RP2_LOGGEDIN	User logged into Rear Port2 courier	Logged into RP2
1188	SW	DDB_TNL_LOGGEDIN	User logged into turnneled courier	Logged into TNL
1189	SW	DDB_CPR_LOGGEDIN	User logged into co-processor courier	Logged into CPR
1190	SW	DDB_UNUSED_1190		
1191	SW	DDB_UNUSED_1191		
1192	SW	DDB_UNUSED_1192		
1193	SW	DDB_UNUSED_1193		
1194	SW	DDB_UNUSED_1194		
1195	SW	DDB_UNUSED_1195		
1196	SW	DDB_UNUSED_1196		
1197	SW	DDB_UNUSED_1197		
1198	SW	DDB_UNUSED_1198		
1199	SW	DDB_UNUSED_1199		
1200	SW	DDB_UNUSED_1200		
1201	SW	DDB_UNUSED_1201		
1202	SW	DDB_UNUSED_1202		
1203	SW	DDB_UNUSED_1203		
1204	SW	DDB_UNUSED_1204		
1205	SW	DDB_UNUSED_1205		
1206	SW	DDB_UNUSED_1206		
1207	SW	DDB_UNUSED_1207		

DDB No	Source	Element Name	Description	English Text
1208	SW	DDB_UNUSED_1208		
1209	SW	DDB_UNUSED_1209		
1210	SW	DDB_UNUSED_1210		
1211	SW	DDB_UNUSED_1211		
1212	SW	DDB_UNUSED_1212		
1213	SW	DDB_UNUSED_1213		
1214	SW	DDB_PB_LINK_1_FAIL	Process Bus Network Interface link 1 fail indication	PB Link 1 Fail
1215	SW	DDB_PB_LINK_2_FAIL	Process Bus Network Interface link 2 fail indication	PB Link 2 Fail
1216	SW	DDB_PB_LINK_3_FAIL	Process Bus Network Interface link 3 fail indication	PB Link 3 Fail
1217	SW	DDB_MU1_ABSENCE	MU1 Absence	MU1 Absence
1218	SW	DDB_MU2_ABSENCE	MU2 Absence	MU2 Absence
1219	SW	DDB_MU3_ABSENCE	MU3 Absence	MU3 Absence
1220	SW	DDB_MU4_ABSENCE	MU4 Absence	MU4 Absence
1221	SW	DDB_MU5_ABSENCE	MU5 Absence	MU5 Absence
1222	SW	DDB_MU6_ABSENCE	MU6 Absence	MU6 Absence
1223	SW	DDB_MU7_ABSENCE	MU7 Absence	MU7 Absence
1224	SW	DDB_MU8_ABSENCE	MU8 Absence	MU8 Absence
1225	SW	DDB_MAIN_VT_INHIBIT	Main VT Inhibit	Main VT Inhibit
1226	SW	DDB_CS_VT_INHIBIT	CS VT Inhibit	CS VT Inhibit
1227	SW	DDB_PHASE_CT_INHIBIT	Phs CT Inhibit	Phs CT Inhibit
1228	SW	DDB_NEUTRAL_CT_INHIBIT	In CT Inhibit	In CT Inhibit
1229	SW	DDB_SEF_CT_INHIBIT	SEF CT Inhibit	SEF CT Inhibit
1230	SW	DDB_MAIN_VT_SYNC_ALM	Main VT Synch alarm	Main VT Sync Alm
1231	SW	DDB_CS_VT_SYNC_ALM	CS VT Synch alarm	CS VT Sync Alm
1232	SW	DDB_PHASE_CT_SYNC_ALM	Phs CT Synch alarm	Phs CT Sync Alm
1233	SW	DDB_NEUTRAL_CT_SYNC_ALM	In CT Synch alarm	In CT Sync Alm
1234	SW	DDB_SEF_CT_SYNC_ALM	SEF CT Synch alarm	SEF CT Sync Alm
1235	SW	DDB_UNUSED_1235		
1236	SW	DDB_UNUSED_1236		
1237	SW	DDB_UNUSED_1237		
1238	SW	DDB_UNUSED_1238		
1239	SW	DDB_UNUSED_1239		
1240	SW	DDB_UNUSED_1240		
1241	SW	DDB_UNUSED_1241		
1242	SW	DDB_UNUSED_1242		
1243	SW	DDB_UNUSED_1243		
1244	SW	DDB_UNUSED_1244		
1245	SW	DDB_UNUSED_1245		
1246	SW	DDB_UNUSED_1246		
1247	SW	DDB_UNUSED_1247		
1248	SW	DDB_UNUSED_1248		
1249	SW	DDB_UNUSED_1249		
1250	SW	DDB_UNUSED_1250		
1251	SW	DDB_UNUSED_1251		

DDB No	Source	Element Name	Description	English Text
1252	SW	DDB_UNUSED_1252		
1253	SW	DDB_UNUSED_1253		
1254	SW	DDB_UNUSED_1254		
1255	SW	DDB_UNUSED_1255		
1256	SW	DDB_UNUSED_1256		
1257	SW	DDB_UNUSED_1257		
1258	SW	DDB_UNUSED_1258		
1259	SW	DDB_UNUSED_1259		
1260	SW	DDB_UNUSED_1260		
1261	SW	DDB_UNUSED_1261		
1262	SW	DDB_UNUSED_1262		
1263	SW	DDB_UNUSED_1263		
1264	SW	DDB_UNUSED_1264		
1265	SW	DDB_UNUSED_1265		
1266	SW	DDB_UNUSED_1266		
1267	SW	DDB_UNUSED_1267		
1268	SW	DDB_UNUSED_1268		
1269	SW	DDB_UNUSED_1269		
1270	SW	DDB_UNUSED_1270		
1271	SW	DDB_UNUSED_1271		
1272	SW	DDB_UNUSED_1272		
1273	SW	DDB_UNUSED_1273		
1274	SW	DDB_UNUSED_1274		
1275	SW	DDB_UNUSED_1275		
1276	SW	DDB_UNUSED_1276		
1277	SW	DDB_UNUSED_1277		
1278	SW	DDB_UNUSED_1278		
1279	SW	DDB_UNUSED_1279		
1280	PSL	DDB_ADV_FREQ_INHIBIT	Inhibits advanced frequency protection	Adv Freq Inh
1281	SW	DDB_STG1_F_T_START	Stage 1 f+t Element Start	Stg1 f+t Sta
1282	SW	DDB_STG1_F_T_TRIP	Stage 1 f+t Element Trip	Stg1 f+t Trp
1283	SW	DDB_STG1_F_DFDT_TRIP	Stage 1 f+df/dt Element Trip	Stg1 f+df/dt Trp
1284	SW	DDB_STG1_DFDT_T_START	Stage 1 df/dt+t Element Start	Stg1 df/dt+t Sta
1285	SW	DDB_STG1_DFDT_T_TRIP	Stage 1 df/dt+t Element Trip	Stg1 df/dt+t Trp
1286	SW	DDB_STG1_F_DELF_DELT_START	Stage 1 f+DeltaF/DeltaT Element Start	Stg1 f+Df/Dt Sta
1287	SW	DDB_STG1_F_DELF_DELT_TRIP	Stage 1 f+DeltaF/DeltaT Element Trip	Stg1 f+Df/Dt Trp
1288	PSL	DDB_STG1_ADV_FREQ_BLOCK	Blocks all stage 1 elements	Stg1 Block
1289	SW	DDB_UNUSED_1289		
1290	SW	DDB_UNUSED_1290		
1291	SW	DDB_STG1_RESTORE_CLOSE	Stage 1 Load Restoration Close	Stg1 Restore Cls
1292	SW	DDB_STG1_RESTORE_START	Stage 1 Load Restoration Start	Stg1 Restore Sta
1293	SW	DDB_UNUSED_1293		
1294	SW	DDB_UNUSED_1294		
1295	SW	DDB_STG2_F_T_START	Stage 2 f+t Element Start	Stg2 f+t Sta

DDB No	Source	Element Name	Description	English Text
1296	SW	DDB_STG2_F_T_TRIP	Stage 2 f+t Element Trip	Stg2 f+t Trp
1297	SW	DDB_STG2_F_DFDT_TRIP	Stage 2 f+df/dt Element Trip	Stg2 f+df/dt Trp
1298	SW	DDB_STG2_DFDT_T_START	Stage 2 df/dt+t Element Start	Stg2 df/dt+t Sta
1299	SW	DDB_STG2_DFDT_T_TRIP	Stage 2 df/dt+t Element Trip	Stg2 df/dt+t Trp
1300	SW	DDB_STG2_F_DELF_DELT_START	Stage 2 f+DeltaF/DeltaT Element Start	Stg2 f+Df/Dt Sta
1301	SW	DDB_STG2_F_DELF_DELT_TRIP	Stage 2 f+DeltaF/DeltaT Element Trip	Stg2 f+Df/Dt Trp
1302	PSL	DDB_STG2_ADV_FREQ_BLOCK	Blocks all stage 2 elements	Stg2 Block
1303	SW	DDB_UNUSED_1303		
1304	SW	DDB_UNUSED_1304		
1305	SW	DDB_STG2_RESTORE_CLOSE	Stage 2 Load Restoration Close	Stg2 Restore Cls
1306	SW	DDB_STG2_RESTORE_START	Stage 2 Load Restoration Start	Stg2 Restore Sta
1307	SW	DDB_UNUSED_1307		
1308	SW	DDB_UNUSED_1308		
1309	SW	DDB_STG3_F_T_START	Stage 3 f+t Element Start	Stg3 f+t Sta
1310	SW	DDB_STG3_F_T_TRIP	Stage 3 f+t Element Trip	Stg3 f+t Trp
1311	SW	DDB_STG3_F_DFDT_TRIP	Stage 3 f+df/dt Element Trip	Stg3 f+df/dt Trp
1312	SW	DDB_STG3_DFDT_T_START	Stage 3 df/dt+t Element Start	Stg3 df/dt+t Sta
1313	SW	DDB_STG3_DFDT_T_TRIP	Stage 3 df/dt+t Element Trip	Stg3 df/dt+t Trp
1314	SW	DDB_STG3_F_DELF_DELT_START	Stage 3 f+DeltaF/DeltaT Element Start	Stg3 f+Df/Dt Sta
1315	SW	DDB_STG3_F_DELF_DELT_TRIP	Stage 3 f+DeltaF/DeltaT Element Trip	Stg3 f+Df/Dt Trp
1316	PSL	DDB_STG3_ADV_FREQ_BLOCK	Blocks all stage 3 elements	Stg3 Block
1317	SW	DDB_UNUSED_1317		
1318	SW	DDB_UNUSED_1318		
1319	SW	DDB_STG3_RESTORE_CLOSE	Stage 3 Load Restoration Close	Stg3 Restore Cls
1320	SW	DDB_STG3_RESTORE_START	Stage 3 Load Restoration Start	Stg3 Restore Sta
1321	SW	DDB_UNUSED_1321		
1322	SW	DDB_UNUSED_1322		
1323	SW	DDB_STG4_F_T_START	Stage 4 f+t Element Start	Stg4 f+t Sta
1324	SW	DDB_STG4_F_T_TRIP	Stage 4 f+t Element Trip	Stg4 f+t Trp
1325	SW	DDB_STG4_F_DFDT_TRIP	Stage 4 f+df/dt Element Trip	Stg4 f+df/dt Trp
1326	SW	DDB_STG4_DFDT_T_START	Stage 4 df/dt+t Element Start	Stg4 df/dt+t Sta
1327	SW	DDB_STG4_DFDT_T_TRIP	Stage 4 df/dt+t Element Trip	Stg4 df/dt+t Trp
1328	SW	DDB_STG4_F_DELF_DELT_START	Stage 4 f+DeltaF/DeltaT Element Start	Stg4 f+Df/Dt Sta
1329	SW	DDB_STG4_F_DELF_DELT_TRIP	Stage 4 f+DeltaF/DeltaT Element Trip	Stg4 f+Df/Dt Trp
1330	PSL	DDB_STG4_ADV_FREQ_BLOCK	Blocks all stage 4 elements	Stg4 Block
1331	SW	DDB_UNUSED_1331		
1332	SW	DDB_UNUSED_1332		
1333	SW	DDB_STG4_RESTORE_CLOSE	Stage 4 Load Restoration Close	Stg4 Restore Cls
1334	SW	DDB_STG4_RESTORE_START	Stage 4 Load Restoration Start	Stg4 Restore Sta
1335	SW	DDB_UNUSED_1335		
1336	SW	DDB_UNUSED_1336		
1337	SW	DDB_STG5_F_T_START	Stage 5 f+t Element Start	Stg5 f+t Sta
1338	SW	DDB_STG5_F_T_TRIP	Stage 5 f+t Element Trip	Stg5 f+t Trp
1339	SW	DDB_STG5_F_DFDT_TRIP	Stage 5 f+df/dt Element Trip	Stg5 f+df/dt Trp

DDB No	Source	Element Name	Description	English Text
1340	SW	DDB_STG5_DFDT_T_START	Stage 5 df/dt+t Element Start	Stg5 df/dt+t Sta
1341	SW	DDB_STG5_DFDT_T_TRIP	Stage 5 df/dt+t Element Trip	Stg5 df/dt+t Trp
1342	SW	DDB_STG5_F_DELF_DELT_START	Stage 5 f+DeltaF/DeltaT Element Start	Stg5 f+Df/Dt Sta
1343	SW	DDB_STG5_F_DELF_DELT_TRIP	Stage 5 f+DeltaF/DeltaT Element Trip	Stg5 f+Df/Dt Trp
1344	PSL	DDB_STG5_ADV_FREQ_BLOCK	Blocks all stage 5 elements	Stg5 Block
1345	SW	DDB_UNUSED_1345		
1346	SW	DDB_UNUSED_1346		
1347	SW	DDB_STG5_RESTORE_CLOSE	Stage 5 Load Restoration Close	Stg5 Restore Cls
1348	SW	DDB_STG5_RESTORE_START	Stage 5 Load Restoration Start	Stg5 Restore Sta
1349	SW	DDB_UNUSED_1349		
1350	SW	DDB_UNUSED_1350		
1351	SW	DDB_STG6_F_T_START	Stage 6 f+t Element Start	Stg6 f+t Sta
1352	SW	DDB_STG6_F_T_TRIP	Stage 6 f+t Element Trip	Stg6 f+t Trp
1353	SW	DDB_STG6_F_DFDT_TRIP	Stage 6 f+df/dt Element Trip	Stg6 f+df/dt Trp
1354	SW	DDB_STG6_DFDT_T_START	Stage 6 df/dt+t Element Start	Stg6 df/dt+t Sta
1355	SW	DDB_STG6_DFDT_T_TRIP	Stage 6 df/dt+t Element Trip	Stg6 df/dt+t Trp
1356	SW	DDB_STG6_F_DELF_DELT_START	Stage 6 f+DeltaF/DeltaT Element Start	Stg6 f+Df/Dt Sta
1357	SW	DDB_STG6_F_DELF_DELT_TRIP	Stage 6 f+DeltaF/DeltaT Element Trip	Stg6 f+Df/Dt Trp
1358	PSL	DDB_STG6_ADV_FREQ_BLOCK	Blocks all stage 6 elements	Stg6 Block
1359	SW	DDB_UNUSED_1359		
1360	SW	DDB_UNUSED_1360		
1361	SW	DDB_STG6_RESTORE_CLOSE	Stage 6 Load Restoration Close	Stg6 Restore Cls
1362	SW	DDB_STG6_RESTORE_START	Stage 6 Load Restoration Start	Stg6 Restore Sta
1363	SW	DDB_UNUSED_1363		
1364	SW	DDB_UNUSED_1364		
1365	SW	DDB_STG7_F_T_START	Stage 7 f+t Element Start	Stg7 f+t Sta
1366	SW	DDB_STG7_F_T_TRIP	Stage 7 f+t Element Trip	Stg7 f+t Trp
1367	SW	DDB_STG7_F_DFDT_TRIP	Stage 7 f+df/dt Element Trip	Stg7 f+df/dt Trp
1368	SW	DDB_STG7_DFDT_T_START	Stage 7 df/dt+t Element Start	Stg7 df/dt+t Sta
1369	SW	DDB_STG7_DFDT_T_TRIP	Stage 7 df/dt+t Element Trip	Stg7 df/dt+t Trp
1370	SW	DDB_STG7_F_DELF_DELT_START	Stage 7 f+DeltaF/DeltaT Element Start	Stg7 f+Df/Dt Sta
1371	SW	DDB_STG7_F_DELF_DELT_TRIP	Stage 7 f+DeltaF/DeltaT Element Trip	Stg7 f+Df/Dt Trp
1372	PSL	DDB_STG7_ADV_FREQ_BLOCK	Blocks all stage 7 elements	Stg7 Block
1373	SW	DDB_UNUSED_1373		
1374	SW	DDB_UNUSED_1374		
1375	SW	DDB_STG7_RESTORE_CLOSE	Stage 7 Load Restoration Close	Stg7 Restore Cls
1376	SW	DDB_STG7_RESTORE_START	Stage 7 Load Restoration Start	Stg7 Restore Sta
1377	SW	DDB_UNUSED_1377		
1378	SW	DDB_UNUSED_1378		
1379	SW	DDB_STG8_F_T_START	Stage 8 f+t Element Start	Stg8 f+t Sta
1380	SW	DDB_STG8_F_T_TRIP	Stage 8 f+t Element Trip	Stg8 f+t Trp
1381	SW	DDB_STG8_F_DFDT_TRIP	Stage 8 f+df/dt Element Trip	Stg8 f+df/dt Trp
1382	SW	DDB_STG8_DFDT_T_START	Stage 8 df/dt+t Element Start	Stg8 df/dt+t Sta
1383	SW	DDB_STG8_DFDT_T_TRIP	Stage 8 df/dt+t Element Trip	Stg8 df/dt+t Trp

DDB No	Source	Element Name	Description	English Text
1384	SW	DDB_STG8_F_DELF_DELT_START	Stage 8 f+DeltaF/DeltaT Element Start	Stg8 f+Df/Dt Sta
1385	SW	DDB_STG8_F_DELF_DELT_TRIP	Stage 8 f+DeltaF/DeltaT Element Trip	Stg8 f+Df/Dt Trp
1386	PSL	DDB_STG8_ADV_FREQ_BLOCK	Blocks all stage 8 elements	Stg8 Block
1387	SW	DDB_UNUSED_1387		
1388	SW	DDB_UNUSED_1388		
1389	SW	DDB_STG8_RESTORE_CLOSE	Stage 8 Load Restoration Close	Stg8 Restore Cls
1390	SW	DDB_STG8_RESTORE_START	Stage 8 Load Restoration Start	Stg8 Restore Sta
1391	SW	DDB_UNUSED_1391		
1392	SW	DDB_UNUSED_1392		
1393	SW	DDB_STG9_F_T_START	Stage 9 f+t Element Start	Stg9 f+t Sta
1394	SW	DDB_STG9_F_T_TRIP	Stage 9 f+t Element Trip	Stg9 f+t Trp
1395	SW	DDB_STG9_F_DFDT_TRIP	Stage 9 f+df/dt Element Trip	Stg9 f+df/dt Trp
1396	SW	DDB_STG9_DFDT_T_START	Stage 9 df/dt+t Element Start	Stg9 df/dt+t Sta
1397	SW	DDB_STG9_DFDT_T_TRIP	Stage 9 df/dt+t Element Trip	Stg9 df/dt+t Trp
1398	SW	DDB_STG9_F_DELF_DELT_START	Stage 9 f+DeltaF/DeltaT Element Start	Stg9 f+Df/Dt Sta
1399	SW	DDB_STG9_F_DELF_DELT_TRIP	Stage 9 f+DeltaF/DeltaT Element Trip	Stg9 f+Df/Dt Trp
1400	PSL	DDB_STG9_ADV_FREQ_BLOCK	Blocks all stage 9 elements	Stg9 Block
1401	SW	DDB_UNUSED_1401		
1402	SW	DDB_UNUSED_1402		
1403	SW	DDB_STG9_RESTORE_CLOSE	Stage 9 Load Restoration Close	Stg9 Restore Cls
1404	SW	DDB_STG9_RESTORE_START	Stage 9 Load Restoration Start	Stg9 Restore Sta
1405	PSL	DDB_RESTORE_RESET	Resets all load restoration stages	Restore Reset
1406	PSL	**DDB_RESET_STATISTICS**	Resets all Statistics counters	Reset Stats
1407	SW	DDB_GOOSEIN_65		Virtual Input 65
1408	SW	DDB_GOOSEIN_66		Virtual Input 66
1409	SW	DDB_GOOSEIN_67		Virtual Input 67
1410	SW	DDB_GOOSEIN_68		Virtual Input 68
1411	SW	DDB_GOOSEIN_69		Virtual Input 69
1412	SW	DDB_GOOSEIN_70		Virtual Input 70
1413	SW	DDB_GOOSEIN_71		Virtual Input 71
1414	SW	DDB_GOOSEIN_72		Virtual Input 72
1415	SW	DDB_GOOSEIN_73		Virtual Input 73
1416	SW	DDB_GOOSEIN_74		Virtual Input 74
1417	SW	DDB_GOOSEIN_75		Virtual Input 75
1418	SW	DDB_GOOSEIN_76		Virtual Input 76
1419	SW	DDB_GOOSEIN_77		Virtual Input 77
1420	SW	DDB_GOOSEIN_78		Virtual Input 78
1421	SW	DDB_GOOSEIN_79		Virtual Input 79
1422	SW	DDB_GOOSEIN_80		Virtual Input 80
1423	SW	DDB_GOOSEIN_81		Virtual Input 81
1424	SW	DDB_GOOSEIN_82		Virtual Input 82
1425	SW	DDB_GOOSEIN_83		Virtual Input 83
1426	SW	DDB_GOOSEIN_84		Virtual Input 84
1427	SW	DDB_GOOSEIN_85		Virtual Input 85

DDB No	Source	Element Name	Description	English Text
1428	SW	DDB_GOOSEIN_86		Virtual Input 86
1429	SW	DDB_GOOSEIN_87		Virtual Input 87
1430	SW	DDB_GOOSEIN_88		Virtual Input 88
1431	SW	DDB_GOOSEIN_89		Virtual Input 89
1432	SW	DDB_GOOSEIN_90		Virtual Input 90
1433	SW	DDB_GOOSEIN_91		Virtual Input 91
1434	SW	DDB_GOOSEIN_92		Virtual Input 92
1435	SW	DDB_GOOSEIN_93		Virtual Input 93
1436	SW	DDB_GOOSEIN_94		Virtual Input 94
1437	SW	DDB_GOOSEIN_95		Virtual Input 95
1438	SW	DDB_GOOSEIN_96		Virtual Input 96
1439	SW	DDB_GOOSEIN_97		Virtual Input 97
1440	SW	DDB_GOOSEIN_98		Virtual Input 98
1441	SW	DDB_GOOSEIN_99		Virtual Input 99
1442	SW	DDB_GOOSEIN_100		Virtual Input100
1443	SW	DDB_GOOSEIN_101		Virtual Input101
1444	SW	DDB_GOOSEIN_102		Virtual Input102
1445	SW	DDB_GOOSEIN_103		Virtual Input103
1446	SW	DDB_GOOSEIN_104		Virtual Input104
1447	SW	DDB_GOOSEIN_105		Virtual Input105
1448	SW	DDB_GOOSEIN_106		Virtual Input106
1449	SW	DDB_GOOSEIN_107		Virtual Input107
1450	SW	DDB_GOOSEIN_108		Virtual Input108
1451	SW	DDB_GOOSEIN_109		Virtual Input109
1452	SW	DDB_GOOSEIN_110		Virtual Input110
1453	SW	DDB_GOOSEIN_111		Virtual Input111
1454	SW	DDB_GOOSEIN_112		Virtual Input112
1455	SW	DDB_GOOSEIN_113		Virtual Input113
1456	SW	DDB_GOOSEIN_114		Virtual Input114
1457	SW	DDB_GOOSEIN_115		Virtual Input115
1458	SW	DDB_GOOSEIN_116		Virtual Input116
1459	SW	DDB_GOOSEIN_117		Virtual Input117
1460	SW	DDB_GOOSEIN_118		Virtual Input118
1461	SW	DDB_GOOSEIN_119		Virtual Input119
1462	SW	DDB_GOOSEIN_120		Virtual Input120
1463	SW	DDB_GOOSEIN_121		Virtual Input121
1464	SW	DDB_GOOSEIN_122		Virtual Input122
1465	SW	DDB_GOOSEIN_123		Virtual Input123
1466	SW	DDB_GOOSEIN_124		Virtual Input124
1467	SW	DDB_GOOSEIN_125		Virtual Input125
1468	SW	DDB_GOOSEIN_126		Virtual Input126
1469	SW	DDB_GOOSEIN_127		Virtual Input127
1470	SW	DDB_GOOSEIN_128		Virtual Input128
1471	SW	DDB_VIP_QUALITY_65	GOOSE Virtual input 65 Quality bit	Quality VIP 65

DDB No	Source	Element Name	Description	English Text
1472	SW	DDB_VIP_QUALITY_66	GOOSE Virtual input 66 Quality bit	Quality VIP 66
1473	SW	DDB_VIP_QUALITY_67	GOOSE Virtual input 67 Quality bit	Quality VIP 67
1474	SW	DDB_VIP_QUALITY_68	GOOSE Virtual input 68 Quality bit	Quality VIP 68
1475	SW	DDB_VIP_QUALITY_69	GOOSE Virtual input 69 Quality bit	Quality VIP 69
1476	SW	DDB_VIP_QUALITY_70	GOOSE Virtual input 70 Quality bit	Quality VIP 70
1477	SW	DDB_VIP_QUALITY_71	GOOSE Virtual input 71 Quality bit	Quality VIP 71
1478	SW	DDB_VIP_QUALITY_72	GOOSE Virtual input 72 Quality bit	Quality VIP 72
1479	SW	DDB_VIP_QUALITY_73	GOOSE Virtual input 73 Quality bit	Quality VIP 73
1480	SW	DDB_VIP_QUALITY_74	GOOSE Virtual input 74 Quality bit	Quality VIP 74
1481	SW	DDB_VIP_QUALITY_75	GOOSE Virtual input 75 Quality bit	Quality VIP 75
1482	SW	DDB_VIP_QUALITY_76	GOOSE Virtual input 76 Quality bit	Quality VIP 76
1483	SW	DDB_VIP_QUALITY_77	GOOSE Virtual input 77 Quality bit	Quality VIP 77
1484	SW	DDB_VIP_QUALITY_78	GOOSE Virtual input 78 Quality bit	Quality VIP 78
1485	SW	DDB_VIP_QUALITY_79	GOOSE Virtual input 79 Quality bit	Quality VIP 79
1486	SW	DDB_VIP_QUALITY_80	GOOSE Virtual input 80 Quality bit	Quality VIP 80
1487	SW	DDB_VIP_QUALITY_81	GOOSE Virtual input 81 Quality bit	Quality VIP 81
1488	SW	DDB_VIP_QUALITY_82	GOOSE Virtual input 82 Quality bit	Quality VIP 82
1489	SW	DDB_VIP_QUALITY_83	GOOSE Virtual input 83 Quality bit	Quality VIP 83
1490	SW	DDB_VIP_QUALITY_84	GOOSE Virtual input 84 Quality bit	Quality VIP 84
1491	SW	DDB_VIP_QUALITY_85	GOOSE Virtual input 85 Quality bit	Quality VIP 85
1492	SW	DDB_VIP_QUALITY_86	GOOSE Virtual input 86 Quality bit	Quality VIP 86
1493	SW	DDB_VIP_QUALITY_87	GOOSE Virtual input 87 Quality bit	Quality VIP 87
1494	SW	DDB_VIP_QUALITY_88	GOOSE Virtual input 88 Quality bit	Quality VIP 88
1495	SW	DDB_VIP_QUALITY_89	GOOSE Virtual input 89 Quality bit	Quality VIP 89
1496	SW	DDB_VIP_QUALITY_90	GOOSE Virtual input 90 Quality bit	Quality VIP 90
1497	SW	DDB_VIP_QUALITY_91	GOOSE Virtual input 91 Quality bit	Quality VIP 91
1498	SW	DDB_VIP_QUALITY_92	GOOSE Virtual input 92 Quality bit	Quality VIP 92
1499	SW	DDB_VIP_QUALITY_93	GOOSE Virtual input 93 Quality bit	Quality VIP 93
1500	SW	DDB_VIP_QUALITY_94	GOOSE Virtual input 94 Quality bit	Quality VIP 94
1501	SW	DDB_VIP_QUALITY_95	GOOSE Virtual input 95 Quality bit	Quality VIP 95
1502	SW	DDB_VIP_QUALITY_96	GOOSE Virtual input 96 Quality bit	Quality VIP 96
1503	SW	DDB_VIP_QUALITY_97	GOOSE Virtual input 97 Quality bit	Quality VIP 97
1504	SW	DDB_VIP_QUALITY_98	GOOSE Virtual input 98 Quality bit	Quality VIP 98
1505	SW	DDB_VIP_QUALITY_99	GOOSE Virtual input 99 Quality bit	Quality VIP 99
1506	SW	DDB_VIP_QUALITY_100	GOOSE Virtual input 100 Quality bit	Quality VIP 100
1507	SW	DDB_VIP_QUALITY_101	GOOSE Virtual input 101 Quality bit	Quality VIP 101
1508	SW	DDB_VIP_QUALITY_102	GOOSE Virtual input 102 Quality bit	Quality VIP 102
1509	SW	DDB_VIP_QUALITY_103	GOOSE Virtual input 103 Quality bit	Quality VIP 103
1510	SW	DDB_VIP_QUALITY_104	GOOSE Virtual input 104 Quality bit	Quality VIP 104
1511	SW	DDB_VIP_QUALITY_105	GOOSE Virtual input 105 Quality bit	Quality VIP 105
1512	SW	DDB_VIP_QUALITY_106	GOOSE Virtual input 106 Quality bit	Quality VIP 106
1513	SW	DDB_VIP_QUALITY_107	GOOSE Virtual input 107 Quality bit	Quality VIP 107
1514	SW	DDB_VIP_QUALITY_108	GOOSE Virtual input 108 Quality bit	Quality VIP 108
1515	SW	DDB_VIP_QUALITY_109	GOOSE Virtual input 109 Quality bit	Quality VIP 109

DDB No	Source	Element Name	Description	English Text
1516	SW	DDB_VIP_QUALITY_110	GOOSE Virtual input 110 Quality bit	Quality VIP 110
1517	SW	DDB_VIP_QUALITY_111	GOOSE Virtual input 111 Quality bit	Quality VIP 111
1518	SW	DDB_VIP_QUALITY_112	GOOSE Virtual input 112 Quality bit	Quality VIP 112
1519	SW	DDB_VIP_QUALITY_113	GOOSE Virtual input 113 Quality bit	Quality VIP 113
1520	SW	DDB_VIP_QUALITY_114	GOOSE Virtual input 114 Quality bit	Quality VIP 114
1521	SW	DDB_VIP_QUALITY_115	GOOSE Virtual input 115 Quality bit	Quality VIP 115
1522	SW	DDB_VIP_QUALITY_116	GOOSE Virtual input 116 Quality bit	Quality VIP 116
1523	SW	DDB_VIP_QUALITY_117	GOOSE Virtual input 117 Quality bit	Quality VIP 117
1524	SW	DDB_VIP_QUALITY_118	GOOSE Virtual input 118 Quality bit	Quality VIP 118
1525	SW	DDB_VIP_QUALITY_119	GOOSE Virtual input 119 Quality bit	Quality VIP 119
1526	SW	DDB_VIP_QUALITY_120	GOOSE Virtual input 120 Quality bit	Quality VIP 120
1527	SW	DDB_VIP_QUALITY_121	GOOSE Virtual input 121 Quality bit	Quality VIP 121
1528	SW	DDB_VIP_QUALITY_122	GOOSE Virtual input 122 Quality bit	Quality VIP 122
1529	SW	DDB_VIP_QUALITY_123	GOOSE Virtual input 123 Quality bit	Quality VIP 123
1530	SW	DDB_VIP_QUALITY_124	GOOSE Virtual input 124 Quality bit	Quality VIP 124
1531	SW	DDB_VIP_QUALITY_125	GOOSE Virtual input 125 Quality bit	Quality VIP 125
1532	SW	DDB_VIP_QUALITY_126	GOOSE Virtual input 126 Quality bit	Quality VIP 126
1533	SW	DDB_VIP_QUALITY_127	GOOSE Virtual input 127 Quality bit	Quality VIP 127
1534	SW	DDB_VIP_QUALITY_128	GOOSE Virtual input 128 Quality bit	Quality VIP 128
1535	SW	DDB_VIP_PUB_PRES_65	GOOSE Virtual input 65 publisher bit	PubPres VIP 65
1536	SW	DDB_VIP_PUB_PRES_66	GOOSE Virtual input 66 publisher bit	PubPres VIP 66
1537	SW	DDB_VIP_PUB_PRES_67	GOOSE Virtual input 67 publisher bit	PubPres VIP 67
1538	SW	DDB_VIP_PUB_PRES_68	GOOSE Virtual input 68 publisher bit	PubPres VIP 68
1539	SW	DDB_VIP_PUB_PRES_69	GOOSE Virtual input 69 publisher bit	PubPres VIP 69
1540	SW	DDB_VIP_PUB_PRES_70	GOOSE Virtual input 70 publisher bit	PubPres VIP 70
1541	SW	DDB_VIP_PUB_PRES_71	GOOSE Virtual input 71 publisher bit	PubPres VIP 71
1542	SW	DDB_VIP_PUB_PRES_72	GOOSE Virtual input 72 publisher bit	PubPres VIP 72
1543	SW	DDB_VIP_PUB_PRES_73	GOOSE Virtual input 73 publisher bit	PubPres VIP 73
1544	SW	DDB_VIP_PUB_PRES_74	GOOSE Virtual input 74 publisher bit	PubPres VIP 74
1545	SW	DDB_VIP_PUB_PRES_75	GOOSE Virtual input 75 publisher bit	PubPres VIP 75
1546	SW	DDB_VIP_PUB_PRES_76	GOOSE Virtual input 76 publisher bit	PubPres VIP 76
1547	SW	DDB_VIP_PUB_PRES_77	GOOSE Virtual input 77 publisher bit	PubPres VIP 77
1548	SW	DDB_VIP_PUB_PRES_78	GOOSE Virtual input 78 publisher bit	PubPres VIP 78
1549	SW	DDB_VIP_PUB_PRES_79	GOOSE Virtual input 79 publisher bit	PubPres VIP 79
1550	SW	DDB_VIP_PUB_PRES_80	GOOSE Virtual input 80 publisher bit	PubPres VIP 80
1551	SW	DDB_VIP_PUB_PRES_81	GOOSE Virtual input 81 publisher bit	PubPres VIP 81
1552	SW	DDB_VIP_PUB_PRES_82	GOOSE Virtual input 82 publisher bit	PubPres VIP 82
1553	SW	DDB_VIP_PUB_PRES_83	GOOSE Virtual input 83 publisher bit	PubPres VIP 83
1554	SW	DDB_VIP_PUB_PRES_84	GOOSE Virtual input 84 publisher bit	PubPres VIP 84
1555	SW	DDB_VIP_PUB_PRES_85	GOOSE Virtual input 85 publisher bit	PubPres VIP 85
1556	SW	DDB_VIP_PUB_PRES_86	GOOSE Virtual input 86 publisher bit	PubPres VIP 86
1557	SW	DDB_VIP_PUB_PRES_87	GOOSE Virtual input 87 publisher bit	PubPres VIP 87
1558	SW	DDB_VIP_PUB_PRES_88	GOOSE Virtual input 88 publisher bit	PubPres VIP 88
1559	SW	DDB_VIP_PUB_PRES_89	GOOSE Virtual input 89 publisher bit	PubPres VIP 89

DDB No	Source	Element Name	Description	English Text
1560	SW	DDB_VIP_PUB_PRES_90	GOOSE Virtual input 90 publisher bit	PubPres VIP 90
1561	SW	DDB_VIP_PUB_PRES_91	GOOSE Virtual input 91 publisher bit	PubPres VIP 91
1562	SW	DDB_VIP_PUB_PRES_92	GOOSE Virtual input 92 publisher bit	PubPres VIP 92
1563	SW	DDB_VIP_PUB_PRES_93	GOOSE Virtual input 93 publisher bit	PubPres VIP 93
1564	SW	DDB_VIP_PUB_PRES_94	GOOSE Virtual input 94 publisher bit	PubPres VIP 94
1565	SW	DDB_VIP_PUB_PRES_95	GOOSE Virtual input 95 publisher bit	PubPres VIP 95
1566	SW	DDB_VIP_PUB_PRES_96	GOOSE Virtual input 96 publisher bit	PubPres VIP 96
1567	SW	DDB_VIP_PUB_PRES_97	GOOSE Virtual input 97 publisher bit	PubPres VIP 97
1568	SW	DDB_VIP_PUB_PRES_98	GOOSE Virtual input 98 publisher bit	PubPres VIP 98
1569	SW	DDB_VIP_PUB_PRES_99	GOOSE Virtual input 99 publisher bit	PubPres VIP 99
1570	SW	DDB_VIP_PUB_PRES_100	GOOSE Virtual input 100 publisher bit	PubPres VIP 100
1571	SW	DDB_VIP_PUB_PRES_101	GOOSE Virtual input 101 publisher bit	PubPres VIP 101
1572	SW	DDB_VIP_PUB_PRES_102	GOOSE Virtual input 102 publisher bit	PubPres VIP 102
1573	SW	DDB_VIP_PUB_PRES_103	GOOSE Virtual input 103 publisher bit	PubPres VIP 103
1574	SW	DDB_VIP_PUB_PRES_104	GOOSE Virtual input 104 publisher bit	PubPres VIP 104
1575	SW	DDB_VIP_PUB_PRES_105	GOOSE Virtual input 105 publisher bit	PubPres VIP 105
1576	SW	DDB_VIP_PUB_PRES_106	GOOSE Virtual input 106 publisher bit	PubPres VIP 106
1577	SW	DDB_VIP_PUB_PRES_107	GOOSE Virtual input 107 publisher bit	PubPres VIP 107
1578	SW	DDB_VIP_PUB_PRES_108	GOOSE Virtual input 108 publisher bit	PubPres VIP 108
1579	SW	DDB_VIP_PUB_PRES_109	GOOSE Virtual input 109 publisher bit	PubPres VIP 109
1580	SW	DDB_VIP_PUB_PRES_110	GOOSE Virtual input 110 publisher bit	PubPres VIP 110
1581	SW	DDB_VIP_PUB_PRES_111	GOOSE Virtual input 111 publisher bit	PubPres VIP 111
1582	SW	DDB_VIP_PUB_PRES_112	GOOSE Virtual input 112 publisher bit	PubPres VIP 112
1583	SW	DDB_VIP_PUB_PRES_113	GOOSE Virtual input 113 publisher bit	PubPres VIP 113
1584	SW	DDB_VIP_PUB_PRES_114	GOOSE Virtual input 114 publisher bit	PubPres VIP 114
1585	SW	DDB_VIP_PUB_PRES_115	GOOSE Virtual input 115 publisher bit	PubPres VIP 115
1586	SW	DDB_VIP_PUB_PRES_116	GOOSE Virtual input 116 publisher bit	PubPres VIP 116
1587	SW	DDB_VIP_PUB_PRES_117	GOOSE Virtual input 117 publisher bit	PubPres VIP 117
1588	SW	DDB_VIP_PUB_PRES_118	GOOSE Virtual input 118 publisher bit	PubPres VIP 118
1589	SW	DDB_VIP_PUB_PRES_119	GOOSE Virtual input 119 publisher bit	PubPres VIP 119
1590	SW	DDB_VIP_PUB_PRES_120	GOOSE Virtual input 120 publisher bit	PubPres VIP 120
1591	SW	DDB_VIP_PUB_PRES_121	GOOSE Virtual input 121 publisher bit	PubPres VIP 121
1592	SW	DDB_VIP_PUB_PRES_122	GOOSE Virtual input 122 publisher bit	PubPres VIP 122
1593	SW	DDB_VIP_PUB_PRES_123	GOOSE Virtual input 123 publisher bit	PubPres VIP 123
1594	SW	DDB_VIP_PUB_PRES_124	GOOSE Virtual input 124 publisher bit	PubPres VIP 124
1595	SW	DDB_VIP_PUB_PRES_125	GOOSE Virtual input 125 publisher bit	PubPres VIP 125
1596	SW	DDB_VIP_PUB_PRES_126	GOOSE Virtual input 126 publisher bit	PubPres VIP 126
1597	SW	DDB_VIP_PUB_PRES_127	GOOSE Virtual input 127 publisher bit	PubPres VIP 127
1598	SW	DDB_VIP_PUB_PRES_128	GOOSE Virtual input 128 publisher bit	PubPres VIP 128
1599	PSL	DDB_PSLINT_101		
1600	PSL	DDB_PSLINT_102		
1601	PSL	DDB_PSLINT_103		
1602	PSL	DDB_PSLINT_104		
1603	PSL	DDB_PSLINT_105		

DDB No	Source	Element Name	Description	English Text
1604	PSL	DDB_PSLINT_106		
1605	PSL	DDB_PSLINT_107		
1606	PSL	DDB_PSLINT_108		
1607	PSL	DDB_PSLINT_109		
1608	PSL	DDB_PSLINT_110		
1609	PSL	DDB_PSLINT_111		
1610	PSL	DDB_PSLINT_112		
1611	PSL	DDB_PSLINT_113		
1612	PSL	DDB_PSLINT_114		
1613	PSL	DDB_PSLINT_115		
1614	PSL	DDB_PSLINT_116		
1615	PSL	DDB_PSLINT_117		
1616	PSL	DDB_PSLINT_118		
1617	PSL	DDB_PSLINT_119		
1618	PSL	DDB_PSLINT_120		
1619	PSL	DDB_PSLINT_121		
1620	PSL	DDB_PSLINT_122		
1621	PSL	DDB_PSLINT_123		
1622	PSL	DDB_PSLINT_124		
1623	PSL	DDB_PSLINT_125		
1624	PSL	DDB_PSLINT_126		
1625	PSL	DDB_PSLINT_127		
1626	PSL	DDB_PSLINT_128		
1627	PSL	DDB_PSLINT_129		
1628	PSL	DDB_PSLINT_130		
1629	PSL	DDB_PSLINT_131		
1630	PSL	DDB_PSLINT_132		
1631	PSL	DDB_PSLINT_133		
1632	PSL	DDB_PSLINT_134		
1633	PSL	DDB_PSLINT_135		
1634	PSL	DDB_PSLINT_136		
1635	PSL	DDB_PSLINT_137		
1636	PSL	DDB_PSLINT_138		
1637	PSL	DDB_PSLINT_139		
1638	PSL	DDB_PSLINT_140		
1639	PSL	DDB_PSLINT_141		
1640	PSL	DDB_PSLINT_142		
1641	PSL	DDB_PSLINT_143		
1642	PSL	DDB_PSLINT_144		
1643	PSL	DDB_PSLINT_145		
1644	PSL	DDB_PSLINT_146		
1645	PSL	DDB_PSLINT_147		
1646	PSL	DDB_PSLINT_148		
1647	PSL	DDB_PSLINT_149		

DDB No	Source	Element Name	Description	English Text
1648	PSL	DDB_PSLINT_150		
1649	PSL	DDB_PSLINT_151		
1650	PSL	DDB_PSLINT_152		
1651	PSL	DDB_PSLINT_153		
1652	PSL	DDB_PSLINT_154		
1653	PSL	DDB_PSLINT_155		
1654	PSL	DDB_PSLINT_156		
1655	PSL	DDB_PSLINT_157		
1656	PSL	DDB_PSLINT_158		
1657	PSL	DDB_PSLINT_159		
1658	PSL	DDB_PSLINT_160		
1659	PSL	DDB_PSLINT_161		
1660	PSL	DDB_PSLINT_162		
1661	PSL	DDB_PSLINT_163		
1662	PSL	DDB_PSLINT_164		
1663	PSL	DDB_PSLINT_165		
1664	PSL	DDB_PSLINT_166		
1665	PSL	DDB_PSLINT_167		
1666	PSL	DDB_PSLINT_168		
1667	PSL	DDB_PSLINT_169		
1668	PSL	DDB_PSLINT_170		
1669	PSL	DDB_PSLINT_171		
1670	PSL	DDB_PSLINT_172		
1671	PSL	DDB_PSLINT_173		
1672	PSL	DDB_PSLINT_174		
1673	PSL	DDB_PSLINT_175		
1674	PSL	DDB_PSLINT_176		
1675	PSL	DDB_PSLINT_177		
1676	PSL	DDB_PSLINT_178		
1677	PSL	DDB_PSLINT_179		
1678	PSL	DDB_PSLINT_180		
1679	PSL	DDB_PSLINT_181		
1680	PSL	DDB_PSLINT_182		
1681	PSL	DDB_PSLINT_183		
1682	PSL	DDB_PSLINT_184		
1683	PSL	DDB_PSLINT_185		
1684	PSL	DDB_PSLINT_186		
1685	PSL	DDB_PSLINT_187		
1686	PSL	DDB_PSLINT_188		
1687	PSL	DDB_PSLINT_189		
1688	PSL	DDB_PSLINT_190		
1689	PSL	DDB_PSLINT_191		
1690	PSL	DDB_PSLINT_192		
1691	PSL	DDB_PSLINT_193		

DDB No	Source	Element Name	Description	English Text
1692	PSL	DDB_PSLINT_194		
1693	PSL	DDB_PSLINT_195		
1694	PSL	DDB_PSLINT_196		
1695	PSL	DDB_PSLINT_197		
1696	PSL	DDB_PSLINT_198		
1697	PSL	DDB_PSLINT_199		
1698	PSL	DDB_PSLINT_200		
1699	PSL	DDB_PSLINT_201		
1700	PSL	DDB_PSLINT_202		
1701	PSL	DDB_PSLINT_203		
1702	PSL	DDB_PSLINT_204		
1703	PSL	DDB_PSLINT_205		
1704	PSL	DDB_PSLINT_206		
1705	PSL	DDB_PSLINT_207		
1706	PSL	DDB_PSLINT_208		
1707	PSL	DDB_PSLINT_209		
1708	PSL	DDB_PSLINT_210		
1709	PSL	DDB_PSLINT_211		
1710	PSL	DDB_PSLINT_212		
1711	PSL	DDB_PSLINT_213		
1712	PSL	DDB_PSLINT_214		
1713	PSL	DDB_PSLINT_215		
1714	PSL	DDB_PSLINT_216		
1715	PSL	DDB_PSLINT_217		
1716	PSL	DDB_PSLINT_218		
1717	PSL	DDB_PSLINT_219		
1718	PSL	DDB_PSLINT_220		
1719	PSL	DDB_PSLINT_221		
1720	PSL	DDB_PSLINT_222		
1721	PSL	DDB_PSLINT_223		
1722	PSL	DDB_PSLINT_224		
1723	PSL	DDB_PSLINT_225		
1724	PSL	DDB_PSLINT_226		
1725	PSL	DDB_PSLINT_227		
1726	PSL	DDB_PSLINT_228		
1727	PSL	DDB_PSLINT_229		
1728	PSL	DDB_PSLINT_230		
1729	PSL	DDB_PSLINT_231		
1730	PSL	DDB_PSLINT_232		
1731	PSL	DDB_PSLINT_233		
1732	PSL	DDB_PSLINT_234		
1733	PSL	DDB_PSLINT_235		
1734	PSL	DDB_PSLINT_236		
1735	PSL	DDB_PSLINT_237		

DDB No	Source	Element Name	Description	English Text
1736	PSL	DDB_PSLINT_238		
1737	PSL	DDB_PSLINT_239		
1738	PSL	DDB_PSLINT_240		
1739	PSL	DDB_PSLINT_241		
1740	PSL	DDB_PSLINT_242		
1741	PSL	DDB_PSLINT_243		
1742	PSL	DDB_PSLINT_244		
1743	PSL	DDB_PSLINT_245		
1744	PSL	DDB_PSLINT_246		
1745	PSL	DDB_PSLINT_247		
1746	PSL	DDB_PSLINT_248		
1747	PSL	DDB_PSLINT_249		
1748	PSL	DDB_PSLINT_250		
1749	PSL	DDB_PSLINT_251		
1750	PSL	DDB_PSLINT_252		
1751	PSL	DDB_PSLINT_253		
1752	PSL	DDB_PSLINT_254		
1753	PSL	DDB_PSLINT_255		
1754	PSL	DDB_PSLINT_256		
1755	PSL	DDB_PSLINT_257		
1756	PSL	DDB_PSLINT_258		
1757	PSL	DDB_PSLINT_259		
1758	PSL	DDB_PSLINT_260		
1759	PSL	DDB_PSLINT_261		
1760	PSL	DDB_PSLINT_262		
1761	PSL	DDB_PSLINT_263		
1762	PSL	DDB_PSLINT_264		
1763	PSL	DDB_PSLINT_265		
1764	PSL	DDB_PSLINT_266		
1765	PSL	DDB_PSLINT_267		
1766	PSL	DDB_PSLINT_268		
1767	PSL	DDB_PSLINT_269		
1768	PSL	DDB_PSLINT_270		
1769	PSL	DDB_PSLINT_271		
1770	PSL	DDB_PSLINT_272		
1771	PSL	DDB_PSLINT_273		
1772	PSL	DDB_PSLINT_274		
1773	PSL	DDB_PSLINT_275		
1774	PSL	DDB_PSLINT_276		
1775	PSL	DDB_PSLINT_277		
1776	PSL	DDB_PSLINT_278		
1777	PSL	DDB_PSLINT_279		
1778	PSL	DDB_PSLINT_280		
1779	PSL	DDB_PSLINT_281		

DDB No	Source	Element Name	Description	English Text
1780	PSL	DDB_PSLINT_282		
1781	PSL	DDB_PSLINT_283		
1782	PSL	DDB_PSLINT_284		
1783	PSL	DDB_PSLINT_285		
1784	PSL	DDB_PSLINT_286		
1785	PSL	DDB_PSLINT_287		
1786	PSL	DDB_PSLINT_288		
1787	PSL	DDB_PSLINT_289		
1788	PSL	DDB_PSLINT_290		
1789	PSL	DDB_PSLINT_291		
1790	PSL	DDB_PSLINT_292		
1791	PSL	DDB_PSLINT_293		
1792	PSL	DDB_PSLINT_294		
1793	PSL	DDB_PSLINT_295		
1794	PSL	DDB_PSLINT_296		
1795	PSL	DDB_PSLINT_297		
1796	PSL	DDB_PSLINT_298		
1797	PSL	DDB_PSLINT_299		
1798	PSL	DDB_PSLINT_300		
1799	SW	DDB_UNUSED_1799		
1800	SW	DDB_UNUSED_1800		
1801	SW	DDB_UNUSED_1801		
1802	SW	DDB_UNUSED_1802		
1803	SW	DDB_UNUSED_1803		
1804	SW	DDB_UNUSED_1804		
1805	SW	DDB_UNUSED_1805		
1806	SW	DDB_UNUSED_1806		
1807	SW	DDB_UNUSED_1807		
1808	SW	DDB_UNUSED_1808		
1809	SW	DDB_UNUSED_1809		
1810	SW	DDB_UNUSED_1810		
1811	SW	DDB_UNUSED_1811		
1812	SW	DDB_UNUSED_1812		
1813	SW	DDB_UNUSED_1813		
1814	SW	DDB_UNUSED_1814		
1815	SW	DDB_UNUSED_1815		
1816	SW	DDB_UNUSED_1816		
1817	SW	DDB_UNUSED_1817		
1818	SW	DDB_UNUSED_1818		
1819	SW	DDB_UNUSED_1819		
1820	SW	DDB_UNUSED_1820		
1821	SW	DDB_UNUSED_1821		
1822	SW	DDB_UNUSED_1822		
1823	SW	DDB_UNUSED_1823		

DDB No	Source	Element Name	Description	English Text
1824	SW	DDB_UNUSED_1824		
1825	SW	DDB_UNUSED_1825		
1826	SW	DDB_UNUSED_1826		
1827	SW	DDB_UNUSED_1827		
1828	SW	DDB_UNUSED_1828		
1829	SW	DDB_UNUSED_1829		
1830	SW	DDB_UNUSED_1830		
1831	SW	DDB_UNUSED_1831		
1832	SW	DDB_UNUSED_1832		
1833	SW	DDB_UNUSED_1833		
1834	SW	DDB_UNUSED_1834		
1835	SW	DDB_UNUSED_1835		
1836	SW	DDB_UNUSED_1836		
1837	SW	DDB_UNUSED_1837		
1838	SW	DDB_UNUSED_1838		
1839	SW	DDB_UNUSED_1839		
1840	SW	DDB_UNUSED_1840		
1841	SW	DDB_UNUSED_1841		
1842	SW	DDB_UNUSED_1842		
1843	SW	DDB_UNUSED_1843		
1844	SW	DDB_UNUSED_1844		
1845	SW	DDB_UNUSED_1845		
1846	SW	DDB_UNUSED_1846		
1847	SW	DDB_UNUSED_1847		
1848	SW	DDB_UNUSED_1848		
1849	SW	DDB_UNUSED_1849		
1850	SW	DDB_UNUSED_1850		
1851	SW	DDB_UNUSED_1851		
1852	SW	DDB_UNUSED_1852		
1853	SW	DDB_UNUSED_1853		
1854	SW	DDB_UNUSED_1854		
1855	SW	DDB_UNUSED_1855		
1856	SW	DDB_UNUSED_1856		
1857	SW	DDB_UNUSED_1857		
1858	SW	DDB_UNUSED_1858		
1859	SW	DDB_UNUSED_1859		
1860	SW	DDB_UNUSED_1860		
1861	SW	DDB_UNUSED_1861		
1862	SW	DDB_UNUSED_1862		
1863	SW	DDB_UNUSED_1863		
1864	SW	DDB_UNUSED_1864		
1865	SW	DDB_UNUSED_1865		
1866	SW	DDB_UNUSED_1866		
1867	SW	DDB_UNUSED_1867		

DDB No	Source	Element Name	Description	English Text
1868	SW	DDB_UNUSED_1868		
1869	SW	DDB_UNUSED_1869		
1870	SW	DDB_UNUSED_1870		
1871	SW	DDB_UNUSED_1871		
1872	SW	DDB_UNUSED_1872		
1873	SW	DDB_UNUSED_1873		
1874	SW	DDB_UNUSED_1874		
1875	SW	DDB_UNUSED_1875		
1876	SW	DDB_UNUSED_1876		
1877	SW	DDB_UNUSED_1877		
1878	SW	DDB_UNUSED_1878		
1879	SW	DDB_UNUSED_1879		
1880	SW	DDB_UNUSED_1880		
1881	SW	DDB_UNUSED_1881		
1882	SW	DDB_UNUSED_1882		
1883	SW	DDB_UNUSED_1883		
1884	SW	DDB_UNUSED_1884		
1885	SW	DDB_UNUSED_1885		
1886	SW	DDB_UNUSED_1886		
1887	SW	DDB_UNUSED_1887		
1888	SW	DDB_UNUSED_1888		
1889	SW	DDB_UNUSED_1889		
1890	SW	DDB_UNUSED_1890		
1891	SW	DDB_UNUSED_1891		
1892	SW	DDB_UNUSED_1892		
1893	SW	DDB_UNUSED_1893		
1894	SW	DDB_UNUSED_1894		
1895	SW	DDB_UNUSED_1895		
1896	SW	DDB_UNUSED_1896		
1897	SW	DDB_UNUSED_1897		
1898	SW	DDB_UNUSED_1898		
1899	SW	DDB_UNUSED_1899		
1900	SW	DDB_UNUSED_1900		
1901	SW	DDB_UNUSED_1901		
1902	SW	DDB_UNUSED_1902		
1903	SW	DDB_UNUSED_1903		
1904	SW	DDB_UNUSED_1904		
1905	SW	DDB_UNUSED_1905		
1906	SW	DDB_UNUSED_1906		
1907	SW	DDB_UNUSED_1907		
1908	SW	DDB_UNUSED_1908		
1909	SW	DDB_UNUSED_1909		
1910	SW	DDB_UNUSED_1910		
1911	SW	DDB_UNUSED_1911		

DDB No	Source	Element Name	Description	English Text
1912	SW	DDB_UNUSED_1912		
1913	SW	DDB_UNUSED_1913		
1914	PSL	DDB_CHAN_ALT	Alternate other analogue channels	Channel Alt
1915	PSL	DDB_VCS1_ALT	Alternate VCS 1	Check Sync Alt1
1916	SW	DDB_UNUSED_1916		
1917	SW	DDB_UNUSED_1917		
1918	SW	DDB_UNUSED_1918		
1919	SW	DDB_UNUSED_1919		
1920	SW	DDB_UNUSED_1920		
1921	SW	DDB_UNUSED_1921		
1922	SW	DDB_UNUSED_1922		
1923	SW	DDB_UNUSED_1923		
1924	SW	DDB_UNUSED_1924		
1925	SW	DDB_UNUSED_1925		
1926	SW	DDB_UNUSED_1926		
1927	SW	DDB_UNUSED_1927		
1928	SW	DDB_UNUSED_1928		
1929	SW	DDB_UNUSED_1929		
1930	SW	DDB_UNUSED_1930		
1931	SW	DDB_UNUSED_1931		
1932	SW	DDB_UNUSED_1932		
1933	SW	DDB_UNUSED_1933		
1934	SW	DDB_UNUSED_1934		
1935	SW	DDB_UNUSED_1935		
1936	SW	DDB_UNUSED_1936		
1937	SW	DDB_UNUSED_1937		
1938	SW	DDB_UNUSED_1938		
1939	SW	DDB_UNUSED_1939		
1940	SW	DDB_UNUSED_1940		
1941	SW	DDB_UNUSED_1941		
1942	SW	DDB_UNUSED_1942		
1943	SW	DDB_UNUSED_1943		
1944	SW	DDB_UNUSED_1944		
1945	SW	DDB_UNUSED_1945		
1946	SW	DDB_UNUSED_1946		
1947	SW	DDB_UNUSED_1947		
1948	SW	DDB_UNUSED_1948		
1949	SW	DDB_UNUSED_1949		
1950	SW	DDB_UNUSED_1950		
1951	SW	DDB_UNUSED_1951		
1952	SW	DDB_UNUSED_1952		
1953	SW	DDB_UNUSED_1953		
1954	SW	DDB_UNUSED_1954		
1955	SW	DDB_UNUSED_1955		

DDB No	Source	Element Name	Description	English Text
1956	SW	DDB_UNUSED_1956		
1957	SW	DDB_UNUSED_1957		
1958	SW	DDB_UNUSED_1958		
1959	SW	DDB_UNUSED_1959		
1960	SW	DDB_UNUSED_1960		
1961	SW	DDB_UNUSED_1961		
1962	SW	DDB_UNUSED_1962		
1963	SW	DDB_UNUSED_1963		
1964	SW	DDB_UNUSED_1964		
1965	SW	DDB_UNUSED_1965		
1966	SW	DDB_UNUSED_1966		
1967	SW	DDB_UNUSED_1967		
1968	SW	DDB_UNUSED_1968		
1969	SW	DDB_UNUSED_1969		
1970	SW	DDB_UNUSED_1970		
1971	SW	DDB_UNUSED_1971		
1972	SW	DDB_UNUSED_1972		
1973	SW	DDB_UNUSED_1973		
1974	SW	DDB_UNUSED_1974		
1975	SW	DDB_UNUSED_1975		
1976	SW	DDB_UNUSED_1976		
1977	SW	DDB_UNUSED_1977		
1978	SW	DDB_UNUSED_1978		
1979	SW	DDB_UNUSED_1979		
1980	SW	DDB_UNUSED_1980		
1981	SW	DDB_UNUSED_1981		
1982	SW	DDB_UNUSED_1982		
1983	SW	DDB_UNUSED_1983		
1984	SW	DDB_UNUSED_1984		
1985	SW	DDB_UNUSED_1985		
1986	SW	DDB_UNUSED_1986		
1987	SW	DDB_UNUSED_1987		
1988	SW	DDB_UNUSED_1988		
1989	SW	DDB_UNUSED_1989		
1990	SW	DDB_UNUSED_1990		
1991	SW	DDB_UNUSED_1991		
1992	SW	DDB_UNUSED_1992		
1993	SW	DDB_UNUSED_1993		
1994	SW	DDB_UNUSED_1994		
1995	SW	DDB_UNUSED_1995		
1996	SW	DDB_UNUSED_1996		
1997	SW	DDB_UNUSED_1997		
1998	SW	DDB_UNUSED_1998		
1999	SW	DDB_UNUSED_1999		

DDB No	Source	Element Name	Description	English Text
2000	SW	DDB_UNUSED_2000		
2001	SW	DDB_UNUSED_2001		
2002	SW	DDB_UNUSED_2002		
2003	SW	DDB_UNUSED_2003		
2004	SW	DDB_UNUSED_2004		
2005	SW	DDB_UNUSED_2005		
2006	SW	DDB_UNUSED_2006		
2007	SW	DDB_UNUSED_2007		
2008	SW	DDB_UNUSED_2008		
2009	SW	DDB_UNUSED_2009		
2010	SW	DDB_UNUSED_2010		
2011	SW	DDB_UNUSED_2011		
2012	SW	DDB_UNUSED_2012		
2013	SW	DDB_UNUSED_2013		
2014	SW	DDB_UNUSED_2014		
2015	SW	DDB_UNUSED_2015		
2016	SW	DDB_UNUSED_2016		
2017	SW	DDB_UNUSED_2017		
2018	SW	DDB_UNUSED_2018		
2019	SW	DDB_UNUSED_2019		
2020	SW	DDB_UNUSED_2020		
2021	SW	DDB_UNUSED_2021		
2022	SW	DDB_UNUSED_2022		
2023	SW	DDB_UNUSED_2023		
2024	SW	DDB_UNUSED_2024		
2025	SW	DDB_UNUSED_2025		
2026	SW	DDB_UNUSED_2026		
2027	SW	DDB_UNUSED_2027		
2028	SW	DDB_UNUSED_2028		
2029	SW	DDB_UNUSED_2029		
2030	SW	DDB_UNUSED_2030		
2031	SW	DDB_UNUSED_2031		
2032	SW	DDB_UNUSED_2032		
2033	SW	DDB_UNUSED_2033		
2034	SW	DDB_UNUSED_2034		
2035	SW	DDB_UNUSED_2035		
2036	SW	DDB_UNUSED_2036		
2037	SW	DDB_UNUSED_2037		
2038	SW	DDB_UNUSED_2038		
2039	SW	DDB_UNUSED_2039		
2040	SW	DDB_UNUSED_2040		
2041	SW	DDB_UNUSED_2041		
2042	SW	DDB_UNUSED_2042		
2043	SW	DDB_UNUSED_2043		

DDB No	Source	Element Name	Description	English Text
2044	SW	DDB_UNUSED_2044		
2045	SW	DDB_UNUSED_2045		
2046	SW	DDB_UNUSED_2046		
2047	SW	DDB_UNUSED_2047		
2035	SW	DDB_UNUSED_2035		
2036	SW	DDB_UNUSED_2036		
2037	SW	DDB_UNUSED_2037		
2038	SW	DDB_UNUSED_2038		
2039	SW	DDB_UNUSED_2039		
2040	SW	DDB_UNUSED_2040		
2041	SW	DDB_UNUSED_2041		
2042	SW	DDB_UNUSED_2042		
2043	SW	DDB_UNUSED_2043		
2044	SW	DDB_UNUSED_2044		
2045	SW	DDB_UNUSED_2045		
2046	SW	DDB_UNUSED_2046		
2047	SW	DDB_UNUSED_2047		

Table 1 - Description of Logic Nodes

2.1 Factory Default Programmable Scheme Logic

The following section details the default settings of the PSL.

Note	*The default PSL has been implemented for the base variants of the P14x with no expansion as highlighted in the table.*

The P14x model options are as follows:

Model	P141 Inputs/Outputs	P142 Inputs/Outputs	P143 Inputs/Outputs	P145 Inputs/Outputs
P14xxxxAxxxxxxx	8/7	8/7	16/14	16I/16O
P14xxxxBxxxxxxx		12/11	N/A	12/12
P14xxxxCxxxxxxx		16/7	24/14	24/16
P14xxxxDxxxxxxx		8/15	16/22	16/24
P14xxxxExxxxxxx			24/22	24/24
P14xxxxFxxxxxxx			32/14	32/16
P14xxxxGxxxxxxx			16/30	16/32
P14xxxxHxxxxxxx		8/7 + 4 High-Break Output Relays	16/14 + 4 High-Break Output Relays	12/12 + 4 High-Break Output Relays
P14xxxxJxxxxxxx			24/14 + 4 High-Break Output Relays	20/12 + 4 High-Break Output Relays
P14xxxxKxxxxxxx			16/22 + 4 High-Break Output Relays	12/20 + 4 High-Break Output Relays
P14xxxxLxxxxxxx			16/14 + 8 High-Break Output Relays	12/12 + 8 High-Break Output Relays
P14xxxxMxxxxxxx			32/32	
P14xxxxNxxxxxxx	8/8			

Table 2 - P14x model options

2.2 Logic Input Mapping

The default mappings for each of the opto-isolated inputs are as shown in the following tables for all P14x models:

2.2.1 P141/P142/P143 Models

Opto-Input No	P141 Relay Text	P142 Relay Text	P143 Relay Text	Function
1	Input L1	Input L1	Input L1	Setting group selection
2	Input L2	Input L2	Input L2	Setting group selection
3	Input L3	Input L3	Input L3	Block earth fault stages IN1>3 & 4
4	Input L4	Input L4	Input L4	Block overcurrent stages I>3 & 4
5	Input L5	Input L5	Input L5	Reset input for lockout trip contacts, auto-reclose lockout and LEDs
6	Input L6	Input L6	Input L6	External trip input
7	Input L7	Input L7	Input L7	Circuit breaker 52-A auxiliary contact input
8	Input L8	Input L8	Input L8	Circuit Breaker 52-B auxiliary contact input
9		L9 Not Mapped (A)	Input L9	Auto-reclose in service input
10		L10 Not Mapped (A)	Input L10	Activates telecontrol mode for AR
11		L11 Not Mapped (A)	Input L11	Activates live line mode
12		L12 Not Mapped (A)	Input L12	Circuit breaker healthy input
13		L13 Not Mapped (B)	Input L9	External auto-reclose block
14		L14 Not Mapped (B)	Input L10	External AR lockout reset
15		L15 Not Mapped (B)	L15 Not Mapped	L15 Not Mapped
16		L16 Not Mapped (B)	L16 Not Mapped	L16 Not Mapped
17			L17 Not Mapped (B)	L17 Not Mapped
18			L18 Not Mapped (B)	L18 Not Mapped
19			L19 Not Mapped (B)	L19 Not Mapped
20			L20 Not Mapped (B)	L20 Not Mapped
21			L21 Not Mapped (B)	L21 Not Mapped
22			L22 Not Mapped (B)	L22 Not Mapped
23			L23 Not Mapped (B)	L23 Not Mapped
24			L24 Not Mapped (B)	L24 Not Mapped
25			L25 Not Mapped (C)	L25 Not Mapped
26			L26 Not Mapped (C)	L26 Not Mapped
27			L27 Not Mapped (C)	L27 Not Mapped
28			L28 Not Mapped (C)	L28 Not Mapped
29			L29 Not Mapped (C)	L29 Not Mapped
30			L30 Not Mapped (C)	L30 Not Mapped
31			L31 Not Mapped (C)	L31 Not Mapped
32			L32 Not Mapped (C)	L32 Not Mapped
Note A	Represents 4 + 4 or additional 8 input expansion			
Note B	Represents additional 8 input expansion only			
Note C	Represents 2nd additional 8 input expansion only			

Table 3 - Logic Input Mapping for P141/P142/P143

2.2.2 P145 Model

Opto-Input No	P145 Relay Text	Function
1	Input L1	Setting group selection
2	Input L2	Setting group selection
3	Input L3	Block earth fault stages IN1>3 & 4
4	Input L4	Block overcurrent stages I>3 & 4
5	Input L5	L5 not mapped
6	Input L6	External 3-phase trip input
7	Input L7	Circuit breaker 52-A auxiliary contact input
8	Input L8	Circuit breaker 52-B auxiliary contact input
9	Input L9	L9 not mapped
10	Input L10	Activates telecontrol mode for AR
11	Input L11	External auto-reclose block
12	Input L12	Circuit breaker healthy input
13	L13 Not Mapped	L13 Not Mapped
14	L14 Not Mapped	L14 Not Mapped
15	L15 Not Mapped	L15 Not Mapped
16	L16 Not Mapped	L16 Not Mapped
17	L17 Not Mapped	L17 Not Mapped
18	L18 Not Mapped	L18 Not Mapped
19	L19 Not Mapped	L19 Not Mapped
20	L20 Not Mapped	L20 Not Mapped
21	L21 Not Mapped	L21 Not Mapped
22	L22 Not Mapped	L22 Not Mapped
23	L23 Not Mapped	L23 Not Mapped
24	L24 Not Mapped	L24 Not Mapped
25	L25 Not Mapped	L25 Not Mapped
26	L26 Not Mapped	L26 Not Mapped
27	L27 Not Mapped	L27 Not Mapped
28	L28 Not Mapped	L28 Not Mapped
29	L29 Not Mapped	L29 Not Mapped
30	L30 Not Mapped	L30 Not Mapped
31	L31 Not Mapped	L31 Not Mapped
32	L32 Not Mapped	L32 Not Mapped

Table 4 - Logic Input Mapping for P145

2.3 Relay Output Contact Mapping

The default mappings for each of the relay output contacts are as shown in the following table:

2.3.1 P141/P142/P143 Models

Relay Contact Number	P141 Relay Text	P142 Relay Text	P143 Relay Text	Function
1	Output R1	Output R1	Output R1	Earth fault/sensitive earth fault started IN>/ISEF> start
2	Output R2	Output R2	Output R2	Overcurrent I> start
3	Output R3	Output R3	Output R3	Protection trip output
4	Output R4	Output R4	Output R4	General alarm output
5	Output R5	Output R5	Output R5	Circuit breaker fail tmr. 1 trip
6	Output R6	Output R6	Output R6	Circuit breaker control close
7	Output R7	Output R7	Output R7	Circuit breaker control trip
8		R8 Not Mapped (A)	Output R8	Any protection start output
9		R9 Not Mapped (A)	Output R9	Auto-reclose successful close indication
10		R10 Not Mapped (A)	Output R10	R10 non-auto
11		R11 Not Mapped (A)	Output R11	Auto-reclose in progress indication
12		R12 Not Mapped (B)	Output R12	Auto-reclose lockout indication
13		R13 Not Mapped (B)	Output R13	Auto-reclose in service indication
14		R14 Not Mapped (B)	Output R14	Auto-reclose in liveline mode indication
15		R15 Not Mapped (B)	R15 Not Mapped (B)	R15 Not Mapped
16			R16 Not Mapped (B)	R16 Not Mapped
17			R17 Not Mapped (B)	R17 Not Mapped
18			R18 Not Mapped (B)	R18 Not Mapped
19			R19 Not Mapped (B)	R19 Not Mapped
20			R20 Not Mapped (B)	R20 Not Mapped
21			R21 Not Mapped (B)	R21 Not Mapped
22			R22 Not Mapped (B)	R22 Not Mapped
23			R23 Not Mapped (C)	R23 Not Mapped
24			R24 Not Mapped (C)	R24 Not Mapped
25			R25 Not Mapped (C)	R25 Not Mapped
26			R26 Not Mapped (C)	R26 Not Mapped
27			R27 Not Mapped (C)	R27 Not Mapped
28			R28 Not Mapped (C)	R28 Not Mapped
29			R29 Not Mapped (C)	R29 Not Mapped
30			R30 Not Mapped (C)	R30 Not Mapped
31			R31 Not Mapped (C)	R31 Not Mapped
32			R32 Not Mapped (C)	R32 Not Mapped
Note A	Represents 4 + 4 or additional 8 input expansion			
Note B	Represents additional 8 input expansion only			
Note C	Represents 2nd additional 8 input expansion only			

Table 5 - Relay Output Contact Mapping for P141/P142/P143

A fault record can be generated by connecting one or a number of contacts to the “**Fault Record Trigger**” in PSL. It is recommended that the triggering contact be ‘**self reset**’ and not latching. If a latching contact was chosen the fault record would not be generated until the contact had fully reset.

The default conditioning of each of the output contacts is as shown in the following table:

Relay Contact Number	P141 Relay Text	P142 Relay Text	P143 Relay Text
1	Straight	Straight	Straight
2	Straight	Straight	Straight
3	Dwell 100ms	Dwell 100ms	Dwell 100ms
4	Dwell 100ms	Dwell 100ms	Dwell 100ms
5	Dwell 100ms	Dwell 100ms	Dwell 100ms
6	Straight	Straight	Straight
7	Straight	Straight	Straight
8		R8 Not Mapped (A)	Straight
9		R9 Not Mapped (A)	Straight
10		R10 Not Mapped (A)	Straight
11		R11 Not Mapped (A)	Straight
12		R12 Not Mapped (B)	Straight
13		R13 Not Mapped (B)	Straight
14		R14 Not Mapped (B)	Straight
15		R15 Not Mapped (B)	R15 Not Mapped (B)
16			R16 Not Mapped (B)
17			R17 Not Mapped (B)
18			R18 Not Mapped (B)
19			R19 Not Mapped (B)
20			R20 Not Mapped (B)
21			R21 Not Mapped (B)
22			R22 Not Mapped (B)
23			R23 Not Mapped (C)
24			R24 Not Mapped (C)
25			R25 Not Mapped (C)
26			R26 Not Mapped (C)
27			R27 Not Mapped (C)
28			R28 Not Mapped (C)
29			R29 Not Mapped (C)
30			R30 Not Mapped (C)
Note A Represents 4 + 4 or additional 8 input expansion			
Note B Represents additional 8 input expansion only			
Note C Represents 2nd additional 8 input expansion only			

Table 6 - Default conditioning for P141/P142/P143

2.3.2 P145 Model

Relay Contact Number	P145 Relay Text	P145 Relay Conditioner	Function
1	Output R1	Straight	Earth fault/sensitive earth fault started IN>/ISEF> start
2	Output R2	Straight	Overcurrent I> start
3	Output R3	Dwell 100ms	Protection trip output
4	Output R4	Dwell 100ms	General alarm output
5	Output R5	Dwell 100ms	Circuit breaker fail tmr. 1 trip
6	Output R6	Straight	Circuit breaker control close
7	Output R7	Straight	Circuit breaker control trip
8	Output R8	Straight	Any protection start output
9	Output R9	Straight	Auto-reclose successful close indication
10	Output R10	Straight	Auto-reclose in service indication
11	Output R11	Straight	Auto-reclose in progress indication
12	Output R12	Straight	Auto-reclose lockout indication
13	R13 Not Mapped	Not Mapped	R13 Not Mapped
14	R14 Not Mapped	Not Mapped	R14 Not Mapped
15	R15 Not Mapped	Not Mapped	R15 Not Mapped
16	R16 Not Mapped	Not Mapped	R16 Not Mapped
17	R17 Not Mapped	Not Mapped	R17 Not Mapped
18	R18 Not Mapped	Not Mapped	R18 Not Mapped
19	R19 Not Mapped	Not Mapped	R19 Not Mapped
20	R20 Not Mapped	Not Mapped	R20 Not Mapped
21	R21 Not Mapped	Not Mapped	R21 Not Mapped
22	R22 Not Mapped	Not Mapped	R22 Not Mapped
23	R23 Not Mapped	Not Mapped	R23 Not Mapped
24	R24 Not Mapped	Not Mapped	R24 Not Mapped
25	R25 Not Mapped	Not Mapped	R25 Not Mapped
26	R26 Not Mapped	Not Mapped	R26 Not Mapped
27	R27 Not Mapped	Not Mapped	R27 Not Mapped
28	R28 Not Mapped	Not Mapped	R28 Not Mapped
29	R29 Not Mapped	Not Mapped	R29 Not Mapped
30	R30 Not Mapped	Not Mapped	R30 Not Mapped
31	R31 Not Mapped	Not Mapped	R31 Not Mapped
32	R32 Not Mapped	Not Mapped	R32 Not Mapped
	Note It is essential that Relay 3 is used for tripping purposes as this output drives the trip LED on the frontplate. It also feeds into other logic sections that require CB trip information such as the CB fail, auto-reclose, condition monitoring etc.		

Table 7 - Relay Output Contact Mapping for P145

A fault record can be generated by connecting one or a number of contacts to the "**Fault Record Trigger**" in PSL. It is recommended that the triggering contact be '**self reset**' and not latching. If a latching contact were chosen the fault record would not be generated until the contact had fully reset.

2.4 Programmable LED Output Mapping

The default mappings for each of the programmable LEDs are as shown in this table:

2.4.1 P141/P142/P143 Models

LED No	P141 Relay	P142 Relay	P143 Relay
1	E/F Trip	E/F Trip	E/F Trip
2	I>1/2 Trip	I>1/2 Trip	I>1/2 Trip
3	I>3/4 Trip	I>3/4 Trip	I>3/4 Trip
4	Thermal Alarm	A/R In Progress	A/R In Progress
5	Thermal Trip	A/R Lockout	A/R Lockout
6	Any Start	Any Start	Any Start
7	CB Open	CB Open	CB Open
8	CB Closed	CB Closed	CB Closed

Table 8 - P141/P142/P143 programmable LED output mapping

2.4.2 P145 Model

LED No	LED Input Connection/Text	Latched	P145 LED Function Indication
1	LED 1 Red	Yes	E/F Trip Indication
2	LED 2 Red	Yes	Overcurrent Stage I>1/2 Trip
3	LED 3 Red	Yes	Overcurrent Stage I>3/4 Trip
4	LED 4 Red	No	Auto-reclose In Progress
5	LED 5 Red	No	Auto-reclose Lockout
6	LED 6 Red	No	Any Start
7	LED 7 Grn.	No	Circuit Breaker Open
8	LED 8 Red	No	Circuit Breaker Closed
9	FnKey LED1 Red	No	Remote SCADA Comms. CB operation enabled
10	FnKey LED2 Red/ FnKey LED2 Grn. (Yellow)	No	Circuit Breaker Trip
11	FnKey LED3 Red/ FnKey LED3 Grn. (Yellow)	No	Circuit Breaker Close
12	FnKey LED4 Red	No	Sensitive Earth Fault Protection Enable
13	FnKey LED5 Red	No	Enable Setting Group 2
14	FnKey LED6 Red	No	Enable Auto-reclose
15	FnKey LED7 Red	No	Enable Live Line Mode
16	FnKey LED8 Red	No	Not Mapped
17	FnKey LED9 Red/ FnKey LED9 Grn.	No	Reset Alarms/LEDs
18	FnKey LED10 Red	No	Reset Auto-reclose Lockout

Table 9 - P145 programmable LED output mapping

2.5 Fault Recorder Start Mapping

The default mapping for the signal which initiates a fault record is as shown in the following table:

Initiating Signal	Fault Trigger
Output R3	Initiate fault recording from main protection trip

Table 10 - Fault recorder start mapping

2.6 PSL DATA Column

The relay contains a PSL DATA column that can be used to track PSL modifications. A total of 12 cells are contained in the PSL DATA column, 3 for each setting group. The function for each cell is shown below:

Grp PSL Ref	When downloading a PSL to the relay, the user will be prompted to enter which groups the PSL is for and a reference ID. The first 32 characters of the reference ID will be displayed in this cell. The ◄ and ► keys can be used to scroll through 32 characters as only 16 can be displayed at any one time.
18 Nov 2002 08:59:32.047	This cell displays the date and time when the PSL was down loaded to the relay.
Grp 1 PSL ID - 2062813232	This is a unique number for the PSL that has been entered. Any change in the PSL will result in a different number being displayed.

Note *The above cells are repeated for each setting group.*

2.7 Monitor Bits in PSL

Monitor bits are included in PSL, which gives greater flexibility when testing. The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor / download port. Eight DDBs are provided in the psl, which allows mapped monitor signals to be mapped to disturbance recorder or contacts.

DDB Signals:

Element Name	Ordinal	Description
DDB_MONITOR1	589	Monitor Bit 1
DDB_MONITOR2	590	Monitor Bit 2
DDB_MONITOR3	591	Monitor Bit 3
DDB_MONITOR4	592	Monitor Bit 4
DDB_MONITOR5	593	Monitor Bit 5
DDB_MONITOR6	594	Monitor Bit 6
DDB_MONITOR7	595	Monitor Bit 7
DDB_MONITOR8	596	Monitor Bit 8

Table 11 - Monitor Bits in PSL

3 VIEWING AND PRINTING DEFAULT PSL DIAGRAMS

3.1 Typical Mappings

It is possible to view and print the default PSL diagrams for the device. Typically, these diagrams allow you to see these mappings:

- Opto Input Mappings
- Output Relay Mappings
- LED Mappings
- Start Indications
- Phase Trip Mappings
- System Check Mapping

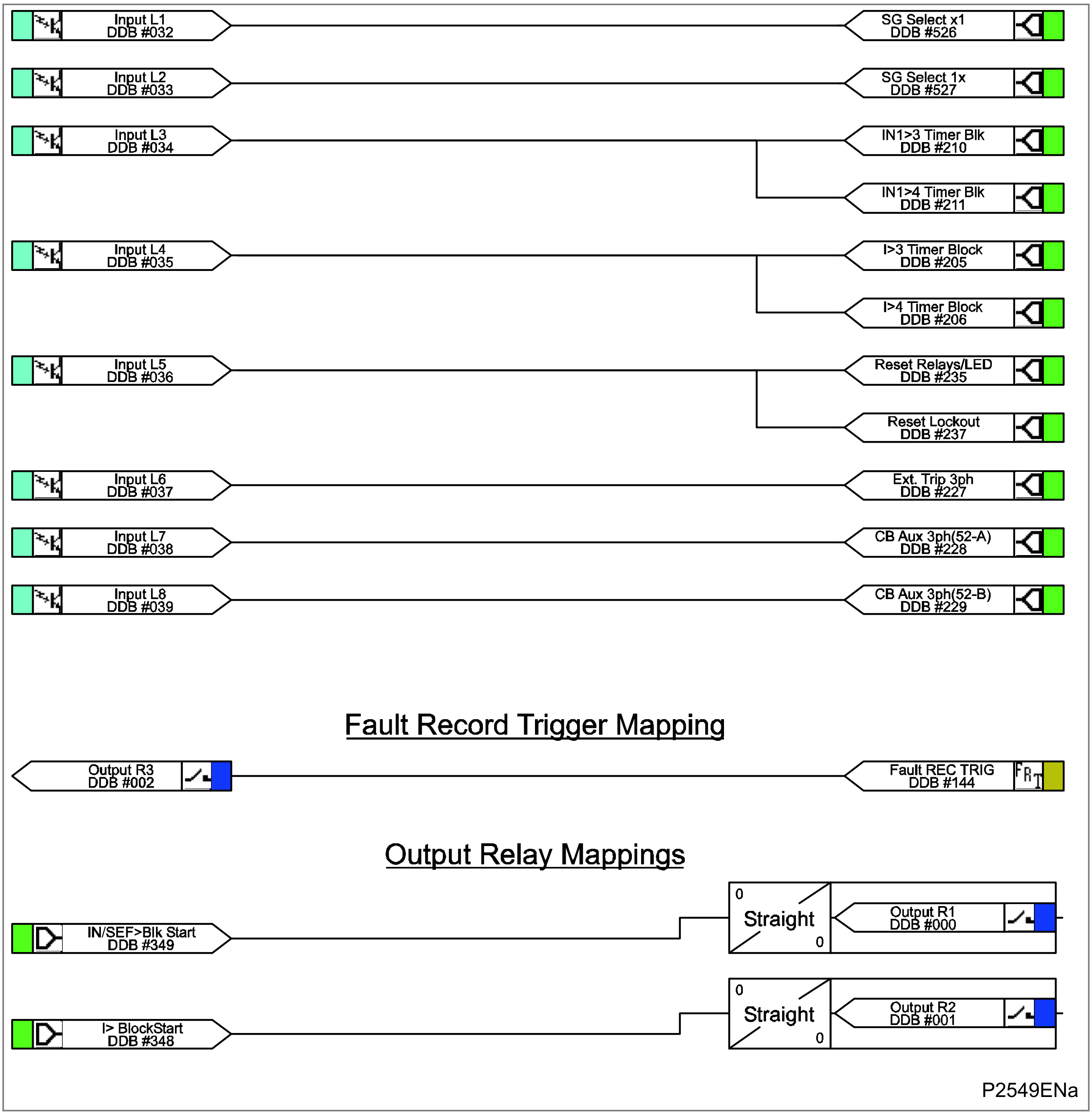
3.2 Download and Print PSL Diagrams

To download and print the default PSL diagrams for the device:

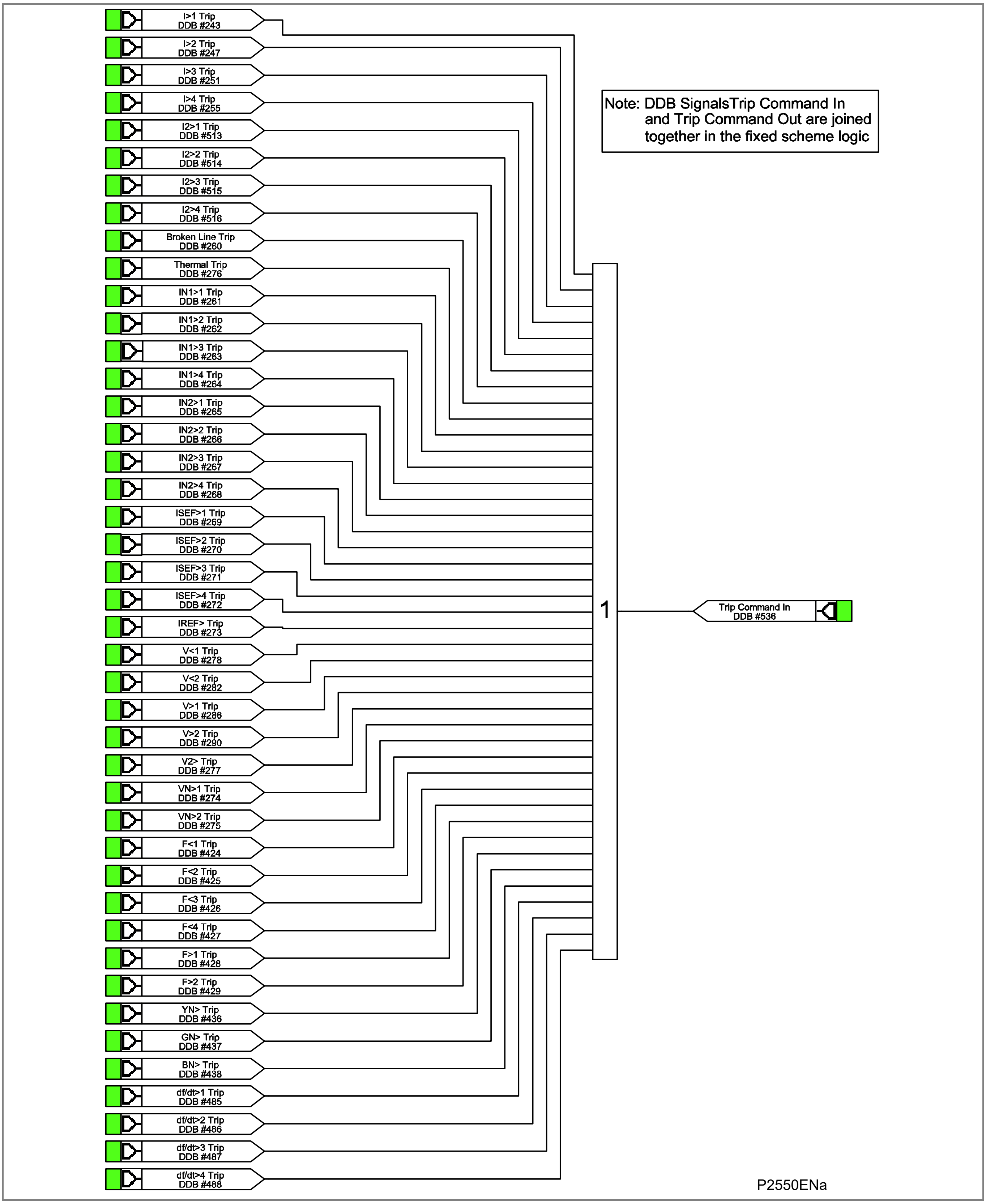
1. Close Easergy Studio.
2. Select **Programs** > then navigate through to > **Easergy Studio** > **Data Model Manager**.
3. Click **Add** then **Next**.
4. Click **Internet** then **Next**.
5. Select your language then click **Next**.
6. From the tree view, select the model and software version.
7. Click **Install**. When complete click **OK**.
8. Close the Data Model Manager and start Easergy Studio.
9. Select Tools > PSL Editor (Px40).
10. In the PSL Editor select **File** > **Open**. The downloaded PSL files are in C:\Program Files\ directory located in the \Easergy Studio\Courier\PSL\Defaults sub-directory.
11. Highlight the required PSL diagram and select **File** > **Print**.

4 P141 PROGRAMMABLE SCHEME LOGIC

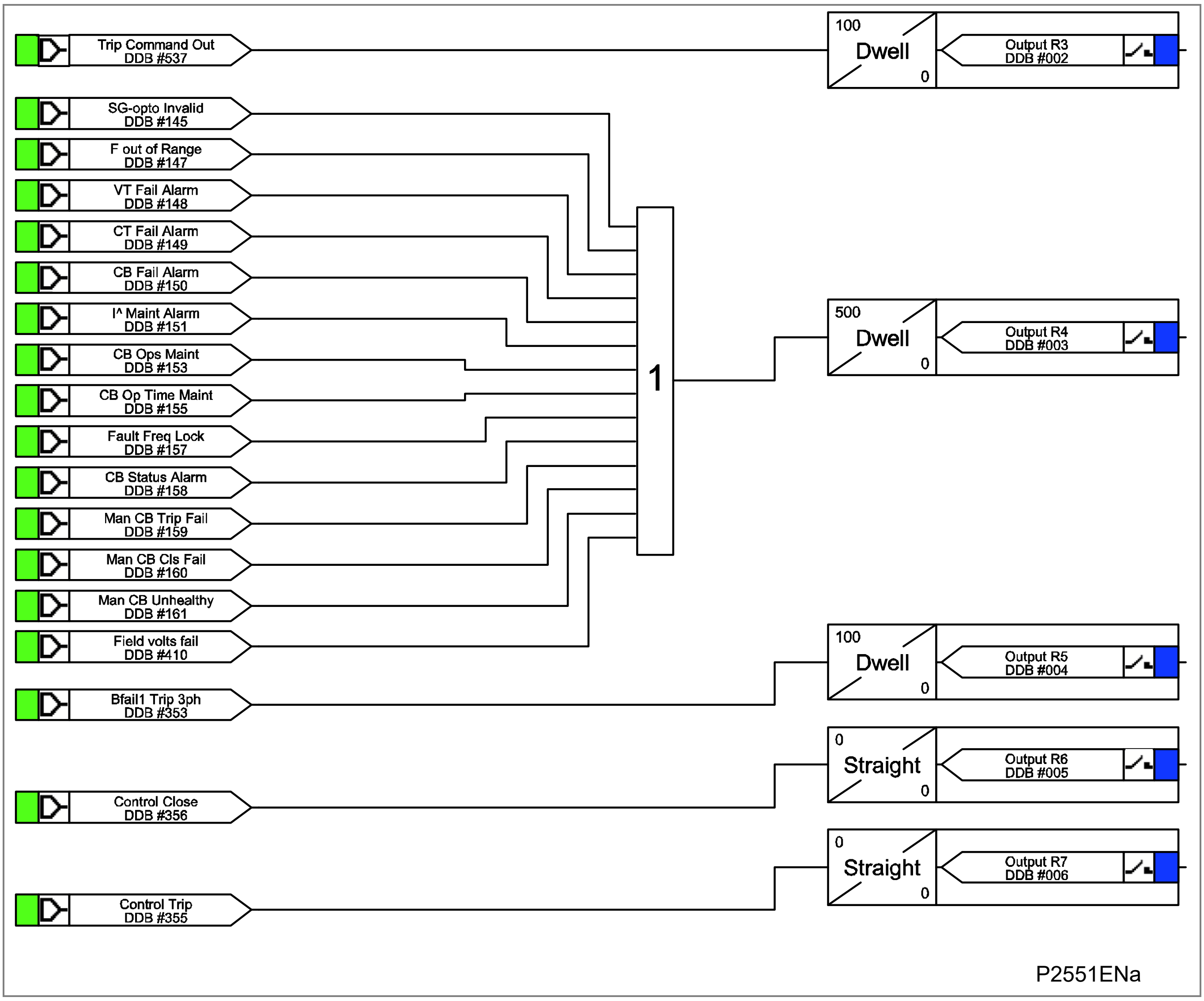
4.1 Opto Input Mappings



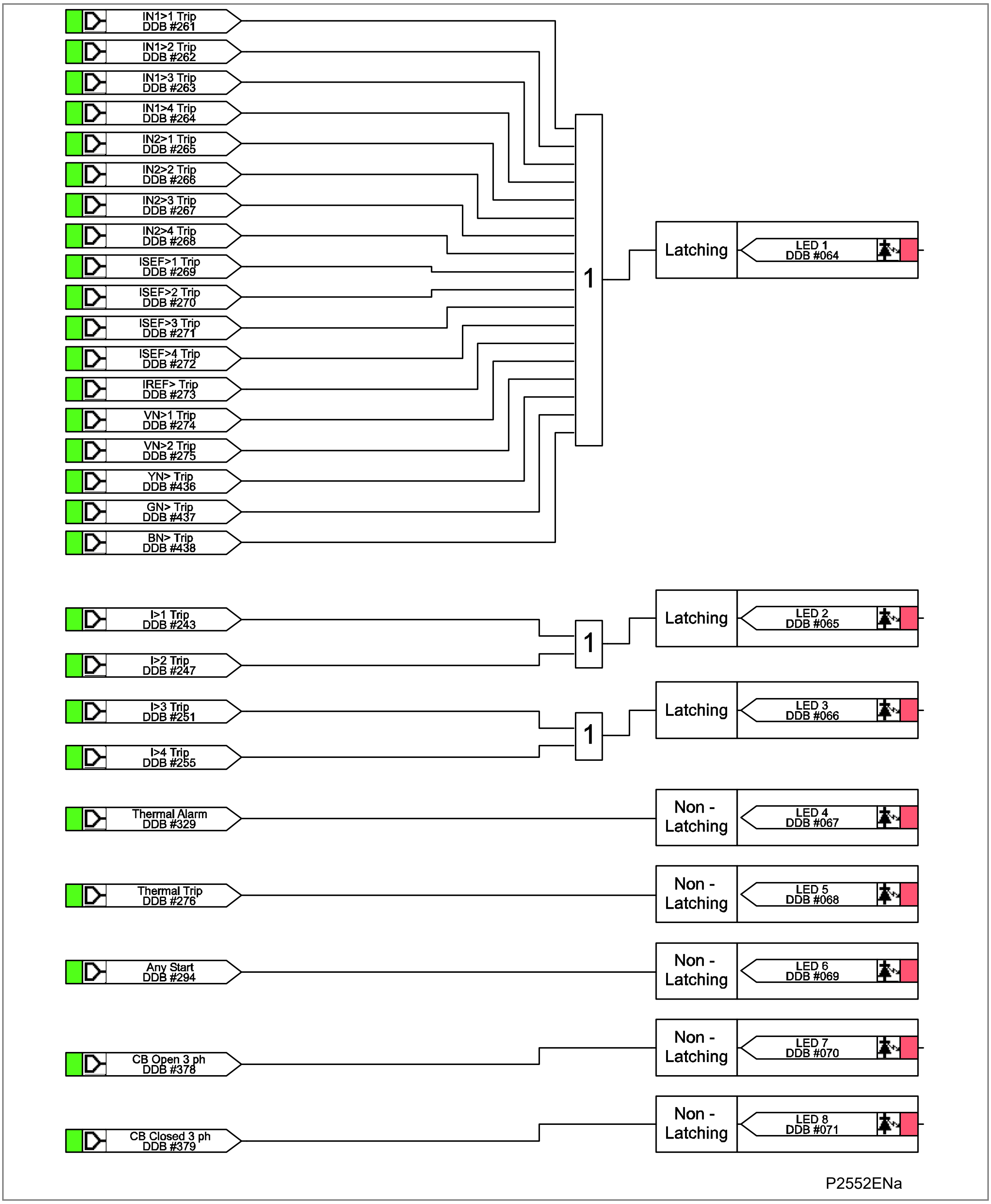
4.2 Trip Relay Mappings



4.3 Output Relay Mappings

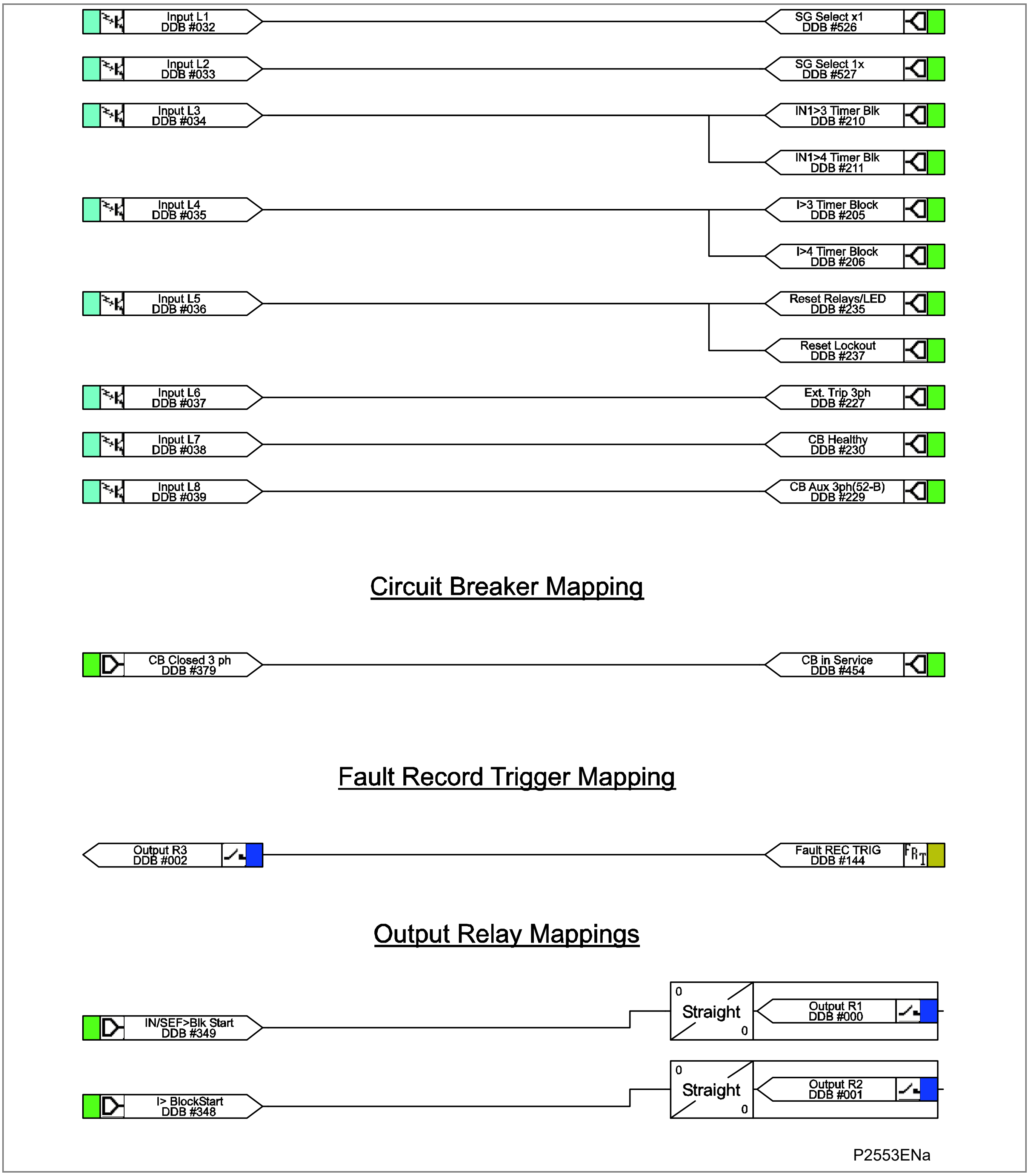


4.4 LED Mappings

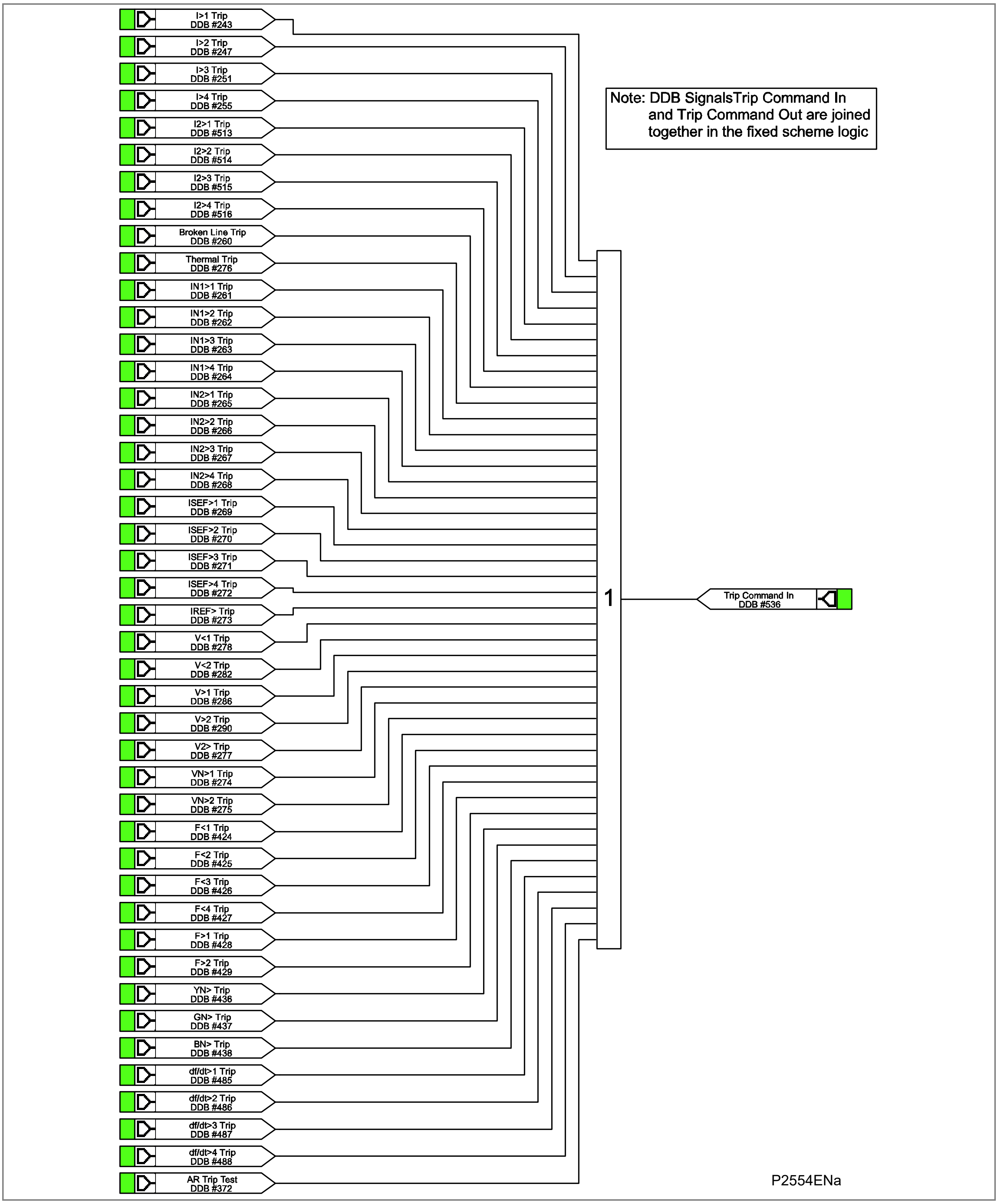


5 P142 PROGRAMMABLE SCHEME LOGIC

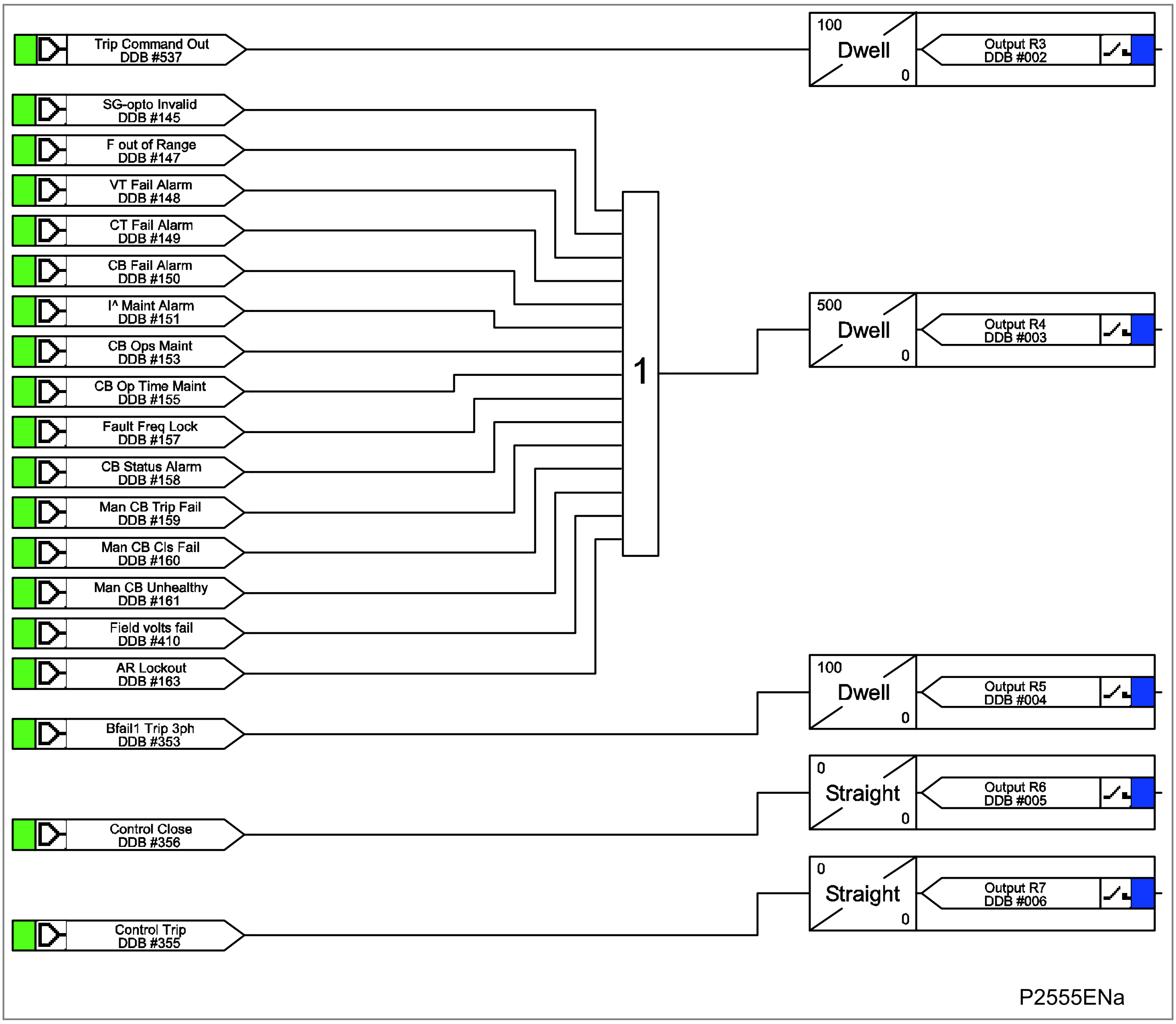
5.1 Opto Input Mappings



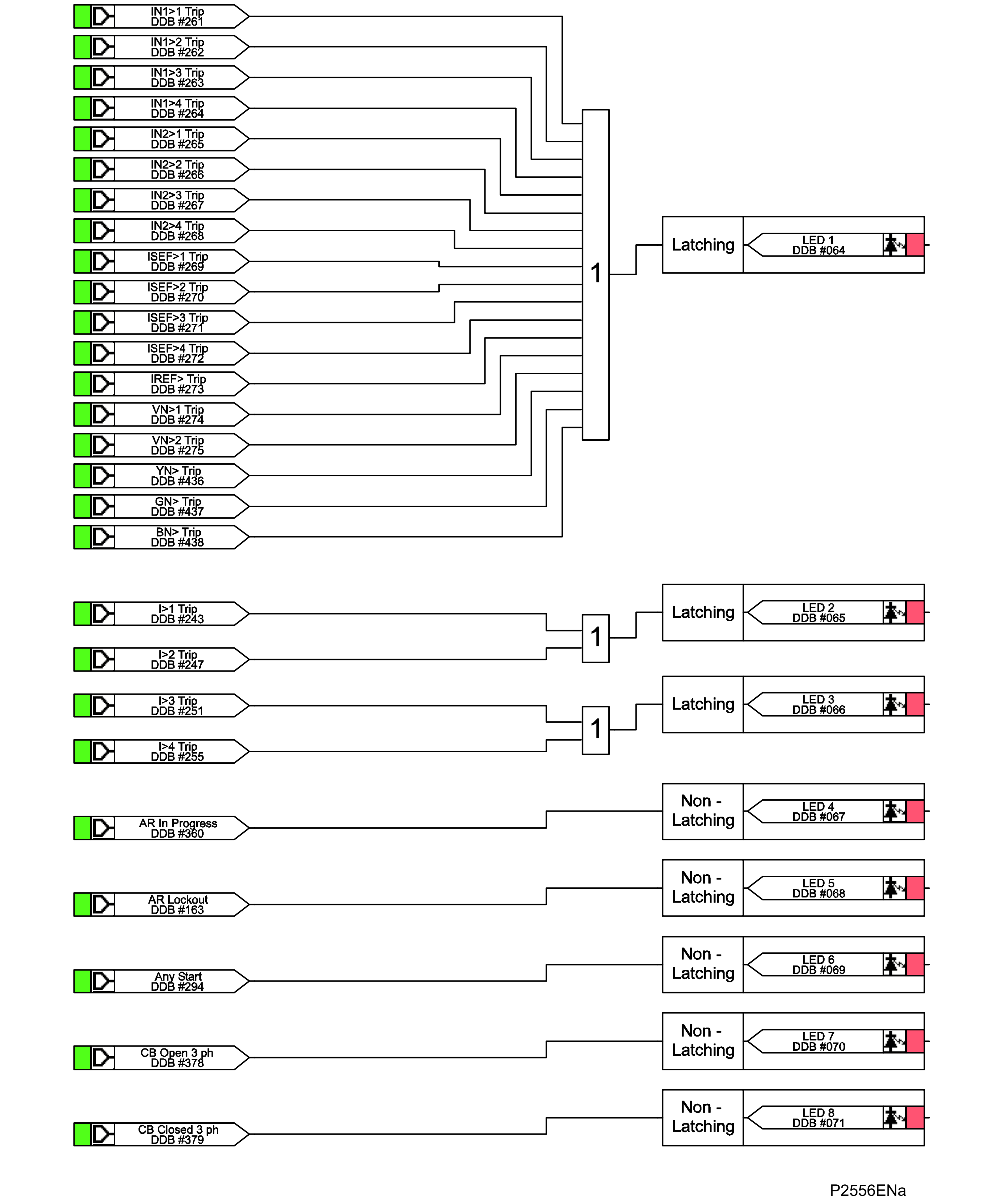
5.2 Trip Relay Mappings



5.3 Output Relay Mappings



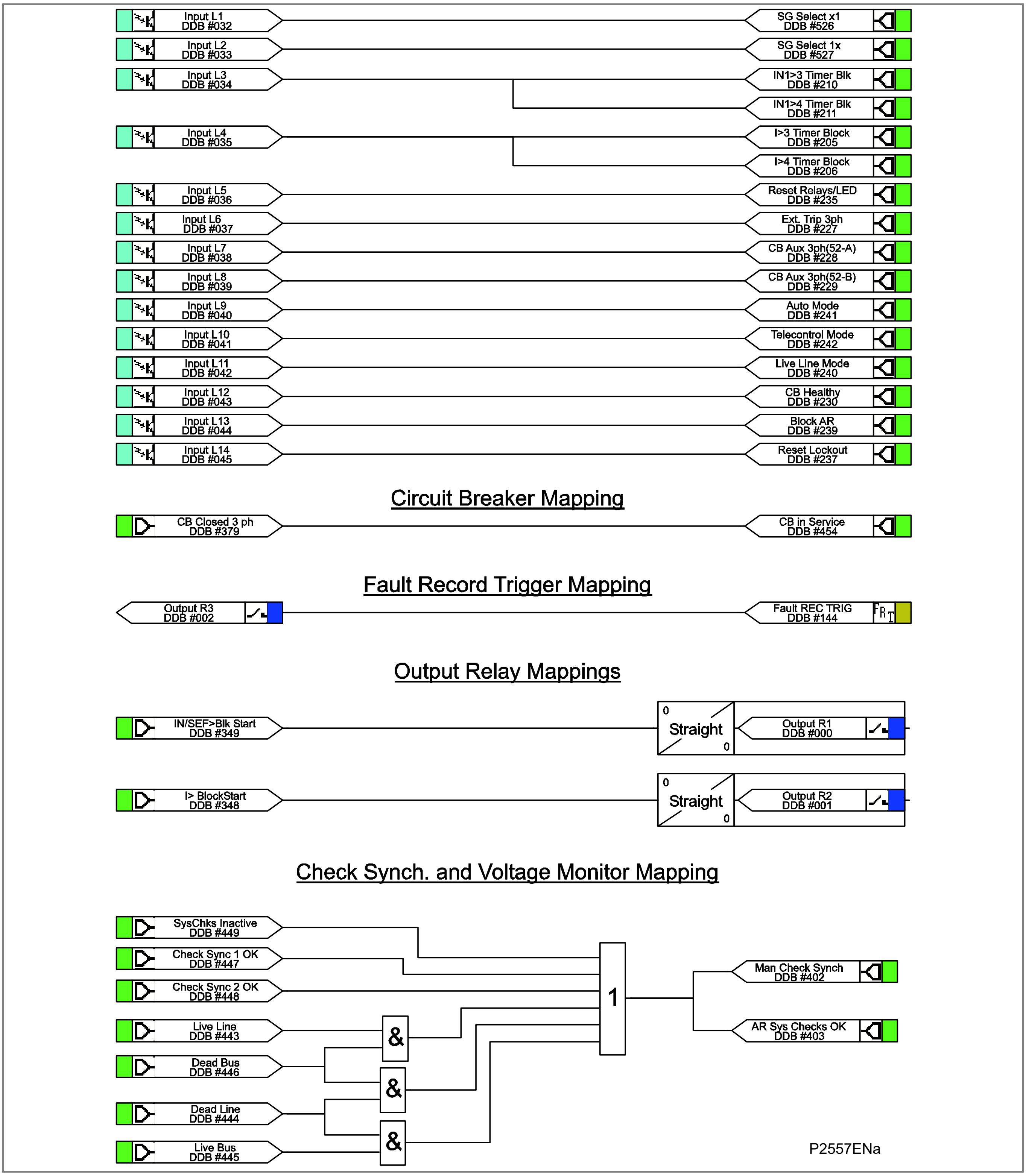
5.4 LED Mappings



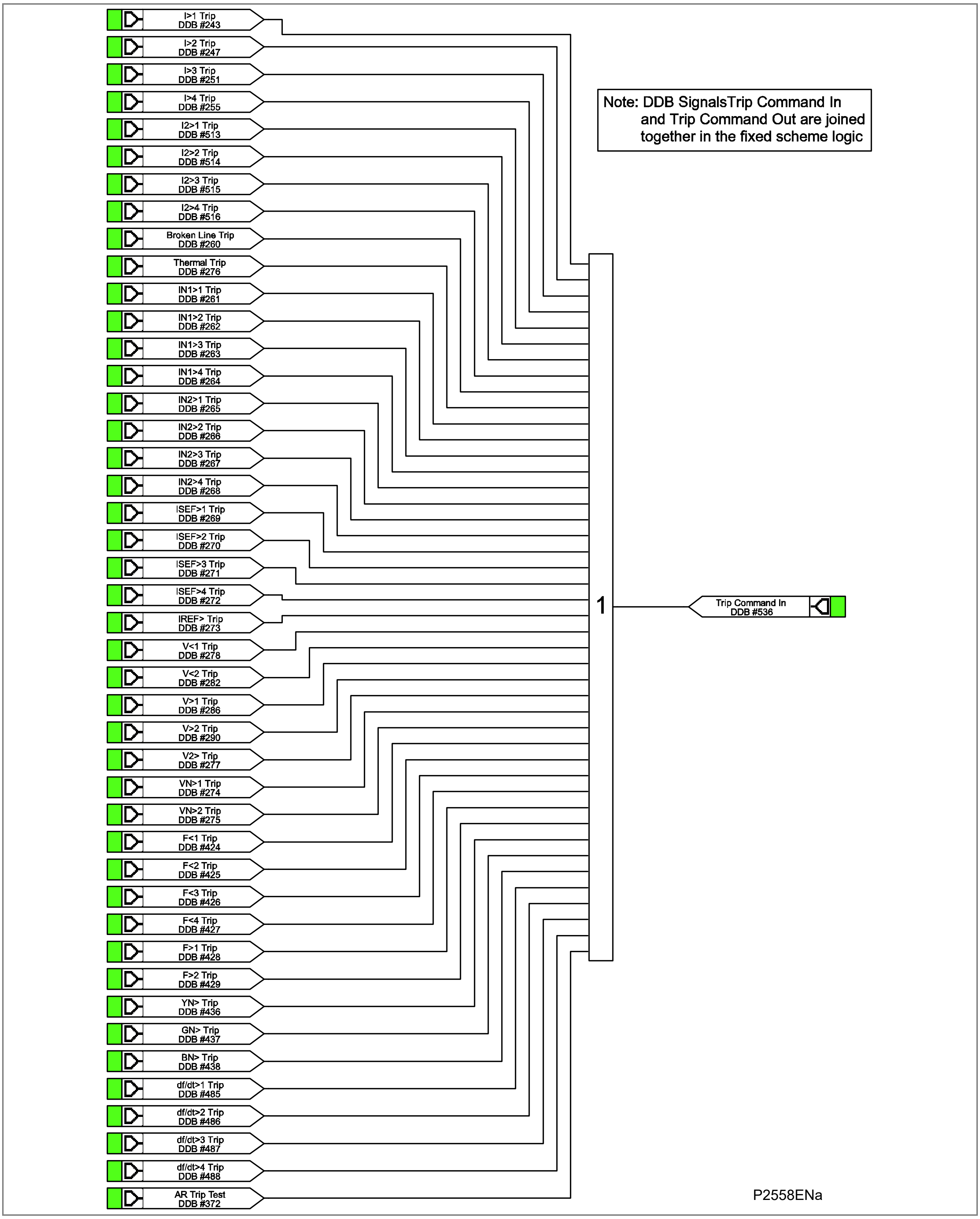
P2556ENa

6 P143 PROGRAMMABLE SCHEME LOGIC

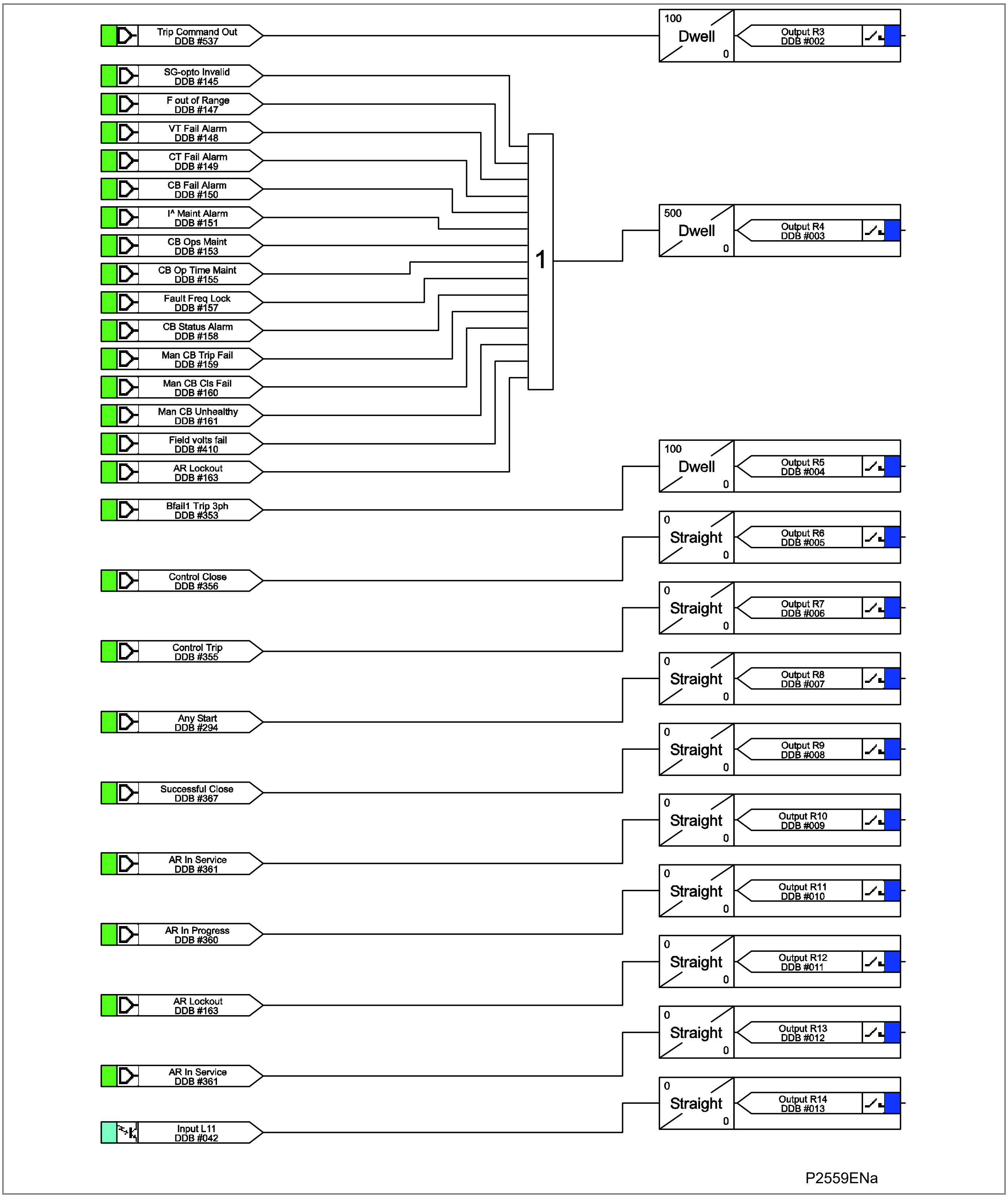
6.1 Opto Input Mappings



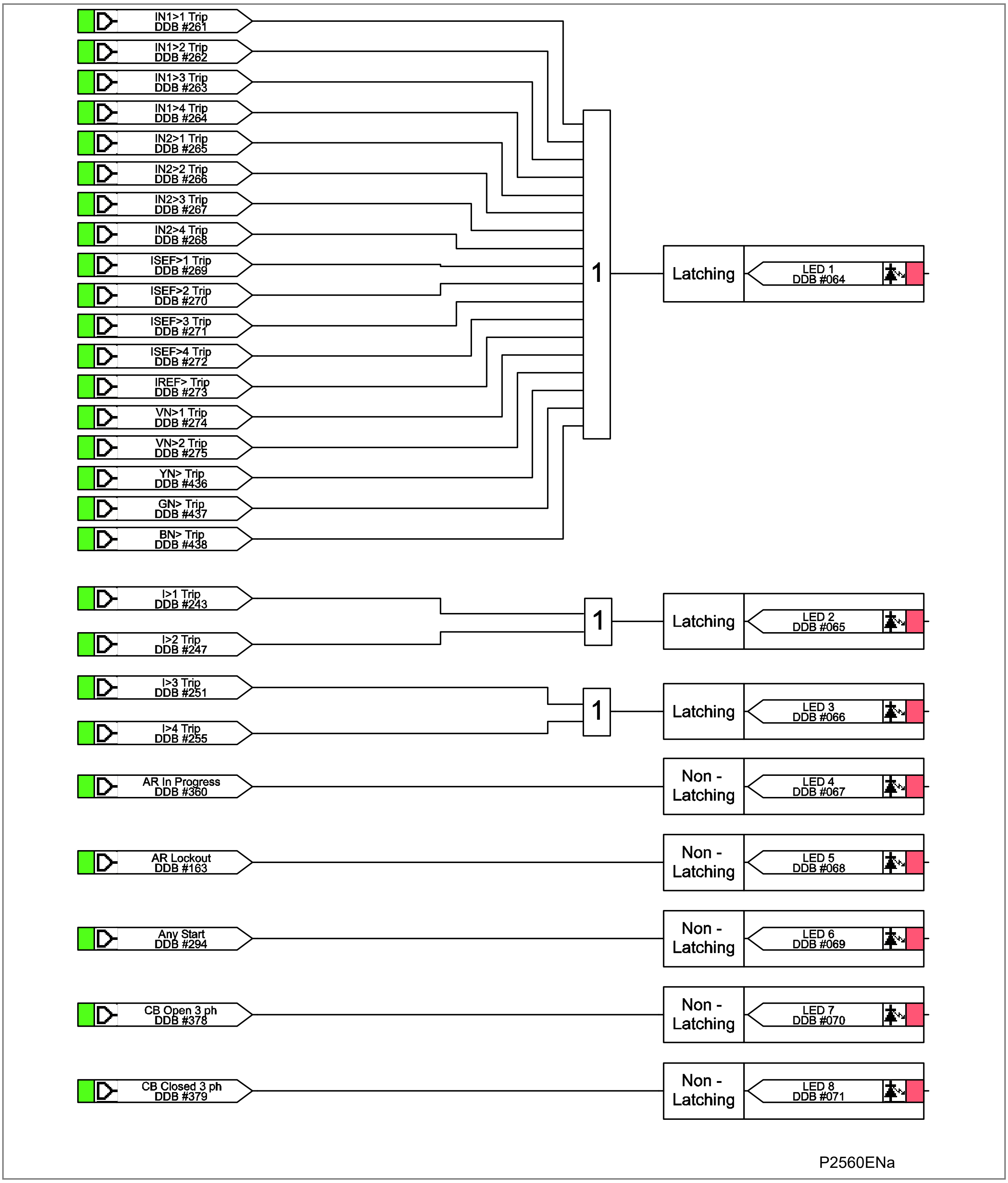
6.2 Trip Relay Mappings



6.3 Output Relay Mappings

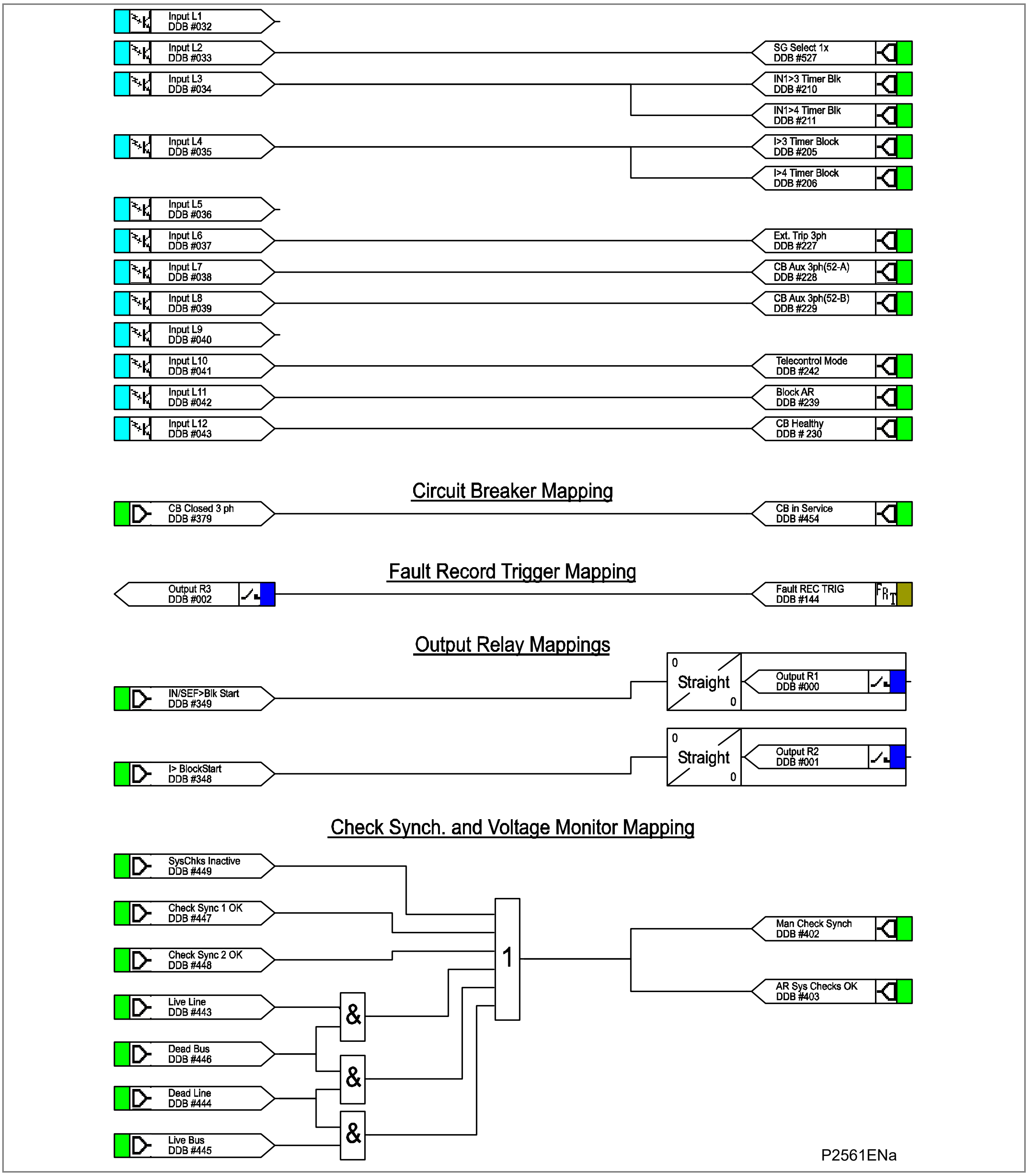


6.4 LED Mappings

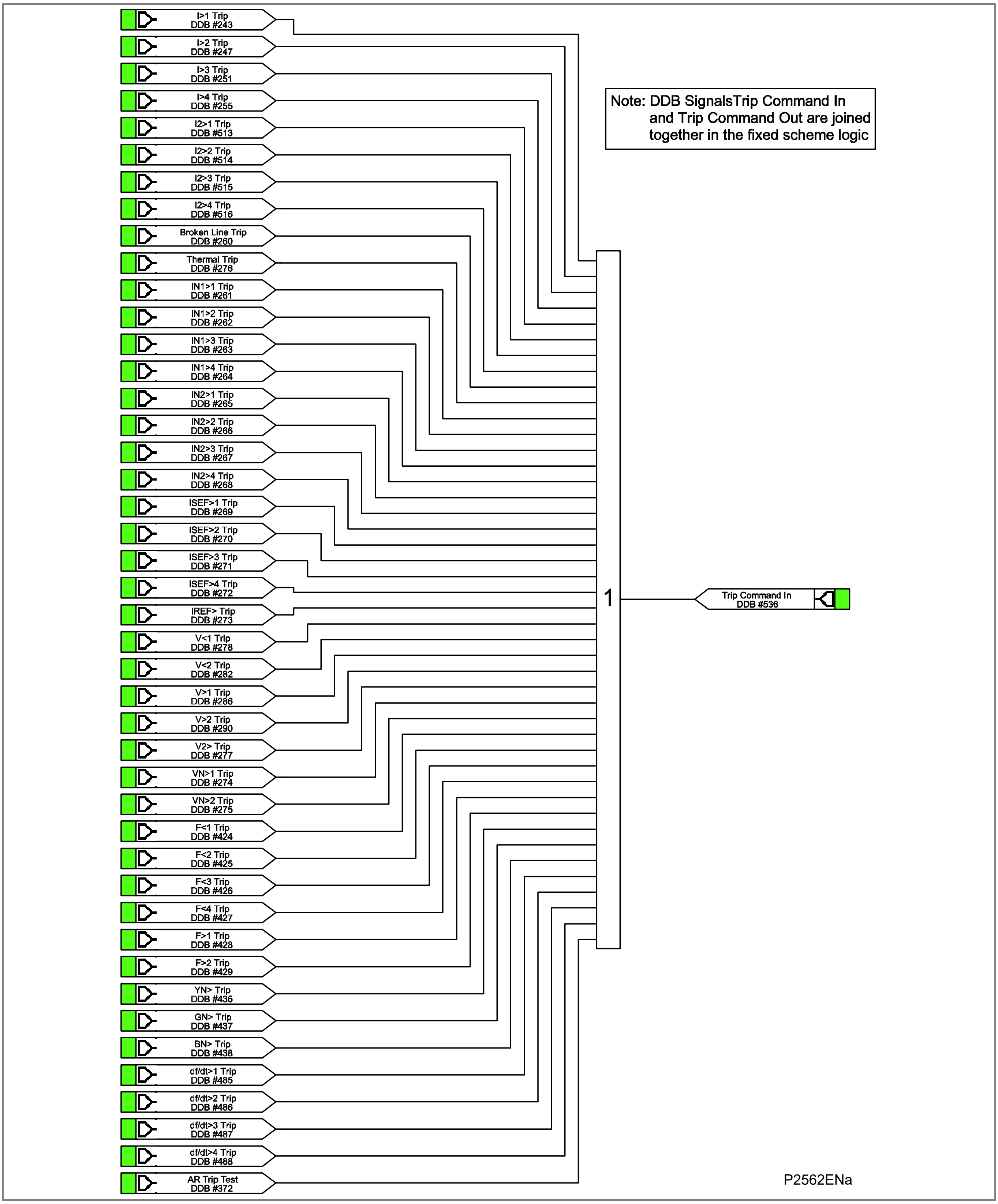


7 P145 PROGRAMMABLE SCHEME LOGIC

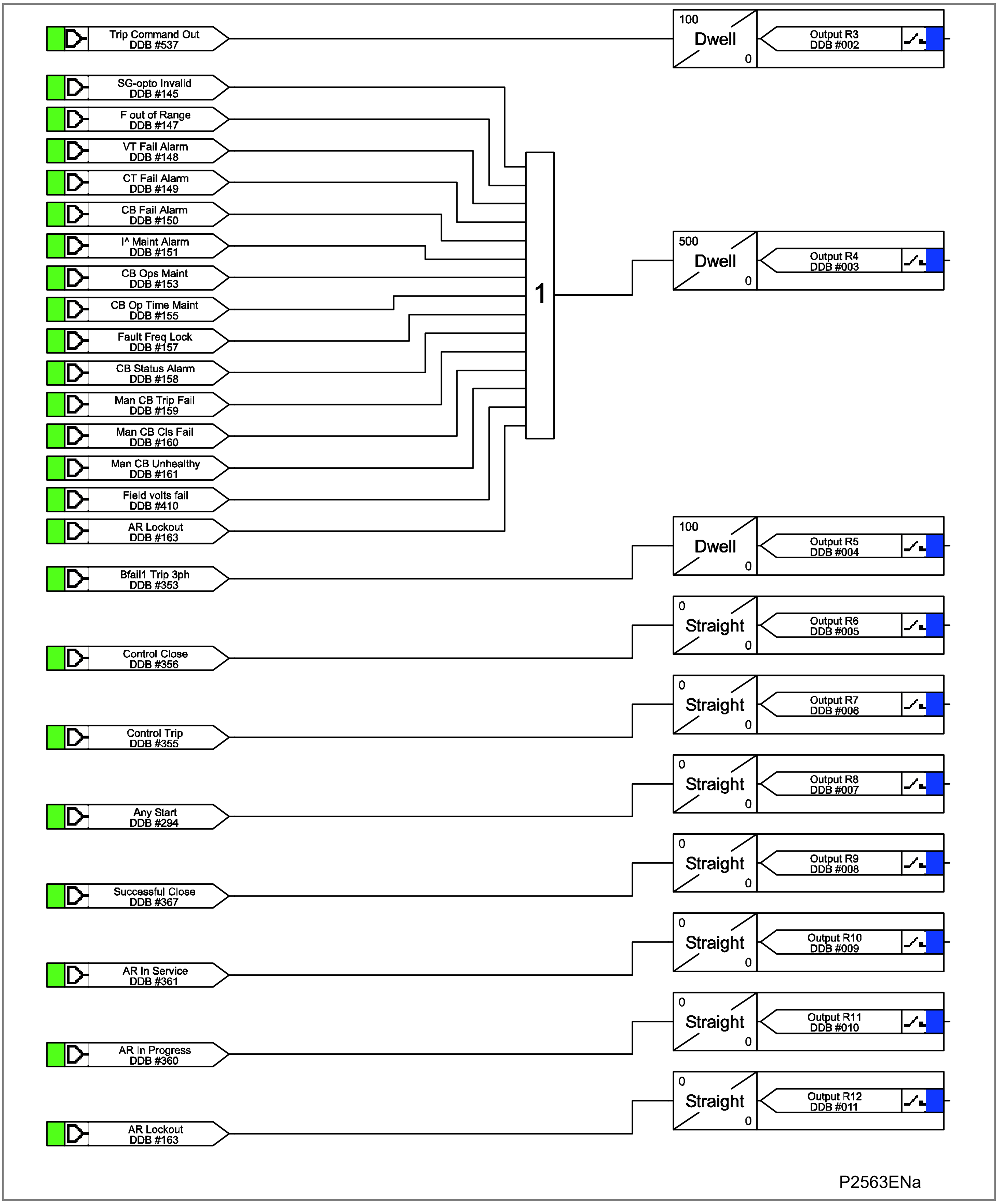
7.1 Opto Input Mappings



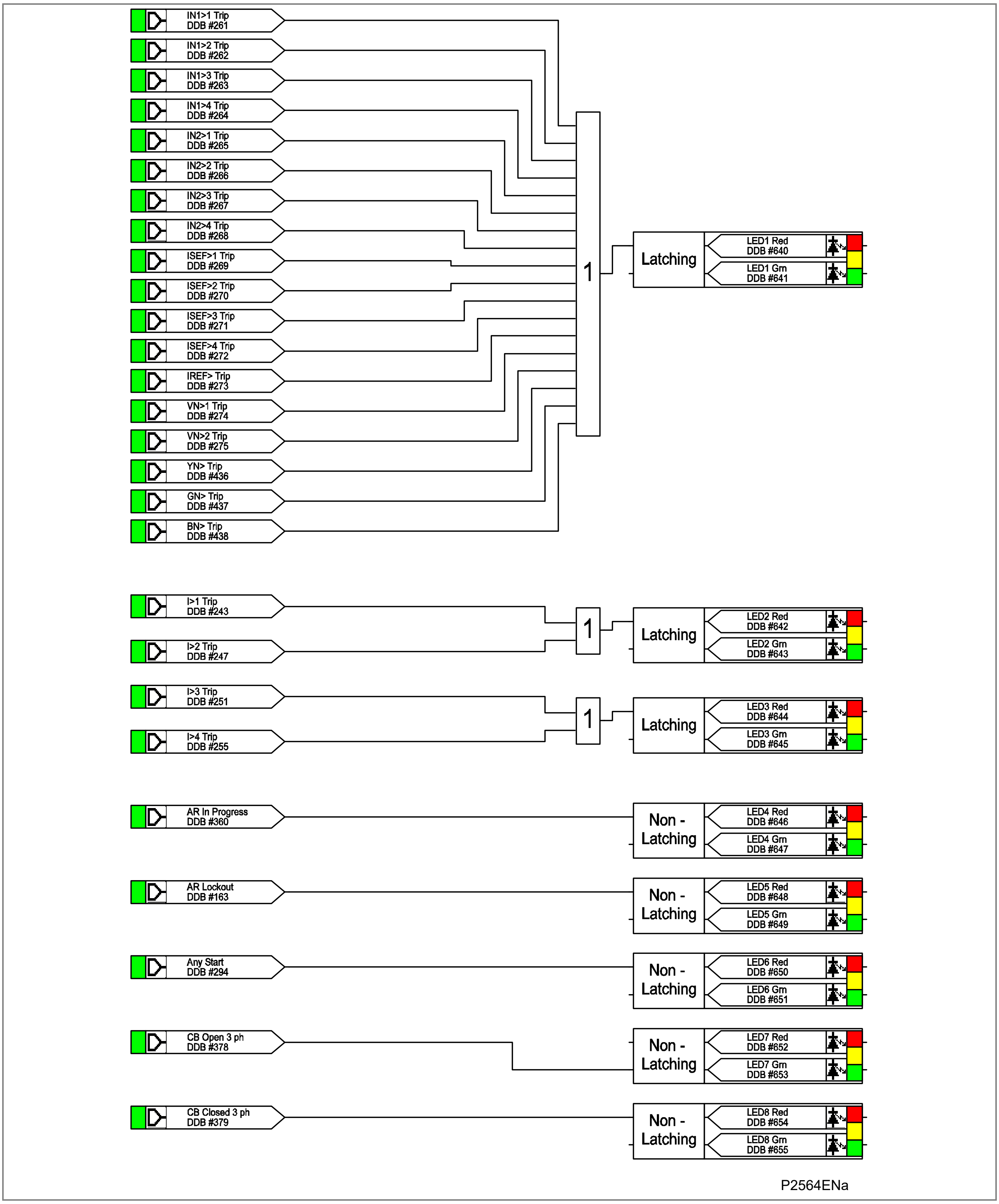
7.2 Trip Relay Mappings



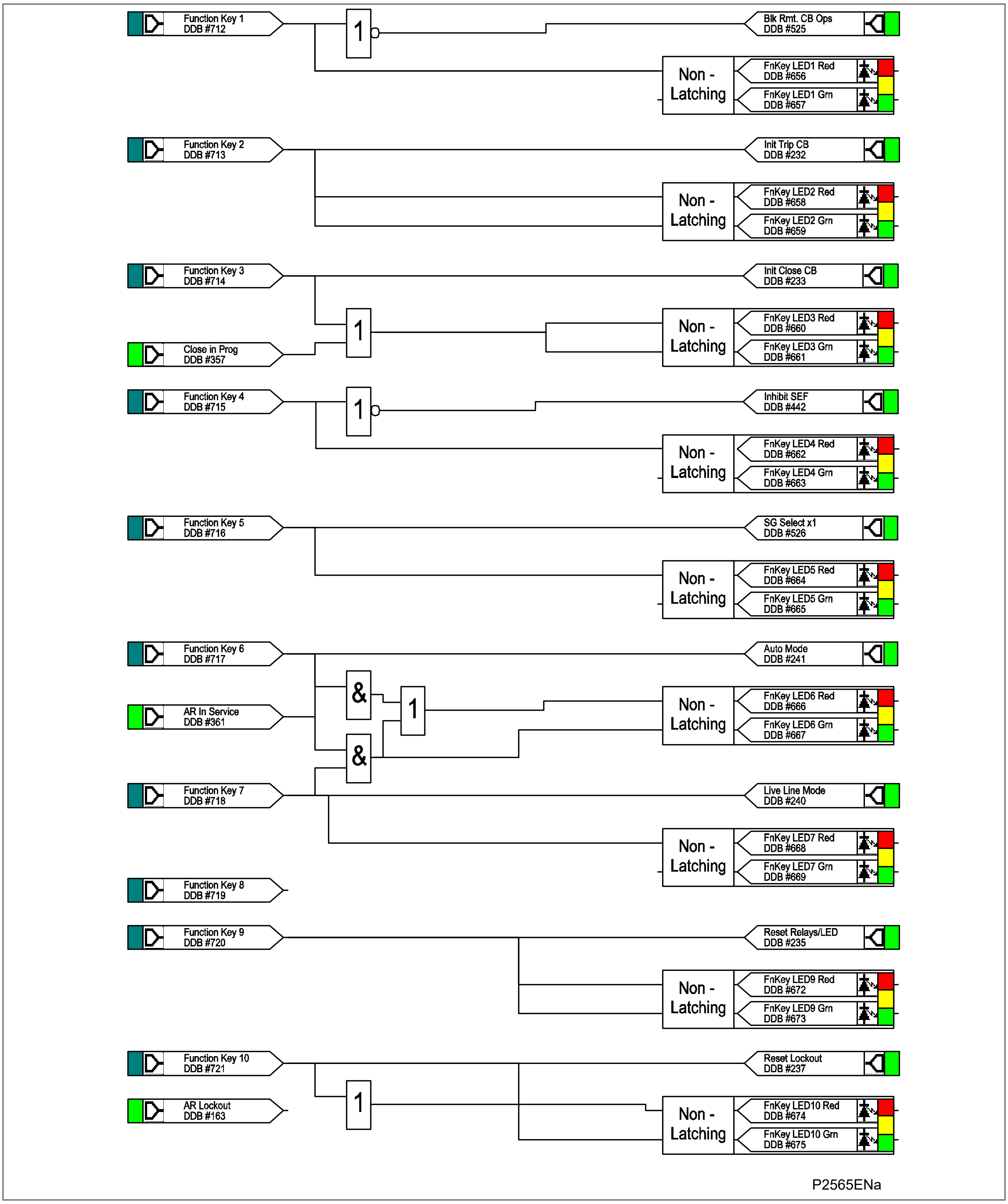
7.3 Output Relay Mappings



7.4 LED Mappings



7.5 Function Key Mappings



Notes:

MEASUREMENTS AND RECORDING

CHAPTER 9

Date:	07/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142 & P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

CONTENTS

TABLES

1 INTRODUCTION

The relay is equipped with integral measurements, event, fault and disturbance recording facilities suitable for analysis of complex system disturbances.

The relay is flexible enough to allow for the programming of these facilities to specific user application requirements. These requirements are discussed in the sections which follow.

2 EVENT & FAULT RECORDS

The relay records and time tags up to 250 or 512 events (only up to 250 events in the P24x and P44x) and stores them in non-volatile (battery-backed up) memory. This lets the system operator establish the sequence of events that occurred in the relay following a particular power system condition or switching sequence. When the available space is used up, the oldest event is automatically overwritten by the new one (i.e. first in, first out).

The relay's real-time clock provides the time tag to each event, to a resolution of 1 ms.

The event records can be viewed either from the front plate LCD or remotely using the communications ports (using any available protocols, such as Courier or MODBUS).

For local viewing on the LCD of event, fault and maintenance records, select the **VIEW RECORDS** menu column.

For extraction from a remote source using communications, see the *SCADA Communications* chapter or the MiCOM S1 Studio instructions.

For a full list of all the event types and the meaning of their values, see the Menu Database document.

VIEW RECORDS	
LCD Reference	**Description**
Select Event	Setting range from 0 to 511. This selects the required event record from the possible 512 that may be stored. A value of 0 corresponds to the latest event and so on.
Time & Date	Time & Date Stamp for the event given by the internal Real Time Clock.
Event Text	Up to 16 Character description of the Event refer to following sections).
Event Value	Up to 32 Bit Binary Flag or integer representative of the Event (refer to following sections).
Select Fault	Setting range from 0 to 4. This selects the required fault record from the possible 10 that may be stored. A value of 0 corresponds to the latest fault and so on.
	The following cells show all the fault flags, protection starts, protection trips, fault location, measurements etc. associated with the fault, i.e. the complete fault record.
Select Maint.	Setting range from 0 to 4. This selects the required maintenance report from the possible 10 that may be stored. A value of 0 corresponds to the latest report and so on.
Maint. Text	Up to 16 Character description of the occurrence (refer to following sections).
Maint. Type/Main Data	These cells are numbers representative of the occurrence. They form a specific error code which should be quoted in any related correspondence to Report Data.
Reset Indication	Either Yes or No. This serves to reset the trip LED indications provided that the relevant protection element has reset.

Table 1 - View Records

2.1 Types of Event

An event may be a change of state of a control input or output relay, an alarm condition, or a setting change. The following sections show the various items that constitute an event:

2.1.1 Change of State of Opto-Isolated Inputs

If one or more of the opto (logic) inputs has changed state since the last time the protection algorithm ran, the new status is logged as an event. When this event is selected to be viewed on the LCD, three cells appear, as in shown here:

```
Time & date of event
“LOGIC INPUTS1 (or 2)”
“Event Value 0101010101010101”
```

The Event Value is a multi-bit word (see note) showing the status of the opto inputs, where the least significant bit (extreme right) corresponds to opto input 1. The same information is present if the event is extracted and viewed using a PC.

Note	*For P14x the Event Value is a 12, 16, 24 or 32-bit word.*

2.1.2 Change of State of one or more Output Relay Contacts

If one or more of the output relay contacts have changed state since the last time the protection algorithm ran, the new status is logged as an event. When this event is selected to be viewed on the LCD, three cells appear, as shown here:

```
Time and Date of Event
Output Contacts1
Event Value 010101010101010101010
```

The Event Value is a multi-bit word (see Note) showing the status of the output contacts, where the least significant bit (extreme right) corresponds to output contact 1, etc. The same information is present if the event is extracted and viewed using a PC.

Note	*For P14x the Event Value is a 12, 16, 24 or 32 bit word.*

2.1.3 Relay Alarm Conditions

Any alarm conditions generated by the relays are logged as individual events. This table shows examples of some of the alarm conditions and how they appear in the event list:

Alarm Condition	Event Text	Event Value
Battery Fail	Battery Fail ON/OFF	Bit position 0 in 32 bit field
Field Voltage Fail	Field Volt Fail ON/OFF	Bit position 1 in 32 bit field
Setting Group via Opto Invalid	Setting Grp. Invalid ON/OFF	Bit position 2 in 32 bit field
Protection Disabled	Prot'n. Disabled ON/OFF	Bit position 3 in 32 bit field
Frequency out of Range	Freq. out of Range ON/OFF	Bit position 4 in 32 bit field
VTS Alarm	VT Fail Alarm ON/OFF	Bit position 5 in 32 bit field
CB Trip Fail Protection	CB Fail ON/OFF	Bit position 7 in 32 bit field

Table 2 - Alarm Conditions

The previous table shows the abbreviated description given to the various alarm conditions and a corresponding value between 0 and 31. This value is appended to each alarm event in a similar way to the input and output events described previously. It is used by the event extraction software, such as MiCOM S1 Studio, to identify the alarm and is therefore invisible if the event is viewed on the LCD. ON or OFF is shown after the description to signify whether the particular condition has become operated or has reset.

2.1.4 Protection Element Starts and Trips

Any operation of protection elements, (either a start or a trip condition) is logged as an event record, consisting of a text string indicating the operated element and an event value. This value is intended for use by the event extraction software, such as MiCOM S1 Studio, rather than for the user, and is invisible when the event is viewed on the LCD.

2.1.5 General Events

Several events come under the heading of **General Events**. An example appears here.

Nature of event	Displayed text in event record	Displayed value
Password modified, either from the front or the rear port.	PW modified F, R or R2	0 F=11, R=16, R2=38. For P44x, the value displayed is 0.

A complete list of the General Events is in the Relay Menu Database document. This is a separate document, for each MiCOM Px4x product or product range. They are normally available for download from www.schneider-electric.com

2.1.6 Fault Records

Each time a fault record is generated, an event is also created. The event states that a fault record was generated, with a corresponding time stamp.

Further down the **VIEW RECORDS** column, select the **Select Fault** cell to view the actual fault record, which is selectable from up to 5, 15 or 20 records (see Note). These records consist of fault flags, fault location, fault measurements, etc. The time stamp given in the fault record is more accurate than the corresponding stamp given in the event record as the event is logged some time after the actual fault record is generated.

Note	*Up to 5 records for the P14x, P24x, P34x, P44x and P74x.* *Up to 15 records for the P445, P44y, P54x, P547 and P841.* *Up to 20 records for the P746.*

The latest fault record can also be retrieved over DNP3.0 and IEC61850, please refer to the ***Object 30 Analog Input*** section in the SCADA Communications chapter as well as the ***IEC 61850 in MiCOM Relays*** section for detailed information.

The fault record is triggered from the **Fault REC. TRIG.** signal assigned in the default programmable scheme logic. Normally this is assigned to relay 3, protection trip, but in the P746 it is assigned to Any Start or Any Trip. The fault measurements in the fault record are given at the time of the protection start.

The fault recorder does not stop recording until the reset of the ‘Fault REC. TRIG.’ signal in order to record all the protection flags during the fault.

It is recommended that the triggering contact be ‘self reset’ and not latching. If a latching contact were chosen the fault record would not be generated until the contact had fully reset.

2.1.7 Maintenance Reports

Internal failures detected by the self-monitoring circuitry, such as watchdog failure, field voltage failure etc. are logged into a maintenance report. The maintenance report holds up to 10 such ‘**events**’ (only 5 events for the P24x/P54x/P547) and is accessed from the "**Select Report**" cell at the bottom of the "**VIEW RECORDS**" column.

Each entry consists of a self explanatory text string and a ‘**Type**’ and ‘**Data**’ cell, which are explained in the menu extract at the beginning of this section.

Each time a Maintenance Report is generated, an event is also created. The event simply states that a report was generated, with a corresponding time stamp.

2.1.8 Setting Changes

Changes to any setting within the relay are logged as an event. Two examples are shown in the following table:

Type of Setting Change	Displayed Text in Event Record
Control/Support Setting	C & S Changed
Group 1 / 2 / 3 or 4 Change	Group 1, 2, 3 or 4 updated
Disturbance setting	Disturbance recorder
Active group change	Active group changed

Note	*Control/Support settings are communications, measurement, CT/VT ratio settings etc, which are not duplicated within the four setting groups. When any of these settings are changed, the event record is created simultaneously. However, changes to protection or disturbance recorder settings will only generate an event once the settings have been confirmed at the ‘setting trap’.*

2.2 Viewing Event Records via MiCOM S1 Support Software

When the event records are extracted and viewed on a PC they look slightly different than when viewed on the LCD. The following shows an example of how various events appear when displayed using MiCOM S1 Studio:

Monday 03 January 2011 15:32:49 GMT I>1 Start ON
MiCOM: MiCOM P145
Model Number: P145318B4M0430J
Address: 001 Column: 00 Row: 23
Event Type: Protection operation

Monday 03 January 2011 15:32:52 GMT Fault Recorded
MiCOM: MiCOM P145
Model Number: P145318B4M0430J
Address: 001 Column: 01 Row: 00
Event Type: Fault record

Monday 03 January 2011 15:33:11 GMT Logic Inputs
MiCOM: MiCOM P145
Model Number: P145318B4M0430J
Address: 001 Column: 00 Row: 20
Event Type: Logic input changed state

Monday 03 January 2011 15:34:54 GMT Output Contacts
MiCOM: MiCOM P145
Model Number: P145318B4M0430J
Address: 001 Column: 00 Row: 21
Event Type: Relay output changed state

Monday 03 January 2011 15:35:55 GMT A/R Lockout ON
MiCOM: MiCOM P145
Model Number: P145318B4M0430J
Address: 001 Column: 00 Row: 22
Event Type: Alarm event

Tuesday 04 January 2011 20:18:22.988 GMT V<1 Trip ON
MiCOM: MiCOM P145
Model Number: P145318B4M0430J
Address: 001 Column: 0F Row: 28
Event Type: Setting event

The first line gives the description and time stamp for the event, while the additional information displayed below may be collapsed using the +/– symbol.

For further information regarding events and their specific meaning, refer to the *Menu Database* document. This standalone document not included in this manual.

2.3 Event Filtering

Event reporting can be disabled from all interfaces that support setting changes. The settings that control the various types of events are in the RECORD CONTROL column. The effect of setting each to disabled is in shown in the following table:

Note	Some occurrences can result in more than one type of event, e.g. a battery failure will produce an alarm event and a maintenance record event.

If the Protection Event setting is Enabled, a further set of settings is revealed which allow the event generation by individual DDB signals to be enabled or disabled.

For further information on events and their specific meaning, see the *Relay Menu Database* document.

Menu Text	Col	Row	Default Setting	Available Settings
Description				
RECORD CONTROL	0B	00		
This column contains settings for Record Controls				
Clear Events	0B	01	No	0 = No or 1 = Yes
Clear Event records				
Clear Faults	0B	02	No	1 = No or 1 = Yes
Clear Fault records				
Clear Maint	0B	03	No	2 = No or 1 = Yes
Clear Maintenance records				
Alarm Event	0B	04	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event is generated for alarms				
Relay O/P Event	0B	05	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any change in logic output state.				
Opto Input Event	0B	06	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any change in logic input state.				
General Event	0B	07	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no General Events are generated				
Fault Rec Event	0B	08	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any fault that produces a fault record				
Maint Rec Event	0B	09	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any occurrence that produces a maintenance record.				
Protection Event	0B	0A	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that any operation of protection elements will not be logged as an event				
Clear Dist Recs	0B	30	No	0 = No or 1 = Yes
Clear Disturbance records				
Security Event	0B	31	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that any operation of security elements will not be logged as an event				
DDB 31 - 0	0B	40	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 63 - 32	0B	41	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 95 - 64	0B	42	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DDB 127 - 96	0B	43	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 159 - 128	0B	44	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 191 - 160	0B	45	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 223 - 192	0B	46	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 255 - 224	0B	47	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 287 - 256	0B	48	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 319 - 288	0B	49	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 351 - 320	0B	4A	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 383 - 352	0B	4B	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 415 - 384	0B	4C	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 447 - 416	0B	4D	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 479 - 448	0B	4E	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 511 - 480	0B	4F	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 543 - 512	0B	50	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 575 - 544	0B	51	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 607 - 576	0B	52	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DDB 639 - 608	0B	53	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 671 - 640	0B	54	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 703 - 672	0B	55	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 735 - 704	0B	56	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 767 - 736	0B	57	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 799 - 768	0B	58	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 831 - 800	0B	59	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 863 - 832	0B	5A	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 895 - 864	0B	5B	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 927 - 896	0B	5C	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 959 - 928	0B	5D	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 991 - 960	0B	5E	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1023 - 992	0B	5F	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1055 - 1024	0B	60	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1087 - 1056	0B	61	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1119 - 1088	0B	62	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DDB 1151 - 1120	0B	63	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1183 - 1152	0B	64	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1215 - 1184	0B	65	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1247 - 1216	0B	66	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1279 - 1248	0B	67	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1311 - 1280	0B	68	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1343 - 1312	0B	69	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1375 - 1344	0B	6A	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1407 - 1376	0B	6B	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1439 - 1408	0B	6C	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1471 - 1440	0B	6D	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1503 - 1472	0B	6E	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1535 - 1504	0B	6F	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1567 - 1536	0B	70	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1599 - 1568	0B	71	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1631 - 1600	0B	72	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DDB 1663 - 1632	0B	73	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1695 - 1664	0B	74	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1727 - 1696	0B	75	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1759- 1728	0B	76	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1791- 1760	0B	77	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1823 - 1792	0B	78	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1855 - 1824	0B	79	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1887 - 1856	0B	7A	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1919 - 1888	0B	7B	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1951 - 1920	0B	7C	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1983 - 1952	0B	7D	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 2015 - 1984	0B	7E	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 2047 - 2016	0B	7F	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Note	*Some occurrences will result in more than one type of event, e.g. a battery failure will produce an alarm event and a maintenance record event.*

Table 3 - Event Filtering

3 DISTURBANCE RECORDER

The integral enhanced disturbance recorder has an area of memory specifically set aside for record storage. The number of records that may be stored by the relay is dependent on the selected recording duration and the installed software release.

The relay can typically store a pre-set minimum number of records, each of a pre-set duration. These may vary between different MiCOM products.

Disturbance records continue to be recorded until the available memory is exhausted, at which time the oldest record(s) are overwritten to make space for the newest one.

The recorder stores actual samples that are taken at a rate of pre-defined number of samples per cycle. Again, this may vary between different MiCOM products.

Each disturbance record consists of a number of analog data channels and digital data channels.

The relevant CT and VT ratios for the analog channels are also extracted to enable scaling to primary quantities. If a CT ratio is set less than unity, the relay will choose a scaling factor of zero for the appropriate channel.

This relay can typically store a minimum of 50 records each of 1.5 seconds duration. However, relays with IEC 60870-5 CD 103 (VDEW) have the same total record length but the IEC 60870-5 CD 103 protocol dictates that only 8 records (of 3 seconds duration) can be extracted via the rear port.

The record stores samples taken at 24 samples per second.

Each disturbance record consists of 9 analog data channels and 128 (XCPU3) digital data channels.

The "**DISTURBANCE RECORDER**" menu column is shown in the following table:

Menu Text	Col	Row	Default Setting	Available Settings
Description				
DISTURB RECORDER	0C	00		
This column contains settings for the Disturbance Recorder				
Duration	0C	01	1.5	0.1s to 10.5s step 0.01s
This sets the overall recording time.				
Trigger Position	0C	02	33.3	0 to 100 step 0.1
This sets the trigger point as a percentage of the duration. For example, the default settings show that the overall recording time is set to 1.5 s with the trigger point being at 33.3% of this, giving 0.5 s pre-fault and 1s post fault recording times.				
Trigger Mode	0C	03	Single	0 = Single or 1 = Extended
If set to single mode, if a further trigger occurs whilst a recording is taking place, the recorder will ignore the trigger. However, if this has been set to Extended, the post trigger timer will be reset to zero, thereby extending the recording time.				
Analog Channel 1	0C	04	VA	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Analog Channel 2	0C	05	VB	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Analog Channel 3	0C	06	VC	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Analog Channel 4	0C	07	IA	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Analog Channel 5	0C	08	IB	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Analog Channel 6	0C	09	IC	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Analog Channel 7	0C	0A	IN	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Analog Channel 8	0C	0B	IN Sensitive	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Analog Channel 9	0C	0C	Frequency	0=VA 1=VB 2=VC 3=IA 4=IB 5=IC 6=IN 7=IN Sensitive 8=Frequency 9=Unused 0=VA 1=VB 2=VC 3=V Checksync 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency 0=VA 1=VB 2=VC 3=VN 4=IA 5=IB 6=IC 7=IN 8=IN Sensitive 9=Frequency
Selects any available analogue input to be assigned to this channel.				
Digital Input 1	0C	0D	Relay 1	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 1 Trigger	0C	0E	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 2	0C	0F	Relay 2	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 2 Trigger	0C	10	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 3	0C	11	Relay 3	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 3 Trigger	0C	12	Trigger L/H	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 4	0C	13	Relay 4	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 4 Trigger	0C	14	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Digital Input 5	0C	15	Relay 5	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 5 Trigger	0C	16	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 6	0C	17	Relay 6	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 6 Trigger	0C	18	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 7	0C	19	Relay 7	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 7 Trigger	0C	1A	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 8	0C	1B	Opto Input 1 Relay 8	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 8 Trigger	0C	1C	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 9	0C	1D	Opto Input 2 Relay 9	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 9 Trigger	0C	1E	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 10	0C	1F	Opto Input 3 Relay 10	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 10 Trigger	0C	20	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 11	0C	21	Opto Input 4 Relay 11	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 11 Trigger	0C	22	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 12	0C	23	Opto Input 5 Relay 12	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 12 Trigger	0C	24	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 13	0C	25	Opto Input 6 Relay 13 Opto Input 1	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 13 Trigger	0C	26	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 14	0C	27	Opto Input 7 Relay 14 Opto Input 2	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 14 Trigger	0C	28	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 15	0C	29	Opto Input 8 Opto Input 1 Opto Input 3	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 15 Trigger	0C	2A	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 16	0C	2B	Unused Opto Input 2 Opto Input 4	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 16 Trigger	0C	2C	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 17	0C	2D	Unused Opto Input 3 Opto Input 5	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 17 Trigger	0C	2E	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 18	0C	2F	Unused Opto Input 4 Opto Input 6	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 18 Trigger	0C	30	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 19	0C	31	Unused Opto Input 5 Opto Input 7	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 19 Trigger	0C	32	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 20	0C	33	Unused Opto Input 6 Opto Input 8	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 20 Trigger	0C	34	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 21	0C	35	Unused Opto Input 7 Opto Input 9	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 21 Trigger	0C	36	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 22	0C	37	Unused Opto Input 8 Opto Input 10	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 22 Trigger	0C	38	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 23	0C	39	Unused Opto Input 9 Opto Input 11	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 23 Trigger	0C	3A	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 24	0C	3B	Unused Opto Input 10 Opto Input 12	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 24 Trigger	0C	3C	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 25	0C	3D	Unused Opto Input 11	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 25 Trigger	0C	3E	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 26	0C	3F	Unused Opto Input 12	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 26 Trigger	0C	40	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 27	0C	41	Unused Opto Input 13	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 27 Trigger	0C	42	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L

Menu Text	Col	Row	Default Setting	Available Settings
Description				
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 28	0C	43	Unused Opto Input 14	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 28 Trigger	0C	44	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 29	0C	45	Unused Opto Input 15	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 29 Trigger	0C	46	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 30	0C	47	Unused Opto Input 16	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 30 Trigger	0C	48	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 31	0C	49	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 31 Trigger	0C	4A	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 32	0C	4B	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 32 Trigger	0C	4C	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 33	0C	70	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 34	0C	71	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 35	0C	72	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 36	0C	73	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 37	0C	74	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 38	0C	75	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 39	0C	76	Unused	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 40	0C	77	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 41	0C	78	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 42	0C	79	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 43	0C	7A	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 44	0C	7B	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 45	0C	7C	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 46	0C	7D	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 47	0C	7E	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 48	0C	7F	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 49	0C	80	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 50	0C	81	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 51	0C	82	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 52	0C	83	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 53	0C	84	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 54	0C	85	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 55	0C	86	Unused	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 56	0C	87	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 57	0C	88	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 58	0C	89	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 59	0C	8A	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 60	0C	8B	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 61	0C	8C	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 62	0C	8D	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 63	0C	8E	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 64	0C	8F	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 65	0C	90	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 66	0C	91	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 67	0C	92	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 68	0C	93	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 69	0C	94	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 70	0C	95	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 71	0C	96	Unused	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 72	0C	97	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 73	0C	98	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 74	0C	99	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 75	0C	9A	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 76	0C	9B	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 77	0C	9C	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 78	0C	9D	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 79	0C	9E	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 80	0C	9F	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 81	0C	A0	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 82	0C	A1	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 83	0C	A2	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 84	0C	A3	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 85	0C	A4	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 86	0C	A5	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 87	0C	A6	Unused	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 88	0C	A7	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 89	0C	A8	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 90	0C	A9	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 91	0C	AA	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 92	0C	AB	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 93	0C	AC	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 94	0C	AD	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 95	0C	AE	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 96	0C	AF	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 97	0C	B0	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 98	0C	B1	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 99	0C	B2	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 100	0C	B3	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 101	0C	B4	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 102	0C	B5	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 103	0C	B6	Unused	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 104	0C	B7	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 105	0C	B8	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 106	0C	B9	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 107	0C	BA	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 108	0C	BB	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 109	0C	BC	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 110	0C	BD	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 111	0C	BE	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 112	0C	BF	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 113	0C	C0	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 114	0C	C1	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 115	0C	C2	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 116	0C	C3	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 117	0C	C4	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 118	0C	C5	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 119	0C	C6	Unused	See Data Types - G32

Menu Text	Col	Row	Default Setting	Available Settings
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 120	0C	C7	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 121	0C	C8	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 122	0C	C9	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 123	0C	CA	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 124	0C	CB	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 125	0C	CC	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 126	0C	CD	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 127	0C	CE	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 128	0C	CF	Unused	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				

Table 4 - Disturbance Recorder

The pre and post fault recording times are set by a combination of the **Duration** and **Trigger Position** cells. **Duration** sets the overall recording time and the **Trigger Position** sets the trigger point as a percentage of the duration.

- For example, the default settings show that the overall recording time is set to 1.5 s with the trigger point being at 33.3% of this, giving 0.5 s pre-fault and 1 s post-fault recording times.

If a further trigger occurs while a recording is taking place, the recorder ignores the trigger if the **Trigger Mode** is set to **Single**. However, if this is set to **Extended**, the post-trigger timer is reset to zero, extending the recording time.

As can be seen from the menu, each of the analog channels is selectable from the available analog inputs to the relay. The digital channels may be mapped to any of the opto isolated inputs or output contacts, in addition to several internal relay digital signals, such as protection starts and LEDs. The complete list of these signals may be found by viewing the available settings in the relay menu or using a setting file in MiCOM S1 Studio. Any of the digital channels may be selected to trigger the disturbance recorder on either a low-to-high or a high-to-low transition, using the **Input Trigger** cell. The default trigger settings are that any dedicated trip output contacts, such as relay 3, trigger the recorder.

It is not possible to view the disturbance records locally using the LCD; they must be extracted using suitable software such as MiCOM S1 Studio. This process is fully explained in the *SCADA Communications* chapter.

This feature lets the user define customizable labels for digital channels in P14x relays. The label is available only in the Comtrade file. The label can be disabled by placing a ‘ ’ (Space) in the 1st character of the label. If the user does not want to call the digital channel with a special name, the feature will be disabled and will display its original label.

4 MEASUREMENTS

The relay produces a variety of both directly measured and calculated power system quantities. These measurement values are updated every second and can be viewed in the **Measurements** columns (up to three) of the relay or using the MiCOM S1 Studio Measurement viewer.

The relay can measure and display these quantities:

- Phase voltages and currents
- Phase to phase voltage and currents
- Sequence voltages and currents
- Slip frequency
- Power and energy quantities
- Rms. voltages and currents
- Peak, fixed and rolling demand values

There are also measured values from the protection functions, which are also displayed under the measurement columns of the menu; these are described in the section on the relevant protection function.

4.1 Measured Voltages and Currents

The relay produces both phase-to-ground and phase-to-phase voltage and current values. They are produced directly from the Discrete Fourier Transform (DFT) used by the relay protection functions and present both magnitude and phase angle measurement.

4.2 Sequence Voltages and Currents

Sequence quantities are produced by the relay from the measured Fourier values; these are displayed as magnitude and phase angle values.

4.3 Slip Frequency

The relay produces a slip frequency measurement by measuring the rate of change of phase angle, between the bus and line voltages, over a one-cycle period. The slip frequency measurement assumes the bus voltage to be the reference phasor.

4.4 Power and Energy Quantities

Using the measured voltages and currents the relay calculates the apparent, real and reactive power quantities. These are produced phase-by-phase. Three-phase values are based on the sum of the three individual phase values. The signing of the real and reactive power measurements can be controlled using the measurement mode setting. The options are as follows.

Measurement mode	Parameter	Signing
0 (Default)	Export Power Import Power Lagging Vars Leading VArs	+ – + –
1	Export Power Import Power Lagging Vars Leading VArs	– + + –
2	Export Power Import Power Lagging Vars Leading VArs	+ – – +
3	Export Power Import Power Lagging Vars Leading VArs	– + – +

In addition to the measured power quantities, the relay calculates the power factor phase-by-phase, in addition to a three-phase power factor.

These power values are also used to increment the total real and reactive energy measurements. Separate energy measurements are maintained for the total exported and imported energy. The energy measurements are incremented up to maximum values of 1000 GWhr or 1000 GVARhr, at which point they reset to zero. It is also possible to reset these values using the menu or remote interfaces using the **Reset Demand** cell.

4.5 RMS. Voltages and Currents

RMS phase voltage and current values are calculated by the relay using the sum of the samples squared over a cycle of sampled data.

4.6 Demand Values

The relay produces fixed, rolling and peak demand values. Using the reset demand menu cell it is possible to reset these quantities from the user interface or the remote communications.

4.6.1 Fixed Demand Values

The fixed demand value is the average value of a quantity over the specified interval; values are produced for each phase current and for three-phase real and reactive power. The fixed demand values displayed by the relay are those for the previous interval. The values are updated at the end of the fixed demand period.

4.6.2 Rolling Demand Values

The rolling demand values are similar to the fixed demand values, the difference being that a sliding window is used. The rolling demand window consists of several smaller sub-periods. The resolution of the sliding window is the sub-period length, with the displayed values updated at the end of each of the sub-periods.

4.6.3 Peak Demand Values

Peak demand values are produced for each phase current and the real and reactive power quantities. These display the maximum value of the measured quantity since the last reset of the demand values.

4.7 Settings

The settings shown under the heading **MEASURE'T SETUP** can be used to configure the relay measurement function. See the following Measurements table for more details:

Menu Text	Col	Row	Default Setting	Available Settings	Descript
MEASURE'T SETUP	**0D**	**00**			**This column contains settings f**
Default Display	0D	01	Banner	0 = User Banner, 1 = 3Ph + N Current, 2 = 3Ph Voltage, 3 = Power, 4 = Date and Time, 5 = Description, 6 = Plant Reference, 7 = Frequency, 8 = Access Level	This setting can be used to select th of options, note that it is also possib displays whilst at the default level us keys. However once the 15 minute t display will revert to that selected by
Local Values	0D	02	Primary	0 = Primary or 1 = Secondary	This setting controls whether measu user interface and the front courier p secondary quantities.
Remote Values	0D	03	Primary	0 = Primary or 1 = Secondary	This setting controls whether measu communication port are displayed as quantities.
Measurement Ref	0D	04	VA	0 = VA, 1 = VB, 2 = VC, 3 = IA, 4 = IB, 5 = IC	Using this setting the phase referenc by the IED can be selected. This re Measurements 3 uses always IA loc
Measurement Mode	0D	05	0	0 to 3 step 1	This setting is used to control the sig power quantities.
Fix Dem Period	0D	06	30	From 1m to 99m step 1m	This setting defines the length of the
Roll Sub Period	0D	07	30	From 1m to 99m step 1m	These two settings are used to set th for the calculation of rolling demand
Num Sub Periods	0D	08	1	1 to 15 step 1	This setting is used to set the resolu
Distance Unit	0D	09	Miles	0 = Kilometres or 1 = Miles	This setting is used to select the uni purposes, note that the length of the converting from km to miles and vice
Fault Location	0D	0A	Distance	0 = Distance, 1 = Ohms, 2 = % of Line	The calculated fault location can be options selected using this setting
Remote 2 Values	0D	0B	Primary	0 = Primary or 1 = Secondary	The setting defines whether the valu Rear Communication port are displa terms.

Table 5 - Measurement setup

4.8 Measurement Display Quantities

The relay has Measurement columns for viewing measurement quantities. These can also be viewed with MiCOM S1 Studio and are shown below.

MEASUREMENTS 1		MEASUREMENTS 2		MEASUREMENTS 3	
IA Magnitude	0 A	A Phase Watts	0 W	Highest Phase I	0 A
IA Phase Angle	0 deg.	B Phase Watts	0 W	Thermal State	0%
IB Magnitude	0 A	C Phase Watts	0 W	Reset Thermal	No
IB Phase Angle	0 deg.	A Phase VArs	0 Var	IREF Diff.	1.000 A
IC Magnitude	0 A	B Phase VArs	0 Var	IREF Bias	1.000 A
IC Phase Angle	0 deg.	C Phase VArs	0 Var	Admittance	0 S
IN Measured Mag.	0 A	A Phase VA	0 VA	Conductance	0 S
IN Measured Ang.	0 deg.	B Phase VA	0 VA	Susceptance	0 S
IN Derived Mag.	0 A	C Phase VA	0 VA	Admittance	0 S
IN Derived Angle	0 deg.	3 Phase Watts	0 W	Conductance	0 S

MEASUREMENTS 1		MEASUREMENTS 2		MEASUREMENTS 3	
ISEF Magnitude	0 A	3 Phase VArs	0 VAr	Susceptance	0 S
ISEF Angle	0 deg.	3 Phase VA	0 VA	I2/I1 Ratio	0
I1 Magnitude	0 A	3Ph Power Factor	0	SEF Power	0 W
I2 Magnitude	0 A	APh Power Factor	0	df/dt	
I0 Magnitude	0 A	BPh Power Factor	0		
IA RMS	0 A	CPh Power Factor	0		
IB RMS	0 A	3Ph WHours Fwd	0 Wh		
IC RMS	0 A	3Ph WHours Rev	0 Wh		
VAB Magnitude	0 V	3Ph VArHours Fwd	0 VArh		
VAB Phase Angle	0 deg.	3Ph VArHours Rev	0 VArh		
VBC Magnitude	0 V	3Ph W Fix Demand	0 W		
VBC Phase Angle	0 deg.	3Ph VArs Fix Dem.	0 VAr		
VCA Magnitude	0 V	IA Fixed Demand	0 A		
VCA Phase Angle	0 deg.	IB Fixed Demand	0 A		
VAN Magnitude	0 V	IC Fixed Demand	0 A		
VAN Phase Angle	0 deg.	3 Ph W Roll Dem.	0 W		
VBN Magnitude	0 V	3Ph VArs Roll Dem.	0 VAr		
VBN Phase Angle	0 deg.	IA Roll Demand	0 A		
VCN Magnitude	0 V	IB Roll Demand	0 A		
VCN Phase Angle	0 deg.	IC Roll Demand	0 A		
VN Derived Mag.	0 V	3Ph W Peak Dem.	0 W		
VN Derived Ang.	0 deg.	3Ph VAr Peak Dem.	0 VAr		
V1 Magnitude	0 V	IA Peak Demand	0 A		
V2 Magnitude	0 V	IB Peak Demand	0 A		
V0 Magnitude	0 V	IC Peak Demand	0 A		
VAN RMS	0 V	Reset Demand	No		
VBN RMS	0 V				
VCN RMS	0 V				
Frequency					
C/S Voltage Mag.	0 V				
C/S Voltage Ang.	0 deg.				
C/S Bus-Line Ang.	0 deg.				
Slip Frequency					
I1 Magnitude	0 A				
I1 Phase Angle	0 deg.				
I2 Magnitude	0 A				
I2 Phase Angle	0 deg.				
I0 Magnitude	0 A				
I0 Phase Angle	0 deg.				
V1 Magnitude	0 V				
V1 Phase Angle	0 deg.				
V2 Magnitude	0 V				
V2 Phase Angle	0 deg.				
V0 Magnitude	0 V				

MEASUREMENTS 1		MEASUREMENTS 2		MEASUREMENTS 3	
V0 Phase Angle	0 deg.				

Table 6 - Measurements

Notes:

PRODUCT DESIGN

CHAPTER 10

Date:	07/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142, P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

CONTENTS

FIGURES

TABLES

EQUATIONS

1 RELAY SYSTEM OVERVIEW

1.1 Hardware Overview

The relay is based on a modular hardware design where each module performs a separate function. This section describes the functional operation of the various hardware modules. Some modules are essential while others are optional depending on the user's requirements (see *Product Specific Options* and *Hardware Communications Options*).

All modules are connected by a parallel data and address bus which allows the processor board to send and receive information to and from the other modules as required.

There is also a separate serial data bus for transferring sample data from the input module to the processor. See the *Relay modules* diagram.

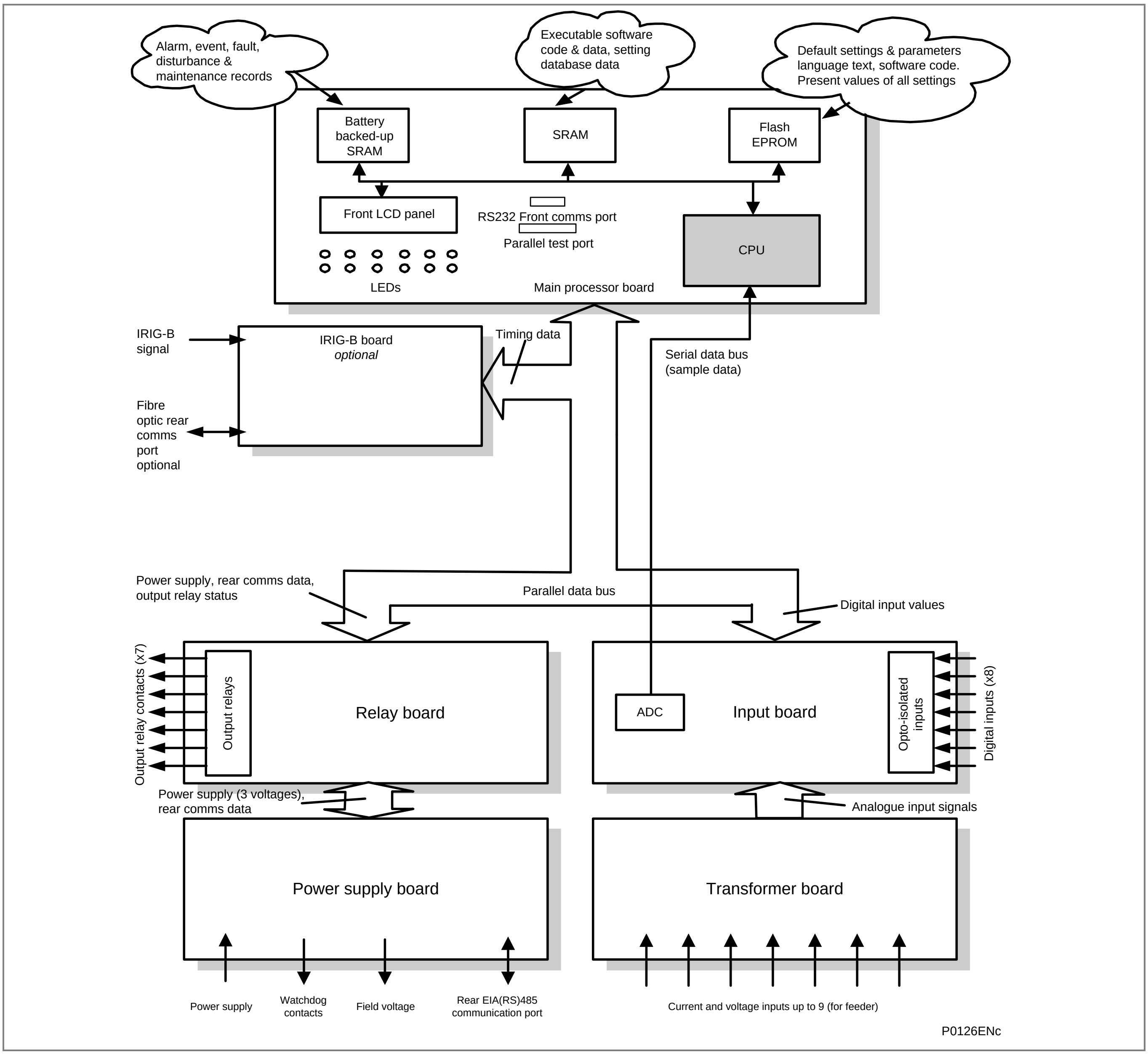


Figure 1 - Relay modules and information flow

1.2 Mechanical Layout

The relay case is pre-finished steel with a conductive covering of aluminum and zinc. This provides good earthing at all joints with a low impedance path to earth that is essential for shielding from external noise. The boards and modules use multi-point grounding (earthing) to improve immunity to external noise and minimize the effect of circuit noise. Ground planes are used on boards to reduce impedance paths and spring clips are used to ground the module metalwork.

Heavy duty terminal blocks are used at the rear of the relay for the current and voltage signal connections. Medium duty terminal blocks are used for the digital logic input signals, output relay contacts, power supply and rear communication port. A BNC connector is used for the optional IRIG-B signal. 9-pin and 25-pin female D-connectors are used at the front of the relay for data communication.

Inside the relay the boards plug into the connector blocks at the rear, and can be removed from the front of the relay only. The connector blocks to the relay's CT inputs have internal shorting links inside the relay. These automatically short the current transformer circuits before they are broken when the board is removed.

The front panel consists of a membrane keypad with tactile dome keys, an LCD and 12 or 22 LEDs (depending on the model) mounted on an aluminum backing plate.

1.3 Processor Board

The processor board performs all calculations for the relay and controls the operation of all other modules in the relay. The processor board also contains and controls the user interfaces (LCD, LEDs, keypad and communication interfaces).

The relay is based around a TMS320VC33-150MHz (peak speed), floating-point, 32-bit Digital Signal Processor (DSP) operating at a clock frequency of half this speed. This processor performs all of the calculations for the relay, including the protection functions, control of the data communication and user interfaces including the operation of the LCD, keypad and LEDs.

The processor board is directly behind the relay's front panel. This allows the LCD and LEDs and front panel communication ports to be mounted on the processor board. These ports are:

- The 9-pin D-connector for EIA(RS)232 serial communications used for MiCOM S1 Studio and Courier communications.
- The 25-pin D-connector relay test port for parallel communication.

All serial communication is handled using a Field Programmable Gate Array (FPGA).

The main processor board has:

- 2 MB SRAM for the working area. This is fast access (zero wait state) volatile memory used to temporarily store and execute the processor software.
- 4 MB flash ROM to store the software code, text, configuration data, default settings, and present settings.
- 4 MB battery-backed SRAM to store disturbance, event, fault and maintenance records.

Note	*With hardware revisions L and M, the SRAM size has changed from 2MB to 8MB; and the Flash size has changed from 4MB to 8MB.*

1.4 Internal Communication Buses

The relay has two internal buses for the communication of data between different modules. The main bus is a parallel link that is part of a 64-way ribbon cable. The ribbon cable carries the data and address bus signals in addition to control signals and all power supply lines. Operation of the bus is driven by the main processor board that operates as a master while all other modules in the relay are slaves.

The second bus is a serial link that is used exclusively for communicating the digital sample values from the input module to the main processor board. The DSP has a built-in serial port that is used to read the sample data from the serial bus. The serial bus is also carried on the 64-way ribbon cable.

1.5 Input Module

The input module provides the interface between the relay processor board(s) and the analog and digital signals coming into the relay. The input module consists of the main input board and the transformer board.

The relay provides an additional voltage input for the check sync. function.

1.5.1 Transformer Board

The transformer board holds up to four Voltage Transformers (VTs) and up to five Current Transformers (CTs).

The current inputs will accept either 1A or 5A nominal current (observe menu and wiring options) and the voltage inputs can be specified for either 110V or 440V nominal voltage (order option). The transformers are used both to step-down the currents and voltages to levels appropriate to the relay's electronic circuitry and to provide effective isolation between the relay and the power system. The connection arrangements of both the current and voltage transformer secondary's provide differential input signals to the main input board to reduce noise.

1.5.2 Input Board

The main input board is shown as a block diagram in the *Main input board* diagram. It provides the circuitry for the digital input signals and the Analog-to-Digital (A-D) conversion for the analog signals. It takes the differential analog signals from the CTs and VTs on the transformer board(s), converts these to digital samples and transmits the samples to the main processor board through the serial data bus. On the input board, the analog signals are converted using a dedicated sigma-delta A-D convertor for each channel. This allows all of the channels to be sampled concurrently with no sampling skew between channels. The sampled signals are then digitally filtered prior to the data being sent to the main processor via the serial link. In relay models using the second transformer board, a second input board is also fitted to provide the A-D conversion for the additional channels

The signal multiplexing arrangement provides for 16 analog channels to be sampled. The P14x relay provides 5 current inputs and 4 voltage inputs. 3 spare channels are used to sample 3 different reference voltages for the purpose of continually checking the operation of the multiplexer and the accuracy of the A - D converter.

The sample rate is kept at 24 samples per cycle of the power waveform by a logic control circuit driven by the frequency tracking function on the main processor board. The calibration non-volatile memory holds the calibration coefficients that are used by the processor board to correct for any amplitude or phase error introduced by the transformers and analog circuitry.

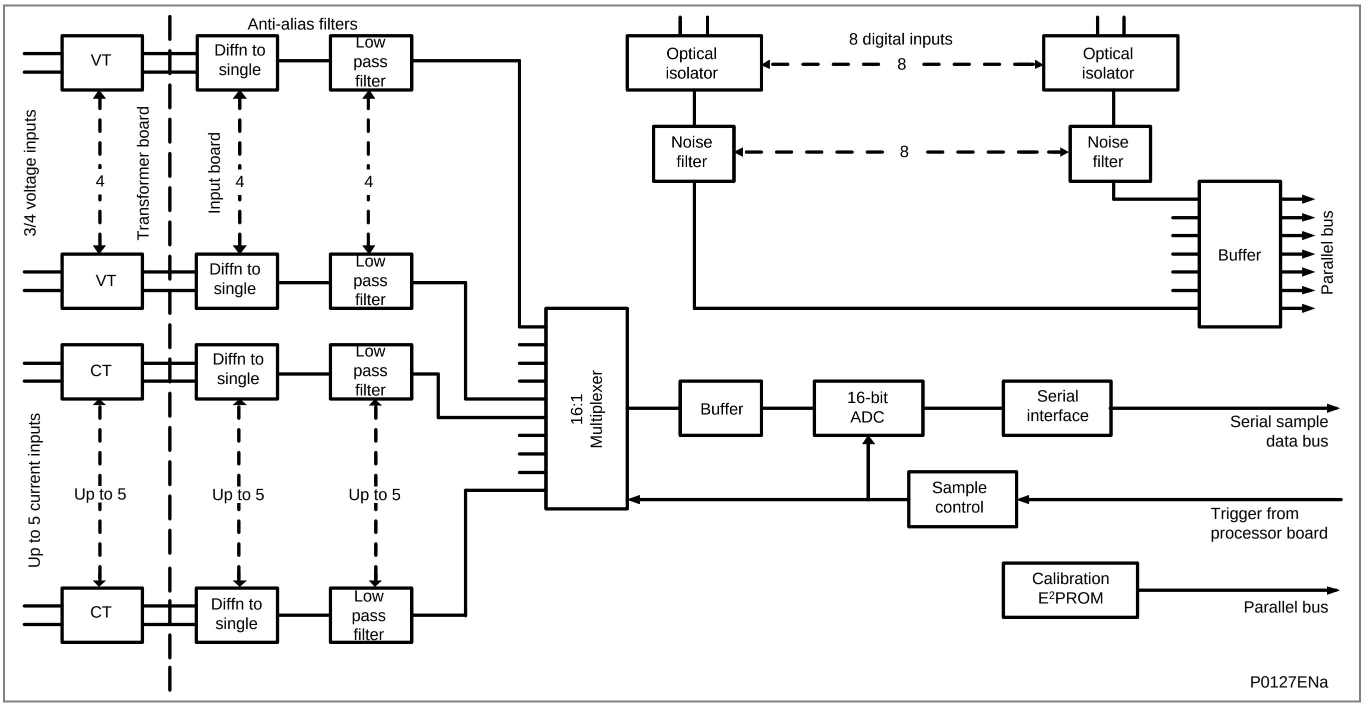


Figure 2 - Main input board

The other function of the input board is to read the signals on the digital inputs and send them through the parallel data bus to the processor board. The input board holds eight optical isolators for connecting up to eight digital input signals. Opto-isolators are used with digital signals for the same reason as transformers are used with analog signals: to isolate the relay's electronics from the power system environment. A 48 V 'field voltage' supply at the back of the relay is used to drive the digital opto-inputs. The input board has hardware filters to remove noise from the digital signals. The digital signals are then buffered so they can be read on the parallel data bus. Depending on the relay model, more than eight digital input signals can be accepted by the relay. This is done using an additional opto-board that contains the same provision for eight isolated digital inputs as the main input board, but does not contain any of the circuits for analog signals which are provided on the main input board.

1.5.3 Universal Opto Isolated Logic Inputs

The P14x relay is fitted with universal opto isolated logic inputs that can be programmed for the nominal battery voltage of the circuit of which they are a part. The inputs can be programmed with a pick-up/drop-off characteristic selectable as the standard 60% - 80% value or an optional characteristic of 50% - 70%. This implies, that they nominally provide a Logic 1 or On value for Voltages ≥80% or 70% of the set lower nominal voltage and a Logic 0 or Off value for the voltages ≤60% or 50% of the set higher nominal voltage. This lower value eliminates fleeting pickups that may occur during a battery earth fault, when stray capacitance may present up to 50% of battery voltage across an input. Each input also has a selectable filter of ½ cycle which renders the input immune to induced noise on the wiring; although this method is secure it can be slow, particularly for intertripping and back-tripping. This can be improved by switching off the ½ cycle filter in which case one of the following methods to reduce ac noise should be considered. The first method is to use double pole switching on the input, the second is to use screened twisted cable on the input circuit.

In the Opto Config. menu the nominal battery voltage can be selected for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.

Depending on the model, the P14x can have up to three opto-input cards that will increase the total number of opto inputs to 32.

Threshold levels are shown in the following table:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
OPTO CONFIG				
Global Nominal V	24-27	24 - 27, 30 - 34, 48 - 54, 110 - 125, 220 - 250, Custom		
Opto Input 1	24-27	24 - 27, 30 - 34, 48 - 54, 110 - 125, 220 - 250		
Opto Input 2-32	24-27	24 - 27, 30 - 34, 48 - 54, 110 - 125, 220 - 250		
Opto Filter Cntrl.	111111111111			
Characteristic	Standard 60% - 80%	Standard 60% - 80%, 50% - 70%		

Table 1 - Opto Config

Each opto input also has a pre-set filter of ½ cycle which renders the input immune to induced noise on the wiring; although this method is secure it can be slow, particularly for intertripping.

For the P14x feeder protection relay, the protection task is executed twice per cycle, i.e. after every 12 samples for the sample rate of 24 samples per power cycle used by the relay. Therefore, the time taken to register a change in the state of an opto input can vary between a half to one cycle. The time to register the change of state will depend on if the opto input changes state at the start or end of a protection task cycle with the additional half cycle filtering time.

1.6 Power Supply Module (including Output Relays)

The power supply module contains two boards, one for the power supply unit and the other for the output relays. It provides power to all of the other modules in the relay, as well as the EIA(RS)485 electrical connection for the rear communication port. The second board of the power supply module contains the relays that provide the output contacts.

1.6.1 Power Supply Board (including EIA(RS)485 Communication Interface)

The power supply module also provides a 48V external field supply output to drive the opto isolated digital inputs (or the substation battery may be used to drive the optos).

One of three different configurations of the power supply board can be fitted to the relay. This will be specified at the time of order and depends on the nature of the supply voltage that will be connected to the relay. The options are shown in the following table:

Nominal dc range	Nominal ac range
24 - 32 V dc	dc only
48 - 110 V dc	dc only
110 - 250 V dc	100 - 240 V ac rms

Table 2 - Power supply options

The output from all versions of the power supply module are used to provide isolated power supply rails to all of the other modules in the relay. Three voltage levels are used in the relay: 5.1 V for all of the digital circuits, ±16 V for the analog electronics such as on the input board, and 22 V for driving the output relay coils. All power supply voltages including the 0 V earth line are distributed around the relay through the 64-way ribbon cable. The power supply board also provides the 48 V field voltage. This is brought out to terminals on the back of the relay so that it can be used to drive the optically-isolated digital inputs.

The two other functions provided by the power supply board are the EIA(RS)485 communications interface and the watchdog contacts for the relay. The EIA(RS)485 interface is used with the relay's rear communication port to provide communication using one of either Courier, MODBUS, IEC60870-5-103, or DNP3.0 protocols. The EIA(RS)485 hardware supports half-duplex communication and provides optical isolation of the serial data that is transmitted and received. All internal communication of data from the power supply board is through the output relay board connected to the parallel bus.

The watchdog facility has two output relay contacts, one Normally Open (N/O)and one Normally Closed (N/C). These are driven by the main processor board and indicate that the relay is in a healthy state.

The power supply board incorporates inrush current limiting. This limits the peak inrush current, during energization, to approximately 10 A.

1.6.2 Output Relay Board

The output relay board has eight relays, six normally open contacts and two changeover contacts.

The relays are driven from the 22 V power supply line. The relays' state is written to or read from using the parallel data bus.

Depending on the relay model, up to three output relay boards may be fitted to the P145 relay to provide a total number of 32 relay outputs.

1.6.3 High-Break Relay Board

One '**high break**' output relay board is available for the P142 and one or two boards are available for the P143/P145 as an option.

The output relay board holds four relays, all normally open. The relays are driven from the 22V power supply line. The relays' state is written to or read from using the parallel data bus.

This board uses a hybrid of MOSFET Solid State Devices (SSD) in parallel with high capacity relay output contacts. The MOSFET has a varistor across it to provide protection which is required when switching off inductive loads because the stored energy in the inductor causes a reverse high voltage which could damage the MOSFET.

When there is a control input command to operate an output contact, the miniature relay is operated at the same time as the SSD. The miniature relay contact closes in nominally 3.5 ms and is used to carry the continuous load current; the SSD operates in <0.2 ms and is switched off after 7.5 ms. When the control input resets to open the contacts, the SSD is again turned on for 7.5 ms. The miniature relay resets in nominally 3.5 ms before the SSD so the SSD is used to break the load. The SSD absorbs the energy when breaking inductive loads and so limits the resulting voltage surge. This contact arrangement is for switching dc circuits only. As the SSD comes on very fast (<0.2 ms) these high break output contacts have the added advantage of being very fast operating. See the *High break contact operation* diagram below:

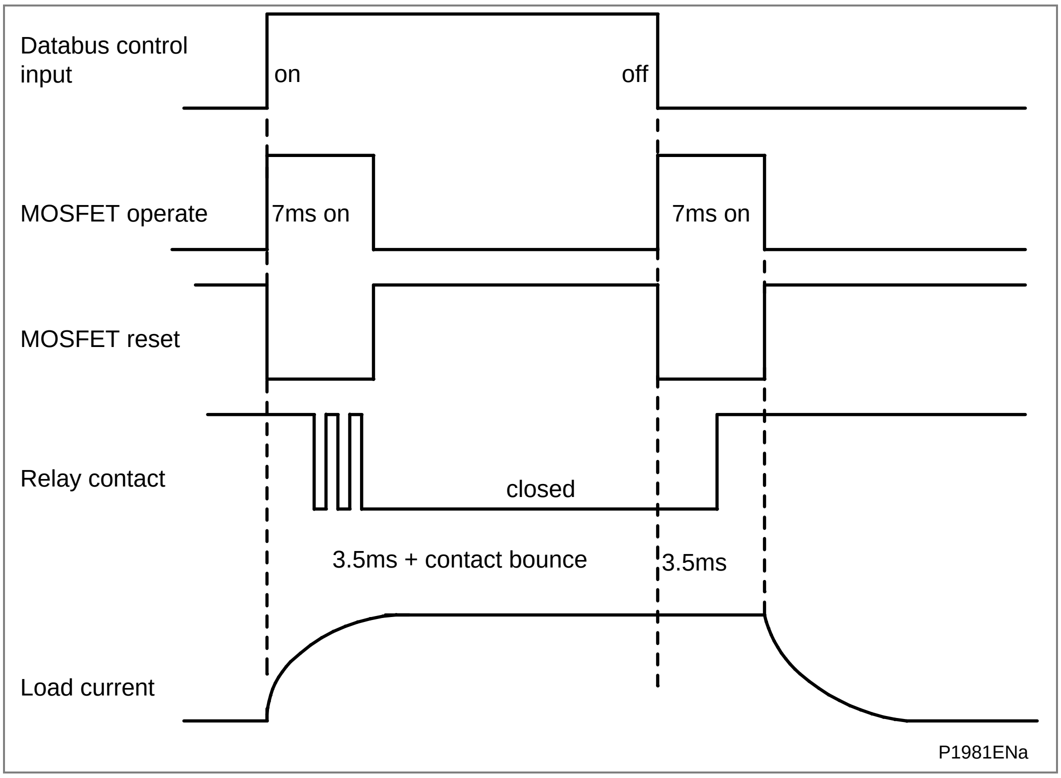


Figure 3 - High break contact operation

1.6.4 Input/Output (4 + 4) Relay Board

The input/output relay board has four isolated digital inputs and four output relays. Two of the relays have normally open contacts and two have changeover contacts. The output relays are driven from the 22 V power supply line. The relays' state is written to or read from using the parallel data bus.

This is used with variants of:

- P142 relay that has 12 opto inputs and 11 output contacts.
- P145 (B model) that has 12 opto inputs and 12 output contacts.

1.7 Hardware Communications Options

The Hardware Communications Options could mean that a second additional board is present if it was specified when the relay was ordered. Any such board is fitted into Slot A, as this is the optional communications slot.

The hardware options board commonly allows a choice of IRIG-B, Ethernet and Second Rear Comms Ports. Some of these choices are mutually exclusive whereas others provide more than one option on the same board. An up-to-date list of the available combinations for the Hardware/Software combination of this product is shown in the *Ordering Options* section in *Chapter 1 – Introduction*.

The main options are described in more detail in the these sections:

- IRIG-B Modulated and/or Un-modulated Board (Optional)
- Second Rear Communications Board (Optional)
- Ethernet Board (Options)

1.8 IRIG-B Board

The optional IRIG-B board is an order option that can be fitted to provide an accurate timing reference for the relay. This can be used wherever an IRIG-B signal is available. The IRIG-B signal is connected to the board with a BNC connector on the back of the relay. The timing information is used to synchronize the relay's internal real-time clock to an accuracy of 1 ms. The internal clock is then used for the time tagging of the event, fault maintenance and disturbance records. The IRIG-B board can also be specified with a fiber optic or Ethernet rear communication port.

The IRIG-B board can also be specified with a fiber optic transmitter/receiver that can be used for the rear communication port instead of the EIA(RS)485 electrical connection (Courier, MODBUS, DNP3.0 and IEC60870-5-103).

1.9 Second Rear Comms. Board

For relays with Courier, MODBUS, IEC60870-5-103 or DNP3.0 protocol on the first rear communications port there is the hardware option of a second rear communications port, which runs the Courier language. This can be used over one of three physical links: twisted pair K-BUS (non-polarity sensitive), twisted pair EIA(RS)485 (connection polarity sensitive) or EIA(RS)232.

This optional second rear port is designed typically for dial-up modem access by protection engineers and operators, when the main port is reserved for SCADA traffic.

The port supports full local or remote protection and control access by MiCOM S1 Studio software. The second rear port is also available with an on board IRIG-B input.

The second rear communications board, Ethernet and IRIG-B boards are mutually exclusive since they use the same hardware slot. For this reason two versions of second rear communications and Ethernet boards are available; one with an IRIG-B input and one without. The second rear communications board is shown in the following diagram.

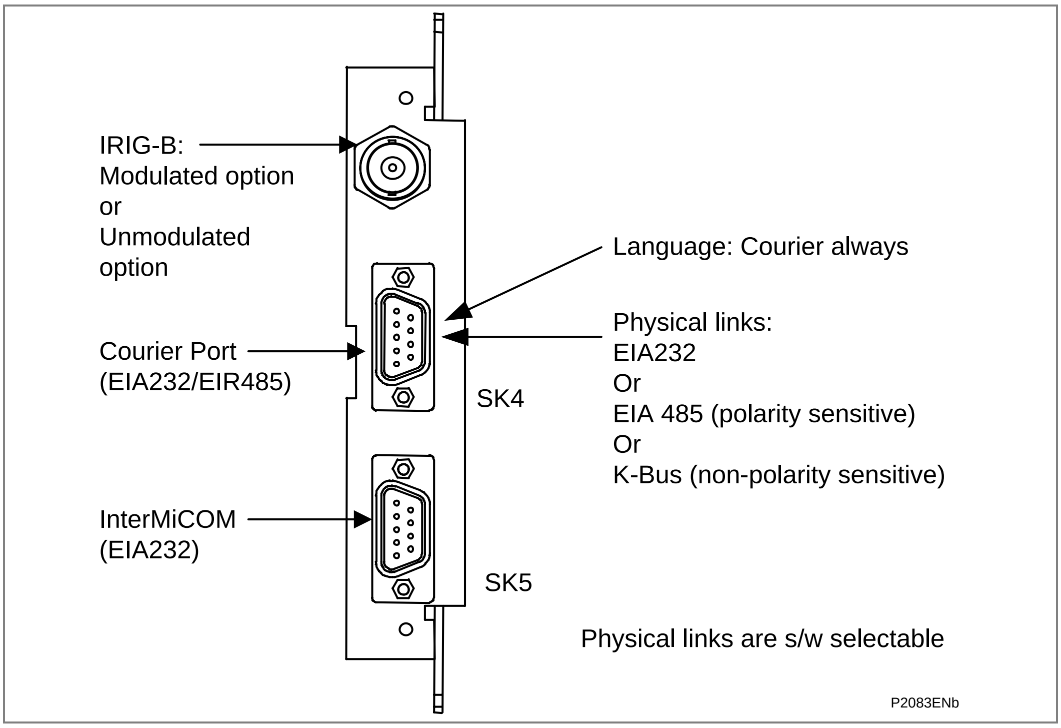


Figure 4 - Rear comms. Port

1.10 Ethernet Board (Options)

This is a mandatory board for IEC 61850 enabled relays. It provides network connectivity through copper or fiber media at 100Mb/s. This board, the IRIG-B board and second rear comms. board are mutually exclusive as they all use slot A within the relay case.

All modules are connected by a parallel data and address bus that allows the processor board to send and receive information to and from the other modules as required. There is also a separate serial data bus for conveying sample data from the input module to the processor. The relay modules and information flow diagram shows the modules of the relay and the flow of information between them.

This optional board is required for providing network connectivity using IEC 61850 and/or DNP3oE. There are a variety of different boards which provide Ethernet connectivity.

Important	**The choice of communication board options varies according to the Hardware Suffix and the Software Version of the MiCOM product. These are shown in the *Ordering Options* section in *Chapter 1 – Introduction*.**

By way of example, the board options may include:

- single-port Ethernet boards (which use 100 Mbits/s Copper and modulated/unmodulated IRIG-B connectivity)
- Redundant Ethernet with PRP/HSR/Dual IP and a mixture of LC/RJ45 ports and modulated/unmodulated IRIG-B connectivity

These options are mutually exclusive as they all use slot A in the relay case.

Note	*Each Ethernet board has a unique MAC address used for each Ethernet communication interface. The MAC address is printed on the rear of the board, next to the Ethernet sockets.*

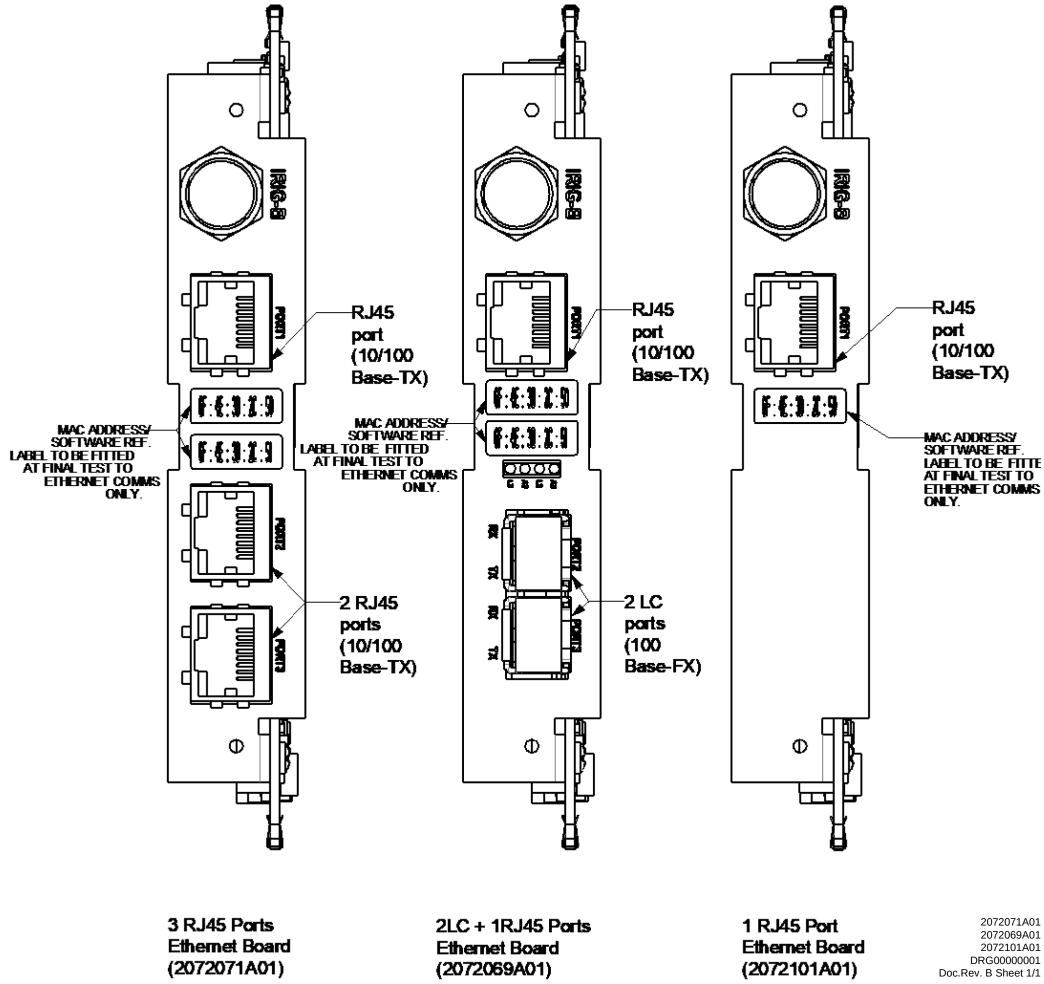
Note	*The 100 Mbits/s Fiber Optic ports use ST/LC type connectors and are suitable for 1310 nm multi-mode fiber type.*

Copper ports use RJ45 type connectors. When using copper Ethernet, it is important to use Shielded Twisted Pair (STP) or Foil Twisted Pair (FTP) cables, to shield the IEC 61850 communications against electromagnetic interference. The RJ45 connector at each end of the cable must be shielded, and the cable shield must be connected to this RJ45 connector shield, so that the shield is grounded to the relay case. Both the cable and the RJ45 connector at each end of the cable must be Category 5 minimum, as specified by the IEC 61850 standard.

It is recommended that each copper Ethernet cable is limited to a maximum length of 3 m and confined to one bay or cubicle.

When using IEC61850 communications through the Ethernet board, the rear EIA(RS)485 and front EIA(RS)232 ports are available for simultaneous use. The front port always uses the Courier protocol. The rear port protocol depends upon the protocol option selected.

One example of an Ethernet board is shown in this *Ethernet board connectors* diagram:



Note: The 3 RJ45 and the 2LC+1RJ45 port versions provide redundant Ethernet functions. The 1RJ45 port version does not provide redundant Ethernet functions. It is shown for illustration purposes only.

P1980ENe

Figure 5 - Ethernet board connectors (3 RJ45 or 2 LC + RJ45 or 1 RJ45)

2 RELAY SOFTWARE

The relay software was introduced in the overview of the relay at the start of this chapter. The software can be considered to be made up of these sections:

- The real-time operating system
- The system services software
- The platform software
- The protection and control software

These four elements are all processed by the same processor board.This section describes in detail the ***platform software*** and the ***protection and control software***, which between them control the functional behavior of the relay. The following *Relay software structure* diagram shows the structure of the relay software.

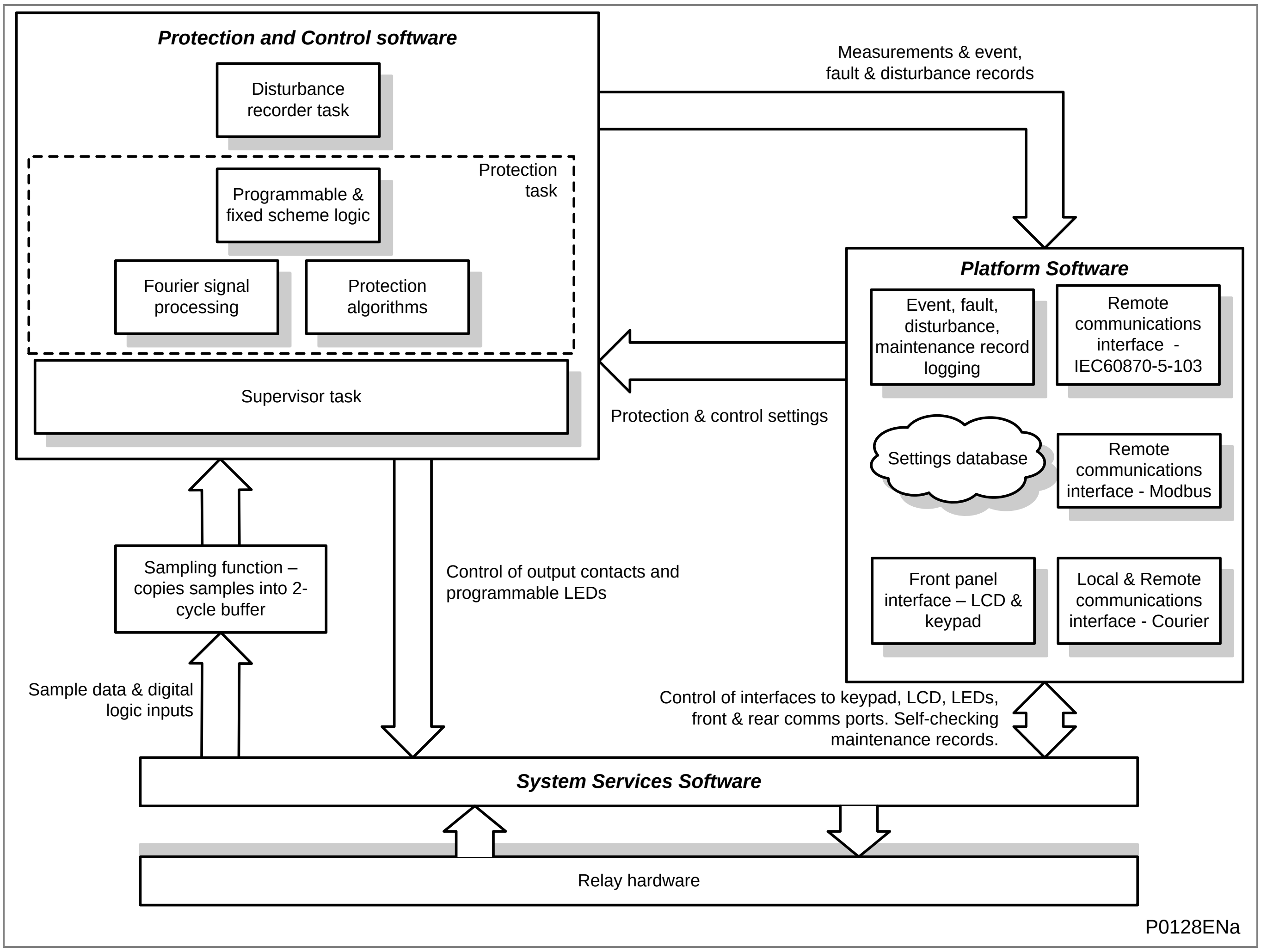


Figure 6 - Relay software structure

2.1 Real-Time Operating System

The real-time operating system provides a framework for the different parts of the relay's software to operate in.

The software is split into tasks; the real-time operating system is used to schedule the processing of the tasks to ensure that they are processed in the time available and in the desired order of priority. The operating system is also responsible in part for controlling the communication between the software tasks through the use of operating system messages.

2.2 System Services Software

As shown in the above *Relay software structure* diagram, the system services software provides the low-level control of the relay hardware. It also provides the interface between the relay's hardware and the higher-level functionality of the platform software and the protection and control software.

For example, the system services software provides drivers for items such as the LCD display, the keypad and the remote communication ports. It also controls the boot of the processor and downloading of the processor code into SRAM from non-volatile flash EPROM at power up.

2.3 Platform Software

The platform software has these main functions:

- To deal with the management of the relay settings.
- To control the logging of all records that are generated by the protection software, including alarms and event, fault, disturbance and maintenance records.
- To store and maintain a database of all of the relay's settings in non-volatile memory.
- To provide the internal interface between the settings database and each of the relay's user interfaces. These interfaces are the front panel interface and the front and rear communication ports, using whichever communication protocol has been specified (Courier, MODBUS, IEC60870-5-103 and DNP3.0). The platform software converts the information from the database into the format required.

The platform software notifies the protection and control software of all settings changes and logs data as specified by the protection and control software.

2.3.1 Record Logging

The logging function is provided to store all alarms, events, faults and maintenance records. The records for all of these incidents are logged in battery backed-up SRAM in order to provide a non-volatile log of what has happened. The relay maintains four logs: one each for up to 32 alarms, 512 event records, 5 fault records and 5 maintenance records. The logs are maintained such that the oldest record is overwritten with the newest record.

The logging function can be initiated from the protection software or the platform software, and is responsible for logging of a maintenance record in the event of a relay failure. This includes errors that have been detected by the platform software itself or error that are detected by either the system services or the protection software functions. See also the section on *Self-Testing and Diagnostics* later in this section.

2.3.2 Settings Database

The settings database contains all of the settings and data for the relay, including the protection, disturbance recorder and control and support settings. The settings are maintained in non-volatile memory. The platform software's management of the settings database make sure that only one user interface modifies the database settings at any one time. This feature is used to avoid confusion between different parts of the software during a setting change. For changes to protection settings and disturbance recorder settings, the platform software operates a 'scratchpad' in SRAM memory. This allows a number of setting changes to be made in any order but applied to the protection elements, disturbance recorder and saved in the database in non-volatile memory, at the same time. If a setting change affects the protection and control task, the database advises it of the new values.

The database is directly compatible with Courier communications.

2.3.3 Database Interface

The other function of the platform software is to implement the relay’s internal interface between the database and each of the relay’s user interfaces. The database of settings and measurements must be accessible from all of the relay’s user interfaces to allow read and modify operations. The platform software presents the data in the appropriate format for each user interface.

2.4 Protection and Control Software

The protection and control software interfaces with the platform software for settings changes and logging of records, and with the system services software for acquisition of sample data and access to output relays and digital opto-isolated inputs. It also performs the calculations for all of the protection algorithms of the relay. This includes digital signal processing such as Fourier filtering and ancillary tasks such as the disturbance recorder.

The protection and control software task processes all of the protection elements and measurement functions of the relay. It has to communicate with both the system services software and the platform software, and organize its own operations. The protection software has the highest priority of any of the software tasks in the relay, to provide the fastest possible protection response. It also has a supervisor task that controls the start-up of the task and deals with the exchange of messages between the task and the platform software.

2.4.1 Overview - Protection and Control Scheduling

After initialization at start-up, the protection and control task is suspended until there are sufficient samples available for it to process. The acquisition of samples is controlled by a ‘**sampling function**’ which is called by the system services software and takes each set of new samples from the input module and stores them in a two-cycle buffer. The protection and control software resumes execution when the number of unprocessed samples in the buffer reaches a certain number. For the P14x feeder protection relay, the protection task is executed twice per cycle, i.e. after every 12 samples for the sample rate of 24 samples per power cycle used by the relay. The protection and control software is suspended again when all of its processing on a set of samples is complete. This allows operations by other software tasks to take place.

2.4.2 Signal Processing

The sampling function filters the digital input signals from the opto-isolators and tracks the frequency of the analog signals. The digital inputs are checked against their previous value over a period of half a cycle. Therefore a change in the state of one of the inputs must be maintained over at least half a cycle before it is registered with the protection and control software.

The frequency tracking of the analog input signals is achieved by a recursive Fourier algorithm which is applied to one of the input signals, and works by detecting a change in the measured signal’s phase angle. The calculated value of the frequency is used to modify the sample rate being used by the input module to achieve a constant sample rate of 24 samples per cycle of the power waveform. The value of the frequency is also stored for use by the protection and control task.

When the protection and control task is re-started by the sampling function, it calculates the Fourier components for the analog signals. The Fourier components are calculated using a one-cycle, 24-sample Discrete Fourier Transform (DFT). The DFT is always calculated using the last cycle of samples from the 2-cycle buffer, which is the most recent data. Used in this way, the DFT extracts the power frequency fundamental component from the signal and produces the magnitude and phase angle of the fundamental in rectangular component format. The DFT provides an accurate measurement of the fundamental frequency component, and effective filtering of harmonic frequencies and noise. This performance is achieved with the relay input module which provides hardware anti-alias filtering to attenuate frequencies above the half sample rate, and frequency tracking to maintain a sample rate of 24 samples per cycle. The Fourier components of the input current and voltage signals are stored in memory so they can be accessed by all of the protection elements' algorithms. The samples from the input module are also used in an unprocessed form by the disturbance recorder for waveform recording and to calculate true RMS values of current, voltage and power for metering purposes.

2.4.3 Frequency Response

With the exception of the RMS measurements, all other measurements and protection functions are based on the Fourier-derived fundamental component. The fundamental component is extracted by using a 24-sample DFT. This gives good harmonic rejection for frequencies up to the 23rd harmonic. The 23rd is the first predominant harmonic that is not attenuated by the Fourier filter and this is known as an 'Alias'. However, the Alias is attenuated by approximately 85% by an additional, analog, 'anti-aliasing' filter (low pass filter). The combined affect of the anti-aliasing and Fourier filters is shown in the following *Frequency response* diagram.

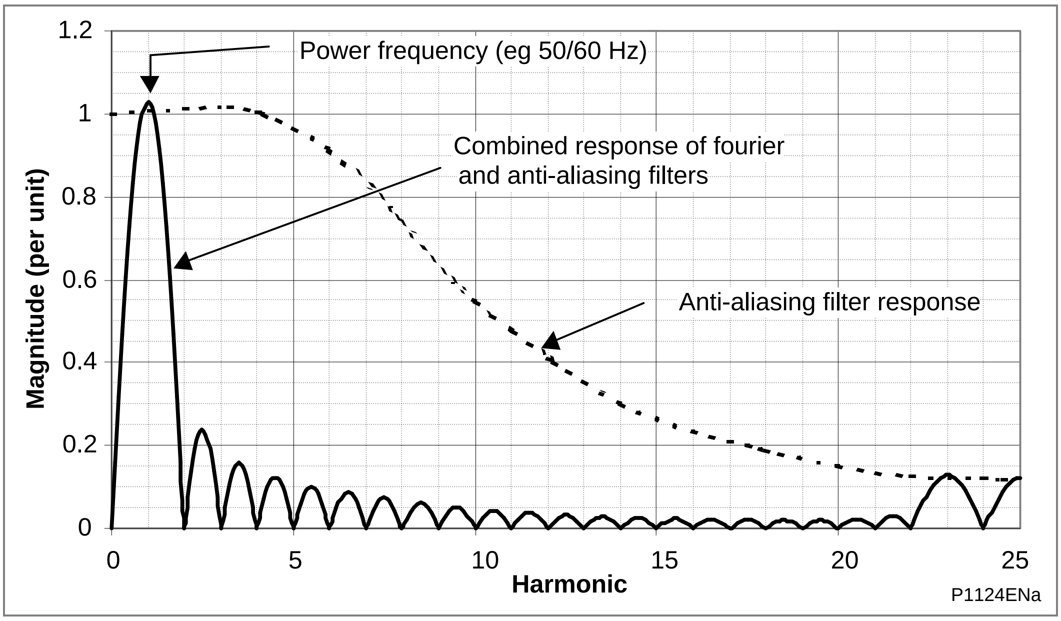


Figure 7 - Frequency response

For power frequencies that are not equal to the selected rated frequency, the harmonics are attenuated to zero amplitude. For small deviations of ±1Hz, this is not a problem but to allow for larger deviations, frequency tracking is used.

2.4.4 Programmable Scheme Logic (PSL)

The Programmable Scheme Logic (PSL) allows the relay user to configure an individual protection scheme to suit their own particular application. This is done with programmable logic gates and delay timers.

The input to the PSL is any combination of the status of the digital input signals from the opto-isolators on the input board, the outputs of the protection elements such as protection starts and trips, and the outputs of the fixed PSL. The fixed PSL provides the relay's standard protection schemes. The PSL consists of software logic gates and timers. The logic gates can be programmed to perform a range of different logic functions and can accept any number of inputs. The timers are used either to create a programmable delay or to condition the logic outputs, such as to create a pulse of fixed duration on the output, regardless of the length of the pulse on the input. The outputs of the PSL are the LEDs on the front panel of the relay and the output contacts at the rear.

The execution of the PSL logic is event driven: the logic is processed whenever any of its inputs change, for example as a result of a change in one of the digital input signals or a trip output from a protection element. Also, only the part of the PSL logic that is affected by the particular input change that has occurred is processed. This reduces the amount of processing time that is used by the PSL. The protection and control software updates the logic delay timers and checks for a change in the PSL input signals every time it runs.

This system provides flexibility for the user to create their own scheme logic design. However, it also means that the PSL can be configured into a very complex system, and because of this setting of the PSL is implemented through the PC support package Easergy Studio/MiCOM S1 Studio.

2.4.5 Function Key Interface

The ten function keys interface directly into the PSL as digital input signals and are processed based on the PSLs event-driven execution. However, a change of state is only recognized when a key press is executed, on average for longer than 200 ms. The time to register a change of state depends on whether the function key press is executed at the start or the end of a protection task cycle, with the additional hardware and software scan time included. A function key press can provide a latched (toggled mode) or output on key press only (normal mode) depending on how it is programmed and can be configured to individual protection scheme requirements. The latched state signal for each function key is written to non-volatile memory and read from non-volatile memory during relay power up, allowing the function key state to be reinstated after power-up if the relay power is lost.

2.4.6 Event, Fault and Maintenance Recording

A change in any digital input signal or protection element output signal is used to indicate that an event has taken place. When this happens, the protection and control task sends a message to the supervisor task to show that an event is available to be processed. The protection and control task writes the event data to a fast buffer in SRAM that is controlled by the supervisor task. When the supervisor task receives either an event or fault record message, it instructs the platform software to create the appropriate log in battery backed-up SRAM. The supervisor's buffer is faster than battery backed-up SRAM, therefore the protection software is not delayed waiting for the records to be logged by the platform software. However, if a large number of records to be logged are created in a short time, some may be lost if the supervisor's buffer is full before the platform software is able to create a new log in battery backed-up SRAM. If this occurs, an event is logged to indicate this loss of information.

Maintenance records are created in a similar manner with the supervisor task instructing the platform software to log a record when it receives a maintenance record message. However, it is possible that a maintenance record may be triggered by a fatal error in the relay, in which case it may not be possible to successfully store a maintenance record, depending on the nature of the problem. See the *Self-Testing and Diagnostics* section.

Fault records are stored in the sequence of events. They can be viewed locally or remotely and include:

- Faulty phase(s)
- Protection Tripped
- Protection Started
- Fault duration
- Fault type (Zone internal or external fault)
- Operating time
- Primary or Secondary RMS values of each current input
- Primary or Secondary RMS values of differential and biased current of each phase

2.4.7 Disturbance Recorder

The analog values and logic signals are routed from the protection and control software to the disturbance recorder software. The platform software interfaces with the disturbance recorder to allow the stored records to be extracted.

The disturbance recorder operates as a separate task from the protection and control task. It can record the waveforms for up to 9 analog channels and the values of up to 128 digital signals. The recording time is user selectable up to a maximum of 10.5 seconds. The disturbance recorder is supplied with data by the protection and control task once per cycle. The disturbance recorder collates the data that it receives into the required length disturbance record. The disturbance records can be extracted by MiCOM S1 that can also store the data in COMTRADE format, thus allowing the use of other packages to view the recorded data.

3 FAULT LOCATOR

The relay has an integral fault locator (which is separate from the protection and control task). The fault locator samples data from analog current and voltage inputs and writes it to a cyclic 12-cycle buffer until a fault condition is detected. . It then uses this data to provide a distance to fault location feature.

The data in the input buffer is then held to allow the fault calculation to be made and to calculate a distance to fault location. The calculated location of the fault is sent to the protection and control task which includes it in the fault record for the fault. When the fault record is complete (i.e. includes the fault location), the protection and control task can send a message to the supervisor task to log the fault record.

3.1 Basic Theory for Ground Faults

A two-machine equivalent circuit of a faulted power system is shown below.

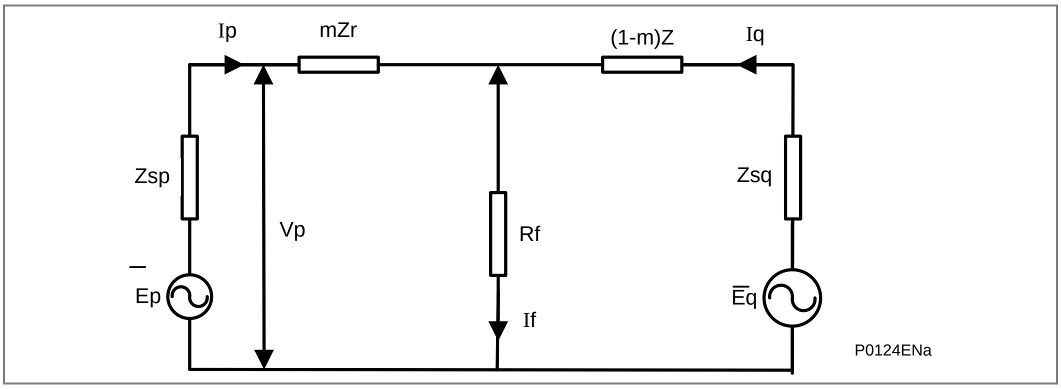


Figure 8 - Two machine equivalent circuit

From this diagram, the fault location (m) can be found by estimating *If* and solving the following *Fault Location* equation.

Equation 1 – Fault Location

$$Vp = mIpZr + IfRf$$

3.2 Data Acquisition and Buffer Processing

The fault locator stores the sampled data within a 12 cycle cyclic buffer at a resolution of 24 samples per cycle. When the fault recorder is triggered the data in the buffer is frozen such that the buffer contains 6 cycles of pre-trigger data and 6 cycles of post-trigger data. Fault calculation commences shortly after this trigger point.

The trigger for the fault locator is user selectable via the PSL.

The fault locator can store data for up to four faults. This ensures that fault location can be calculated for all shots on a typical multiple re-close sequence.

3.3 Faulted Phase Selection

Selection of the faulted phase(s) is performed by comparing the magnitude of the pre fault and post fault values of the three phase-to-phase currents. A single phase-to-ground fault produces the same change on two of these signals and zero on the third. A phase-to-phase or double phase-to-ground fault produces one signal that is larger than the other two. A three-phase fault produces the same change on all 3 currents.

Current changes are considered to be the same if they are within 20% of each other. Phase selection and fault location calculation can only be made if the current change exceeds 5%In.

3.4 Fault Location Calculation

This works by:

1. First obtaining the vectors
2. Selecting the faulted phase(s)
3. Estimating the phase of the fault current, If, for the faulted phase(s)
4. Solving the *Fault Location* equation for the fault location m at the instant of time where If = 0

3.4.1 Obtaining the Vectors

Different sets of vectors are chosen depending on the type of fault identified by the phase selection algorithm. The calculation using the *Fault Location* equation is applied for either a phase-to-ground fault or a phase-to-phase fault.

Thus for an A-phase to ground fault:

Equation 2 – A-phase to ground fault

IpZr = Ia (Zline /THETA line) + In (Zresidual /THETA residual)
And
Vp = VA

For an A-phase to B-phase fault:

Equation 3 - A-phase to B-phase fault

IpZr = Ia (Zline /THETA line) – Ib (Zresidual /THETA residual)
And
Vp = VA – VB

3.4.2 Solving the Equation for the Fault Location

As the sine wave of If passes through zero, the instantaneous values of the sine waves Vp and Ip can be used to solve the *Fault Location* equation for the fault location m. (The term IfRf being zero.)

This is determined by shifting the calculated vectors of Vp and IpZr by the angle (90° - angle of fault current) and then dividing the real component of Vp by the real component of IpZr. See the *Fault locator selection of fault current zero* diagram below.

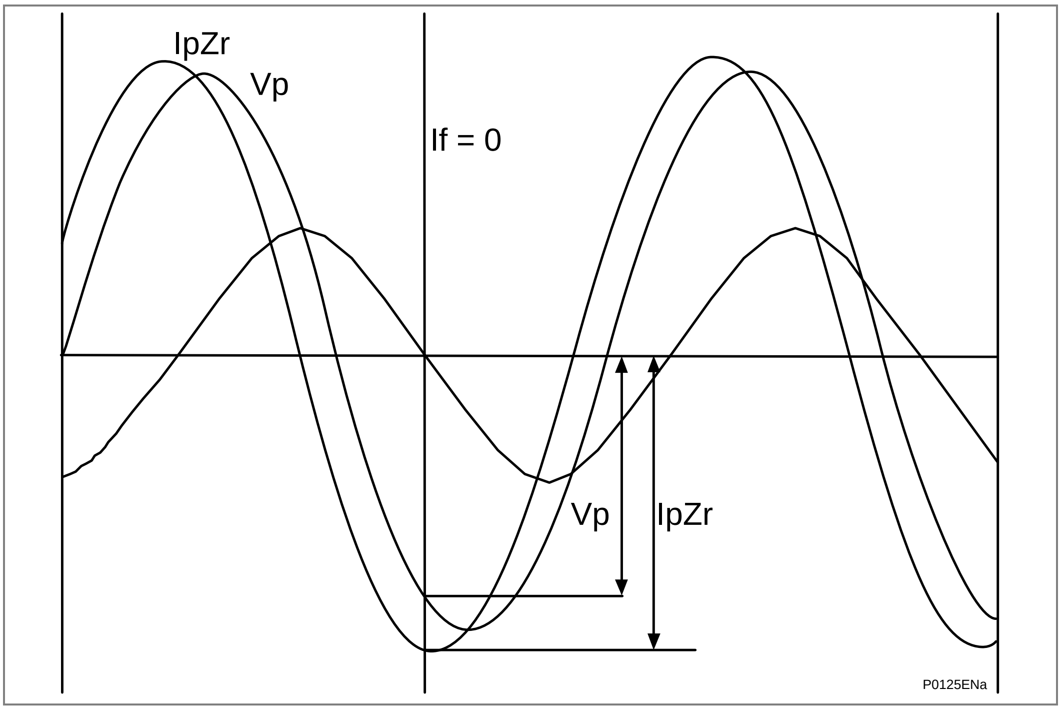


Figure 9 - Fault locator selection of fault current zero

i.e.:

Phase advanced vector Vp

Vp = | Vp | (cos(s) + jsin(s)) * (sin(d) + jcos(d))

Vp = | Vp | [- sin(s-d) + jcos(s-d)]

Phase advanced vector IpZr

IpZr = | IpZr | (cos (e) + jsin (e)) * (sin (d) + jcos (d))

IpZr = | IpZr | [- sin(e-d) + jcos(e-d)]

Therefore from the *Fault Location* equation:

m = Vp ÷ (Ip * Zr) at If = 0

m = Vpsin(s-d) / (IpZr * sin(e-d))

Where:

d = angle of fault current If

s = angle of Vp

e = angle of IpZr

Hence, the relay evaluates m which is the fault location as a percentage of the fault locator line impedance setting and then calculates the output fault location by multiplying this by the line length setting. When calculated, the fault location can be found in the fault record under the "**VIEW RECORDS**" column in the Fault Location cells. Distance to fault is available in kilometers, miles, impedance or percentage of line length.

4 SELF TESTING AND DIAGNOSTICS

The relay includes several self-monitoring functions to check the operation of its hardware and software when it is in service. These are included so that if an error or fault occurs in the relay's hardware or software, the relay is able to detect and report the problem and attempt to resolve it by performing a reboot. The relay must therefore be out of service for a short time, during which the **Healthy** LED on the front of the relay is OFF and, the watchdog contact at the rear is ON. If the reboot fails to resolve the problem, the relay takes itself permanently out of service; the **Healthy** LED stays OFF and watchdog contact stays ON.

If a problem is detected by the self-monitoring functions, the relay stores a maintenance record in battery backed-up SRAM.

The self-monitoring is implemented in two stages:

- firstly a thorough diagnostic check that is performed when the relay is booted-up
- secondly a continuous self-checking operation that checks the operation of the relay's critical functions while it is in service.

4.1 Start-up Self-Testing

The self-testing that is carried out when the relay is started takes a few seconds to complete, during which time the relay's protection is unavailable. This is shown by the **Healthy** LED on the front of the relay which is ON when the relay has passed all tests and entered operation. If the tests detect a problem, the relay remains out of service until it is manually restored to working order.

The operations that are performed at start-up are:

- System Boot
- Initialization Software
- Platform Software Initialization and Monitoring.

4.1.1 System Boot

The integrity of the flash memory is verified using a checksum before the program code and data are copied into SRAM and executed by the processor. When the copy is complete the data then held in SRAM is checked against that in flash memory to ensure they are the same and that no errors have occurred in the transfer of data from flash memory to SRAM. The entry point of the software code in SRAM is then called which is the relay initialization code.

4.1.2 Initialization Software

The initialization process includes the operations of initializing the processor registers and interrupts, starting the watchdog timers (used by the hardware to determine whether the software is still running), starting the real-time operating system and creating and starting the supervisor task.

In the initialization process the relay checks the following.

- The status of the battery
- The integrity of the battery backed-up SRAM that stores event, fault and disturbance records
- The voltage level of the field voltage supply that drives the opto-isolated inputs
- The operation of the LCD controller
- The watchdog operation

When the initialization software routine is complete, the supervisor task starts the platform software.

4.1.3 Platform Software Initialization and Monitoring

In starting the platform software, the relay checks the integrity of the data held in non-volatile memory with a checksum, the operation of the real-time clock, and the IRIG-B board if fitted. The final test that is made concerns the input and output of data; the presence and healthy condition of the input board is checked and the analog data acquisition system is checked through sampling the reference voltage.

At the successful conclusion of all of these tests the relay is entered into service and the protection started-up.

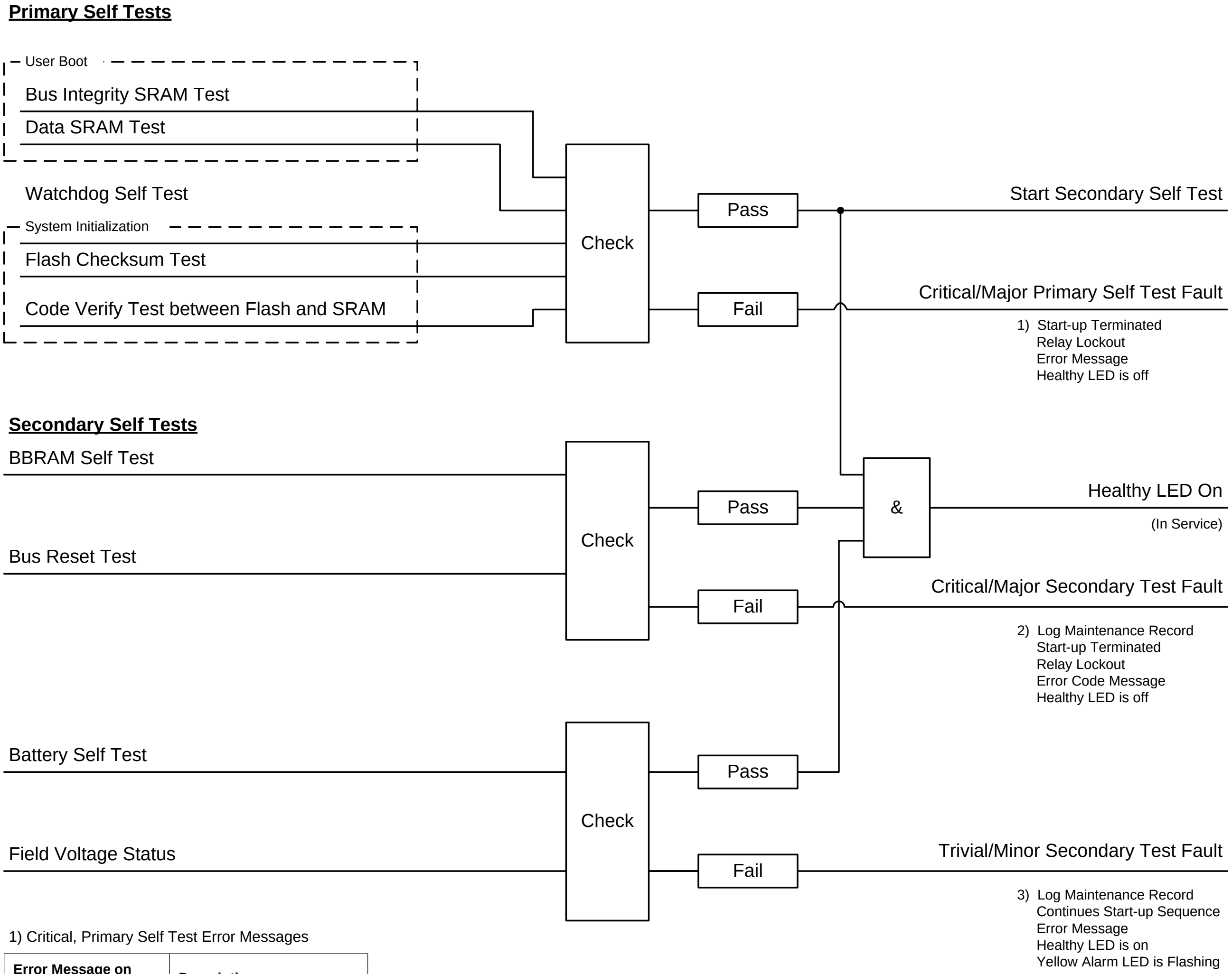
4.2 Continuous Self-Testing

When the relay is in service, it continually checks the operation of the critical parts of its hardware and software. The checking is carried out by the system services software (see section on relay software earlier in this section) and the results reported to the platform software.
The functions that are checked are as follows:

- The flash EPROM containing all program code and language text is verified by a checksum
- The code and constant data held in SRAM is checked against the corresponding data in flash EPROM to check for data corruption
- The SRAM containing all data other than the code and constant data is verified with a checksum
- The non-volatile memory containing setting values is verified by a checksum, whenever its data is accessed
- The battery status
- The level of the field voltage
- The integrity of the digital signal I/O data from the opto-isolated inputs and the relay contacts, is checked by the data acquisition function every time it is executed. The operation of the analog data acquisition system is checked by the acquisition function every time it is executed. This is done by sampling the reference voltage on a spare multiplexed channel
- The operation of the IRIG-B board is checked, where it is fitted, by the software that reads the time and date from the board

If the Ethernet board is fitted, it is checked by the software on the main processor board. If the Ethernet board fails to respond, an alarm is raised and the board is reset in an attempt to resolve the problem

In the unlikely event that one of the checks detects an error in the relay's subsystems, the platform software is notified and it will attempt to log a maintenance record in battery backed-up SRAM. If the problem is with the battery status or the IRIG-B board, the relay continues in operation. However, for problems detected in any other area the relay shuts down and reboots. This result in a period of up to 12 seconds when protection is unavailable, but the complete restart of the relay including all initializations should clear most problems that could occur. An integral part of the start-up procedure is a thorough diagnostic self-check. If this detects the same problem that caused the relay to restart, the restart has not cleared the problem and the relay takes itself permanently out of service. This is indicated by the **Healthy** LED on the front of the relay which goes OFF, and the watchdog contact that goes ON.



1) Critical, Primary Self Test Error Messages

Error Message on User Interface	Description
Bus Fail	Integrity Bus Test Error
SRAM Fail	SRAM Test Error
Flash Fail (Checksum)	Flash Test Error detected in the flash structure
Code Verify Fail	Error in code comparison test flash
Watchdog fail	Watchdog circuit fails to operate

2) Critical, Secondary Self Test Error Messages

Error Code	Description
0x0C170017	The secondary self tests detected an error in the Battery Backed SRAM (BBRAM)
0x0C170018	The secondary self tests detected an error in the Bus Curcuit

3) Trivial, Secondary Power on Self Tests Alarm Indications

Alarm	Description
Battery Failure	The secondary self tests detected battery self test has failed
Field Volt Fail	The secondary self tests detected Field Voltage failure

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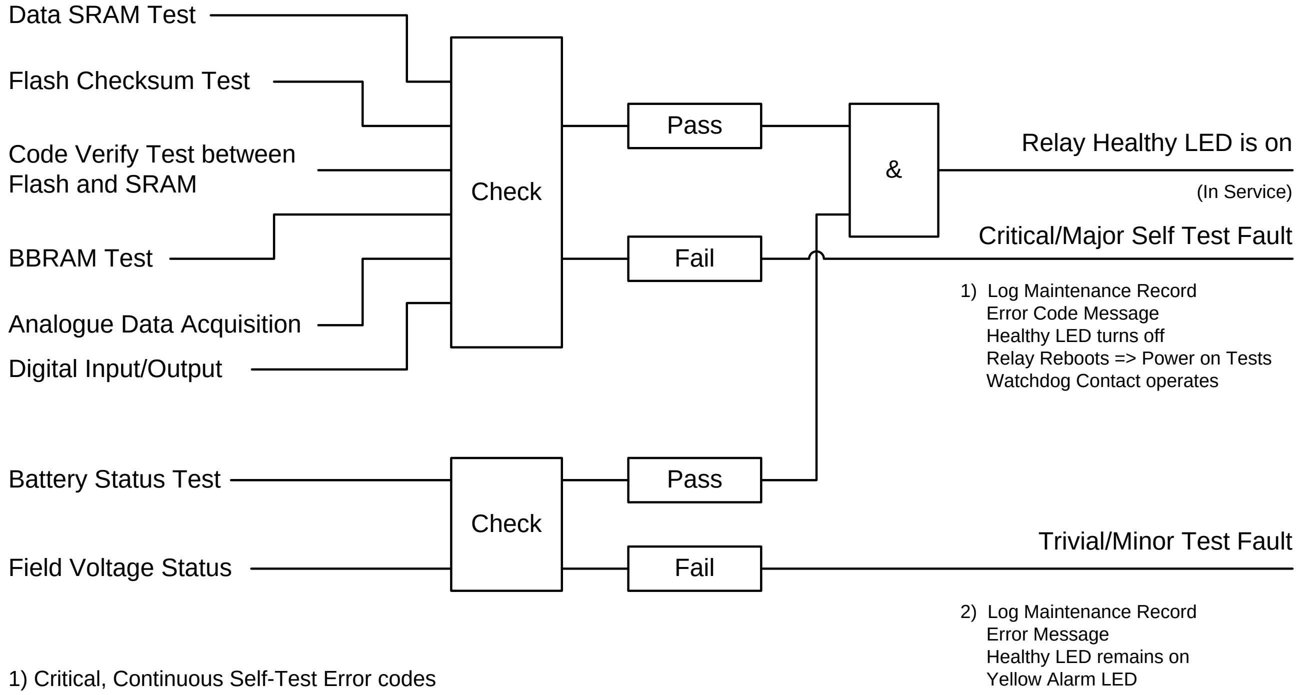
Figure 10 - Start-up self-testing logic



1) Critical, Continuous Self-Test Error codes

Error Code	**Description**
0x0C160011	The continuous self tests detected an error in SRAM
0x0C160012	The continuous self tests detected an error in the Flash memory checksum
0x0C160013	The continuous self tests detected an error in the code comparison
0x0C160014	The continuous self tests detected an error in the Battery Backed RAM
0x0C1600A0	The continuous self tests detected an error in the acquisition card
0x0C1600Bn	The continuous self tests detected an error in relay card n (number from 0)
0x0C1600Cn	The continuous self tests detected an error in opto card n (number from 0)

2) Trivial, Continuous Self-Test alarm indications

Error Code	**Description**
Battery Failure	The secondary self tests detected battery self test has failed
Field Volt Fail	The secondary self tests detected Field Voltage failure

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Figure 11 - Continuous self-testing logic

Notes:

COMMISSIONING

CHAPTER 11

Date:	07/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142 & P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

CONTENTS

Page (CM) 11-

TABLES

FIGURES

Page (CM) 11-

Notes:

1 INTRODUCTION

MiCOM P40 relays are fully numerical in their design, implementing all protection and non-protection functions in software. The relays use a high degree of self-checking and give an alarm in the unlikely event of a failure. Therefore, the commissioning tests do not need to be as extensive as with non-numeric electronic or electro-mechanical relays.

To commission numeric relays, you only need to verify that the hardware is functioning correctly and the application-specific software settings have been applied to the relay. You don't need to test every function of the relay if the settings have been verified by one of these methods:

- Extracting the settings applied to the relay using appropriate setting software (preferred method)
- Using the operator interface

To confirm that the product is operating correctly once the application-specific settings have been applied, perform a test on a single protection element.

Unless previously agreed to the contrary, the customer is responsible for determining the application-specific settings to be applied to the relay and for testing any scheme logic applied by external wiring or configuration of the relay's internal Programmable Scheme Logic (PSL).

Blank commissioning test and setting records are available for completion as needed.

As the relay's menu language is user-selectable, the Commissioning Engineer can change it to allow accurate testing as long as the menu is restored to the customer's preferred language on completion.

To simplify the specifying of menu cell locations in these Commissioning Instructions, they are given in the form [courier reference: COLUMN HEADING, Cell Text]. For example, the cell for selecting the menu language (first cell under the column heading) is in the System Data column (column 00) so it is given as [0001: SYSTEM DATA, Language].

Warning	**Before carrying out any work on the equipment, you should be familiar with the contents of the latest issue of the Safety Guide, Safety Information and Technical Data chapters and the equipment rating label(s).**

Caution	***The relay must not be disassembled in any way during commissioning.***

2 SETTING FAMILIARIZATION

When first commissioning a relay, allow sufficient time to become familiar with how to apply the settings.

The *Menu Database document* and the *Introduction* or *Settings* chapters contain a detailed description of the menu structure of Schneider Electric relays. The menu database is a separate document which can be downloaded from our website:

www.schneider-electric.com

With the secondary front cover in place, all keys except the key are accessible. All menu cells can be read. LEDs and alarms can be reset. However, no protection or configuration settings can be changed, or fault and event records cleared.

Removing the secondary front cover allows access to all keys so that settings can be changed, LEDs and alarms reset, and fault and event records cleared. However, to make changes to menu cells, the appropriate user role and password is needed.

Alternatively, if a portable PC with suitable setting software is available (such as Easergy Studio), the menu can be viewed one page at a time, to display a full column of data and text. This PC software also allows settings to be entered more easily, saved to a file for future reference, or printed to produce a settings record. Refer to the PC software user manual for details. If the software is being used for the first time, allow sufficient time to become familiar with its operation.

3 COMMISSIONING TEST MENU

To help minimize the time needed to test MiCOM relays the relay provides several test facilities under the '**COMMISSION TESTS**' menu heading. There are menu cells which allow the status of the opto-isolated inputs, output relay contacts, internal Digital Data Bus (DDB) signals and user-programmable LEDs to be monitored. Additionally there are cells to test the operation of the output contacts, user-programmable LEDs and, where available, the auto-reclose cycles.

The following table shows the relay menu of commissioning tests, including the available setting ranges and factory defaults. Each of the main menu tests are described in more detail in the following sections.

COMMISSION TESTS for P14x		
Menu Text	**Default Setting**	**Settings**
Opto I/P Status	-	-
Relay O/P Status	-	-
Test Port Status	-	-
LED Status	-	-
Monitor Bit 1	64 - (LED 1)	0 to 2047
Monitor Bit 2	65 - (LED 2)	0 to 2047
Monitor Bit 3	66 - (LED 3)	0 to 2047
Monitor Bit 4	67 - (LED 4)	0 to 2047
Monitor Bit 5	68 - (LED 5)	0 to 2047
Monitor Bit 6	69 - (LED 6)	0 to 2047
Monitor Bit 7	70 - (LED 7)	0 to 2047
Monitor Bit 8	71 - (LED 8)	0 to 2047
Test Mode	Disabled	Disabled, Test Mode, Contacts Blocked
Test Pattern	All bits set to 0	0 = Not Operated, 1 = Operated
Contact Test	No Operation	No Operation, Apply Test, Remove Test
Test LEDs	No Operation	No Operation, Apply Test
Test Auto-reclose	No Operation	No Operation, 3 Pole Test
Red LED Status	P145 only	-
Green LED Status	P145 only	-
Note *See Relay Menu Database for details of DDB signals*		

Table 1 - Commission Tests

3.1 Opto I/P Status

This menu cell displays the status of the relay's opto-isolated inputs as a binary string, a '**1**' indicating an energized opto-isolated input and a '**0**' a de-energized one. If the cursor is moved along the binary numbers the corresponding label text will be displayed for each logic input.

It can be used during commissioning or routine testing to monitor the status of the opto-isolated inputs whilst they are sequentially energized with a suitable dc voltage.

3.2 Relay O/P Status

This menu cell displays the status of the Digital Data Bus (DDB) signals that result in energization of the output relays as a binary string, a '**1**' indicating an operated state and '**0**' a non-operated state. If the cursor is moved along the binary numbers the corresponding label text will be displayed for each relay output.

The information displayed can be used during commissioning or routine testing to indicate the status of the output relays when the relay is '**in service**'. Additionally fault finding for output relay damage can be performed by comparing the status of the output contact under investigation with it's associated bit.

> *Note* *When the '**Test Mode**' cell is set to '**Enabled**' this cell will continue to indicate which contacts would operate if the relay was in-service, it does not show the actual status of the output relays.*

3.3 Test Port Status

This menu cell displays the status of the eight Digital Data Bus (DDB) signals that have been allocated in the '**Monitor Bit**' cells. If the cursor is moved along the binary numbers the corresponding DDB signal text string will be displayed for each monitor bit.

By using this cell with suitable monitor bit settings, the state of the DDB signals can be displayed as various operating conditions or sequences are applied to the relay. Thus the Programmable Scheme Logic (PSL) can be tested.

As an alternative to using this cell, the optional monitor/download port test box can be plugged into the monitor/download port located behind the bottom access cover. Details of the monitor/download port test box can be found in the *Using a Monitor/Download Port Test Box* section of this chapter.

3.4 LED Status (P141, P142 & P143 only)

The '**LED Status**' is an eight bit binary strings that indicate which of the user-programmable LEDs on the relay are illuminated when accessing the relay from a remote location, a '**1**' indicating a particular LED is lit and a '**0**' not lit.

3.5 Monitor Bits 1 to 8

The eight '**Monitor Bit**' cells allow the user to select the status of which digital data bus signals can be observed in the '**Test Port Status**' cell or via the monitor/download port.

Each '**Monitor Bit**' is set by entering the required Digital Data Bus (DDB) signal number from the list of available DDB signals in the Programmable Logic chapter. The pins of the monitor/download port used for monitor bits are given in the following table. The signal ground is available on pins 18, 19, 22 and 25.

Monitor bit	1	2	3	4	5	6	7	8
Monitor/download port pin	11	12	15	13	20	21	23	24

The required DDB signal numbers are 0 – 2047.

Table 2 - Monitor bit pins

> **Warning** **The monitor/download port is not electrically isolated against induced voltages on the communications channel. It should therefore only be used for local communications.**

3.6 Test Mode

The **Test Mode** menu cell (in the **COMMISSION TESTS** column) is used to allow secondary injection testing to be performed on the relay.

To select test mode set the Test Mode menu cell to '**Test Mode**'. It causes an alarm condition to be recorded, the yellow ALARM LED to light and an alarm message '**Test Mode Alm**' to be generated.

Test Mode freezes any information stored in the **CB CONDITION** column and (in IEC60870-5-103 builds) changes the Cause Of Transmission (COT) to Test Mode. For relays supporting IEC 61850 Edition 2, the test bit for data quality attribute shall set to TRUE, and the Logical Device Mode will set to test.

Test mode can also be enabled by energizing an opto mapped to the **Test Mode** signal.

To enable testing of output contacts set the **Test Mode** cell to **Contacts Blocked**. It causes an alarm condition to be recorded, the yellow ALARM LED to light and an alarm message '**Contacts Blk Alm**' to be generated.

In **Contact Blocked** mode, the protection function still works but the contacts will not operate. Also the **test pattern** and contact test functions are visible, which can be used to manually operate the output contacts. For relays supporting IEC 61850 Edition 2, the test bit for data quality attribute shall set to TRUE, and the Logical Device Mode will set to test/blocked.

Contacts Blocked can also be enabled by energizing an opto mapped to the **Contacts Blocked** signal.

Once testing is complete the cell must be set back to '**Disabled**' to restore the relay back to service.

WARNING	**If you use or enable Test Mode, you must disable Test Mode before putting the relay back into active service. IT IS POTENTIALLY EXTREMELY UNSAFE TO ATTEMPT TO USE ANY RELAY WHICH IS STILL IN TEST MODE IN ACTIVE SERVICE.**

3.7 Test Pattern

The '**Test Pattern**' cell is used to select the output relay contacts that will be tested when the '**Contact Test**' cell is set to '**Apply Test**'. The cell has a binary string with one bit for each user-configurable output contact which can be set to '**1**' to operate the output under test conditions and '**0**' to not operate it.

3.8 Contact Test

When the '**Apply Test**' command in this cell is issued the contacts set for operation (set to '**1**') in the '**Test Pattern**' cell change state. After the test has been applied the command text on the LCD will change to '**No Operation**' and the contacts will remain in the Test State until reset issuing the '**Remove Test**' command. The command text on the LCD will again revert to '**No Operation**' after the '**Remove Test**' command has been issued.

Note	*When the '**Test Mode**' cell is set to '**Enabled**' the '**Relay O/P Status**' cell does not show the current status of the output relays and hence can not be used to confirm operation of the output relays. Therefore it will be necessary to monitor the state of each contact in turn.*

3.9 Test LEDs

When the '**Apply Test**' command in this cell is issued the eight/eighteen user-programmable LEDs will illuminate for approximately 2 seconds before they extinguish and the command text on the LCD reverts to '**No Operation**'.

3.10 Test Auto-Reclose

Where the relay provides an auto-reclose function, this cell will be available for testing the sequence of circuit breaker trip and auto-reclose cycles with the settings applied.

Issuing the command '**3 Pole Trip**' will cause the relay to perform the first three-phase trip/reclose cycle so that associated output contacts can be checked for operation at the correct times during the cycle. Once the trip output has operated the command text will revert to '**No Operation**' whilst the rest of the auto-reclose cycle is performed. To test subsequent three-phase auto-reclose cycles repeat the '**3 Pole Trip**' command.

Note *The factory settings for the relay's Programmable Scheme Logic (PSL) has the '**AR Trip Test**' signal mapped to Trip Command In. If the PSL has been changed, it is essential that this signal remains mapped to Trip Command In for the '**Test Auto-reclose**' facility to work.*

3.11 Red LED Status and Green LED Status (P145 Model Only)

The **Red LED Status** and **Green LED Status** cells are 18-bit binary strings that show which of the user-programmable LEDs on the relay are ON when accessing the relay from a remote location. **1** indicates a particular LED is ON and a **0** OFF. When the status of a particular LED in both cells is **1**, this means the LED is yellow.

3.12 Using a Monitor/Download Port Test Box

A monitor/download port test box containing 8 LEDs and a switchable audible indicator is available from Schneider Electric, or one of their regional sales offices. It is housed in a small plastic box with a 25-pin male D-connector that plugs directly into the relay's monitor/download port. There is also a 25-pin female D-connector which allows other connections to be made to the monitor/download port whilst the monitor/download port test box is in place.

Each LED corresponds to one of the monitor bit pins on the monitor/download port with '**Monitor Bit 1**' being on the left hand side when viewing from the front of the relay. The audible indicator can either be selected to sound if a voltage appears on any of the eight monitor pins or remain silent so that indication of state is by LED alone.

4 EQUIPMENT REQUIRED FOR COMMISSIONING

4.1 Minimum Equipment Required

The minimum equipment needed varies slightly, depending on the features provided by each type of MiCOM product. The list of minimum equipment is given below:

- A portable PC, with an RS232 port as well as appropriate software
- Multifunctional dynamic current and voltage injection test set
- Multimeter with suitable ac current range, and ac and dc voltage ranges of 0 - 440V and 0 - 250V respectively
- Continuity tester (if not included in multimeter)
- Phase angle meter
- Phase rotation meter

Note	*Modern test equipment may contain many of the above features in one unit.*

4.2 Optional Equipment

- Fiber optic power meter (and fibre optic test leads may be required depending upon application).
- Multi-finger test plug type Easergy test plug (if Easergy test block type is installed)
- An electronic or brushless insulation tester with a dc output not exceeding 500 V (for insulation resistance testing when required)
- K-Bus to EIA(RS)232 protocol converter (if the first rear EIA(RS)485 K-Bus port or second rear port configured for K-Bus is being tested and one is not already installed)
- EIA(RS)485 to EIA(RS)232 converter (if first rear EIA(RS)485 port or second rear port configured for EIA(RS)485 is being tested)
- A printer, for printing a setting record from the portable PC

5 PRODUCT CHECKS

These product checks cover all aspects of the relay that need to be checked to ensure:

- that it has not been physically damaged before commissioning
- that it is functioning correctly and
- that all input quantity measurements are within the stated tolerances

If the application-specific settings have been applied to the relay before commissioning, it is advisable to make a copy of the settings to allow their restoration later.

If Programmable Scheme Logic (PSL) (other than the default settings with which the relay was supplied) has been applied, the default settings should be restored before commissioning. This can be done by:

- Obtaining a setting file from the customer. This requires a portable PC with appropriate setting software for transferring the settings from the PC to the relay.
- Extracting the settings from the relay itself. This requires a portable PC with appropriate setting software.
- Manually creating a setting record. This could be done by stepping through the front panel menu using the front panel user interface.

If the default RBAC has been changed then a username/password combination must be provided to allow access to change relay settings.

Note	*If the password has been lost, a recovery password can be obtained from Schneider Electric.*

5.1 With the Relay De-Energized

The following group of tests should be carried out without the auxiliary supply applied to the relay and with the trip circuit isolated.

Before inserting the test plug, refer to the scheme diagram to ensure this will not cause damage or a safety hazard. For example, the test block may be associated with protection current transformer circuits. Before the test plug is inserted into the test block, make sure the sockets in the test plug which correspond to the current transformer secondary windings are linked.

Warning	**The current and voltage transformer connections must be isolated from the relay for these checks. If a MiCOM P991 or an Easergy test block is provided, insert the Easergy or MiCOM P992 test plug, which open-circuits all wiring routed through the test block.**

Danger	**Never open-circuit the secondary circuit of a current transformer because the high voltage produced may be lethal. It could also damage insulation.**

If a test block is not provided, isolate the voltage transformer supply to the relay using the panel links or connecting blocks. Short-circuit and disconnect the line current transformers from the relay terminals. Where means of isolating the auxiliary supply and trip circuit (such as isolation links, fuses and MCB) are provided, these should be used. If this is impossible, the wiring to these circuits must be disconnected and the exposed ends suitably terminated to prevent them from being a safety hazard.

5.1.1 Visual Inspection

Caution	Check the rating information under the top access cover on the front of the relay. Check that the relay being tested is correct for the protected line or circuit. Ensure that the circuit reference and system details are entered onto the setting record sheet. Double-check the CT secondary current rating, and be sure to record the actual CT tap which is in use.

Carefully examine the relay to see that no physical damage has occurred since installation.

Ensure that the case earthing connections, at the bottom left-hand corner at the rear of the relay case, are used to connect the relay to a local earth bar using an adequate conductor.

5.1.2 Current Transformer Shorting Contacts (Optional Check)

If needed, the current transformer shorting contacts can be checked to ensure they close when the heavy-duty terminal block shown in the following figure is disconnected from the current input PCB. The heavy-duty terminal block location depends on the relay model.

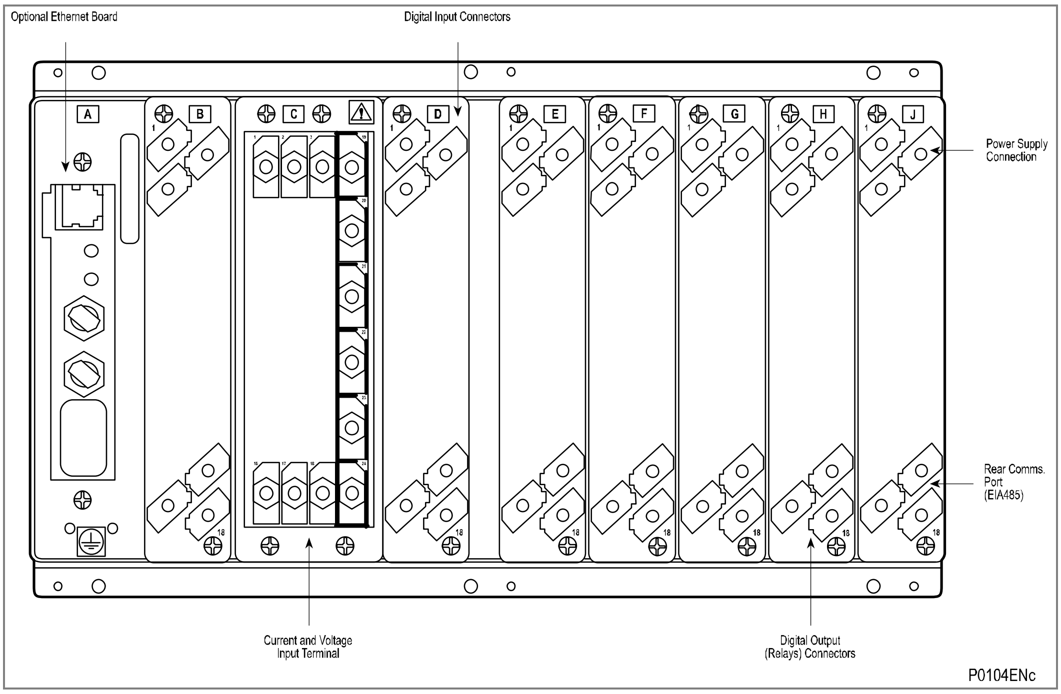


Figure 1 - Rear terminal blocks on size 60TE case (P145 G variant shown)

Heavy duty terminal blocks are fastened to the rear panel using four Pozidriv or PZ1 screws. These are at the top and bottom between the first and second, and third and fourth, columns of terminals (see the *Location of Securing Screws for Terminal Blocks* diagram below).

Note	*Use a magnetic-bladed screwdriver to avoid losing screws or leaving them in the terminal block.*

Pull the terminal block away from the rear of the case and check with a continuity tester that all the shorting switches being used are closed. The following table(s) shows the terminals between which shorting contacts are fitted.

Current Input	Shorting Contact Between Terminals	
	1A CTs	5A CTs
IA	C3 - C2	C1 - C2

Current Input	Shorting Contact Between Terminals	
IB	C6 - C5	C4 - C5
IC	C9 - C8	C7 - C8
IN	C12 - C11	C10 - C11
IN SENSITIVE	C15 - C14	C13 - C14

Table 3 - Current transformer shorting contact locations

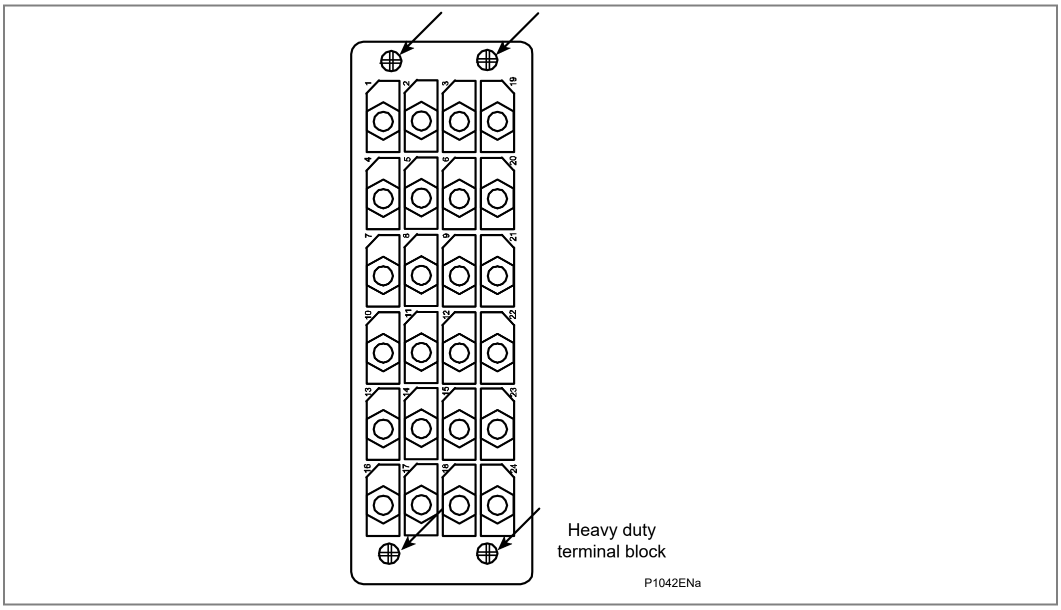


Figure 2 - Location of securing screws for heavy duty terminal blocks

5.1.3 Insulation

Insulation resistance tests are only necessary during commissioning if it is required for them to be done and they haven't been performed during installation.

Isolate all wiring from the earth and test the insulation with an electronic or brushless insulation tester at a dc voltage not exceeding 500 V. Terminals of the same circuits should be temporarily connected together.

The main groups of relay terminals are:

- Voltage transformer circuits
- Current transformer circuits
- Auxiliary voltage supply
- Field voltage output and opto-isolated control inputs
- Relay contacts
- First rear EIA(RS)485 communication port
- RTD inputs (where available)
- Current Loop (analog) Inputs and Outputs (CLIO) (where available)
- Case earth

The insulation resistance should be greater than 100 MΩ at 500 V.

On completion of the insulation resistance tests, ensure all external wiring is correctly reconnected to the unit.

5.1.4 External Wiring

Caution	Check that the external wiring is correct to the relevant relay diagram and scheme diagram. Ensure as far as practical that phasing/phase rotation appears to be as expected. The relay diagram number appears on the rating label under the top access cover on the front of the relay. Schneider Electric supply the corresponding connection diagram with the order acknowledgement for the relay.

If a MiCOM P991 or an Easergy test block is provided, check the connections against the wiring diagram. It is recommended that the supply connections are to the live side of the test block (with the odd numbered terminals 1, 3, 5, 7, and so on).

5.1.5 Watchdog Contacts

Using a continuity tester, check that the watchdog contacts are in the states shown in the *Watchdog contact status* table for a de-energized relay.

Terminals		Contact State	
		Relay De-energized	Relay Energized
F11 - F12	(P141/P142)	Closed	Open
F13 - F14	(P141/P142)	Open	Closed
J11 – J12	(P143/P145 60TE)	Closed	Open
J13 – J14	(P143/P145 60TE)	Open	Closed
N11 - N12	(P143 80TE)	Closed	Open
N13 - N14	(P143 80TE)	Open	Closed

Table 4 - Watchdog contact status

5.1.6 Auxiliary Supply

Caution	***The relay can be operated from either a dc only or an ac/dc auxiliary supply depending on the relay's nominal supply rating. The incoming voltage must be within the operating range specified in the following table.***

Without energizing the relay, measure the auxiliary supply to ensure it is within the operating range.

Note	*The relay can withstand an ac ripple of up to 12% of the upper rated voltage on the dc auxiliary supply.*

Nominal Supply Rating		Operating Ranges	
DC	AC rms	DC	AC
24/32V dc	-	19 - 38V dc	-
48/110V dc	-	37 - 150V dc	-
110/250V dc	100/240V ac	87 - 300V dc	80 - 265V ac

Table 5 - Operational range of auxiliary supply Vx

Caution	***Do not energize the relay using the battery charger with the battery disconnected as this can irreparably damage the relay's power supply circuitry.***

Caution	**Energize the relay only if the auxiliary supply is within the operating range. If a test block is provided, it may be necessary to link across the front of the test plug to connect the auxiliary supply to the relay.**

5.2 With the Relay Energized

The following group of tests verify that the relay hardware and software is functioning correctly and should be carried out with the auxiliary supply applied to the relay.

Caution	***The current and voltage transformer connections must remain isolated from the relay for these checks. The trip circuit should also remain isolated to prevent accidental operation of the associated circuit breaker.***

5.2.1 Watchdog Contacts

Using a continuity tester, check the watchdog contacts are in the states given in the *Watchdog contact status* table for an energized relay.

5.2.2 LCD Front Panel Display

The Liquid Crystal Display (LCD) is designed to operate in a wide range of substation ambient temperatures. For this purpose, the Px40 relays have an **LCD Contrast** setting. This allows the user to adjust the lightness or darkness of the displayed characters. The contrast is factory preset to account for a standard room temperature, however it may be necessary to adjust the contrast to give the best in-service display. To change the contrast, at the bottom of the **CONFIGURATION** column, use cell [09FF: LCD Contrast] to increment (darker) or decrement (lighter), as required.

Important	***Before applying a contrast setting, ensure that it does not make the display too light or dark so the menu text becomes unreadable. If this happens, it is possible to restore the display by downloading an Easergy Studio setting file, with the LCD Contrast set in the typical range of 7 to 11.***

5.2.3 Date and Time

Before setting the date and time, ensure that the factory-fitted battery isolation strip that prevents battery drain during transportation and storage has been removed. With the lower access cover open, the presence of the battery isolation strip can be checked by a red tab protruding from the positive side of the battery compartment. Lightly pressing the battery to prevent it falling out of the battery compartment, pull the red tab to remove the isolation strip.

The data and time should now be set to the correct values. The method of setting depends on whether accuracy is being maintained through the optional Inter-Range Instrumentation Group standard B (IRIG-B) port on the rear of the relay or by using IEEE1588 and SNTP via Ethernet.

5.2.3.1 With an IRIG-B Signal

Note	*For P741 the IRIG-B signal may apply to the Central Unit only.*

If a satellite time clock signal conforming to IRIG-B is provided and the relay has the optional IRIG-B port fitted, the satellite clock equipment should be energized.

To allow the relay's time and date to be maintained from an external IRIG-B source cell [DATE and TIME, IRIG-B Sync.] must be set to **Enabled**.

Ensure the relay is receiving the IRIG-B signal by checking that cell [DATE and TIME, IRIG-B Status] reads **Active**.

Once the IRIG-B signal is active, adjust the time offset of the universal coordinated time (satellite clock time) on the satellite clock equipment so that local time is displayed.

Check the time, date and month are correct in cell [0801: DATE and TIME, Date/Time]. The IRIG-B signal does not contain the current year so needs to be set manually in this cell.

If the auxiliary supply fails, with a battery fitted in the compartment behind the bottom access cover, the time and date is maintained. Therefore, when the auxiliary supply is restored, the time and date are correct and need not be set again.

To test this, remove the IRIG-B signal, then remove the auxiliary supply from the relay. Leave the relay de-energized for approximately 30 seconds. On re-energization, the time in cell [DATE and TIME, Date/Time] should be correct. Then reconnect the IRIG-B signal.

5.2.3.2 With SNTP

If SNTP time synch has been configured for IEC61850 or DNP3oE communications then check the SNTP Status in the DATE and TIME column.

Once the SNTP signal is active, adjust the time offset of the universal coordinated time (satellite clock time) on the satellite clock equipment so that local time is displayed. Check the time, date and month are correct in cell [0801: DATE and TIME, Date/Time].

5.2.3.3 Without an IRIG-B or SNTP Signal

Note	*For P741 the IRIG-B signal may not apply to the Central Unit only. For the P742/P743 it may apply to the Peripheral Unit only.*

If the time and date is not being maintained by an IRIG-B signal, ensure that cell [0804: DATE and TIME, IRIG-B Sync.] is set to **Disabled**.

Set the date and time to the correct local time and date using cell [0801: DATE and TIME, Date/Time].

If the auxiliary supply fails, with a battery fitted in the compartment behind the bottom access cover, the time and date are maintained. Therefore when the auxiliary supply is restored, the time and date are correct and need not be set again.

To test this, remove the auxiliary supply from the relay for approximately 30 seconds. On re-energization, the time in cell [0801: DATE and TIME, Date/Time] should be correct.

A Time Synch input can be configured in the PSL which will adjust the time to the nearest minute when the input is energised

5.2.4 Light Emitting Diodes (LEDs)

On power-up, the green LED should switch on and stay on, indicating that the relay is healthy. The relay has non-volatile memory which stores the state (on or off) of the alarm, trip and, if configured to latch, user-programmable LED indicators when the relay was last energized from an auxiliary supply. Therefore, these indicators may also switch on when the auxiliary supply is applied.

If any of these LEDs are on, reset them before proceeding with further testing. If the LED successfully resets (the LED switches off), there is no testing required for that LED because it is known to be operational.

Note	*It is likely that alarms related to the communications channels will not reset at this stage.*

5.2.4.1 Testing the Alarm and Out-Of-Service LEDs

The alarm and out of service LEDs can be tested using the **COMMISSIONING TESTS** menu column. Set cell [0F0D: COMMISSIONING TESTS, Test Mode] to **Contacts Blocked**. Check that the out of service LED is on continuously and the alarm LED flashes.

It is not necessary to return cell [0F0D: COMMISSIONING TESTS, Test Mode] to **Disabled** at this stage because the test mode will be required for later tests.

5.2.4.2 Testing the Trip LED

The trip LED can be tested by initiating a manual circuit breaker trip from the relay. However, the trip LED will operate during the setting checks performed later. Therefore, no further testing of the trip LED is required at this stage.

5.2.4.3 Testing the User-Programmable LEDs

To test the user-programmable LEDs set cell [0F10: COMMISSIONING TESTS, Test LEDs] to **Apply Test**. Check that all the programmable LEDs on the relay switch on.

5.2.5 Field Voltage Supply

The relay generates a field voltage of nominally 48 V that can be used to energize the opto-isolated inputs (alternatively the substation battery may be used).

Measure the field voltage across terminals 7 and 9 on the terminal block shown in the following table. Check that the field voltage is in the range 40 V to 60 V when no load is connected and that the polarity is correct.

Repeat for terminals 8 and 10

Supply Rail	Terminals	
	MiCOM P141/P142	MiCOM P143/P145
+ve	F7/F8	J7/J8
–ve	F9/F10	J9/J10

Table 6 - Field voltage terminals

5.2.6 Input Opto-Isolators

This test checks that all the opto-isolated inputs on the relay are functioning correctly.

Model	P141	P142	P143	P145
P14**x**xxxAxxxxxxx	8 inputs	8 inputs	16 inputs	16 inputs
P14**x**xxxBxxxxxxx		12 inputs		12 inputs
P14**x**xxxCxxxxxxx		16 inputs	24 inputs	24 inputs
P14**x**xxxDxxxxxxx		8 inputs	16 inputs	16 inputs
P14**x**xxxExxxxxxx			24 inputs	24 inputs
P14**x**xxxFxxxxxxx			32 inputs	32 inputs
P14**x**xxxGxxxxxxx			16 inputs	16 inputs

Model	P141	P142	P143	P145
P14**x**xxxHxxxxxxx		8 inputs	16 inputs	12 inputs
P14**x**xxxJxxxxxxx			24 inputs	20 inputs
P14**x**xxxKxxxxxxx			16 inputs	12 inputs
P14**x**xxxLxxxxxxx			16 inputs	12 inputs

Note *For the P14x product, P141, P142 and P143 uses Hardware Suffix L, whereas P145 uses Hardware Suffix M*

Table 7 - Opto-isolated inputs

Energize the opto-isolated inputs one at a time; see the external connection diagrams in the *Connection Diagrams* chapter for terminal numbers. Ensure that the correct opto input nominal voltage is set in the **Opto Config**. Menu. Ensure correct polarity and connect the field supply voltage to the appropriate terminals for the input being tested. Each opto input also has selectable filtering. This allows use of a pre-set filter of ½ cycle that renders the input immune to induced noise on the wiring.

Note *The opto-isolated inputs may be energized from an external dc auxiliary supply (such as the station battery) in some installations. Check that this is not the case before connecting the field voltage, otherwise damage to the relay may result. If an external 24/27 V, 30/34 V, 48/54 V, 110/125 V, 220/250 V supply is being used it will be connected to the relay's optically isolated inputs directly. If an external supply is used it must be energized for this test, but only after confirming that it is suitably rated, with less than 12% ac ripple.*

The status of each opto-isolated input can be viewed using either cell [0020: SYSTEM DATA, Opto I/P Status] or [0F01: COMMISSIONING TESTS, Opto I/P Status], a **1** indicating an energized input and a **0** indicating a de-energized input. When each opto-isolated input is energized, one of the characters on the bottom line of the display changes, to indicate the new state of the inputs.

5.2.7 Output Relays

This test checks that all the output relays are functioning correctly.

Model	Outputs
P141 with Model Number P14**x**xxxAxxxxxxx	7
P142 with Model Number P14**x**xxxAxxxxxxx	7
P142 with Model Number P14**x**xxxBxxxxxxx	11
P142 with Model Number P14**x**xxxCxxxxxxx	7
P142 with Model Number P14**x**xxxDxxxxxxx	15
P142 with Model Number P14**x**xxxHxxxxxxx	7 + 4 High-Break
P143 with Model Number P14**x**xxxAxxxxxxx	14
P143 with Model Number P14**x**xxxCxxxxxxx	14
P143 with Model Number P14**x**xxxDxxxxxxx	22
P143 with Model Number P14**x**xxxExxxxxxx	22
P143 with Model Number P14**x**xxxFxxxxxxx	14
P143 with Model Number P14**x**xxxGxxxxxxx	30
P143 with Model Number P14**x**xxxHxxxxxxx	14 + 4 High-Break
P143 with Model Number P14**x**xxxJxxxxxxx	14 + 4 High-Break
P143 with Model Number P14**x**xxxKxxxxxxx	22 + 4 High-Break
P143 with Model Number P14**x**xxxLxxxxxxx	14 + 8 High-Break
P145 with Model Number P14**x**xxxAxxxxxxx	16
P145 with Model Number P14**x**xxxBxxxxxxx	12
P145 with Model Number P14**x**xxxCxxxxxxx	16
P145 with Model Number P14**x**xxxDxxxxxxx	24
P145 with Model Number P14**x**xxxExxxxxxx	24
P145 with Model Number P14**x**xxxFxxxxxxx	16
P145 with Model Number P14**x**xxxGxxxxxxx	32
P145 with Model Number P14**x**xxxHxxxxxxx	12 + 4 High-Break
P145 with Model Number P14**x**xxxJxxxxxxx	12 + 4 High-Break
P145 with Model Number P14**x**xxxKxxxxxxx	20 + 4 High-Break
P145 with Model Number P14**x**xxxLxxxxxxx	12 + 8 High-Break
Note *The High-Break contacts are polarity sensitive. External wiring should, wherever possible, be verified against polarity requirements described in the external connection diagram to ensure correct high break operation when in service.*	

Table 8 - Output relays

Ensure that the cell [0F0D: COMMISSIONING TESTS, Test Mode] is set to **Contacts Blocked**.

The output relays should be energized one at a time. To select output relay 1 for testing, set cell [0F0E: COMMISSIONING TESTS, Test Pattern] to 00000000000000000000000000000001.

Connect a continuity tester across the terminals corresponding to output relay 1 as shown in the relevant external connection diagram in the *Connection Diagrams* chapter.

To operate the output relay, set cell [0F0F: COMMISSIONING TESTS, Contact Test] to **Apply Test**. Operation is confirmed by the continuity tester operating for a normally open contact and ceasing to operate for a normally closed contact. Measure the resistance of the contacts in the closed state.

Reset the output relay by setting cell [0F0F: COMMISSIONING TESTS, Contact Test] to **Remove Test**.

Note	*Ensure that the thermal ratings of anything connected to the output relays during the contact test procedure are not exceeded by the associated output relay being operated for too long. Keep the time between application and removal of contact test to a minimum.*

Repeat the test for the rest of the relays (the numbers depend on the model).

Return the relay to service by setting cell [0F0D: COMMISSIONING TESTS, Test Mode] to **Disabled**.

5.2.8 Rear Communications Port

This test should only be performed where the relay is to be accessed from a remote location and varies depending on the communications standard adopted.

It is not the intention of the test to verify the operation of the complete system from the relay to the remote location, just the relay's rear communications port and any protocol converter necessary.

A variety of communications protocols may be available. For further details, please see whichever of these sections are relevant for the device you are commissioning:

5.2.8.1 Courier Communications

If a K-Bus to EIA(RS)232 KITZ protocol converter is installed, connect a portable PC running the appropriate software (such as MiCOM S1 Studio or PAS&T) to the incoming (remote from relay) side of the protocol converter.

If a KITZ protocol converter is not installed, it may not be possible to connect the PC to the relay installed. In this case a KITZ protocol converter and portable PC running appropriate software should be temporarily connected to the relay's first rear K-Bus port. The terminal numbers for the relay's first rear K-Bus port are shown in the following table. However, as the installed protocol converter is not being used in the test, only the correct operation of the relay's K-Bus port will be confirmed.

Connection		Terminal	
K-Bus	**IEC60870-5-103 or DNP3.0**	**P141/P142**	**P143/P145**
Screen	Screen	F16	J16
1	+ve	F18	J18
2	–ve	F17	J17

Table 9 - EIA(RS)485 terminals

Ensure that the communications baud rate and parity settings in the application software are set the same as those on the protocol converter (usually a KITZ but could be a SCADA RTU). The relay's Courier address in cell [0E02: COMMUNICATIONS, Remote Address] must be set to a value between 1 and 254.

Check that communications can be established with this relay using the portable PC.

If the relay has the optional fiber optic communications port fitted, the port to be used should be selected by setting cell [0E07: COMMUNICATIONS, Physical Link] to **Fiber Optic**. Ensure that the relay address and baud rate settings in the application software are set the same as those in cell [0E04 COMMUNICATIONS, Baud Rate] of the relay. Check, using the Master Station, that communications with the relay can be established.

5.2.8.2 IEC60870-5-103 (VDEW) Communications

If the relay has the optional fiber optic communications port fitted, the port to be used should be selected by setting cell [xxxx: COMMUNICATIONS, Physical Link] to **Fiber Optic** or **EIA(RS)485**.

- xxxx = 0E07 for P14x, P24x, P34x, P341, P44y, P445, P54x, P547, P64x or P841
  xxxx = 0E09 for P44x

IEC60870-5-103/VDEW communication systems are designed to have a local Master Station and this should be used to verify that the relay's rear fiber optic or EIA(RS)485 port, as appropriate, is working.

Ensure that the relay address and baud rate settings in the application software are set the same as those in cells [0E02: COMMUNICATIONS, Remote Address] and [0E04: COMMUNICATIONS, Baud Rate] of the relay.

Check, using the Master Station, that communications with the relay can be established.

5.2.8.3 DNP 3.0 Interface

Connect a portable PC running the appropriate DNP3.0 Master Station Software to the relay's first rear EIA(RS)485 port using an EIA(RS)485 to EIA(RS)232 interface converter. The terminal numbers for the relay's EIA(RS)485 port are shown in the *EIA(RS)485 terminals* table.

Ensure that the relay address, baud rate and parity settings in the application software are set the same as those in cells [0E02: COMMUNICATIONS, Remote address], [0E04: COMMUNICATIONS, Baud Rate] and [0E05: COMMUNICATIONS, Parity] of the relay.

Check that communications with this relay can be established.

If the relay has the optional fiber optic communications port fitted, the port to be used should be selected by setting cell [0E07: COMMUNICATIONS, Physical Link] to **Fiber Optic**. Ensure that the relay address and baud rate settings in the application software are set the same as those in cell [0E04: COMMUNICATIONS, Baud Rate] of the relay. Check that, using the Master Station, communications with the relay can be established.

5.2.8.4 DNP3oE Test Case

Ensure that the relay address and baud rate settings in the application software are set the same as those in cell [0E04: COMMUNICATIONS, Baud Rate] of the relay.

Check that, using the Master Station, communications with the relay can be established.

Also can connect a portable PC running the appropriate DNP3.0 Master Station Software to the relay's ethernet port. Ensure that a valid DNP setting is configured via MiCOM S1 Studio before connectiong.

If user has configured a valid CID and downloaded to relay, make sure the IP address which is configured in the DNP setting is correct, please refer to Chapter 15 Section 7.8 for details.

5.2.8.5 **MODBUS Communications**

Connect a portable PC running the appropriate MODBUS Master Station software to the relay's first rear EIA(RS)485 port using an EIA(RS)485 to EIA(RS)232 interface converter. The terminal numbers for the relay's EIA(RS)485 port are shown in the *EIS(RS)485 terminals* table.

Ensure that the relay address, baud rate and parity settings in the application software are set the same as those in cells [xxxx: COMMUNICATIONS, Remote Address], [yyyy: COMMUNICATIONS, Baud Rate] and [zzzz: COMMUNICATIONS, Parity] of the relay.

- xxxx = 0E03 for P44x, 0E02 for P14x, P24x, P34x or P64x
- yyyy = 0E06 for P44x, 0E04 for P14x, P24x, P34x or P64x
- zzzz = 0E07 for P44x, 0E05 for P14x, P24x, P34x or P64x

Check that communications with this relay can be established.

5.2.9 Second Rear Communications Port

This test should only be performed where the relay is to be accessed from a remote location and varies depending on the communications standard being adopted.

It is not the intention of the test to verify the operation of the complete system from the relay to the remote location, just the relay's rear communications port and any protocol converter necessary.

A variety of communications protocols may be available. For further details, please see whichever of these sections are relevant for the device you are commissioning:

5.2.9.1 **K-Bus Configuration**

If a K-Bus to EIA(RS)232 KITZ protocol converter is installed, connect a portable PC running the appropriate software (MiCOM S1 Studio or PAS&T) to the incoming (remote from relay) side of the protocol converter.

If a KITZ protocol converter is not installed, it may not be possible to connect the PC to the relay installed. In this case a KITZ protocol converter and portable PC running appropriate software should be temporarily connected to the relay's second rear communications port configured for K-Bus. The terminal numbers for the relay's K-Bus port are shown in the following table. However, as the installed protocol converter is not being used in the test, only the correct operation of the relay's K-Bus port is confirmed.

Pin*	Connection
4	EIA(RS)485 - 1 (+ ve)
7	EIA(RS)485 - 2 (- ve)
* All other pins unconnected.	

Table 10 - 2nd rear communications port K-Bus terminals

Ensure that the communications baud rate and parity settings in the application software are set the same as those on the protocol converter (usually a KITZ but could be a SCADA RTU). The relay's Courier address in cell [0E90: COMMUNICATIONS, RP2 Address] must be set to a value between 1 and 254. The second rear communication's port configuration [0E88: COMMUNICATIONS RP2 Port Config.] must be set to K-Bus.

Check that communications can be established with this relay using the portable PC.

5.2.9.2 EIA(RS)485 Configuration

If an EIA(RS)485 to EIA(RS)232 converter (Schneider Electric CK222) is installed, connect a portable PC running the appropriate software (Easergy Studio) to the EIA(RS)232 side of the converter and the second rear communications port of the relay to the EIA(RS)485 side of the converter.

The terminal numbers for the relay's EIA(RS)485 port are shown in the *Second rear communications port EIA(RS)232 terminals* table.

Ensure that the communications baud rate and parity settings in the application software are the same as those in the relay. The relay's Courier address in cell [0E90: COMMUNICATIONS, RP2 Address] must be set to a value between 1 and 254. The second rear communications port's configuration [0E88: COMMUNICATIONS RP2 Port Config.] must be set to EIA(RS)485.

Check that communications can be established with this relay using the portable PC.

5.2.9.3 EIA(RS)232 Configuration

Connect a portable PC running the appropriate software (Easergy Studio) to the rear EIA(RS)232 port of the relay. This port is compliant with EIA(RS)574; the 9-pin version of EIA(RS)232, see www.tiaonline.org.

The second rear communications port connects using the 9-way female D-type connector (SK4). The connection is compliant with EIA(RS)574.

Pin	Connection
1	No Connection
2	RxD
3	TxD
4	DTR#
5	Ground
6	No Connection
7	RTS#
8	CTS#
9	No Connection
# These pins are control lines for use with a modem.	

Table 11 - Second rear communications port EIA(RS)232 terminals

Connections to the second rear port configured for EIA(RS)232 operation can be made using a screened multi-core communication cable up to 15 m long, or a total capacitance of 2500 pF. Terminate the cable at the relay end with a 9-way, metal-shelled, D-type male plug. The terminal numbers for the relay's EIA(RS)232 port are shown in the previous table.

Ensure that the communications baud rate and parity settings in the application software are set the same as those in the relay. The relay's Courier address in cell [0E90: COMMUNICATIONS, RP2 Address] must be set to a value between 1 and 254. The second rear communication's port configuration [0E88: COMMUNICATIONS RP2 Port Config] must be set to EIA(RS)232.

Check that communications can be established with this relay using the portable PC.

5.2.10 Current Inputs

This test verifies that the accuracy of current measurement is within acceptable tolerances.

All relays leave the factory set for operation at a system frequency of 50 Hz. If operation at 60 Hz is required, this must be set in cell [0009: SYSTEM DATA, Frequency].

Caution	***To avoid spurious operation of protection elements during injection testing, ensure that current operated elements are disabled.***

Apply current equal to the line current transformer secondary winding rating to each current transformer input of the corresponding rating in turn, checking its magnitude using a multimeter. Refer to the *Current input terminals* table for the corresponding reading in the relay's **MEASUREMENTS 1** columns, as appropriate, and record the value displayed.

The measured current values displayed on the relay LCD, or on a portable PC connected to the front communication port, are either in primary or secondary Amperes. If cell [0D02: MEASURE'T SETUP, Local Values] is set to **Primary**, the values displayed should be equal to the applied current multiplied by the corresponding current transformer ratio set in the **CT and VT RATIOS** menu column (see the *CT ratio settings* table). If cell [0D02: MEASURE'T SETUP, Local Values] is set to **Secondary**, the value displayed should be equal to the applied current.

Note	*In the case of a P841B (dual CT inputs), the "measured" value is taken from a combination of the two sets of CTs connected. The check should be performed by first injecting only into the CTs associated with CB1 (IA, IB, IC) and checking the measured IA, IB, and IC values, and then by injecting only into the CTs associated with CB2 (IA2, IB2, IC2) and checking the measured IA, IB, and IC values.*

Note	*If a PC connected to the relay's rear communications port is used to display the measured current, the process is similar. However, the setting of cell [0D03: MEASURE'T SETUP, Remote Values] determines whether the displayed values are in primary or secondary Amperes.*

The measurement accuracy of the relay is ±1% (5% for P741/P742/P743/P746). However, an additional allowance must be made for the accuracy of the test equipment being used.

	P14x
Menu cell	**Corresponding CT ratio (in VT and CT RATIO column (0A) of menu)**
[0201: IA Magnitude] [0203: IB Magnitude] [0205: IC Magnitude]	$\frac{\text{[0A07 : Phase CT Primary]}}{\text{[0A08 : Phase CT Secondary]}}$
[0232: IN Measured Magnitude]	$\frac{\text{[0A07 : E/F CT Primary]}}{\text{[0A08 : E/F CT Secondary]}}$
[0232: ISEF Magnitude]	$\frac{\text{[0A07 : SEF CT Primary]}}{\text{[0A08 : SEF CT Secondary]}}$

Table 12 - CT ratio settings

5.2.11 Voltage Inputs

This test verifies that the accuracy of voltage measurement is within the acceptable tolerances.

For the P24x: Three modes of connection are available on the P24x relay: either 3VTs connection, or 2VTs plus residual VT connection or 2VTs plus remanent voltage VT connection (see the Connection Diagrams for detailed information).

The following tests will be realized with the VT Connecting Mode set to 3 VT which is the most used configuration.

Apply rated voltage to each voltage transformer input in turn, checking its magnitude using a multimeter. Refer to the *Voltage Input Terminals* table for the corresponding reading in the relay's **MEASUREMENTS 1** column and record the value displayed.

	Voltage Applied To
Cell in MEASUREMENTS 1 column	**MiCOM P14x**
[021A: VAN Magnitude]	C19 - C22
[021C: VBN Magnitude]	C20 - C22
[021E: VCN Magnitude]	C21 - C22
[022E: C/S Voltage Mag.] [P143]	C23 - C24
[0222: Voltage Mag.]	C23 - C24

Table 13 - Voltage input terminals

The measured voltage values displayed on the relay LCD or a portable PC connected to the front communication port are either in primary or secondary volts. If cell [0D02: MEASURE'T SETUP, Local Values] is set to **Primary**, the values displayed should be equal to the applied voltage multiplied by the corresponding voltage transformer ratio set in the **VT and CT RATIOS** menu column (see the following *VT ratio settings* table). If cell [0D02: MEASURE'T SETUP, Local Values] is set to **Secondary**, the value displayed should be equal to the applied voltage.

Note	*If a PC connected to the relay's rear communications port is used to display the measured voltage, the process is similar. However, the setting of cell [0D03: MEASURE'T SETUP, Remote Values] determines whether the displayed values are in primary or secondary volts.*

The measurement accuracy of the relay is ±1%. However, an additional allowance must be made for the accuracy of the test equipment being used.

Cell in MEASUREMENTS 1 column (02)	Corresponding CT Ratio (in 'CT and VT RATIO' column(0A) of menu)
[021A: VAN Magnitude] [021C: VBN Magnitude] [021E: VCN Magnitude]	[0A01 : Main VT Primary] / [0A02 : Main VT Secondary]
[022E: C/S Voltage Mag.] (Applicable to P143/P145 models only)	[0A03 : C/S VT Primary] / [0A04 : C/S VT Secondary]

Table 14 - VT ratio settings

5.3 IEDs which use the Process Bus Interface

5.3.1 IED Configured with One Merging Unit (MU)

The settings for the Process Bus interface are in the IED menu ***IED Config***. See the Settings chapter.

1. If necessary, isolate or block any outgoing trips from the IED. If physical contacts from the IED are wired in the scheme, in ***COMMISSION TESTS*** menu, set ***Test Mode*** to *Contacts Blocked* if operation of the contacts is not desired. If GOOSE outputs are used, from the main IED menu COMMISIONING TEST column select ***Test Mode***.
2. Connect the IEDs Ethernet port on the Process Bus board to the Sampled Value source. If necessary this can be routed through an Ethernet switch.
3. Make a valid SV configuration (a CID file via **IED Configurator**) and download it to relay and activate the configuration bank.
4. Check that the MU configuration in the CID file matches the actual Sampled Value source (test kit or Merging Unit). Make any changes in the source Sampled Value configuration. This prevents mismatches in Sampled Value when the IED is put into service when testing existing schemes.
5. Set the IED ***Synchro Mode*** to *No SYNC CLK* so the IED accepts Sampled Value frames with or without synchronization.
6. Generate Sampled Value frames with the rated current and voltage as required in the IED’s Sampled Value configuration.
7. In the ***MEASUREMENTS*** menu, check the magnitudes and phase angles are displayed correctly. The display may be in primary or secondary values. Also, the IED’s CT ratio or VT ratio settings affect the display. A typical accuracy of 1% can be expected for magnitudes.
8. Change the SV configuration configured in the test kit or Merging Unit to mismatch the Sampled Value configuration of the relay. Check the data cell ***SV Absence Alm*** displays '*******1' (where * is a don’t care state for this test, normally its value is 0) for the Merging Unit configured in the CID. Check that all ***MEASUREMENTS*** displays for voltage or current are zero.
9. Depending on the scheme, if Merging Unit is configured to publish SV in IEC61869 format, set ***SMV Version*** to *IEC61869*, if Merging Unit is configured to publish SV in IEC61850-9-2LE compatible format, set ***SMV Version*** to *IEC61850-9-2LE*.

5.3.2 IED Configured with Two or More Merging Units (MUs)

The settings for the IEC61850-9-2LE or IEC61869 interface are in the IED menu ***PB CONFIG***.

1. If necessary, isolate or block any outgoing trips from the IED. If physical contacts from the IED are wired in the scheme, in ***COMMISSION TESTS*** menu, set ***Test Mode*** to *Contacts Blocked* if operation of the contacts is not desired. If GOOSE outputs are used, from the main IED menu COMMISIONING TEST column select ***Test Mode***.
2. Connect the IEDs Ethernet port on Process Bus board to an Ethernet switch, which is connected to the Sampled Value sources. If necessary this can be routed through an Ethernet switch.
3. Make a valid SV configuration (a CID file via **IED Configurator**) and download it to relay and activate the configuration bank.
4. Check that the MU configuration in the CID file matches the actual Sampled Value source (test kit or Merging Unit). Make any changes in the source Sampled Value configuration. This prevents mismatches in Sampled Value when the IED is put into service when testing existing schemes.
5. Set the IED Synchro Alarm to 'Local Clock' so the IED accepts Sampled Value frames with local or global synchronization.
6. Check that the Sampled Value source (test kit or Merging Unit) is GPS synchronized.
7. Check the receipt of Sampled Value frames one by one for each Logical Node configured in the IED.

Repeat the following steps for each Merging Unit, configuring them one by one in the Sampled Value source(s).

1. Generate Sampled Value frames with the rated current and voltage as required in the IED’s Logical Node configuration. You can check the receipt of Sampled Value frames for the configured Logical Node.
2. In the ***MEASUREMENTS*** menu, check the magnitudes and phase angles are displayed correctly. The display may be in primary or secondary values. Also, the IED’s CT ratio or VT ratio settings affect the display. A typical accuracy of 1% can be expected for magnitudes.
3. Change the SV configuration configured in the test kit or Merging Unit to mismatch the Sampled Value configuration of the relay. Check the data cell ***SV Absence Alm*** displays '00000001' (where * is a don’t care state for this test, normally its value is 0) for the first Merging Unit configured in the CID, or '******1*' (where * is a don’t care state for this test, normally its value is 0) for the second Merging Unit configured in the CID. Check that all ***MEASUREMENTS*** displays for voltage or current are zero.

6 SETTING CHECKS

The setting checks ensure that all of the application-specific relay settings (both the relay's function and Programmable Scheme Logic (PSL) settings) for the particular installation have been correctly applied to the relay.

Caution	**The trip circuit should remain isolated during these checks to prevent accidental operation of the associated circuit breaker.**

Important	***If the application-specific settings are not available, ignore sections 6.1 and 6.2.***

Note	*The trip circuit should remain isolated during these checks to prevent accidental operation of the associated circuit breaker.*

6.1 Apply Application-Specific Settings

There are different methods of applying the settings:

- Transferring settings from a pre-prepared setting file to the relay using a laptop PC running the appropriate software (such as Easergy Studio). Use the front EIA(RS)232 port (under the bottom access cover), or the first rear communications port (Courier protocol with a protocol converter connected), or the second rear communications port. This is the preferred method for transferring function settings as it is much faster and there is less margin for error. If PSL other than the default settings with which the relay is supplied is used, this is the only way of changing the settings.

  If a setting file has been created for the particular application and provided on a memory device, the commissioning time is further reduced, especially if application-specific PSL is applied to the relay.
- Enter the settings manually using the relay's operator interface. This method is not suitable for changing the PSL.

Caution	***When the installation needs application-specific Programmable Scheme Logic (PSL), it is essential that the appropriate .psl file is downloaded (sent) to the relay, for each setting group that will be used. If the user fails to download the required .psl file to any setting group that may be brought into service, the factory default PSL will still be resident. This may have severe operational and safety consequences.***

6.2 Demonstrate Correct Relay Operation

The *Current Inputs* and *Voltage Inputs* checks have already demonstrated that the relay is within calibration, thus the purpose of these tests is as follows:

- To determine that the primary protection functions of the relay, overcurrent, earth-fault etc. can trip according to the correct application settings.
- To verify correct assignment of the trip contacts, by monitoring the response to a selection of fault injections.

6.2.1 Overcurrent Protection Testing

This test, performed on stage 1 of the overcurrent protection function in setting group 1, demonstrates that the relay is operating correctly at the application-specific settings.

It is not considered necessary to check the boundaries of operation where cell [3502: GROUP 1 OVERCURRENT, I>1 Direction] is set to '**Directional Fwd**' or '**Directional Rev.**' as tests detailed already confirm the correct functionality between current and voltage inputs, processor and outputs and earlier checks confirmed the measurement accuracy is within the stated tolerance.

6.2.1.1 Connection and Preliminaries

Determine which output relay has been selected to operate when an I>1 trip occurs by viewing the relay's Programmable Scheme Logic (PSL).

The PSL can only be changed using the appropriate software. If this software has not been available then the default output relay allocations will still be applicable.

If the trip outputs are phase-segregated (i.e. a different output relay allocated for each phase), the relay assigned for tripping on '**A**' phase faults should be used.

The associated terminal numbers can be found in the external connection diagram chapter.

Connect the output relay so that its operation will trip the test set and stop the timer.

Connect the current output of the test set to the '**A**' phase current transformer input of the relay (terminals C3 and C2 where 1A current transformers are being used and terminals C1 and C2 for 5A current transformers).

If [3502: GROUP 1 OVERCURRENT, I>1 Direction] is set to '**Directional Fwd**', the current should flow out of terminal C2 but into C2 if set to '**Directional Rev**'.

If cell [351D: GROUP 1 OVERCURRENT, VCO Status] is set to '**Enabled**' (overcurrent function configured for voltage controlled overcurrent operation) or [3502: GROUP 1 OVERCURRENT, I>1 Direction] has been set to '**Directional Fwd**' or '**Directional Rev**' then rated voltage should be applied to terminals C20 and C21.

Ensure that the timer will start when the current is applied to the relay.

Note	*If the timer does not start when the current is applied and stage 1 has been set for directional operation, the connections may be incorrect for the direction of operation set. Try again with the current connections reversed.*

6.2.1.2 Perform the Test

Ensure that the timer is reset.

Apply a current of twice the setting in cell [3503: GROUP 1 OVERCURRENT, I>1 Current Set] to the relay and note the time displayed when the timer stops.

Check that the red trip LED has illuminated. The display will show Alarms/Faults present and the Alarm and Trip LEDs will illuminate. To view the alarm message press the read key (read), repeat presses of this key should be used to verify that phase A was the "**Start Element**". Keep pressing the (read) key until the yellow alarm LED changes from flashing to being steadily on. At the prompt '**Press clear to reset alarms**', press the '**C**' key. This will clear the fault record from the display.

6.2.1.3 Check the Operating Time

Check the operating time recorded by the timer is in the range in the *Characteristic operating times for I>1* table.

Note	*Except for the definite time characteristic, the operating times in the* Characteristic operating times for I>1 *table are for a time multiplier or time dial setting of 1. Therefore, to obtain the operating time at other time multiplier or time dial settings, the time given in the* Characteristic operating times for I>1 *table must be multiplied by the setting of cell [3505: GROUP 1 OVERCURRENT, I>1 TMS] for IEC and UK characteristics or cell [3506: GROUP 1 OVERCURRENT, Time Dial] for IEEE and US characteristics.* *In addition, for definite time and inverse characteristics there is an additional delay of up to 0.02 second and 0.08 second respectively that may need to be added to the relay's acceptable range of operating times.* *For all characteristics, allowance must be made for the accuracy of the test equipment being used.*

Characteristic	Operating Time at Twice Current Setting and Time Multiplier/Time Dial Setting of 1.0	
	Nominal (Seconds)	**Range (Seconds)**
DT	[3529: I>1 Time Delay] Setting	Setting ±5%
IEC S Inverse	10.03	9.53 - 0.53
IEC V Inverse	13.50	12.83 - 14.18
IEC E Inverse	26.67	24.67 - 28.67
UK LT Inverse	120.00	114.00 - 126.00
UK Rectifier	966.26	917.94-1014.57
RI	4.52	4.30-4.75
IEEE M Inverse	3.8	3.61 - 3.99
IEEE V Inverse	7.03	6.68 - 7.38
IEEE E Inverse	9.52	9.04 - 10
US Inverse	2.16	2.05 - 2.27
US ST Inverse	12.12	11.51 - 12.73

Table 15 - Characteristic operating times for I>1

Reconfigure to test a B phase fault. Repeat the test in the previous section, this time ensuring that the breaker trip contacts relative to B phase operation close correctly. Record the phase B trip time. Repeat for C phase fault. Switch OFF the ac supply and reset the alarms.

6.3 Signaling Channel Check

6.3.1 EIA(RS)232 InterMiCOM Communications

6.3.1.1 InterMiCOM Loopback Testing & Diagnostics

The “Loopback” test facilities, located within the [15 INTERMICOM COMMS] column of the relay menu, provide a user with the ability to check the software and hardware of the InterMiCOM signaling. If ‘INTERMICOM COMMS’ column is not visible, check that [0490 InterMiCOM] is enabled in the [09 CONFIGURATION] column.

Note that by selecting the [1550 Loopback Mode] to “Internal”, only the internal software of the relay is checked whereas “External” will check both the software and hardware used by InterMiCOM. When relay is switched into either ‘Loopback Mode’ the relay will automatically use generic addresses and will inhibit the InterMiCOM messages to the PSL by setting all eight InterMiCOM message states to zero.

Set ‘External’ and connect the transmit and receive pins together (pins 2 and 3) and ensure the DCD signal is held high (connect pin 1 and pin 4 together) as per the following diagram:

The loopback mode will be indicated on the relay frontplate by the amber Alarm LED being illuminated and a LCD alarm message, “**IM Loopback**”.

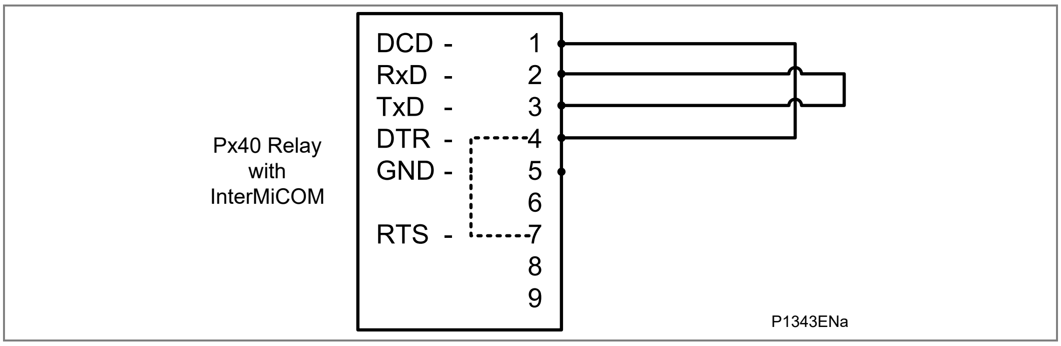


Figure 3 - Connections for external loopback mode

Providing all connections are correct and the software is working correctly, observe that the [1552 Loopback Status] cell that is located within the INTERMICOM COMMS displays “OK”. Set [1540 Ch Diagnostics] within INTERMICOM COMMS to “Visible”.

To test the InterMiCOM enter any test pattern in the [1551 Test Pattern] cell by scrolling and changing selected bits between “1” and “0”. The entered pattern will be transmitted through the software and/or hardware. Check that the [1502 IM Output Status] cell matches with the applied ‘Test Pattern’. Also check that all 8 bits in the [1501 IM Input Status] cell are zero.

Check that the Channel Diagnostics status is displaying:

[1541 Data CD Status]	OK
[1542 FrameSync Status]	OK
[1543 Message Status]	OK
[1544 Channel Status]	OK
[1545 IM H/W Status	OK

To simulate a hardware error, disconnect pin 1. The [1541 Data CD Status] will indicate “FAIL”. Restore pin 1 connection. Observe that status reverts to “OK”. To simulate a channel failure, disconnect the link between pins 2 and 3. The [1542 FrameSync Status], [1543 Message Status] and [1544 Channel Status] will all display “FAIL”.

Note that [1545 IM H/W Status] cell will remain ‘OK’. If displaying “Absent”, it means that the rear communications card that includes EIA(RS)232 InterMiCOM is either not fitted or has failed to initialize.

Alternatively set [0F13 Test Loopback] cell to ‘Internal’ and repeat the ‘Test Pattern’ test as described above. In this mode it is not necessary to make wiring changes.

6.3.1.2 Loopback Removal and Establishing Service Condition

Once the above loopback tests are completed, switch the InterMiCOM channel back in to service by setting the [1550 Loopback Mode] to “Disabled” and restoring the Tx and Rx connections.

The following checks can be made if the remote end is actively communicating, if this is not the case then a comprehensive test cannot be performed until the two ended system is established.

Observe that the amber Alarm LED and a LCD alarm message, “IM Loopback” are not present. Check that the [1502 IM Output Status] cell pattern at the local relay matches with the [1501 IM Input Status] at the remote end and vice versa.

Further checks will be necessary to ensure that the communications between the two relays in the scheme are reliable. To facilitate this, set the [1520 Ch Statistics] cell “Visible” and view a list of channel statistics and diagnostics available in the ‘INTERMiCOM COMMS’ column. The Rx count for Direct, Permissive and Blocking signals (subject to setting) will rise rapidly in proportion to Baud rate setting, whilst the Rx count for “NewData” and “Errored” and the percentage of “Lost Messages” must remain close to zero. Also, all status indications (see above) must display “OK”. That would mean that the comms are of a good quality and that the EIA(RS)232 InterMiCOM has been successfully put back in service. Record all statistics in the Commissioning Test Record provided below.

6.4 Check Trip and Auto-Reclose Cycle

If the autoreclose function is being used, the circuit breaker trip and autoreclose cycle can be tested automatically at the application-specific settings.

To test the first three-phase autoreclose cycle, set cell [xxxx: COMMISSIONING TESTS, Autoreclose Test] to “**3 Pole Test**”. The relay will perform a trip/reclose cycle. Repeat this operation to test the subsequent autoreclose cycles.

Note	*xxxx = 0F11 for P14x, P44y, P547, xxxx = 0F13 for P44x.*

Check that all output relays used for circuit breaker tripping and closing, blocking other devices, etc. operate at the correct times during the trip/close cycle.

6.5 Disable All Commissioning Testing Options

⚠ Ensure that all Test Mode, and Static Test options have been **disabled**. Clear, then re-read any alarms present to be certain that no alarms relating to these test options remain.

6.6 Check Application Settings

Carefully check applied settings against the required application-specific settings to ensure they have been entered correctly. However, this is not considered essential if a customer-prepared setting file on a memory device has been transferred to the relay using a portable PC.

There are two methods of checking the settings:

- Extract the settings from the relay using a portable PC running the appropriate software (Easergy Studio) using the front EIA(RS)232 port, under the bottom access cover, or the first rear communications port (Courier protocol with a KITZ protocol converter connected), or the second rear communications port. Compare the settings transferred from the relay with the original written application-specific setting record (for cases where the customer has only provided a printed copy of the required settings but a portable PC is available).
- Step through the settings using the relay's operator interface and compare them with the original application-specific setting record.

Unless previously agreed to the contrary, the application-specific PSL is not checked as part of the commissioning tests.

Due to the versatility and possible complexity of the PSL, it is beyond the scope of these commissioning instructions to detail suitable test procedures. Therefore, when PSL tests must be performed, written tests that satisfactorily demonstrate the correct operation of the application-specific scheme logic should be devised by the engineer who created it. These tests should be provided to the Commissioning Engineer with the memory device containing the PSL setting file.

There are now a series of checks which may need to be made if certain features are being used. Refer to the following sections:

- 7 - On-Load Checks

7 ON-LOAD CHECKS

The objectives of the on-load checks are to:

- Confirm the external wiring to the current and voltage inputs is correct.
- Measure the magnitude of capacitive current
- Ensure the on-load differential current is well below the relay setting
- Check the polarity of the line current transformers at each end is consistent.
- Directionality check for directional elements.

Caution	**Remove all test leads and temporary shorting leads, and replace any external wiring that was removed to allow testing.**

Caution	**If any of the external wiring was disconnected from the relay to run any tests, make sure that all connections are restored according to the external connection or scheme diagram.**

The following on-load measuring checks ensure the external wiring to the current and voltage inputs is correct but can only be carried out if there are no restrictions preventing the energisation of the plant being protected.

7.1 Confirm Current and Voltage Transformer Wiring

7.1.1 Voltage Connections

Caution	**Using a multimeter, measure the voltage transformer secondary voltages to ensure they are correctly rated. Check that the system phase rotation is correct using a phase rotation meter.**

Compare the values of the secondary phase voltages with the relay's measured values, which can be found in the **MEASUREMENTS 1** menu column.

If cell [0D02: MEASURE'T SETUP, Local Values] is set to **Secondary**, the values displayed on the relay LCD or a portable PC connected to the front EIA(RS)232 communication port should be equal to the applied secondary voltage. The values should be within 1% of the applied secondary voltages/currents (5% for P74x). However, an additional allowance must be made for the accuracy of the test equipment being used.

If cell [0D02: MEASURE'T SETUP, Local Values] is set to **Primary**, the values displayed should be equal to the applied secondary voltage multiplied the corresponding voltage transformer ratio set in the **CT & VT RATIOS** menu column (see the following table). Again, the values should be within 1% of the expected value (5% for P74x), plus an additional allowance for the accuracy of the test equipment being used.

VAB VBC VCA VAN VBN VCN	[0214: VAB Magnitude] [0216: VBC Magnitude] [0218: VCA Magnitude] [021A: VAN Magnitude] [021C: VBN Magnitude] [021E: VCN Magnitude]	$\frac{\text{[0A01 : Main VT Primary]}}{\text{[0A02 : Main VT Secondary]}}$
VCHECKSYNC. (Applicable to P143/P145 only)	[022E: C/S Voltage Mag.]	$\frac{\text{[0A03 : C/S VT Primary]}}{\text{[0A04 : C/S VT Secondary]}}$

Table 16 - Measured voltages and VT ratio settings

7.1.2 Current Connections

Caution	**Measure the current transformer secondary values for each input using a multimeter connected in series with corresponding relay current input.**

Check that the current transformer polarities are correct by measuring the phase angle between the current and voltage, either against a phase meter already installed on site and known to be correct or by determining the direction of power flow by contacting the system control center.

Caution	**Ensure the current flowing in the neutral circuit of the current transformers is negligible.**

Compare the values of the secondary phase currents (and any phase angle) with the relay's measured values, which can be found in the **MEASUREMENTS 1** menu column.

Note	*Under normal load conditions the earth fault function measures little or no current. It is therefore necessary to simulate a phase-to-neutral fault. This can be achieved by temporarily disconnecting one or two of the line current transformer connections to the relay and shorting the terminals of these current transformer secondary windings.*

If cell [0D02: MEASURE'T SETUP, Local Values] is set to **Secondary**, the current displayed on the relay LCD or a portable PC connected to the front EIA(RS)232 communication port should be equal to the applied secondary current. The values should be within 1% (5% for the P741/P742/P743/P746) of the applied secondary currents. However, an additional allowance must be made for the accuracy of the test equipment being used.

If cell [0D02: MEASURE'T SETUP, Local Values] is set to **Primary**, the current displayed should be equal to the applied secondary current multiplied by the corresponding current transformer ratio set in the **CT & VT RATIOS** menu column (see the *Measured Voltages and VT Ratio Settings* table). Again the values should be within 10% (1% for the P34x, 5% for the P741/P742/P743/P746) of the expected value, plus an additional allowance for the accuracy of the test equipment being used.

Note	*If the relay is applied with a single dedicated current transformer for the earth fault function, it may not be possible to check the relay's measured values as the neutral current will be almost zero.*

7.2 On Load Directional Test

This test is important to ensure that directionalized overcurrent and fault locator functions have the correct forward/reverse response to fault and load conditions.

Firstly the actual direction of power flow on the system must be ascertained, using adjacent instrumentation or protection already in-service, or a knowledge of the prevailing network operation conditions.

- For load current flowing in the Forward direction - i.e. power export to the remote line end, cell [0301: MEASUREMENTS 2, A Phase Watts] should show **positive** power signing
- For load current flowing in the Reverse direction - i.e. power import from the remote line end, cell [0301: MEASUREMENTS 2, A Phase Watts] should show **negative** power signing

Note	*The check above applies only for Measurement Modes 0 (default), and 2. This should be checked in [0D05: MEASURE'T. SETUP, Measurement Mode = 0 or 2]. If measurement modes 1 or 3 are used, the expected power flow signing would be opposite to that shown in the bullets above.*

In the event of any uncertainty, check the phase angle of the phase currents with respect to their phase voltage.

8 FINAL CHECKS

The tests are now complete.

Caution	***Remove all test or temporary shorting leads. If it has been necessary to disconnect any of the external wiring from the relay to perform the wiring verification tests, make sure all connections are replaced according to the relevant external connection or scheme diagram.***

Ensure that the relay is restored to service by checking that cell [0Fxx: COMMISSIONING TESTS, Test Mode] and [0F12: COMMISSION TESTS, Static Test] are set to '**Disabled**' (0F0D for P14x/P24x/P34x/P341/P44y/P54x/P841, otherwise 0F0F).

For P14x, P34x, P341, P44x, P44y, P445, P54x, P547 OR P841, if the relay is in a new installation or the circuit breaker has just been maintained, the circuit breaker maintenance and current counters should be zero. These counters can be reset using cell [xxxx: CB CONDITION, Reset All Values]. If the required access level is not active, the relay will prompt for a password to be entered so that the setting change can be made.
(xxxx = 0609 for P14x/P841A, P44y or P54x, xxxx = 0606 for P24x/P34x/P341, xxxx = 0608 for P44x, 0619 for P841B).

If the menu language was changed to allow accurate testing, it must now be restored to the customer's preferred language.

If a MiCOM P991 or Easergy test block is installed, remove the MiCOM P992 or Easergy test plug and replace the test block cover so that the protection is put into service.

Ensure that all event records, fault records, disturbance records, alarms and LEDs have been reset before leaving the relay.

If applicable, replace the secondary front cover on the relay.

TEST AND SETTING RECORDS

CHAPTER 12

Date:	07/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142 & P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

CONTENTS

Notes:

1 COMMISSIONING TEST RECORD

1.1 About this Chapter

The Commissioning chapter provides instructions on how to commission the relay – including how to calibrate it and how to establish that it is functioning as intended.

This chapter provides you with a series of templates. You can use this to record the tests which have been made and the settings which have been used. You should use this chapter in conjunction with the Commissioning chapter and any work instructions you have as to what functionality and settings the relay should use.

1.2 Date Record

Date:		Engineer:	
Station:		Circuit:	
		System Frequency:	……… Hz
VT Ratio:	……… / ……… V	CT Ratio (tap in use):	……… /A

1.3 Front Plate Information

Feeder protection relay	MiCOM P…………
Model number	
Serial number	
Rated current In	1 A or 5 A
Rated voltage Vn	
Auxiliary voltage Vx	

1.4 Test Equipment Used

This section should be completed to allow future identification of protective devices that have been commissioned using equipment that is later found to be defective or incompatible but may not be detected during the commissioning procedure.

Overcurrent test set	Model: Serial No:	
Injection test set	Model: Serial No:	
Phase angle meter	Model: Serial No:	
Phase rotation meter	Model: Serial No:	
Optical power meter	Model: Serial No:	
Insulation tester	Model: Serial No:	
Setting software:	Type: Version:	

1.5 Checklist

	Have all relevant safety instructions been followed?	Yes ☐ No ☐
5.	**PRODUCT CHECKS**	
5.1	**With the relay de-energized**	
5.1.1	Visual inspection	
	Relay damaged?	Yes ☐ No ☐
	Rating information correct for installation?	Yes ☐ No ☐
	Case earth installed?	Yes ☐ No ☐
5.1.2	Current transformer shorting contacts close?	Yes ☐ No ☐ Not checked ☐
5.1.3	Insulation resistance >100 MΩ at 500 V dc	Yes ☐ No ☐ Not tested ☐
5.1.4	External wiring	
	Wiring checked against diagram?	Yes ☐ No ☐
	Test block connections checked?	Yes ☐ No ☐ N/A ☐
5.1.5	Watchdog contacts (auxiliary supply off)	
	Terminals 11 and 12 Contact closed?	Yes ☐ No ☐
	Contact resistance	Ω Not measured ☐
	Terminals 13 and 14 Contact open?	Yes ☐ No ☐
5.1.6	Measured auxiliary supply	V ac/dc
5.2	**With the relay energized**	
5.2.1	Watchdog contacts (auxiliary supply on)	
	Terminals 11 and 12 Contact open?	Yes ☐ No ☐
	Terminals 13 and 14 Contact closed?	Yes ☐ No ☐
	Contact resistance	Ω Not measured ☐
5.2.2	LCD front panel display	
	LCD contrast setting used	
5.2.3	Date and time	
	Clock set to local time?	Yes ☐ No ☐
	Time maintained when auxiliary supply removed?	Yes ☐ No ☐
5.2.4	Light emitting diodes	
	Relay healthy (green) LED working?	Yes ☐ No ☐
	Alarm (yellow) LED working?	Yes ☐ No ☐
	Out of service (yellow) LED working?	Yes ☐ No ☐
	Trip (red) LED working?	Yes ☐ No ☐
	All programmable LEDs working? (may be 8 or 18 depending on the model)	Yes ☐ No ☐
5.2.5	Field supply voltage	
	Value measured between terminals 8 and 9	V dc

4.2.5 Input opto-isolators (numbers vary depending on the product)

	Opto input 1	working?	Yes ☐ No ☐
	Opto input 2	working?	Yes ☐ No ☐
	Opto input 3	working?	Yes ☐ No ☐
	Opto input 4	working?	Yes ☐ No ☐
	Opto input 5	working?	Yes ☐ No ☐
	Opto input 6	working?	Yes ☐ No ☐
	Opto input 7	working?	Yes ☐ No ☐
	Opto input 8	working?	Yes ☐ No ☐ N/A ☐
For P742	Opto input 9	working?	Yes ☐ No ☐ N/A ☐
	Opto input 10	working?	Yes ☐ No ☐ N/A ☐
	Opto input 11	working?	Yes ☐ No ☐ N/A ☐
	Opto input 12	working?	Yes ☐ No ☐ N/A ☐
	Opto input 13	working?	Yes ☐ No ☐ N/A ☐
	Opto input 14	working?	Yes ☐ No ☐ N/A ☐
	Opto input 15	working?	Yes ☐ No ☐ N/A ☐
	Opto input 16	working?	Yes ☐ No ☐ N/A ☐
For P743	Opto input 17	working?	Yes ☐ No ☐ N/A ☐
	Opto input 18	working?	Yes ☐ No ☐ N/A ☐
	Opto input 19	working?	Yes ☐ No ☐ N/A ☐
	Opto input 20	working?	Yes ☐ No ☐ N/A ☐
	Opto input 21	working?	Yes ☐ No ☐ N/A ☐
	Opto input 22	working?	Yes ☐ No ☐ N/A ☐
	Opto input 23	working?	Yes ☐ No ☐ N/A ☐
	Opto input 24	working?	Yes ☐ No ☐ N/A ☐

5.2.7 Output relays

Relay 1	working?		Yes ☐ No ☐
	Contact resistance		Ω ☐ Not measured ☐
Relay 2	working?		Yes ☐ No ☐
	Contact resistance		Ω ☐ Not measured ☐
Relay 3	working?		Yes ☐ No ☐
	Contact resistance		Ω ☐ Not measured ☐
Relay 4	working?		Yes ☐ No ☐
	Contact resistance	(N/C)	Ω ☐ Not measured ☐
		(N/O)	Ω ☐ Not measured ☐
Relay 5	working?		Yes ☐ No ☐
	Contact resistance	(N/C)	Ω ☐ Not measured ☐
		(N/O)	Ω ☐ Not measured ☐
Relay 6	working?		Yes ☐ No ☐
	Contact resistance	(N/C)	Ω ☐ Not measured ☐
		(N/O)	Ω ☐ Not measured ☐
Relay 7	working?		Yes ☐ No ☐
	Contact resistance	(N/C)	Ω ☐ Not measured ☐
		(N/O)	Ω ☐ Not measured ☐
Relay 8	working?		Yes ☐ No ☐ N/A ☐
	Contact resistance	(N/C)	Ω ☐ Not measured ☐
		(N/O)	Ω ☐ Not measured ☐

Relay 9	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance		Ω ☐	Not measured ☐	
Relay 10	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance		Ω ☐	Not measured ☐	
Relay 11	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance	(N/C)	Ω ☐	Not measured ☐	
		(N/O)	Ω ☐	Not measured ☐	
Relay 12	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance	(N/C)	Ω ☐	Not measured ☐	
		(N/O)	Ω ☐	Not measured ☐	
Relay 13	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance	(N/C)	Ω ☐	Not measured ☐	
		(N/O)	Ω ☐	Not measured ☐	
Relay 14	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance	(N/C)	Ω ☐	Not measured ☐	
		(N/O)	Ω ☐	Not measured ☐	
Relay 15	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance	(N/C)	Ω ☐	Not measured ☐	
		(N/O)	Ω ☐	Not measured ☐	
Relay 16	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance	(N/C)	Ω ☐	Not measured ☐	
		(N/O)	Ω ☐	Not measured ☐	

Relay 17	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance		Ω ☐	Not measured ☐	
Relay 18	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance		Ω ☐	Not measured ☐	
Relay 19	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance		Ω ☐	Not measured ☐	
Relay 20	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance		Ω ☐	Not measured ☐	
Relay 21	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance		Ω ☐	Not measured ☐	
Relay 22	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance		Ω ☐	Not measured ☐	
Relay 23	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance	(N/C)	Ω ☐	Not measured ☐	
		(N/O)	Ω ☐	Not measured ☐	
Relay 24	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance	(N/C)	Ω ☐	Not measured ☐	
		(N/O)	Ω ☐	Not measured ☐	

Relay 25	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance		Ω ☐	Not measured ☐	
Relay 26	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance		Ω ☐	Not measured ☐	
Relay 27	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance		Ω ☐	Not measured ☐	
Relay 28	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance		Ω ☐	Not measured ☐	
Relay 29	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance		Ω ☐	Not measured ☐	
Relay 30	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance		Ω ☐	Not measured ☐	
Relay 31	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance	(N/C)	Ω ☐	Not measured ☐	
		(N/O)	Ω ☐	Not measured ☐	
Relay 32	working?		Yes ☐	No ☐	N/A ☐
	Contact resistance	(N/C)	Ω ☐	Not measured ☐	
		(N/O)	Ω ☐	Not measured ☐	

5.2.10 First rear communications port

Communication standard	Courier ☐		IEC 60870-5-103 ☐		DNP3.0 ☐	
	K-Bus ☐		EIS485 ☐		EIA232 ☐	
Communications established?	Yes ☐		No ☐			
Protocol converter tested?	Yes ☐		No ☐		N/A ☐	

5.2.11 Second rear communications port

Communication port configuration	K-Bus	☐	EIA(RS)485	☐
	EIA(RS)232	☐	IEC61850	☐
	DNPoE	☐	IEC61850+DNPoE	☐
	Ethernet	☐		
Communications established?	Yes	☐	No	☐
Protocol converter tested?	Yes	☐	No	☐

5.2.10 Current inputs

Displayed current	Primary	☐	Secondary	☐
Phase CT ratio		N/A		☐

Input CT	Applied Value	Displayed Value
Earth fault CT ratio		………
SEF CT ratio		………
IA	A	A
IB	A	A
IC	A	A
IN	A N/A ☐	A N/A ☐
IN Sensitive/ISEF	A N/A ☐	A N/A ☐

5.2.11 Voltage inputs

Displayed voltage	Primary	☐	Secondary	☐
Main VT ratio	N/A	☐		
C/S VT ratio	N/A	☐		

Input VT	Applied Value	Displayed value
Van	V	V
Vbn	V	V
Vcn	V	V
C/S Voltage	V N/A ☐	V
VN Measured	V N/A ☐	V

6. SETTING CHECKS

Apply Application-Specific Settings

6.1 Application-specific function settings verified?	Yes ☐	No ☐	N/A ☐
6.2 Application-specific PSL tested?	Yes ☐	No ☐	N/A ☐

6.2 Demonstrate correct relay operation

Protection function timing tested?	Yes or No
Overcurrent type (set in cell [I>1 Direction])	Directional or Non-Directional
Applied voltage	V N/A ☐
Applied current	A
Expected operating time	s
Measured operating time	s

6.3 Signaling Channel Check OK?	Yes ☐	No ☐	
6.4 Trip and auto-reclose cycle checked	Yes ☐	No ☐	N/A ☐
6.5 All commissioning test options disabled?	Yes ☐	No ☐	
6.6 Application-specific function settings verified?	Yes ☐	No ☐	N/A ☐
Application-specific PSL tested?	Yes ☐	No ☐	N/A ☐

7. ON-LOAD CHECKS

Test wiring removed?	Yes ☐	No ☐	N/A ☐
Disturbed customer wiring re-checked?	Yes ☐	No ☐	N/A ☐
On-load test performed?	Yes ☐	No ☐	

7.1.1 Voltage inputs and phase rotation OK?	Yes ☐	No ☐	
7.1.2 Current connections inputs and polarities OK?	Yes ☐	No ☐	
7.2 On-load directional test performed?	Yes ☐	No ☐	
(If “No”, give reason why) …			
IED is correctly directionalized?	Yes ☐	No ☐	N/A ☐

8. FINAL CHECKS

All Test equipment, leads, shorts, test blocks and other test wiring removed?	Yes	☐	No	☐	N/A	☐
Disturbed customer wiring re-checked?	Yes	☐	No	☐	N/A	☐
All commissioning tests disabled?	Yes	☐	No	☐		
Test mode disabled?	Yes	☐	No	☐		
Circuit breaker operations counter reset?	Yes	☐	No	☐	N/A	☐
Current counters reset?	Yes	☐	No	☐	N/A	☐
Event records reset?	Yes	☐	No	☐		
Fault records reset?	Yes	☐	No	☐		
Disturbance records reset?	Yes	☐	No	☐		
Alarms reset?	Yes	☐	No	☐		
LEDs reset?	Yes	☐	No	☐		
Secondary front cover replaced?	Yes	☐	No	☐	N/A	☐

COMMENTS #
(# Optional, for site observations or utility-specific notes).

Commissioning Engineer
Date:

Customer Witness
Date:

2 CREATING A SETTING RECORD

You often need to create a record of what settings have been applied to a device. In the past, you could have used paper printouts of all the available settings, and mark up the ones you had used. Keeping such a paper-based Settings Records can be time-consuming and prone to error (e.g. due to being settings written down incorrectly).

The Easergy Studio (MiCOM S1 Studio) software lets you read/write MiCOM devices.

- **Extract** lets you download all the settings from a MiCOM Px40 device. A summary is given in Extract Settings from a MiCOM Px40 Device below.
- **Send** lets you send the settings you currently have open in the Studio software. A summary is given in Send Settings to a MiCOM Px40 Device below.

The Easergy Studio (MiCOM S1 Studio) product is updated periodically. These updates provide support for new features (such as allowing you to manage new MiCOM products, as well as using new software releases and hardware suffixes). The updates may also include fixes. **Accordingly, we strongly advise customers to use the latest Schneider Electric version of Easergy Studio (MiCOM S1 Studio).**
If you need more information regarding bug fixes, please contact your **Schneider Electric** local support.

In most cases, it will be quicker and less error prone to extract settings electronically and store them in a settings file on a memory stick. In this way, there will be a digital record which is certain to be accurate. It is also possible to archive these settings files in a repository; so they can be used again or adapted for another use.

Full details of how to do these tasks is provided in the MiCOM S1 Studio help.

A quick summary of the main steps is given below.

In each case you need to make sure that:

- Your computer includes the MiCOM S1 Studio software.
- Your computer and the MiCOM device are powered on.
- You have used a suitable cable to connect your computer to the MiCOM device (Front Port, Rear Port, Ethernet port or Modem as available).

2.1 Extract Settings from a MiCOM Px40 Device

Full details of how to do this is provided in the MiCOM S1 Studio help.

As a quick guide, you need to do the following:

1. In MiCOM S1 Studio, click the Quick Connect… button.
2. Select the relevant Device Type in the Quick Connect dialog box.
3. Click the relevant port in the Port Selection dialog box.
4. Enter the relevant connection parameters in the Connection Parameters dialog box and click the Finish button
5. MiCOM S1 Studio will try to communicate with the Px40 device. It will display a connected message if the connection attempt is successful.
6. The device will appear in the Studio Explorer pane on the top-left of the interface.
7. Click the + button to expand the options for the device, then click on the Settings folder.
8. Right-click on Settings and select the Extract Settings link to read the settings on the device and store them on your computer or a memory stick.
9. After retrieving the settings file, close the dialog box by clicking the Close button.

2.2 Send Settings to a MiCOM Px40 Device

Full details of how to do this is provided in the MiCOM S1 Studio help.

As a quick guide, you need to do the following:

1. In MiCOM S1 Studio, click the Quick Connect… button.
2. Select the relevant Device Type in the Quick Connect dialog box.
3. Click the relevant port in the Port Selection dialog box.
4. Enter the relevant connection parameters in the Connection Parameters dialog box and click the Finish button
5. MiCOM S1 Studio will try to communicate with the Px40 device. It will display a connected message if the connection attempt is successful.
6. The device will appear in the Studio Explorer pane on the top-left hand side of the interface.
7. Click the + button to expand the options for the device, then click on the Settings link.
8. Right-click on the device name and select the Send link.

Note	*When you send settings to a MiCOM Px40 device, the data is stored in a temporary location at first. This temporary data is tested to make sure it is complete. If the temporary data is complete, it will be programmed into the MiCOM Px40 device. This avoids the risk of a device being programmed with incomplete or corrupt settings.*

9. In the Send To dialog box, select the settings file(s) you wish to send, then click the Send button.
10. Close the the Send To dialog box by clicking the Close button.

MAINTENANCE

CHAPTER 13

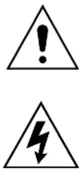
Date:	09/2016	
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.	
Hardware suffix:	All MiCOM Px4x products	
Software version:	All MiCOM Px4x products	
Connection diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P445: 10P445xx (xx = 01 to 04) P44x (P441, P442 & P444): 10P44101 (SH 1 & 2) 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)	P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 1 to 10) 10P643xx (xx = 1 to 6) 10P645xx (xx = 1 to 9) P74x (P741, P742 & P743): 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)

CONTENTS

Page (MT) 13-

Notes:

1 MAINTENANCE PERIOD



Warning	**Before inspecting any wiring, performing any tests or carrying out any work on the equipment, you should be familiar with the contents of the Safety Information and Technical Data sections and the information on the equipment's rating label.**

It is recommended that products supplied by Schneider Electric receive periodic monitoring after installation. In view of the critical nature of protective and control equipment, and their infrequent operation, it is desirable to confirm that they are operating correctly at regular intervals.

Schneider Electric protection and control equipment is designed for a life in excess of 20 years.

MiCOM relays are self-supervising and so require less maintenance than earlier designs. Most problems will result in an alarm so that remedial action can be taken. However, some periodic tests should be done to ensure that the equipment is functioning correctly and the external wiring is intact.

If the customer's organization has a preventative maintenance policy, the recommended product checks should be included in the regular program. Maintenance periods depend on many factors, such as:

- The operating environment
- The accessibility of the site
- The amount of available manpower
- The importance of the installation in the power system
- The consequences of failure

2 MAINTENANCE CHECKS

Although some functionality checks can be performed from a remote location by using the communications ability of the equipment, these are predominantly restricted to checking that the equipment, is measuring the applied currents and voltages accurately, and checking the circuit breaker maintenance counters. Therefore it is recommended that maintenance checks are performed locally (i.e. at the equipment itself).

Warning	Before carrying out any work on the equipment, you should be familiar with the contents of the Safety Information chapter/Safety Guide SFTY/5L M/L11 or later issue, the Technical Data chapter and the ratings on the equipment rating label.

Warning	If a P391 is used, you should also be familiar with the ratings and warning statements in the P391 technical manual.

2.1 Alarms

The alarm status LED should first be checked to identify if any alarm conditions exist. If so, press the read key ( ) repeatedly to step through the alarms.

Clear the alarms to extinguish the LED.

2.2 Opto-Isolators

The opto-isolated inputs can be checked to ensure that the equipment responds to energization by repeating the commissioning test detailed in the Commissioning chapter.

2.3 Output Relays

The output relays can be checked to ensure that they operate by repeating the commissioning test detailed in the Commissioning chapter.

2.4 Measurement Accuracy

If the power system is energized, the values measured by the equipment can be compared with known system values to check that they are in the approximate range that is expected. If they are, the analog/digital conversion and calculations are being performed correctly by the relay. Suitable test methods can be found in the Commissioning chapter.

Alternatively, the values measured by the equipment can be checked against known values injected via the test block, if fitted, or injected directly into the equipment terminals. Suitable test methods can be found in the Commissioning chapter. These tests will prove the calibration accuracy is being maintained.

3 METHOD OF REPAIR

If the equipment should develop a fault whilst in service, depending on the nature of the fault, the watchdog contacts will change state and an alarm condition will be flagged. Due to the extensive use of surface-mount components, faulty Printed Circuit Boards (PCBs) should be replaced, as it is not possible to perform repairs on damaged PCBs. Therefore either the complete equipment module or just the faulty PCB (as identified by the in-built diagnostic software), can be replaced. Advice about identifying the faulty PCB can be found in the Troubleshooting chapter.

The preferred method is to replace the complete equipment module as it ensures that the internal circuitry is protected against electrostatic discharge and physical damage at all times and overcomes the possibility of incompatibility between replacement PCBs. However, it may be difficult to remove installed equipment due to limited access in the back of the cubicle and the rigidity of the scheme wiring.

Replacing PCBs can reduce transport costs but requires clean, dry conditions on site and higher skills from the person performing the repair. If the repair is not performed by an approved service center, the warranty will be invalidated.

Warning **Before carrying out any work on the equipment, you should be familiar with the contents of the Safety Information chapter/Safety Guide SFTY/5L M/L11 or later issue, the Technical Data chapter and the ratings on the equipment rating label.**

This should ensure that no damage is caused by incorrect handling of the electronic components.

3.1 Replacing the Complete Equipment IED/Relay

The case and rear terminal blocks have been designed to facilitate removal of the IED/relay should replacement or repair become necessary without having to disconnect the scheme wiring.

Warning	Before working at the rear of the equipment, isolate all voltage and current supplies to the equipment.

Note	*The MiCOM range has integral current transformer shorting switches which will close when the heavy duty terminal block is removed.*

1. Disconnect the equipment's earth, IRIG-B and fiber optic connections, as appropriate, from the rear of the device.

   There are two types of terminal block used on the equipment, medium and heavy duty, which are fastened to the rear panel using Pozidriv or PZ1 screws. The P24x/P34x/P64x ranges also includes an RTD/CLIO terminal block option. These block types are shown in the ***Commissioning*** chapter.

Important	*The use of a magnetic bladed screwdriver is recommended to minimize the risk of the screws being left in the terminal block or lost.*

2. Without exerting excessive force or damaging the scheme wiring, pull the terminal blocks away from their internal connectors.

3. Remove the screws used to fasten the equipment to the panel, rack, etc. These are the screws with the larger diameter heads that are accessible when the access covers are fitted and open.

Warning	If the top and bottom access covers have been removed, do not remove the screws with the smaller diameter heads which are accessible. These screws secure the front panel to the equipment.

4. Withdraw the equipment carefully from the panel, rack, etc. because it will be heavy due to the internal transformers.

To reinstall the repaired or replacement equipment, follow the above instructions in reverse, ensuring that each terminal block is relocated in the correct position and the case earth, IRIG-B and fiber optic connections are replaced. To facilitate easy identification of each terminal block, they are labeled alphabetically with 'A' on the left-hand side when viewed from the rear.

Once reinstallation is complete, the equipment should be re-commissioned using the instructions in the Commissioning chapter.

3.2 Replacing a PCB

Replacing PCBs and other internal components must be undertaken only by Service Centers approved by Schneider Electric. Failure to obtain the authorization of Schneider Electric after sales engineers prior to commencing work may invalidate the product warranty.

Warning	**Before removing the front panel to replace a PCB, remove the auxiliary supply and wait <u>at least 30 seconds</u> for the capacitors to discharge. We strongly recommend that the voltage and current transformer connections and trip circuit are isolated.**

Schneider Electric support teams are available world-wide. We strongly recommend that any repairs be entrusted to those trained personnel. For this reason, details on product disassembly and re-assembly are not included here.

4 RE-CALIBRATION

Re-calibration is not required when a PCB is replaced **unless it happens to be one of the boards in the input module;** the replacement of either directly affects the calibration.

Warning	**Although it is possible to carry out re-calibration on site, this requires test equipment with suitable accuracy and a special calibration program to run on a PC. It is therefore recommended that the work be carried out by the manufacturer, or entrusted to an approved service center.**

5 CHANGING THE BATTERY

Each relay/IED has a battery to maintain status data and the correct time when the auxiliary supply voltage fails. The data maintained includes event, fault and disturbance records and the thermal state at the time of failure.

This battery will periodically need changing, although an alarm will be given as part of the relay's/IED's continuous self-monitoring in the event of a low battery condition.

If the battery-backed facilities are not required to be maintained during an interruption of the auxiliary supply, the steps below can be followed to remove the battery, but do not replace with a new battery.

Warning **Before carrying out any work on the equipment, you should be familiar with the contents of the Safety Information chapter/Safety Guide SFTY/5L M/L11 or later issue, the Technical Data chapter and the ratings on the equipment rating label.**

5.1 Instructions for Replacing the Battery

1. Open the bottom access cover on the front of the equipment.
2. Gently extract the battery from its socket. If necessary, use a small, insulated screwdriver to prize the battery free.
3. Ensure that the metal terminals in the battery socket are free from corrosion, grease and dust.
4. The replacement battery should be removed from its packaging and placed into the battery holder, taking care to ensure that the polarity markings on the battery agree with those adjacent to the socket.

Note *Only use a type ½AA Lithium battery with a nominal voltage of 3.6 V and safety approvals such as UL (Underwriters Laboratory), CSA (Canadian Standards Association) or VDE (Vereinigung Deutscher Elektrizitätswerke).*

5. Ensure that the battery is securely held in its socket and that the battery terminals are making good contact with the metal terminals of the socket.
6. Close the bottom access cover.

5.2 Post Modification Tests

To ensure that the replacement battery will maintain the time and status data if the auxiliary supply fails, check cell [0806: DATE and TIME, Battery Status] reads 'Healthy'. If further confirmation that the replacement battery is installed correctly is required, the commissioning test is described in the Commissioning chapter, 'Date and Time', can be performed.

5.3 Battery Disposal

The battery that has been removed should be disposed of in accordance with the disposal procedure for Lithium batteries in the country in which the equipment is installed.

6 CLEANING

Warning	**Before cleaning the equipment ensure that all ac and dc supplies, current transformer and voltage transformer connections are isolated to prevent any chance of an electric shock whilst cleaning.**

The equipment may be cleaned using a lint-free cloth moistened with clean water. The use of detergents, solvents or abrasive cleaners is not recommended as they may damage the relay's surface and leave a conductive residue.

TROUBLESHOOTING

CHAPTER 14

<table>
<tr><td>Date:</td><td colspan="2">09/2016</td></tr>
<tr><td>Products covered by this chapter:</td><td colspan="2">This chapter covers the specific versions of the MiCOM products listed below. This includes only the following combinations of Software Version and Hardware Suffix.</td></tr>
<tr><td>Hardware Suffix:</td><td colspan="2">All MiCOM Px4x products</td></tr>
<tr><td>Software Version:</td><td colspan="2">All MiCOM Px4x products</td></tr>
<tr><td>Connection Diagrams:</td><td>P14x (P141, P142, P143 & P145):
10P141xx (xx = 01 to 02)
10P142xx (xx = 01 to 05)
10P143xx (xx = 01 to 11)
10P145xx (xx = 01 to 11)
P24x (P241, P242 & P243):
10P241xx (xx = 01 to 02)
10P242xx (xx = 01)
10P243xx (xx = 01)
P34x (P342, P343, P344, P345 & P391):
10P342xx (xx = 01 to 17)
10P343xx (xx = 01 to 19)
10P344xx (xx = 01 to 12)
10P345xx (xx = 01 to 07)
10P391xx (xx = 01 to 02)
P445:
10P445xx (xx = 01 to 04)
P44x(P442 & P444):
10P44101 (SH 1 & 2)
10P44201 (SH 1 & 2)
10P44202 (SH 1)
10P44203 (SH 1 & 2)
10P44401 (SH 1)
10P44402 (SH 1)
10P44403 (SH 1 & 2)
10P44404 (SH 1)
10P44405 (SH 1)
10P44407 (SH 1 & 2)
P44y (P443 & P446):
10P44303 (SH 01 and 03)
10P44304 (SH 01 and 03)
10P44305 (SH 01 and 03)
10P44306 (SH 01 and 03)
10P44600
10P44601 (SH 1 to 2)
10P44602 (SH 1 to 2)
10P44603 (SH 1 to 2)</td><td>P54x (P543, P544, P545 & P546):
10P54302 (SH 1 to 2)
10P54303 (SH 1 to 2)
10P54400
10P54404 (SH 1 to 2)
10P54405 (SH 1 to 2)
10P54502 (SH 1 to 2)
10P54503 (SH 1 to 2)
10P54600
10P54604 (SH 1 to 2)
10P54605 (SH 1 to 2)
10P54606 (SH 1 to 2)
P547:
10P54702xx (xx = 01 to 02)
10P54703xx (xx = 01 to 02)
10P54704xx (xx = 01 to 02)
10P54705xx (xx = 01 to 02)
P64x (P642, P643 & P645):
10P642xx (xx = 1 to 10)
10P643xx (xx = 1 to 6)
10P645xx (xx = 1 to 9)
P74x (P741, P742 & P743):
10P740xx (xx = 01 to 07)
P746:
10P746xx (xx = 00 to 21)
P841:
10P84100
10P84101 (SH 1 to 2)
10P84102 (SH 1 to 2)
10P84103 (SH 1 to 2)
10P84104 (SH 1 to 2)
10P84105 (SH 1 to 2)
P849:
10P849xx (xx = 01 to 06)</td></tr>
</table>

CONTENTS

TABLES

Notes:

1 INTRODUCTION

Warning **Before carrying out any work on the equipment, you should be familiar with the contents of the Safety Information chapter/Safety Guide SFTY/5L M/L11 or later issue, the Technical Data chapter and the ratings on the equipment rating label.**

The purpose of this chapter of the service manual is to allow an error condition on the relay to be identified so that appropriate corrective action can be taken.

If the relay has developed a fault, it should be possible in most cases to identify which relay module requires attention. The *Maintenance* chapter advises on the recommended method of repair where faulty modules need replacing. It is not possible to perform an on-site repair to a faulted module.

In cases where a faulty relay/module is being returned to the manufacturer or one of their approved service centers, completed copy of the Repair/Modification Return Authorization Form located at the end of this chapter should be included.

2 INITIAL PROBLEM IDENTIFICATION

Consult the following table to find the description that best matches the problem experienced, then consult the section referenced to perform a more detailed analysis of the problem.

Symptom	Refer To
Relay fails to power up	Power-Up Errors section
Relay powers up - but indicates error and halts during power-up sequence	Error Message/Code On Power-Up section
Relay Powers up but Out of Service LED is illuminated	Out of Service LED illuminated on Power Up section
Error during normal operation	Error Code During Operation section
Mal-operation of the relay during testing	Mal-Operation of the Relay during Testing section

Table 1 - Problem identification

3 POWER UP ERRORS

If the relay does not appear to power up then the following procedure can be used to determine whether the fault is in the external wiring, auxiliary fuse, power supply module of the relay or the relay front panel.

Test	Check	Action
1	Measure auxiliary voltage on terminals 1 and 2; verify voltage level and polarity against rating the label on front. Terminal 1 is –dc, 2 is +dc	If auxiliary voltage is present and correct, then proceed to test 2. Otherwise the wiring/fuses in auxiliary supply should be checked.
2	Do LEDs/and LCD backlight illuminate on power-up, also check the N/O watchdog contact for closing.	If they illuminate or the contact closes and no error code is displayed then error is probably in the main processor board (front panel). If they do not illuminate and the contact does not close then proceed to test 3.
3	Check Field voltage output (nominally 48V DC)	If field voltage is not present then the fault is probably in the relay power supply module.

Table 2 - Failure of relay to power up

4 ERROR MESSAGE/CODE ON POWER-UP

During the power-up sequence of the relay self-testing is performed as indicated by the messages displayed on the LCD. If an error is detected by the relay during these self-tests, an error message will be displayed and the power-up sequence will be halted. If the error occurs when the relay application software is executing, a maintenance record will be created and the relay will reboot.

Test	Check	Action
1	Is an error message or code permanently displayed during power up?	If relay locks up and displays an error code permanently then proceed to Test 2. If the relay prompts for input by the user proceed to Test 4. If the relay re-boots automatically then proceed to Test 5.
2	Record displayed error, then remove and re-apply relay auxiliary supply.	Record whether the same error code is displayed when the relay is rebooted. If no error code is displayed then contact the local service center stating the error code and relay information. If the same code is displayed proceed to Test 3.
3	Error code Identification Following text messages (in English) will be displayed if a fundamental problem is detected preventing the system from booting: Bus Fail address lines SRAM Fail data lines FLASH Fail format error FLASH Fail checksum Code Verify Fail These hex error codes relate to errors detected in specific relay modules:	These messages indicate that a problem has been detected on the main processor board of the relay (located in the front panel).
	0c140005/0c0d0000	Input Module (inc. Opto-isolated inputs)
	0c140006/0c0e0000	Output Relay Cards
	Last 4 digits provide details on the actual error.	Other error codes relate to problems within the main processor board hardware or software. It will be necessary to contact Schneider Electric with details of the problem for a full analysis.
4	Relay displays message for corrupt settings and prompts for restoration of defaults to the affected settings.	The power up tests have detected corrupted relay settings, it is possible to restore defaults to allow the power-up to be completed. It will then be necessary to re-apply the application-specific settings.
5	Relay resets on completion of power up - record error code displayed	Error 0x0E080000, Programmable Scheme Logic (PSL) error due to excessive execution time. Restore default settings by performing a power up with ⇦ and ⇨ keys depressed, confirm restoration of defaults at prompt using (↵) key. If relay powers up successfully, check PSL for feedback paths. Other error codes will relate to software errors on the main processor board, contact Schneider Electric.

Table 3 - Power-up self-test error

5 OUT OF SERVICE LED ILLUMINATED ON POWER UP

<table>
<tr><th>Test</th><th>Check</th><th colspan="2">Action</th></tr>
<tr><td>1</td><td>Using the relay menu confirm whether the Commission Test/Test Mode setting is Contact Blocked. Otherwise proceed to test 2.</td><td colspan="2">If the setting is Contact Blocked then disable the test mode and, verify that the Out of Service LED is extinguished.</td></tr>
<tr><td>2</td><td>Select and view the last maintenance record from the menu (in the View Records).</td><td colspan="2">Check for H/W Verify Fail this indicates a discrepancy between the relay model number and the hardware; examine the “Maint. Data”, this indicates the causes of the failure using bit fields:</td></tr>
<tr><td></td><td></td><td>Bit</td><td>Meaning</td></tr>
<tr><td></td><td></td><td>0</td><td>The application type field in the model number does not match the software ID</td></tr>
<tr><td></td><td></td><td>1</td><td>The application field in the model number does not match the software ID</td></tr>
<tr><td></td><td></td><td>2</td><td>The variant 1 field in the model number does not match the software ID</td></tr>
<tr><td></td><td></td><td>3</td><td>The variant 2 field in the model number does not match the software ID</td></tr>
<tr><td></td><td></td><td>4</td><td>The protocol field in the model number does not match the software ID</td></tr>
<tr><td></td><td></td><td>5</td><td>The language field in the model number does not match the software ID</td></tr>
<tr><td></td><td></td><td>6</td><td>The VT type field in the model number is incorrect (110V VTs fitted)</td></tr>
<tr><td></td><td></td><td>7</td><td>The VT type field in the model number is incorrect (440V VTs fitted)</td></tr>
<tr><td></td><td></td><td>8</td><td>The VT type field in the model number is incorrect (no VTs fitted)</td></tr>
</table>

Table 4 - Out of service LED illuminated

6 ERROR CODE DURING OPERATION

The relay performs continuous self-checking, if an error is detected then an error message will be displayed, a maintenance record will be logged and the relay will reset (after a 1.6 second delay). A permanent problem (for example due to a hardware fault) will generally be detected on the power up sequence, following which the relay will display an error code and halt. If the problem was transient in nature then the relay should reboot correctly and continue in operation. The nature of the detected fault can be determined by examination of the maintenance record logged.

There are also two cases where a maintenance record will be logged due to a detected error where the relay will not reset. These are detection of a failure of either the field voltage or the lithium battery, in these cases the failure is indicated by an alarm message, however the relay will continue to operate.

If the field voltage is detected to have failed (the voltage level has dropped below threshold), then a scheme logic signal is also set. This allows the scheme logic to be adapted in the case of this failure (for example if a blocking scheme is being used).

In the case of a battery failure it is possible to prevent the relay from issuing an alarm using the setting under the Date and Time section of the menu. This setting ‘**Battery Alarm**’ can be set to '**Disabled**' to allow the relay to be used without a battery, without an alarm message being displayed.

In the case of an RTD board failure, an alarm "RTD board fail" message is displayed, the RTD protection is disabled, but the operation of the rest of the relay functionality is unaffected.

7 MAL-OPERATION OF THE RELAY DURING TESTING

7.1 Failure of Output Contacts

An apparent failure of the relay output contacts may be caused by the relay configuration; the following tests should be performed to identify the real cause of the failure.

Note	*The relay self-tests verify that the coil of the contact has been energized, an error will be displayed if there is a fault in the output relay board.*

Test	Check	Action
1	Is the Out of Service LED illuminated?	Illumination of this LED may indicate that the relay is Contact Blocked or that the protection has been disabled due to a hardware verify error (see the *Out of service LED illuminated* table..
2	Examine the Contact status in the Commissioning section of the menu.	If the relevant bits of the contact status are operated, proceed to test 4, if not proceed to test 3.
3	Verify by examination of the fault record or by using the test port whether the protection element is operating correctly.	If the protection element does not operate verify whether the test is being correctly applied. If the protection element does operate, it will be necessary to check the PSL to ensure that the mapping of the protection element to the contacts is correct.
4	Using the Commissioning/Test mode function apply a test pattern to the relevant relay output contacts and verify whether they operate (note the correct external connection diagram should be consulted). A continuity tester can be used at the rear of the relay for this purpose.	If the output relay does operate, the problem must be in the external wiring to the relay. If the output relay does not operate this could indicate a failure of the output relay contacts (note that the self-tests verify that the relay coil is being energized). Ensure that the closed resistance is not too high for the continuity tester to detect.

Table 5 - Failure of output contacts

7.2 Failure of Opto-Isolated Inputs

The opto-isolated inputs are mapped onto the relay internal signals using the PSL. If an input does not appear to be recognized by the relay scheme logic the Commission Tests/Opto Status menu option can be used to verify whether the problem is in the opto-isolated input itself or the mapping of its signal to the scheme logic functions. If the opto-isolated input does appear to be read correctly then it will be necessary to examine its mapping within the PSL.

Ensure the voltage rating for the opto inputs has been configured correctly with applied voltage. If the opto-isolated input state is not being correctly read by the relay the applied signal should be tested. Verify the connections to the opto-isolated input using the correct wiring diagram and the correct nominal voltage settings in any standard or custom menu settings. Next, using a voltmeter verify that 80% opto setting voltage is present on the terminals of the opto-isolated input in the energized state. If the signal is being correctly applied to the relay then the failure may be on the input card itself. Depending on which opto-isolated input has failed this may require replacement of either the complete analog input module (the board within this module cannot be individually replaced without re-calibration of the relay) or a separate opto board.

7.3 Incorrect Analog Signals

The measurements may be configured in primary or secondary to assist. If it is suspected that the analog quantities being measured by the relay are not correct then the measurement function of the relay can be used to verify the nature of the problem. The measured values displayed by the relay should be compared with the actual magnitudes at the relay terminals. Verify that the correct terminals are being used (in particular the dual rated CT inputs) and that the CT and VT ratios set on the relay are correct. The correct 120 degree displacement of the phase measurements should be used to confirm that the inputs have been correctly connected.

7.4 PSL Editor Troubleshooting

A failure to open a connection could be because of one or more of the following:

- The relay address is not valid (note: this address is always 1 for the front port).
- Password is not valid
- Communication Set-up - COM port, Baud rate, or Framing - is not correct
- Transaction values are not suitable for the relay and/or the type of connection
- Modem configuration is not valid. Changes may be necessary when using a modem
- The connection cable is not wired correctly or broken. See MiCOM S1 connection configurations
- The option switches on any KITZ101/102 that is in use may be incorrectly set

7.4.1 Diagram Reconstruction after Recover from Relay

Although the extraction of a scheme from a relay is supported, the facility is provided as a way of recovering a scheme in the event that the original file is unobtainable.

The recovered scheme will be logically correct, but much of the original graphical information is lost. Many signals will be drawn in a vertical line down the left side of the canvas. Links are drawn orthogonally using the shortest path from A to B.

Any annotation added to the original diagram (titles, notes, etc.) are lost.

Sometimes a gate type may not be what was expected, e.g. a 1-input AND gate in the original scheme will appear as an OR gate when uploaded. Programmable gates with an inputs-to-trigger value of 1 will also appear as OR gates.

7.4.2 PSL Version Check

The PSL is saved with a version reference, time stamp and CRC check. This gives a visual check whether the default PSL is in place or whether a new application has been downloaded.

8 REPAIR AND MODIFICATION PROCEDURE

Please follow these steps to return an Automation product to us:

1. Get the Repair and Modification Authorization Form (RMA).

   A copy of the RMA form is shown at the end of this section.

2. Fill in the RMA form.

   Fill in only the white part of the form.

   Please ensure that all fields marked **(M)** are completed such as:

   - Equipment model
   - Model No. and Serial No.
   - Description of failure or modification required (please be specific)
   - Value for customs (in case the product requires export)
   - Delivery and invoice addresses
   - Contact details

3. Receive from local service contact, the information required to ship the product.

   Your local service contact will provide you with all the information:

   - Pricing details
   - RMA No
   - Repair center address

   If required, an acceptance of the quote must be delivered before going to next stage.

4. Send the product to the repair center.

   Address the shipment to the repair center specified by your local contact.

   Ensure all items are protected by appropriate packaging: anti-static bag and foam protection.

   Ensure a copy of the import invoice is attached with the unit being returned.

   Ensure a copy of the RMA form is attached with the unit being returned.

   E-mail or fax a copy of the import invoice and airway bill document to your local contact.

Notes:

Schneider Electric

REPAIR/MODIFICATION RETURN AUTHORIZATION FORM

FIELDS IN GREY TO BE FILLED IN BY SCHNEIDER ELECTRIC PERSONNEL ONLY

Reference **RMA:**		Date:
Repair Center Address (for shipping)	**Service Type** ☐ Retrofit ☐ Warranty ☐ Paid service ☐ Under repair contract ☐ Wrong supply	LSC PO No.:
Schneider Electric - Local Contact Details Name: Telephone No.: Fax No.: E-mail:		

IDENTIFICATION OF UNIT

Fields marked (M) are mandatory, delays in return will occur if not completed.

Model No./Part No.: **(M)**	Site Name/Project:
Manufacturer Reference: **(M)**	Commissioning Date:
Serial No.: **(M)**	Under Warranty: ☐ Yes ☐ No
Software Version:	Additional Information:
Quantity:	Customer P.O (if paid):

FAULT INFORMATION

Type of Failure	**Found Defective**
Hardware fail ☐	During FAT/inspection ☐
Mechanical fail/visible defect ☐	On receipt ☐
Software fail ☐	During installation/commissioning ☐
Other:	During operation ☐
	Other:
Fault Reproducibility	
Fault persists after removing, checking on test bench ☐	
Fault persists after re-energization ☐	
Intermittent fault ☐	

Schneider Electric

Description of Failure Observed or Modification Required - *Please be specific* **(M)**

FOR REPAIRS ONLY

Would you like us to install an updated firmware version after repair?	☐	Yes	☐	No

CUSTOMS & INVOICING INFORMATION

Required to allow return of repaired items

Value for Customs (M)	
Customer Invoice Address ((M) if paid)	**Customer Return Delivery Address** **(full street address) (M)** Part shipment accepted ☐ Yes ☐ No **OR** Full shipment required ☐ Yes ☐ No
Contact Name: Telephone No.: Fax No.: E-mail:	Contact Name: Telephone No.: Fax No.: E-mail:

REPAIR TERMS

1. **Please ensure that a copy of the import invoice is attached with the returned unit, together with the airway bill document.** Please fax/e-mail a copy of the appropriate documentation **(M)**.
2. Please ensure the Purchase Order is released, for paid service, to allow the unit to be shipped.
3. Submission of equipment to Schneider Electric is deemed as authorization to repair and acceptance of quote.
4. Please ensure all items returned are marked as Returned for ‘Repair/Modification’ and **protected by appropriate packaging** (anti-static bag for each board and foam protection).

SCADA COMMUNICATIONS

CHAPTER 15

Date:	07/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142 & P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

CONTENTS

TABLES

Page (SC) 15-

FIGURES

Page (SC) 15-

Notes:

1 INTRODUCTION

This chapter describes the remote interfaces of the MiCOM relay in enough detail to allow integration in a substation communication network. The relay supports a choice of one of a number of protocols through the rear 2-wire EIA(RS)485 communication interface, selected using the model number when ordering. This is in addition to the front serial interface and second rear communications port, which supports the Courier protocol only. According to the protocol and hardware options selected, the interface may alternatively be presented over an optical fiber interface, or via an Ethernet connection.

The supported protocols include:

- Courier
- IEC-60870-5-103
- DNP3.0
- MODBUS
- IEC 61850 Ethernet Interface

Note	*The IEC 60870-5-103 standard may be abbreviated to IEC870-5-103, IEC 60870, or even -103. In some references, it may even be described as the 'VDEW' standard.*

Table 1 - Supported protocols

The implementation of both Courier and IEC 60870-5-103 on RP1 can also, optionally, be presented over fiber as well as EIA(RS)485.

The DNP3.0 implementation is available via EIA(RS)485 port or over Ethernet port.

The rear EIA(RS)-485 interface is isolated and is suitable for permanent connection whichever protocol is selected. The advantage of this type of connection is that up to 32 relays can be daisy-chained together using a simple twisted-pair electrical connection.

Note	*The second rear Courier port and the fiber optic interface are mutually exclusive as they occupy the same physical slot.*

An outline of the connection details for each of the communications ports is provided here. The ports are configurable using settings - a description of the configuration follows the connections part. Details of the protocol characteristics are also shown.

For each of the protocol options, the supported functions and commands are listed with the database definition. The operation of standard procedures such as extraction of event, fault and disturbance records, or setting changes is also described.

The descriptions in this chapter do not aim to fully describe the protocol in detail. Refer to the relevant documentation protocol for this information. This chapter describes the specific implementation of the protocol in the relay.

2 CONNECTIONS TO THE COMMUNICATION PORTS

2.1 Front Port

The front communications port is not intended for permanent connection. The front communications port supports the Courier protocol and is implemented on an EIA(RS)232 connection. A 9-pin connector type, as described in the 'Getting Started' (GS) chapter of this manual, is used, and the cabling requirements are detailed in the 'Connection Diagrams' (CD) chapter of this manual.

2.2 Rear Communication Port - EIA(RS)485

The rear EIA(RS)-485 communication port is provided by a 3-terminal screw connector on the back of the relay. See the Connection Diagrams chapter for details of the connection terminals. The rear port provides K-Bus/EIA(RS)-485 serial data communication and is intended for use with a permanently-wired connection to a remote control center. Of the three connections, two are for the signal connection, and the other is for the earth shield of the cable.

If the IEC60870-5-103, or the DNP3.0 protocols are specified as the interface for the rear port, then connections conform entirely to the EIA(RS)485 standards outline below. If, however, the Courier protocol is specified as the rear port protocol, then the interface can be set either to EIA(RS)485 or K-Bus. The configuration of the port as either EIA(RS)485 or K-Bus is described later together with K-Bus details, but as connection to the port is affected by this choice, the following points should be noted:

- Connection to an EIA(RS)485 device is polarity sensitive, whereas K-Bus connection is not.
- Whilst connection to between an EIA(RS)485 port and an EIA(RS)232 port on, say, a PC might be implemented using a general purpose EIA(RS)485 to EIA(RS)232 converter, connection between an EIA(RS)232 port and K-Bus requires a KITZ101, KITZ102 or KITZ201

Unless the K-Bus option is chosen for the rear port, correct polarity must be observed for the signal connections. In all other respects (bus wiring, topology, connection, biasing and termination) K-Bus can be considered the same as EIA(RS)485.

All rear port communication interfaces are fully isolated and suitable for permanent connection. EIA(RS)485 (and K-Bus) connections allow up to 32 devices to be 'daisy-chained' together using a simple twisted pair electrical connection.

The protocol provided by the relay is shown in the relay menu in the **Communications** column. Using the keypad and LCD, first check that the **Comms. settings** cell in the **Configuration** column is set to **Visible**, then move to the **Communications** column. The first cell down the column shows the communication protocol being used by the rear port.

Note	*Unless the K-Bus option is chosen for the rear port, correct polarity must be observed for the signal connections. In all other respects (bus wiring, topology, connection, biasing and termination) K-Bus can be considered the same as EIA(RS)485.*

2.3 Second Rear Communications Port (RP2) (Courier)

Relays with Courier, MODBUS, IEC60870-5-103 or DNP3.0 protocol on the first rear communications port have the option of a second rear port, running the Courier language. The second port is intended typically for dial-up modem access by protection engineers or operators, when the main port is reserved for SCADA communication traffic. Communication is through one of three physical links: K-Bus, EIA(RS)-485 or EIA(RS)-232. The port supports full local or remote protection and control access using MiCOM S1 Studio.

When changing the port configuration between K-Bus, EIA(RS)-485 and EIA(RS)-232, reboot the relay to update the hardware configuration of the second rear port.

The EIA(RS)-485 and EIA(RS)-232 protocols can be configured to operate with a modem, using an IEC60870 10-bit frame.

If both rear communications ports are connected to the same bus, make sure their address settings are not the same to avoid message conflicts.

Port Configuration	Valid Communication Protocol
K-Bus	K-Bus
EIA(RS)-232	IEC60870 FT1.2, 11-bit frame IEC60870, 10-bit frame
EIA(RS)-485	IEC60870 FT1.2, 11-bit frame IEC60870, 10-bit frame

Table 2 - Port configurations and communication protocols

2.3.1 Courier Protocol

The second rear communications port is functionally the same as described in the previous section for a Courier rear communications port, with the following exceptions:

2.3.1.1 Event Extraction

Automatic event extraction is not supported when the first rear port protocol is Courier, MODBUS or CS103. It is supported when the first rear port protocol is DNP3.0.

2.3.1.2 Disturbance Record Extraction

Automatic disturbance record extraction is not supported when the first rear port protocol is Courier, MODBUS or CS103. It is supported when the first rear port protocol is DNP3.0.

2.3.1.3 Connection to the Second Rear Port

The second rear Courier port connects using the 9-way female D-type connector (SK4) in the middle of the card end plate (between the IRIG-B connector and lower D-type). The connection complies with EIA(RS)-574.

For IEC60870-5-2 over EIA(RS)-232		For K-bus or IEC60870-5-2 over EIA(RS)-485	
Pin	Connection	Pin*	Connection
1	No Connection		
2	RxD		
3	TxD		
4	DTR#	4	EIA(RS)-485 - 1 (+ ve)
5	Ground		
6	No Connection		
7	RTS#	7	EIA(RS)-485 - 2 (- ve)
8	CTS#		
9	No Connection		
# - These pins are control lines for use with a modem.		* - All other pins unconnected.	

Notes *Connector pins 4 and 7 are used by both the EIA(RS)-232and EIA(RS)-485 physical layers, but for different purposes. Therefore, the cables should be removed during configuration switches.*
When using the EIA(RS)-485 protocol, an EIA(RS)-485 to EIA(RS)-232 converter is needed to connect the relay to a modem or PC running Easergy Studio. A Schneider Electric CK222 is recommended.
EIA(RS)-485 is polarity sensitive, with pin 4 positive (+) and pin 7 negative (-).
The K-Bus protocol can be connected to a PC using a KITZ101 or 102.

Table 3 - Pin connections over EIA(RS)-232 and EIS(RS)-485

2.4 EIA(RS)485 Bus

The EIA(RS)-485 two-wire connection provides a half-duplex fully isolated serial connection to the product. The connection is polarized and while the product's connection diagrams show the polarization of the connection terminals, there is no agreed definition of which terminal is which. If the master is unable to communicate with the product and the communication parameters match, make sure the two-wire connection is not reversed.

EIA(RS)-485 provides the capability to connect multiple devices to the same two-wire bus. MODBUS is a master-slave protocol, so one device is the master, and the remaining devices are slaves. It is not possible to connect two masters to the same bus, unless they negotiate bus access.

2.4.1 EIA(RS)485 - Bus Termination

The EIA(RS)-485 bus must have 120 Ω (Ohm) ½ Watt terminating resistors fitted at either end across the signal wires, see the *EIA(RS)-485 bus connection arrangements* diagram below. Some devices may be able to provide the bus terminating resistors by different connection or configuration arrangements, in which case separate external components are not needed. However, this product does not provide such a facility, so if it is located at the bus terminus, an external termination resistor is needed.

2.4.2 EIA(RS)485 - Bus Connections and Topologies

The EIA(RS)-485 standard requires each device to be directly connected to the physical cable that is the communications bus. Stubs and tees are expressly forbidden, as are star topologies. Loop bus topologies are not part of the EIA(RS)-485 standard and are forbidden by it.

Two-core screened cable is recommended. The specification of the cable depends on the application, although a multi-strand 0.5 mm^2 per core is normally adequate. Total cable length must not exceed 1000 m. The screen must be continuous and connected at one end, normally at the master connection point. It is important to avoid circulating currents, especially when the cable runs between buildings, for both safety and noise reasons.

This product does not provide a signal ground connection. If the bus cable has a signal ground connection, it must be ignored. However, the signal ground must have continuity for the benefit of other devices connected to the bus. For both safety and noise reasons, the signal ground must never be connected to the cable's screen or to the product's chassis.

2.4.3 EIA(RS)485 - Biasing

It may also be necessary to bias the signal wires to prevent jabber. Jabber occurs when the signal level has an indeterminate state because the bus is not being actively driven. This can occur when all the slaves are in receive mode and the master is slow to switch from receive mode to transmit mode. This may be because the master purposefully waits in receive mode, or even in a high impedance state, until it has something to transmit. Jabber causes the receiving device(s) to miss the first bits of the first character in the packet, which results in the slave rejecting the message and consequentially not responding. Symptoms of this are poor response times (due to retries), increasing message error counters, erratic communications, and even a complete failure to communicate.

Biasing requires that the signal lines are weakly pulled to a defined voltage level of about 1 V. There should only be one bias point on the bus, which is best situated at the master connection point. The DC source used for the bias must be clean, otherwise noise is injected. Some devices may (optionally) be able to provide the bus bias, in which case external components are not required.

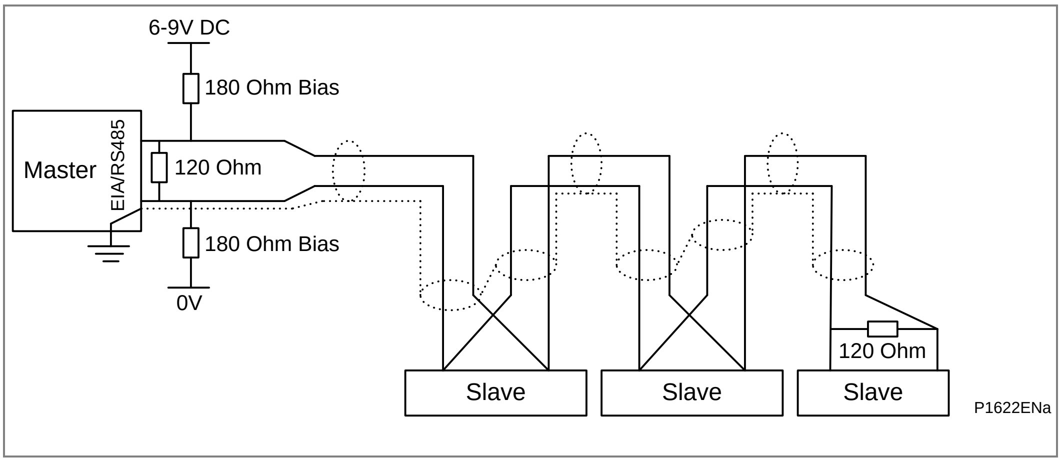


Figure 1 - EIA(RS)485 bus connection arrangements

It is possible to use the product's field voltage output (48 V DC) to bias the bus using values of 2.2 k Ω (½W) as bias resistors instead of the 180 Ω resistors shown in the *EIA(RS)-485 bus connection arrangements* diagram. Note these warnings apply:

Warnings	**It is extremely important that the 120 Ω termination resistors are fitted. Otherwise the bias voltage may be excessive and may damage the devices connected to the bus.** **As the field voltage is much higher than that required, Schneider Electric cannot assume responsibility for any damage that may occur to a device connected to the network as a result of incorrect application of this voltage.** **Ensure the field voltage is not used for other purposes, such as powering logic inputs, because noise may be passed to the communication network.**

2.4.3.1 K-Bus Connections

K-Bus is a robust signaling method based on EIA(RS)485 voltage levels. K-Bus incorporates message framing and uses a 64 kbits/s synchronous HDLC protocol with FM0 modulation to increase speed and security. For this reason is not possible to use a standard EIA(RS)232 to EIA(RS)485 converter to connect with K-Bus devices. Nor is it possible to connect K-Bus to an EIA(RS)485 computer port. A KITZ protocol converter needs to be employed for this purpose.

Please consult Schneider Electric for information regarding the specification and supply of KITZ devices.

As K-Bus is implemented on an EIA(RS)485 layer, the connection details are very similar to those described in the previous sections. A typical connection arrangement, incorporating a KITZ, is shown in the *K-bus remote communication connection arrangements* diagram below. As with EIA(RS)485, each spur of the K-Bus twisted pair wiring can be up to 1000 m in length and have up to 32 relays connected to it.

2.4.4 Courier Communication

Courier works on a master/slave basis where the slave units contain information in the form of a database, and respond with information from the database when it is requested by a master unit.

The relay is a slave unit that is designed to be used with a Courier master unit such as Easergy Studio, PAS&T or a SCADA system.

To use the rear port to communicate with a PC-based master station using Courier, a KITZ K-Bus to EIA(RS)-232 protocol converter is needed. This unit (and information on how to use it) is available from Schneider Electric. A typical connection arrangement is shown in the *K-bus remote communication connection arrangements* diagram below. For more detailed information on other possible connection arrangements, refer to the manual for the Courier master station software and the manual for the KITZ protocol converter. Each spur of the K-Bus twisted pair wiring can be up to 1000 m in length and have up to 32 relays connected to it.

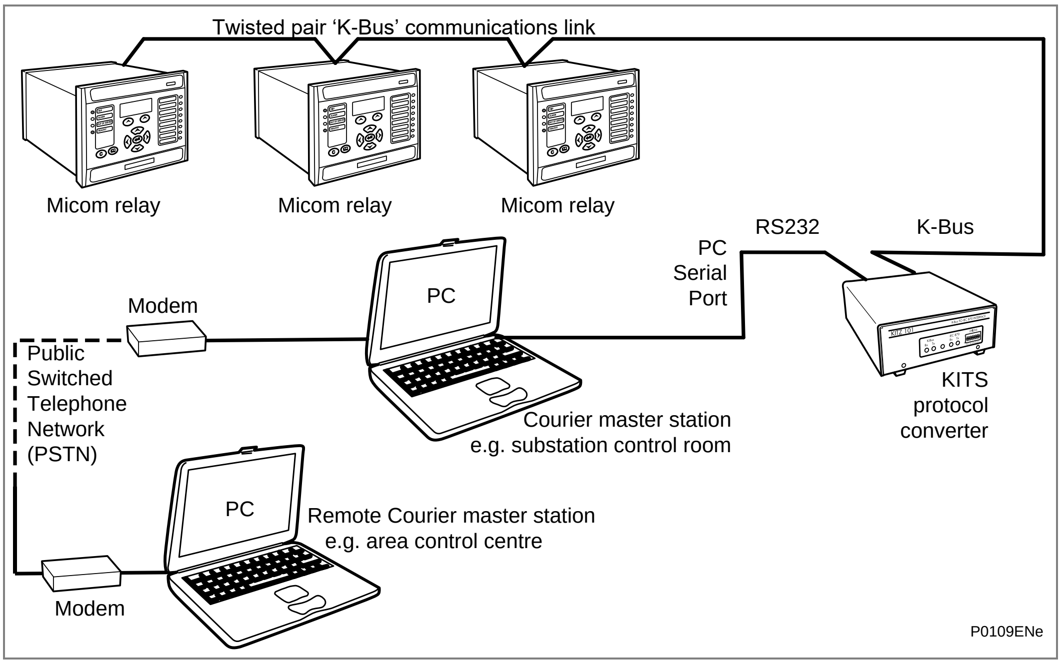


Figure 2 – K-bus remote communication connection arrangements

Once the physical connection is made to the relay, configure the relay's communication settings using the keypad and LCD user interface.

3 CONFIGURING THE COMMUNICATION PORTS

3.1 Introduction

Courier works on a master/slave basis where the slave units contain information in the form of a database, and respond with information from the database when it is requested by a master unit.

The relay is a slave unit that is designed to be used with a Courier master unit such as Easergy Studio, PAS&T or a SCADA system.

3.2 Configuring the Front Courier Port

The front EIA(RS)232 9-pin port supports the Courier protocol for one-to-one communication. It is designed for use during installation, commissioning and maintenance and is not suitable for permanent connection. Since this interface is not intended to link the relay to a substation communication system, not all of the features of the Courier interface are supported; the port is not configurable and the following parameters apply:

- Physical presentation EIA(RS)232 via 9-pin connector
- Frame format IEC60870-5 FT1.2 = 11-bit (8 Even 1)
- Address 1
- Baud rate 19200 bps

Note	*As part of the limited implementation of Courier on the front port, neither automatic extraction of event and disturbance records, nor busy response are supported.)*

3.3 Configuring the First Rear Courier Port (RP1)

Once the physical connection is made to the relay, configure the relay's communication settings using the keypad and LCD user interface.

1. In the relay menu, select the **Configuration** column, then check that the **Comms. settings** cell is set to **Visible**.
2. Select the **Communications** column. Only two settings apply to the rear port using Courier, the relay's address and the inactivity timer. Synchronous communication uses a fixed baud rate of 64 kbits/s.
3. Move down the **Communications** column from the column heading to the first cell down. This shows the communication protocol.

```
Protocol
Courier
```

4. The next cell down the column controls the address of the relay. As up to 32 relays can be connected to one K-Bus spur, each relay must have a unique address so messages from the master control station are accepted by one relay only. Courier uses an integer (from 0 to 254) for the relay address that is set with this cell. Important: no two relays should have the same Courier address. The master station uses the Courier address to communicate with the relay.

```
Address
1
```

5. The next cell down controls the inactivity timer.

```
Inactiv timer
10.00 mins.
```

The inactivity timer controls how long the relay waits without receiving any messages on the rear port before it reverts to its default state, including revoking any password access that was enabled. For the rear port this can be set between 1 and 30 minutes.

Note	*Protection and disturbance recorder settings that are modified using an on-line editor such as PAS&T must be confirmed with a write to the 'Save changes' cell of the 'Configuration' column. Off-line editors such as Easergy Studio do not need this action for the setting changes to take effect.*

The next cell down controls the physical media used for the communication.

```
Physical link
Copper
```

The default setting is to select the electrical (copper) connection. If the optional fiber optic interface is fitted to the relay, then this setting can be changed to '**Fiber optic**'. This cell is invisible if a second rear communications port or an Ethernet card is fitted, as they are mutually exclusive and occupy the same physical location.

6. If the Physical link selection is copper, the next cell down becomes visible to further define the configuration:

```
Port Config
KBus
```

The setting choice is between K-Bus and EIA(RS)485. Selecting K-Bus allows connection with K-series devices, but means that a KITZ converter must be used to make a connection. If the EIA(RS)485 selection is made, direct connections can be made to proprietary equipment such as MODEMs. If the EIA(RS)485 selection is made, then two further cells become visible to control the frame format and the communication speed:

7. The frame format is selected in the RP1 Comms mode setting:

```
Comms Mode
IEC60870 FT1.2
```

The standard default is the IEC 60870-FT1.2. This is an 11-bit framing. Alternatively, a 10-bit framing may be selected for use with MODEMs that do not support 11-bit framing.

8. The final RP1 cell controls the communication speed or baud rate:

```
Baud Rate
19200 bits/s
```

Courier communications is asynchronous and three baud rate selections are available to allow the relay communication rate to be matched to that of the connected equipment. Three baud rates are supported by the relay, '9600 bits/s', '19200 bits/s' and '38400 bits/s'.

Important	**If you modify protection and disturbance recorder settings using an on-line editor such as PAS&T, you must confirm them. To do this, from the Configuration column select the Save changes cell. Off-line editors such as Easergy Studio do not need this action for the setting changes to take effect.**

3.4 Configuring the MODBUS Communication

Important	**MODBUS is not available for all MiCOM products. MODBUS availability is shown in the *Supported Protocols* table.**

MODBUS is a master/slave communication protocol that can be used for network control. In a similar way to Courier, the master device initiates all actions and the slave devices (the relays) respond to the master by supplying the requested data or by taking the requested action. MODBUS communication uses a twisted pair connection to the rear port and can be used over a distance of 1000 m with up to 32 slave devices.

To use the rear port with MODBUS communication, configure the relay's communication settings using the keypad and LCD user interface.

1. In the relay menu firstly check that the '**Comms. settings**' cell in the '**Configuration**' column is set to '**Visible**'.
2. Select the '**Communications**' column. Four settings apply to the rear port using MODBUS, which are described below.
3. Move down the **Communications** column from the column heading to the first cell down which indicates the communication protocol.

```
Protocol
MODBUS
```

4. The next cell down controls the MODBUS address of the relay:

```
MODBUS address
23
```

   Up to 32 relays can be connected to one MODBUS spur, and therefore it is necessary for each relay to have a unique address so that messages from the master control station are accepted by one relay only. MODBUS uses an integer number between 1 and 247 for the relay address. It is important that no two relays have the same MODBUS address. The MODBUS address is then used by the master station to communicate with the relay.

5. The next cell down controls the inactivity timer:

```
Inactivity timer
10.00 mins.
```

   The inactivity timer controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state, including revoking any password access that was enabled. For the rear port this can be set between 1 and 30 minutes.

6. The next cell down the column controls the baud rate to be used:

```
Baud rate
9600 bits/s
```

7. MODBUS communication is asynchronous. Three baud rates are supported by the relay, '**9600 bits/s**', '**19200 bits/s**' and '**38400 bits/s**'. It is important that whatever baud rate is selected on the relay is the same as that set on the MODBUS master station.
8. The next cell down controls the parity format used in the data frames:

```
Parity
None
```

   The parity can be set to be one of '**None**', '**Odd**' or '**Even**'. It is important that whatever parity format is selected on the relay is the same as that set on the MODBUS master station.

9. The next cell down controls the IEC time format used in the data frames:

```
MODBUS IEC time
Standard
```

10. The MODBUS IEC time can be set to '**Standard**' or '**Reverse**'. For a complete definition see the Relay Menu Database (P14x/EN MD), datatype G12.

3.5 Configuring the IEC60870-5 CS 103 Rear Port, RP1

The IEC specification IEC 60870-5-103: Telecontrol Equipment and Systems, Part 5: Transmission Protocols Section 103 defines the use of standards IEC 60870-5-1 to IEC 60870-5-5 to perform communication with protection equipment. The standard configuration for the IEC 60870-5-103 protocol is to use a twisted pair connection over distances up to 1000 m. As an option for IEC 60870-5-103, the rear port can be specified to use a fiber optic connection for direct connection to a master station. The relay operates as a slave in the system, responding to commands from a master station. The method of communication uses standardized messages which are based on the VDEW communication protocol.

To use the rear port with IEC 60870-5-103 communication, configure the relay's communication settings using the keypad and LCD user interface.

1. In the relay menu, select the **Configuration** column, then check that the **Comms. settings** cell is set to **Visible**.
2. Select the **Communications** column. Four settings apply to the rear port using IEC 60870-5-103 that are described below.

   Move down the 'COMMUNICATIONS' column from the column heading to the first cell to confirm the communication protocol:

```
Protocol
IEC60870-5-103
```

3. The next cell sets the address of the relay on the IEC 60870-5-103 network:

```
Remote Address
162
```

   Up to 32 relays can be connected to one IEC 60870-5-103 spur, and therefore it is necessary for each relay to have a unique address so that messages from the master control station are accepted by one relay only. IEC 60870-5-103 uses an integer number between 0 and 254 for the relay address. It is important that no two relays have the same address. The address is then used by the master station to communicate with the relay.

4. The next cell down the column controls the baud rate to be used:

```
Baud rate
9600 bits/s
```

   IEC 60870-5-103 communication is asynchronous. Two baud rates are supported by the relay, '9600 bits/s' and '19200 bits/s'. It is important that whatever baud rate is selected on the relay is the same as that set on the IEC 60870-5-103 master station.

5. The next cell down controls the period between IEC 60870-5-103 measurements:

```
Measure't period
30.00 s
```

   The IEC 60870-5-103 protocol allows the relay to supply measurements at regular intervals. The interval between measurements is controlled by this cell, and can be set between 1 and 60 seconds.

6. An optional fiber optic card is available in the relay to allow optical connection to the IEC 60870-5-103 communication to be made over an optical connection. When fitted, it converts between EIA(RS)485 signals and fiber optic signals and the following cell is visible in the menu column:

```
Physical link
Copper
```

   The default setting is to select the electrical (copper) connection. If the optional fiber optic interface is fitted to the relay, then this setting can be changed to 'Fiber optic'. This cell is invisible if a second rear communications port or an Ethernet card is fitted, as they are mutually exclusive and occupy the same physical location.
7. The following cell which may be displayed, is not currently used but is available for future expansion.

```
InactivTimer
```

8. The next cell down can be used for monitor or command blocking:

```
CS103 Blocking
```

There are three settings associated with this cell; these are:

- **Disabled**
  No blocking selected.
- **Monitor Blocking**
  When the monitor blocking DDB Signal is active high, either by energizing an opto input or control input, reading of the status information and disturbance records is not permitted. When in this mode the relay returns a "Termination of general interrogation" message to the master station.
- **Command Blocking**
  When the command blocking DDB signal is active high, either by energizing an opto input or control input, all remote commands are ignored, such as CB Trip/Close or change setting group. When in this mode the relay returns a **negative acknowledgement of command** message to the master station.

3.6 Configuring the DNP3.0 Communication Rear Port, RP1

The DNP3.0 protocol is defined and administered by the DNP User Group. Information about the user group, DNP3.0 in general and protocol specifications can be found on their website: www.dnp.org

The relay operates as a DNP3.0 slave and supports subset level 2 of the protocol plus some of the features from level 3. DNP3.0 communication is achieved using a twisted pair connection to the rear port and can be used over a distance of 1000 m with up to 32 slave devices.

1. To use the rear port with DNP3.0 communication, configure the relay's communication settings using the keypad and LCD user interface.
2. In the relay menu, select the **Configuration** column, then check that the **Comms. settings** cell is set to **Visible**.
3. Four settings apply to the rear port using IEC 60870-5-103 that are described below.
4. Move down the 'COMMUNICATIONS' column from the column heading to the first cell that indicates the communications protocol:

```
Protocol
DNP 3.0
```

5. The next cell sets the device address on the DNP3.0 network:

```
DNP 3.0 Address
232
```

Up to 32 devices can be connected to one DNP3.0 spur, and therefore it is necessary for each device to have a unique address so that messages from the master control station are accepted by only one device. DNP3.0 uses a decimal number between 1 and 65519 for the device address. It is important that no two devices have the same address. The address is then used by the DNP3.0 master station to communicate with the relay.

6. The next cell sets the baud rate to be used:

```
Baud Rate
9600 bits/s
```

DNP3.0 communication is asynchronous. Six baud rates are supported by the relay '1200bits/s', '2400bits/s', '4800bits/s', '9600bits/s', '19200bits/s' and '38400bits/s'. It is important that whatever baud rate is selected on the relay is the same as that set on the DNP3.0 master station.

7. The next cell controls the parity format used in the data frames:

```
Parity
None
```

The parity can be set to be one of **None**, **Odd** or **Even.** It is important that whatever parity format is selected on the relay is the same as that set on the DNP3.0 master station.

An optional fiber optic card is available in the relay to allow optical connection to the IEC 60870-5-103 communication to be made over an optical connection. When fitted, it converts between EIA(RS)485 signals and fiber optic signals and the following cell is visible in the menu column.

8. The next cell down the column controls the physical media used for the communication.

```
Physical link
Copper
```

The default setting is to select the electrical (copper) connection. If the optional fiber optic interface is fitted to the relay, then this setting can be changed to **Fiber optic**. This cell is invisible if a second rear communications port or an Ethernet card is fitted, as they are mutually exclusive and occupy the same physical location.

9. The next cell down the column sets the time synchronization request from the master by the relay:

```
Time Sync.
Enabled
```

The time synchronization can be set to either enabled or disabled. If enabled it allows the DNP3.0 master to synchronize the time.

10. Analogue values can be set to be reported in terms of primary, secondary or normalized (with respect to the CT/VT ratio setting) values:

```
Meas Scaling
Primary
```

11. A message gap setting is provided:

```
Message Gap
ϕ
```

This allows a gap between message frames to be set to enable compatibility with different master stations.

The setting for enabling/disabling DNP3.0 time synchronization is described above. When DNP3.0 time sync is enabled, the required rate of synchronization, known as the "need time", needs to be set.

12. A setting allows different "need time" to be set with setting range from 1 - 30 minutes, step of 1 minute and default at 10 minutes:

```
DNP Need Time
10mins
```

The transmitted application fragment size can be set to ensure that a Master Station cannot be held too long before a complete reply is received and allow it to move on to next IED in a token ring polling setup.

13. The maximum overall response message length can be configured:

```
DNP App Fragment
2048
```

A single fragment size is 249. Depending on circumstances, a user may set the fragment size as a multiple of 249 in order to optimize segment packing efficiency in fragments. However it can also be useful to allow "odd" sizes for users to choose under specific circumstances, such as if sending data inside SMS frames, through packet radios, etc. In such cases it can be useful to select the fragment size such that each packet occupies a single "transmission media frame".

In some cases, communication to the outstation is made over slow, packet-switched networks which can add seconds to the communication latency.

14. A setting is provided to allow the application layer timeout to be set:

```
DNP App Timeout
2s
```

15. Select Before Operate (SBO) timeouts can be set.
If the DNP3.0 "Select a trip command" causes the relay's internal logic to block automatic tripping, then a corruption of the DNP3.0 "Operate" message could delay the trip. The delay of tripping can be set:

```
DNP SBO Timeout
10s
```

16. The DNP link timeout can be set:

```
DNP Link Timeout
10s
```

3.7 Configuring the Second Rear Communication Port (RP2)

For relays with Courier, MODBUS, IEC60870-5-103 or DNP3.0 protocol on the first rear communications port there is the hardware option of a second rear communications port, which will run the Courier language. This can be used over one of three physical links: twisted pair K-Bus (non-polarity sensitive), twisted pair EIA(RS)485 (connection polarity sensitive) or EIA(RS)232.
The settings for this port are located immediately below the ones for the first port as described in the *Introduction* chapter.

1. Move down the settings until the following sub heading is displayed.

```
Rear Port 2
(RP2)
```

2. The next cell defines the protocol, which is fixed at Courier for RP2.

```
RP2 protocol
Courier
```

3. The following cell indicates the status of the hardware.

```
RP2 card status
EIA(RS)232 OK
```

4. The following cell allows for selection of the port configuration.

```
RP2 port config.
EIA(RS)232
```

5. The port can be configured for EIA(RS)232, EIA(RS)485 or K-Bus.
   As in the case of the first rear Courier port, if K-Bus is not selected certain other cells to control the communication mode and speed become visible. If either EIA(RS)232 or EIA(RS)485 is selected for the port configuration, the next cell is visible and selects the communication mode.

```
RP2 comms.  Mode
IEC60870 FT1.2
```

6. The standard default is the IEC 60870 FT1.2 for normal operation with 11-bit modems. Alternatively, a 10-bit framing with no parity bit can be selected for special cases.
7. The next cell down sets the communications port address.

```
RP2 address
255
```

   Since up to 32 devices can be connected to one K-bus spur, it is necessary for each device to have a unique address so that messages from the master control station are accepted by one device only. Courier uses an integer number between 0 and 254 for the device address that is set with this cell. It is important that no two devices have the same Courier address. The Courier address is then used by the master station to communicate with the device. The default value is 255 and must be changed to a value in the range 0 to 254 before use.
8. The following cell controls the inactivity timer.

```
RP2 InactivTimer
15 mins.
```

9. The inactivity timer controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state. This includes revoking any password access that was enabled. The inactivity timer can be set between 1 and 30 minutes.
10. In the case of EIA(RS)232 and EIA(RS)485 the next cell down controls the baud rate. For K-Bus the baud rate is fixed at 64kbit/second between the relay and the KITZ interface at the end of the relay spur.

```
RP2 baud rate
19200
```

Courier communications is asynchronous and three selections are available to allow the relay communication rate to be matched to that of the connected equipment. The three baud rates supported by the relay are: ‘9600 bits/s’, ‘19200 bits/s’ and ‘38400 bits/s’.

3.8 Fiber Optic Converter (option)

An optional fiber optic card is available in this product. This converts the EIA(RS)485 protocols into a fiber optic output. This communication card is available for use on Courier, MODBUS (for products listed in the *Supported Protocols* table), IEC60870-5-103 and DNP3.0 it adds the following setting to the communication column.

This controls the physical media used for the communication:

```
Physical link
Copper
```

The default setting is to select the electrical EIA(RS)485 connection. If the optional fiber optic connectors are fitted to the relay, then this setting can be changed to '**Fiber optic**'. This cell is also invisible if a second rear comms. port, or Ethernet card is fitted, as it is mutually exclusive with the fiber optic connectors, and occupies the same physical location.

Where this is used, connection should be made using either 50/125µm or 62.5/125µm multi-mode optical fibers terminated with BFOC/2.5 (ST) connectors.

3.9 Second Rear Port K-Bus Application

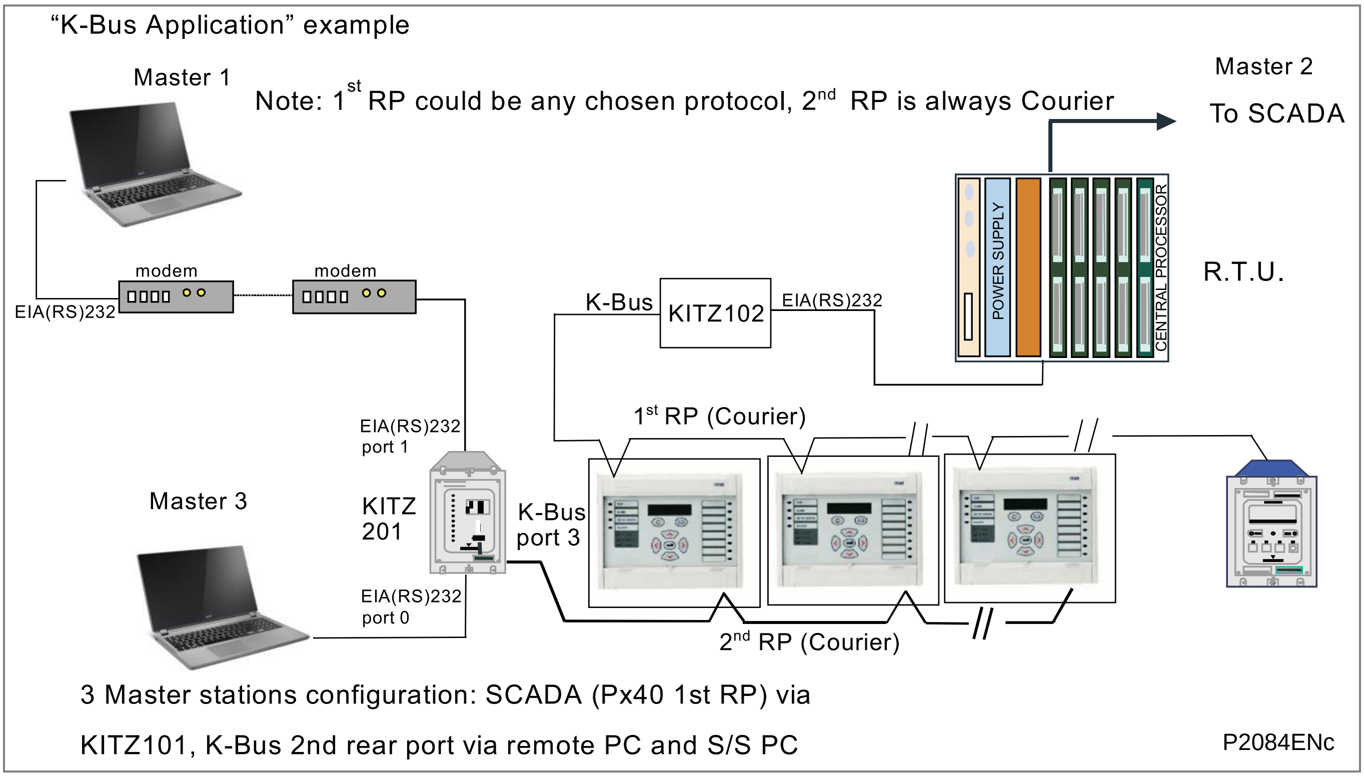


Figure 3 - Second rear port K-Bus application

3.10 Second Rear Port EIA(RS)485 Example

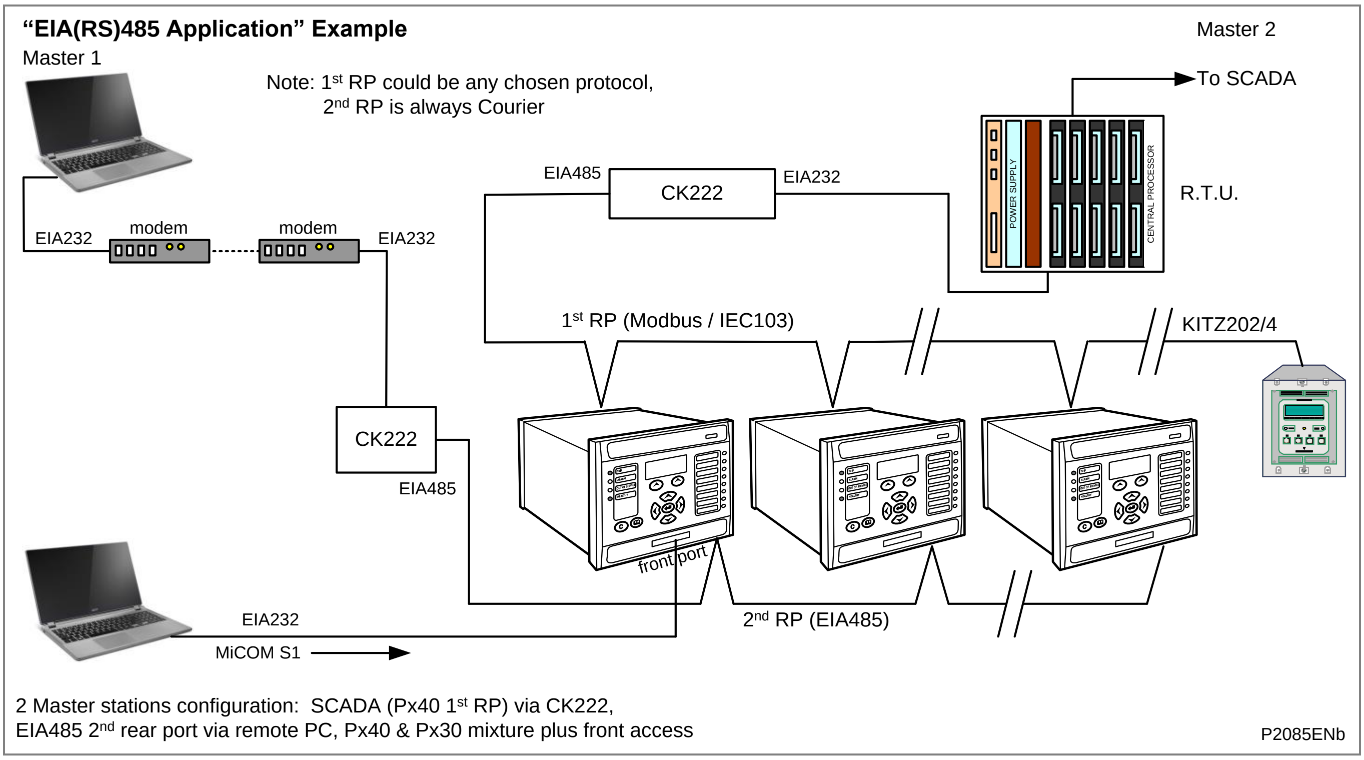


Figure 4 - Second rear port EIA(RS)485 example

3.11 Second Rear Port EIA(RS)232 Example

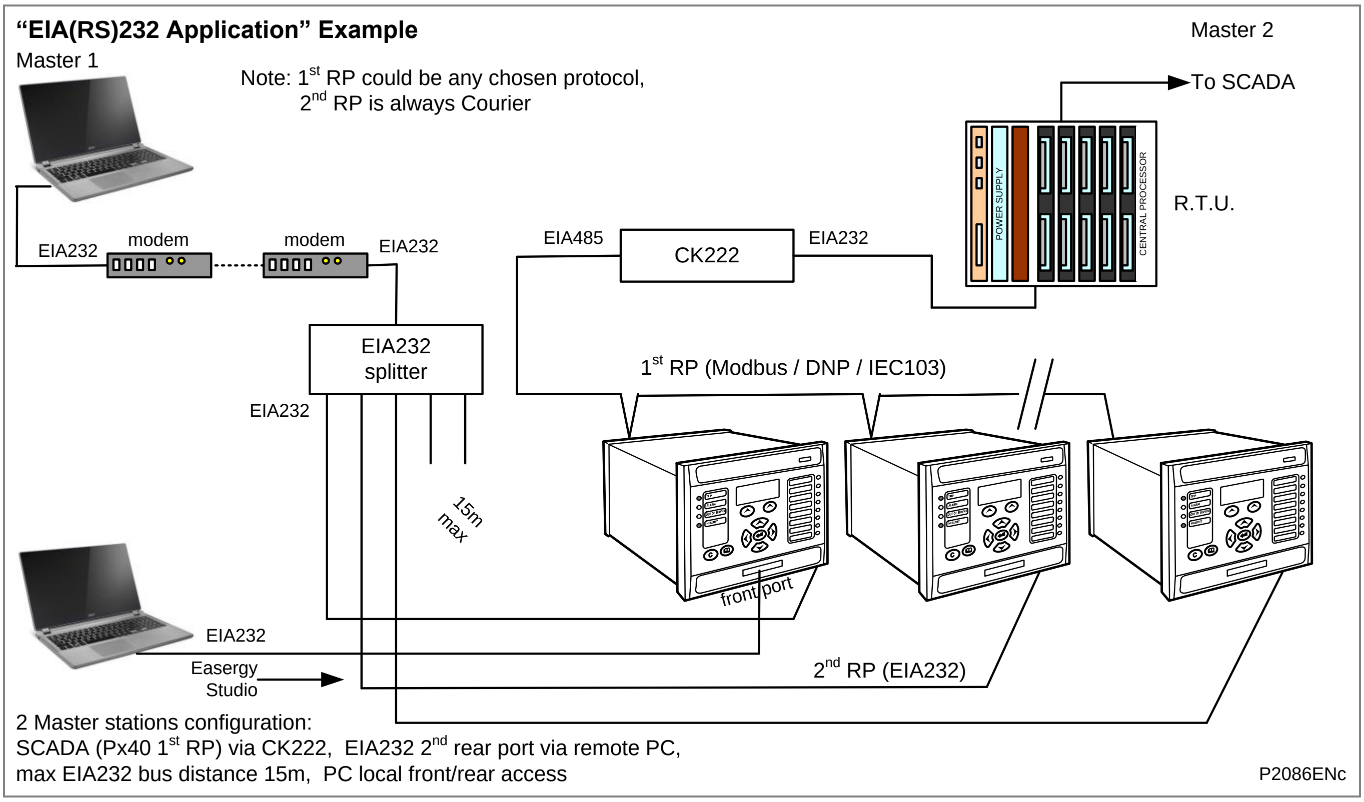


Figure 5 - Second rear port EIA(RS)232 example

3.12 SK5 Port Connection

The lower 9-way D-type connector (SK5) is the InterMiCOM port, which is based on the EIA232 standard.

4 COURIER INTERFACE

4.1 Courier Protocol

Courier is a Schneider Electric communication protocol. The concept of the protocol is that a standard set of commands is used to access a database of settings and data in the relay. This allows a generic master to be able to communicate with different slave devices. The application-specific aspects are contained in the database rather than the commands used to interrogate it, so the master station does not need to be preconfigured.

The same protocol can be used through two physical links K-Bus or EIA(RS)-232.

K-Bus is based on EIA(RS)-485 voltage levels with HDLC FM0 encoded synchronous signaling and its own frame format. The K-Bus twisted pair connection is unpolarized, whereas the EIA(RS)-485 and EIA(RS)-232 interfaces are polarized.

The EIA(RS)-232 interface uses the IEC60870-5 FT1.2 frame format.

The relay supports an IEC60870-5 FT1.2 connection on the front-port. This is intended for temporary local connection and is not suitable for permanent connection. This interface uses a fixed baud rate, 11-bit frame, and a fixed device address.

The rear interface is used to provide a permanent connection for K-Bus and allows multi-drop connection. Although K-Bus is based on EIA(RS)-485 voltage levels, it is a synchronous HDLC protocol using FM0 encoding. It is not possible to use a standard EIA(RS)-232 to EIA(RS)-485 converter to convert IEC60870-5 FT1.2 frames to K-Bus. Also it is not possible to connect K-Bus to an EIA(RS)-485 computer port. A protocol converter, such as the KITZ101, should be used for this purpose.

For a detailed description of the Courier protocol, command-set and link description, see the following documentation:

R6509	K-Bus Interface Guide
R6510	IEC60870 Interface Guide
R6511	Courier Protocol
R6512	Courier User Guide

Alternatively for direct connections, the fiber optic converter card may be used to convert the rear EIA(RS)485 port into a fiber optic (ST) port. See the *Fiber Optic Converter (option)* section for more information.

4.2 Front Courier Port

The front EIA(RS)-232 9 pin port supports the Courier protocol for one-to-one communication. This port complies with EIA(RS)-574; the 9-pin version of EIA(RS)-232, see www.tiaonline.org. It is designed for use during installation and commissioning/maintenance and is not suitable for permanent connection. Since this interface is not used to link the relay to a substation communication system, some of the features of Courier are not implemented. These are as follows:

- Automatic extraction of Event Records:
  - Courier Status byte does not support the Event flag.
  - Send Event/Accept Event commands are not implemented.
- Automatic extraction of Disturbance records:
  - Courier Status byte does not support the Disturbance flag.
- Busy Response Layer:
  - Courier Status byte does not support the Busy flag, the only response to a request is the final data.
- Fixed Address:
  - The address of the front Courier port is always 1; the Change Device address command is not supported.
- Fixed Baud Rate:
  - 19200 bps.
  - Although automatic extraction of event and disturbance records is not supported, it is possible to manually access this data through the front port.

4.3 Supported Command Set

The following Courier commands are supported by the relay:

Protocol Layer:

- Reset Remote Link
- Poll Status
- Poll Buffer*

Low Level Commands:

- Send Event*
- Accept Event*
- Send Block
- Store Block Identifier
- Store Block Footer

Menu Browsing:

- Get Column Headings
- Get Column Text
- Get Column Values
- Get Strings
- Get Text
- Get Value
- Get Column Setting Limits

Setting Changes:

- Enter Setting Mode
- Preload Setting
- Abort Setting
- Execute Setting
- Reset Menu Cell
- Set Value

Control Commands:

- Select Setting Group
- Change Device Address*
- Set Real Time

Note *Commands marked with an asterisk (*) are not supported through the front Courier port.*

4.4 Courier Database

The Courier database is two-dimensional. Each cell in the database is referenced by a row and column address. Both the column and the row can take a range from 0 to 255. Addresses in the database are specified as hexadecimal values, for example, 0A02 is column 0A (10 decimal) row 02. Associated settings or data are part of the same column. Row zero of the column has a text string to identify the contents of the column and to act as a column heading.

The *Relay Menu Database document* contains the complete database definition for the relay. For each cell location the following information is stated:

- Cell Text
- Cell Data type
- Cell value
- Whether the cell is settable, if so
  - Minimum value
  - Maximum value
  - Step size
- Password Level required to allow setting changes
- String information (for Indexed String or Binary flag cells)

4.5 Setting Changes

(See R6512, Courier User Guide - Chapter 9)
Courier provides two mechanisms for making setting changes, both of these are supported by the relay. Either method can be used for editing any of the settings in the relay database.

4.5.1 Method 1

This uses a combination of three commands to perform a settings change:

Enter Setting Mode	Checks that the cell is settable and returns the limits.
Preload Setting	Places a new value to the cell. This value is echoed to ensure that setting corruption has not taken place. The validity of the setting is not checked by this action.
Execute Setting	Confirms the setting change. If the change is valid, a positive response is returned. If the setting change fails, an error response is returned.
Abort Setting	This command can be used to abandon the setting change.

This is the most secure method. It is ideally suited to on-line editors because the setting limits are taken from the relay before the setting change is made. However, this method can be slow if many settings are being changed because three commands are required for each change.

4.5.2 Method 2

The **Set Value** command can be used to directly change a setting, the response to this command is either a positive confirm or an error code to indicate the nature of a failure. This command can be used to implement a setting more rapidly than the previous method, however the limits are not extracted from the relay. This method is most suitable for off-line setting editors such as Easergy Studio, or for issuing preconfigured (SCADA) control commands.

4.5.3 Relay Settings

There are three categories of settings in the relay database:

- Control and support
- Disturbance recorder
- Protection settings group

Setting changes made to the control and support settings are implemented immediately and stored in non-volatile memory. Changes made to either the Disturbance recorder settings or the Protection Settings Groups are stored in a ‘scratchpad’ memory and are not immediately implemented by the relay.

To action setting changes stored in the scratchpad the Save **Changes cell** in the **Configuration** column must be written to. This allows the changes to either be confirmed and stored in non-volatile memory, or the setting changes to be aborted.

4.5.4 Setting Transfer Mode

If it is necessary to transfer all of the relay settings to or from the relay, a cell in the **Communication System Data** column can be used. This cell (location BF03) when set to 1 makes all of the relay settings visible. Any setting changes made with the relay set in this mode are stored in scratchpad memory, including control and support settings. When the value of BF03 is set back to 0, any setting changes are verified and stored in non-volatile memory.

4.6 Event Extraction

Events can be extracted either automatically (rear port only) or manually (either Courier port). For automatic extraction all events are extracted in sequential order using the standard Courier event mechanism, this includes fault/maintenance data if appropriate. The manual approach allows the user to select events, faults, or maintenance data at random from the stored records.

4.6.1 Automatic Event Extraction

(See Chapter 7 Courier User Guide, publication R6512).

This method is intended for continuous extraction of event and fault information as it is produced. It is only supported through the rear Courier port.

When new event information is created, the Event bit is set in the Status byte. This indicates to the Master device that event information is available. The oldest, unextracted event can be extracted from the relay using the Send Event command. The relay responds with the event data, which is either a Courier Type 0 or Type 3 event. The Type 3 event is used for fault records and maintenance records.

Once an event has been extracted from the relay, the Accept Event can be used to confirm that the event has been successfully extracted. If all events have been extracted, the event bit is reset. If there are more events still to be extracted, the next event can be accessed using the **Send Event** command as before.

4.6.2 Event Types

Events are created by the relay under these circumstances:

- Change of state of output contact
- Change of state of opto input
- Protection element operation
- Alarm condition
- Setting change
- Password entered/timed-out
- Fault record (Type 3 Courier Event)
- Maintenance record (Type 3 Courier Event)

4.6.3 Event Format

The Send Event command results in these fields being returned by the relay:

- Cell reference
- Time stamp
- Cell text
- Cell value

The *Relay Menu Database* document for the relevant product, contains a table of the events created by the relay and indicates how the contents of the above fields are interpreted. Fault records and Maintenance records return a Courier Type 3 event, which contains the above fields with two additional fields:

- Event extraction column
- Event number

These events contain additional information that is extracted from the relay using the referenced extraction column. Row 01 of the extraction column contains a setting that allows the fault/maintenance record to be selected. This setting should be set to the event number value returned in the record. The extended data can be extracted from the relay by uploading the text and data from the column.

4.6.4 Manual Event Record Extraction

Column 01 of the database can be used for manual viewing of event, fault, and maintenance records. The contents of this column depend on the nature of the record selected. It is possible to select events by event number and to directly select a fault record or maintenance record by number.

Event Record selection (Row 01)

> This cell can be set to a value between 0 to 249 to select from 250 stored events. 0 selects the most recent record and 249 the oldest stored record. For simple event records, (Type 0) cells 0102 to 0105 contain the event details. A single cell is used to represent each of the event fields. If the event selected is a fault or maintenance record (Type 3), the remainder of the column contains the additional information.

Fault Record Selection (Row 05)

> This cell can be used to select a fault record directly, using a value between 0 and 4 to select one of up to five stored fault records. (0 is the most recent fault and 4 is the oldest). The column then contains the details of the fault record selected.

Maintenance Record Selection (Row F0)

> This cell can be used to select a maintenance record using a value between 0 and 4. This cell operates in a similar way to the fault record selection.

If this column is used to extract event information from the relay, the number associated with a particular record changes when a new event or fault occurs.

4.7 Disturbance Record Extraction

Select Record Number (Row 01)

> This cell can be used to select the record to be extracted. Record 0 is the oldest unextracted record, already extracted older records are assigned positive values, and negative values are used for more recent records. To help automatic extraction through the rear port, the Disturbance bit of the Status byte is set by the relay whenever there are unextracted disturbance records.

Once a record has been selected, using the above cell, the time and date of the record can be read from cell 02. The disturbance record can be extracted using the block transfer mechanism from cell B00B. The file extracted from the relay is in a compressed format. Use Easergy Studio to decompress this file and save the disturbance record in the COMTRADE format.

As has been stated, the rear Courier port can be used to extract disturbance records automatically as they occur. This operates using the standard Courier mechanism, see *Chapter 8 of the Courier User Guide*. The front Courier port does not support automatic extraction although disturbance record data can be extracted manually from this port.

4.8 Programmable Scheme Logic (PSL) Settings

The Programmable Scheme Logic (PSL) settings can be uploaded from and downloaded to the relay using the block transfer mechanism defined in the Courier User Guide.

These cells are used to perform the extraction:

- B204 Domain — Used to select either PSL settings (upload or download) or PSL configuration data (upload only)
- B208 Sub-Domain — Used to select the Protection Setting Group to be uploaded or downloaded.
- B20C Version — Used on a download to check the compatibility of the file to be downloaded with the relay.
- B21C Transfer Mode — Used to set up the transfer process.
- B120 Data Transfer Cell — Used to perform upload or download.

The PSL settings can be uploaded and downloaded to and from the relay using this mechanism. If it is necessary to edit the settings, Easergy Studio must be used because the data is compressed. Easergy Studio also performs checks on the validity of the settings before they are downloaded to the relay.

5 MODBUS INTERFACE

The MODBUS interface is a master/slave protocol and is defined by: www.modbus.org

MODBUS Serial Protocol Reference Guide: PI-MBUS-300 Rev. E

5.1 Communication Link (Serial Interface)

This interface also uses the rear EIA(RS)485 port (or converted fiber optic port) for communication using '**RTU**' mode communication rather than '**ASCII**' mode as this provides more efficient use of the communication bandwidth. This mode of communication is defined by the MODBUS standard.

5.1.1 Character Framing

The character framing is 1 start bit, 7 data bits (least significant bit sent first), 1 bit for even/odd parity or no bit for no parity, 1 stop bit if parity is used or 2 bits if no parity, plus 1 error checking bit. This gives 11 bits per character.

5.1.2 Maximum MODBUS Query and Response Frame Size

The maximum query and response frame size is limited to 260 bytes in total. (This includes the frame header and CRC footer, as defined by the MODBUS protocol.).

5.1.3 User Configurable Communication Parameters

The following parameters can be configured for this port using the product's front panel user interface (in the communications sub-menu):

- Baud rate: 9600, 19200, 38400 bps
- Device address: 1 - 247
- Parity: Odd, even, none.
- Inactivity time: 1 - 30 minutes

The MODBUS interface communication parameters are not part of the product's setting file and cannot be configured with MiCOM S1 Studio.

5.2 Supported MODBUS Query Functions

The MODBUS protocol provides numerous query functions, of which the product supports the subset in the following table. The product responds with exception code 01 if any other query function is received by it.

Query Function Code	MODBUS Query Name	Application / Interpretation
01	Read Coil Status	Read status of output contacts (0x addresses)
02	Read Input Status	Read status of opto-isolated status inputs (1x addresses)
03	Read Holding Registers	Read setting values (4x addresses)
04	Read Input Registers	Read measurement values (3x addresses)
06	Preset Single Register	Write single setting value (4x addresses)
07	Read Exception Status	Read relay status, same value as register 3x1
08	Diagnostics	Application defined by the MODBUS protocol specification
11	Fetch Communication Event Counter	
12	Fetch Communication Event Log	
16	Preset Multiple Registers (127 max)	Write multiple setting values (4x addresses)

Table 4 - MODBUS query functions supported by the product

5.3 MODBUS Response Code Interpretation

Code	MODBUS response name	Product interpretation
01	Illegal Function Code	The function code transmitted is not supported.
02	Illegal Data Address	The start data address in the request is not an allowable value. If any of the addresses in the range cannot be accessed due to password protection, all changes in the request are discarded and this error response is returned. Note If the start address is correct but the range includes non-implemented addresses, this response is not produced.
03	Illegal Value	A value referenced in the data field transmitted by the master is not in range. Other values transmitted in the same packet are executed if they are in the range.
04	Slave Device Failure	An exception arose during the processing of the received query that is not covered by any of the other exception codes in this table.
05	Acknowledge	Not used.
06	Slave Device Busy	The write command cannot be implemented due to the product's internal database being locked by another interface. This response is also produced if the product is busy executing a previous request.

Table 5 - MODBUS response codes interpretation

5.4 Maximum Query and Response Parameters

The following table shows the maximum amount of data that the product can process for each of the supported query functions (see the Supported MODBUS Query Functions section) and the maximum amount of data that can be sent in a corresponding response frame. The principal constraint is the maximum query and response frame size, as noted in the *Maximum MODBUS Query and Response Frame Size* section. Maximum MODBUS query and response frame size.

Query function code	MODBUS query name	Maximum query data request size	Maximum response data size
01	Read Coil Status	32 coils	32 coils
02	Read Input Status	32 inputs	32 inputs
03	Read Holding Registers	127 registers	127 registers
04	Read Input Registers	127 registers	127 registers
06	Preset Single Register	1 register	1 register
07	Read Exception Status	-	8 coils
08	Diagnostics	-	-
11	Fetch Communication Event Counter	-	-
12	Fetch Communication Event Log	-	70 bytes
16	Preset Multiple Registers	127 registers	127 registers

Table 6 - Maximum query and response parameters for supported queries

5.5 Register Mapping

5.5.1 Conventions

5.5.1.1 Memory Pages

The MODBUS specification associates a specific register address space to each query that has a data address field. The address spaces are often called memory pages because they are analogous to separate memory devices. A simplistic view of the queries in MODBUS is that a specified location in a specified memory device is being read from or written to. However, the product's implementation of such queries is not as a memory access but as a translation to an internal database query (see Note).

Note	One consequence of this is that the granularity of the register address space (in the 3x and 4x memory pages) is governed by the size of the data item being requested from the internal database. Since this is often more than the 16 bits of an individual register, not all register addresses are valid. See the Register Data Types section for more details.

Each MODBUS memory page has a name and an ID. The *MODBUS "memory" pages reference and application* table provides a summary of the memory pages, their Ids, and their application in the product.

It is common practice to prefix a decimal register address with the page ID and generally this is the style used in this document.

Memory page ID	MODBUS memory page name	Product application
0xxxx	Coil Status	Read and write access of the Output Relays.
1xxxx	Input Status	Read only access of the Opto-Isolated Status Inputs.
3xxxx	Input Registers	Read-only data access, such as measurements and records.
4xxxx	Holding Registers	Read and write data access, such as product configurations settings and control commands.
6xxxx	Extended Memory File	Not used or supported.
Note xxxx represents the addresses available in the page (0 to 9999).		

Table 7 - MODBUS "memory" pages reference and application

5.5.1.2 MODBUS Register Identification

The MODBUS convention is to document register identifiers with ordinal values (first, second, third…) whereas the actual protocol uses memory-page based register addresses that begin with address zero. Therefore the first register in a memory page is register address zero, the second register is register address 1 and so on. In general, one must be subtracted from a register's identifier to find its equivalent address. The page number notation is not part of the address.

Example:

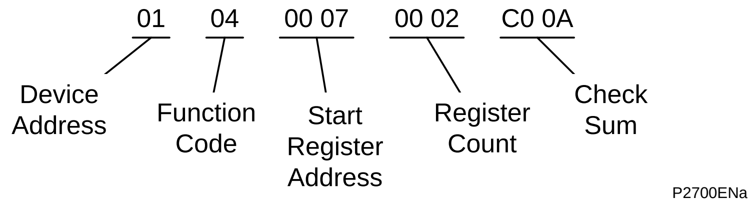
Task:

Obtain the status of the output contacts from the Schneider Electric MiCOM Pxxx device at address 1.

The output contact status is a 32-bit binary string held in input registers 3x8 and 3x9 (see the *Binary Status Information* section).

Select MODBUS function code 4 "Read input registers" and request two registers starting at input register address 7. Note the register address is one less than the required register ordinal.

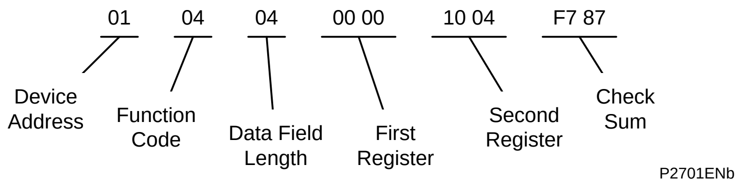
The MODBUS query frame is:



Note that the following frame data is shown in hexadecimal 8-bit bytes.

The frame is transmitted from left to right by the master device. The start register address, register count and check sum are all 16-bit numbers that are transmitted in a high byte - low byte order.

The query may elicit the following response: [4]



The frame was transmitted from left to right by the slave device. The response frame is valid because the eighth bit of the function code field is not set. The data field length is 4 bytes since the query was a read from two 16-bit registers. The data field consists of two pairs of bytes in a high byte - low byte order with the first requested register's data coming first. Therefore the request for the 32-bit output contact status starting at register 3x8 is 00001004h (1000000000100b), which shows that outputs 3 and 13 are energized and the remaining outputs are de-energized.

5.6 Register Map

For a complete map of the MODBUS addresses supported by the product, see the *Relay Menu Database document*.

The register map tables in this document include an Equivalent Courier Cell column. The cell identifiers relate to the product's internal Courier database and may be used in cross-reference with the Courier Protocol documentation or the product's front panel user interface documentation.

The Data Format column specifies the format of the data presented by the associated MODBUS register or registers. The *Register Data Types* section describes the formats used.

The right-hand columns in the tables show whether the register is used in a particular product model. An asterisk indicates that the model uses the register.

5.7 Measurement Values

The product's available measurements are in the form of analog values and counters. Their values are refreshed approximately every second. You can see which entries are measurement values, by opening the Relay Menu Database and looking in the DataCells tab for the word "Measurements" in the Courier Text column. The various rows in the Measurements 1/2/3/4 blocks will show details of the Measurements Name, Equivalent Courier cell, Start/End Register. Data Format and Size, as well as the products the row relates to.

Important	***Values may differ between different MiCOM P40 products.***

5.8 Binary Status Information

Binary status information is available for the product's optically-isolated status inputs (optos), relay contact outputs, alarm flags, control inputs, internal Digital Data Bus (DDB), and the front panel 25-pin test port (see Note).

Note	*The test port allows the product to be configured to map up to eight of its DDB signals (see the Relay Menu Database document) to eight output pins. The usual application is to control test equipment. However, since the test port output status is available on the MODBUS interface, it could be used to efficiently collect up to eight DDB signals.*

The product's internal DDB consists of 1023 binary-status flags. The allocation of the points in the DDB are largely product and version specific. See the *Relay Menu Database document*, for a definition of the product's DDB.

The relay-contact status information is available from the 0x "Coil Status" MODBUS page and from the 3x "Input Register" MODBUS page. For legacy reasons the information is duplicated in the 3x page with explicit registers (8 & 9) and in the DDB status register area (723 & 724).

The current state of the optically isolated status inputs is available from the 1x "Input Status" MODBUS page and from the 3x "Input Register" MODBUS page. The principal 3x registers are part of the DDB status register area (725 & 726). For legacy reasons, a single register at 3x00007 provides the status of the first 16 inputs.

The 0x "Coil Status" and 1x "Input Status" pages allow individual or blocks of binary status flags to be read. The resultant data is left aligned and transmitted in a big-endian (high-order to low-order) format in the response frame. Relay contact 1 is mapped to coil 1, contact 2 to coil 2 and so on. Similarly, opto input 1 is mapped to input 1, opto input 2 to input 2 and so on.

The following table shows the available 3x and 4x binary status information.

Name	Equivalent courier cell	Start register	End register	Data format	Data size (registers)	P642	P643	P645
Opto I/P Status	0030	3x11027	3x11028	G8	2	*	*	*
Relay O/P Status	0040	3x00008	3x00009	G9	2	*	*	*
Alarm Status 1	0050	3x00011	3x00012	G96	2	*	*	*
Alarm Status 2	0051	3x00013	3x00014	G128	2	*	*	*
Alarm Status 3	0052	3x00015	3x00016	G228	2	*	*	*
Ctrl I/P Status	1201	4x00950	4x00951	G202	2	*	*	*
Relay Test Port Status	0F03	3x00722		G1	1	*	*	*
DDB 31 - 0	0F20	3x11023	3x11024	G27	2	*	*	*
DDB 63 - 32	0F21	3x11025	3x11026	G27	2	*	*	*
DDB 95 - 64	0F22	3x11027	3x11028	G27	2	*	*	*
DDB 127 - 96	0F23	3x11029	3x11030	G27	2	*	*	*
DDB 159 - 128	0F24	3x11031	3x11032	G27	2	*	*	*
DDB 191 - 160	0F25	3x11033	3x11034	G27	2	*	*	*
DDB 223 - 192	0F26	3x11035	3x11036	G27	2	*	*	*
DDB 255 - 224	0F27	3x11037	3x11038	G27	2	*	*	*
DDB 287 - 256	0F28	3x11039	3x11040	G27	2	*	*	*
DDB 319 - 288	0F29	3x11041	3x11042	G27	2	*	*	*
DDB 351 - 320	0F2A	3x11043	3x11044	G27	2	*	*	*
DDB 383 - 352	0F2B	3x11045	3x11046	G27	2	*	*	*
DDB 415 - 384	0F2C	3x11047	3x11048	G27	2	*	*	*
DDB 447 - 416	0F2D	3x11049	3x11050	G27	2	*	*	*
DDB 479 - 448	0F2E	3x11051	3x11052	G27	2	*	*	*
DDB 511 - 480	0F2F	3x11053	3x11054	G27	2	*	*	*
DDB 543 - 512	0F30	3x11055	3x11056	G27	2	*	*	*
DDB 575 - 544	0F31	3x11057	3x11058	G27	2	*	*	*
DDB 607 - 576	0F32	3x11059	3x11060	G27	2	*	*	*
DDB 639 - 608	0F33	3x11061	3x11062	G27	2	*	*	*

Name	Equivalent courier cell	Start register	End register	Data format	Data size (registers)	P642	P643	P645
DDB 671 - 640	0F34	3x11063	3x11064	G27	2	*	*	*
DDB 703 - 672	0F35	3x11065	3x11066	G27	2	*	*	*
DDB 735 - 704	0F36	3x11067	3x11068	G27	2	*	*	*
DDB 767 - 736	0F37	3x11069	3x11070	G27	2	*	*	*
DDB 799 - 768	0F38	3x11071	3x11072	G27	2	*	*	*
DDB 831 - 800	0F39	3x11073	3x11074	G27	2	*	*	*
DDB 863 - 832	0F3A	3x11075	3x11076	G27	2	*	*	*
DDB 895 - 864	0F3B	3x11077	3x11078	G27	2	*	*	*
DDB 927 - 896	0F3C	3x11079	3x11080	G27	2	*	*	*
DDB 959 - 928	0F3D	3x11081	3x11082	G27	2	*	*	*
DDB 991 - 960	0F3E	3x11083	3x11084	G27	2	*	*	*
DDB 1023 - 992	0F3F	3x11085	3x11086	G27	2	*	*	*
DDB 1055-1024	0F40	3x11087	3x11088	G27	2	*	*	*
DDB 1087-1056	0F41	3x11089	3x11090	G27	2	*	*	*
DDB 1119-1088	0F42	3x11091	3x11092	G27	2	*	*	*
DDB 1151-1120	0F43	3x11093	3x11094	G27	2	*	*	*
DDB 1183-1152	0F44	3x11095	3x11096	G27	2	*	*	*
DDB 1215-1184	0F45	3x11097	3x11098	G27	2	*	*	*
DDB 1247-1216	0F46	3x11099	3x11100	G27	2	*	*	*
DDB 1279-1248	0F47	3x11101	3x11102	G27	2	*	*	*
DDB 1311-1280	0F48	3x11103	3x11104	G27	2	*	*	*
DDB 1343-1312	0F49	3x11105	3x11106	G27	2	*	*	*
DDB 1375-1344	0F4A	3x11107	3x11108	G27	2	*	*	*
DDB 1407-1376	0F4B	3x11109	3x11110	G27	2	*	*	*
DDB 1439-1408	0F4C	4x10493	4x10494	G27	2	*	*	*
DDB 1471-1440	0F4D	4x10493	4x10494	G27	2	*	*	*
DDB 1503-1472	0F4E	4x10493	4x10494	G27	2	*	*	*
DDB 1535-1504	0F4F	4x10493	4x10494	G27	2	*	*	*
DDB 1567-1536	0F50	4x10493	4x10494	G27	2	*	*	*
DDB 1599-1568	0F51	4x10493	4x10494	G27	2	*	*	*
DDB 1631-1600	0F52	4x10493	4x10494	G27	2	*	*	*
DDB 1663-1632	0F53	4x10493	4x10494	G27	2	*	*	*
DDB 1695-1664	0F54	4x10493	4x10494	G27	2	*	*	*
DDB 1727-1696	0F55	4x10493	4x10494	G27	2	*	*	*
DDB 1759-1728	0F56	4x10493	4x10494	G27	2	*	*	*
DDB 1791-1760	0F57	4x10493	4x10494	G27	2	*	*	*
DDB 1823-1792	0F58	4x10493	4x10494	G27	2	*	*	*
DDB 1855-1824	0F59	4x10493	4x10494	G27	2	*	*	*
DDB 1887-1856	0F5A	4x10493	4x10494	G27	2	*	*	*
DDB 1919-1888	0F5B	4x10493	4x10494	G27	2	*	*	*
DDB 1951-1920	0F5C	4x10493	4x10494	G27	2	*	*	*
DDB 1983-1952	0F5D	4x10493	4x10494	G27	2	*	*	*
DDB 2015-1984	0F5E	4x10493	4x10494	G27	2	*	*	*
DDB 2047-2016	0F5F	4x10493	4x10494	G27	2	*	*	*

Table 8 - Binary status information available in the P64x product range

5.9 Measurement and Binary Status 3x Register Sets

The data available from the 3x input registers is arranged into register sets. A register set is a fixed collection of values in a contiguous block of register addresses. The advantage of this is that multiple values may be read with a single MODBUS query, function code 4 “Read Input Registers”, up to the maximum data limits of the query, see the *Maximum Query and Response Parameters* section.

The definition of a register-set is specified by the selection of a start and end address, which can span multiple contiguous values in the 3x Register, see the *Relay Menu Database document*. The only rule is that a register set must not result in an attempt to read only part of a multi-register data type, see the *Register Data Types* section. A register set can span unused register locations, in which case a value of zero is returned for each such register location.

Some examples of useful register sets are:

- For P64x:
    - 3x701 to 3x786 provide a selection of measurement and binary-status values. Some of these registers are duplicates of other register values.
    - 3x723 to 3x786 provide the DDB status.
    - 3x391 to 3x408 provide the per phase power measurements in floating point format.
    - 3x409 to 3x414 provide the three-phase power measurements in floating point format.
    - 3x184 to 3x193 provide the ten RTD measurement values (P642/P643 only).

There are many other possibilities depending on your application and an appraisal of the 3x Register Map in the *Relay Menu Database document.* The capabilities of the MODBUS master device, performance targets, and communications latencies may also influence the degree to which multiple values are read as register sets, as opposed to individually.

5.10 Controls

The *Control (commands) available in the product range* table shows MODBUS 4x “Holding Registers” that allow the external system to control aspects of the product’s behavior, configuration, records, or items of plant connected to the product such as circuit breakers.

The **Command or setting** column indicates whether the control is a self-resetting “Command” or a state based “Setting”.

“Command” controls automatically return to their default value when the control action has been completed. This may cause problems with masters that try to verify write requests by reading back the value that was written.

“Setting” controls maintain the written value, assuming that it was accepted. For example, the **Active Settings** register reports the current active group on reads. The Active Setting Group register also accepts writes with a valid setting group number to change the active group to the one specified. This assumes that the setting group selection by optically isolated status inputs has not been enabled and that the specified group is enabled.

Entries without a defined setting range, as for the **min.**, **max.** and **step** columns, are binary-string values whose pattern is defined by its stated data type.

5.11 Event Extraction

The product can store up to 512 event records in battery backed-up memory. An event record consists of a time stamp, a record type, and a set of information fields. The record type and the information fields record the event that occurred at the time captured by the time stamp.

The product has several classes of event record:

- Alarm events
- Opto-isolated status input events
- Relay contact output events
- Protection/DDB operation events
- Fault data capture events
- General events

The *Relay Menu Database document* specifies the available events. The product provides an "event filtering" feature that may be used to prevent specific events from being logged. The event filter is configured in the **Record Control** section of the product's menu database in the MiCOM S1 Studio configuration tool.

The product supports two methods of event extraction providing either automatic or manual extraction of the stored event, fault, and maintenance records.

The product stores event, fault, and maintenance records in three separate queues. As entries are added to the fault and maintenance queues, a corresponding event is added to the event queue. Each queue is of different length and each queue may be individually cleared – see the *Event Record Delection* section. It is therefore possible to have a fault event or a maintenance event entry in the event queue with no corresponding entry in the associated queue because it has been overwritten or deleted.

The manual extraction procedure (see the *Manual Extraction Procedure section*) allows each of these three queues to be read independently.

The automatic extraction procedure (sss the *Automatic Extraction Procedure section*) reads records from the event queue. If the event record is a fault or a maintenance record, the record's extended data is read also, if it is available from their queues.

5.11.1 Manual Extraction Procedure

There are three registers used to manually select stored records. For each of these registers, zero represents the most-recent stored record. For example:

- 4x00100 - Select Event, 0 to 511.
  511 was 249 in P24x software version 57, P34x/P64x software versions 01, 02, 03, 04, 05, 06, & 07, since they only stored 250 event records.
- 4x00101 - Select Fault, 0 to 4
- 4x00102 - Select Maintenance Record, 0 to 4

There are also three read-only registers used to determine the number of various types of stored records. For example:

- 3x10000 - Number of stored event records
- 3x10001 - Number of stored fault records
- 3x10002 - Number of stored maintenance records

Each fault or maintenance record logged causes an event record to be created by the product. If this event record is selected, the additional registers showing the fault or maintenance record details are also populated.

5.11.2 Automatic Extraction Procedure

Automatic event-record extraction allows records to be extracted as they occur. Event records are extracted in sequential order, including any fault or maintenance data that may be associated with an event.

The MODBUS master can determine whether the product has any events stored that have not yet been extracted. This is done by reading the product's status register 3x00001 (G26 data type). If the event bit of this register is set, the product contains event records that have not yet been extracted.

To select the next event for sequential extraction, the master station writes a value of one to the record selection register 4x00400 (G18 data type). The event data, plus any fault or maintenance data, can be read from the registers specified in the *Record Data* section. Once the data has been read, the event record is marked. This is done by writing a value of 2 to register 4x00400. The G18 data type consists of bit fields. Therefore it is also possible to both mark the current record as read and automatically select the next unread record. This is done by writing a value of 3 to the register.

When the last (most recent) record is accepted, the event flag in the status register (3x00001) resets. If the last record is accepted by writing a value of 3 to the record selection register (4x00400), a dummy record appears in the event-record registers with an "Event Type" value of 255. Selecting another record when none are available gives a MODBUS exception code 3, "Invalid value" (see the *MODBUS Response Code Interpretation* section).

One possible event record extraction procedure is shown in the following *Automatic event extraction procedure* diagram.

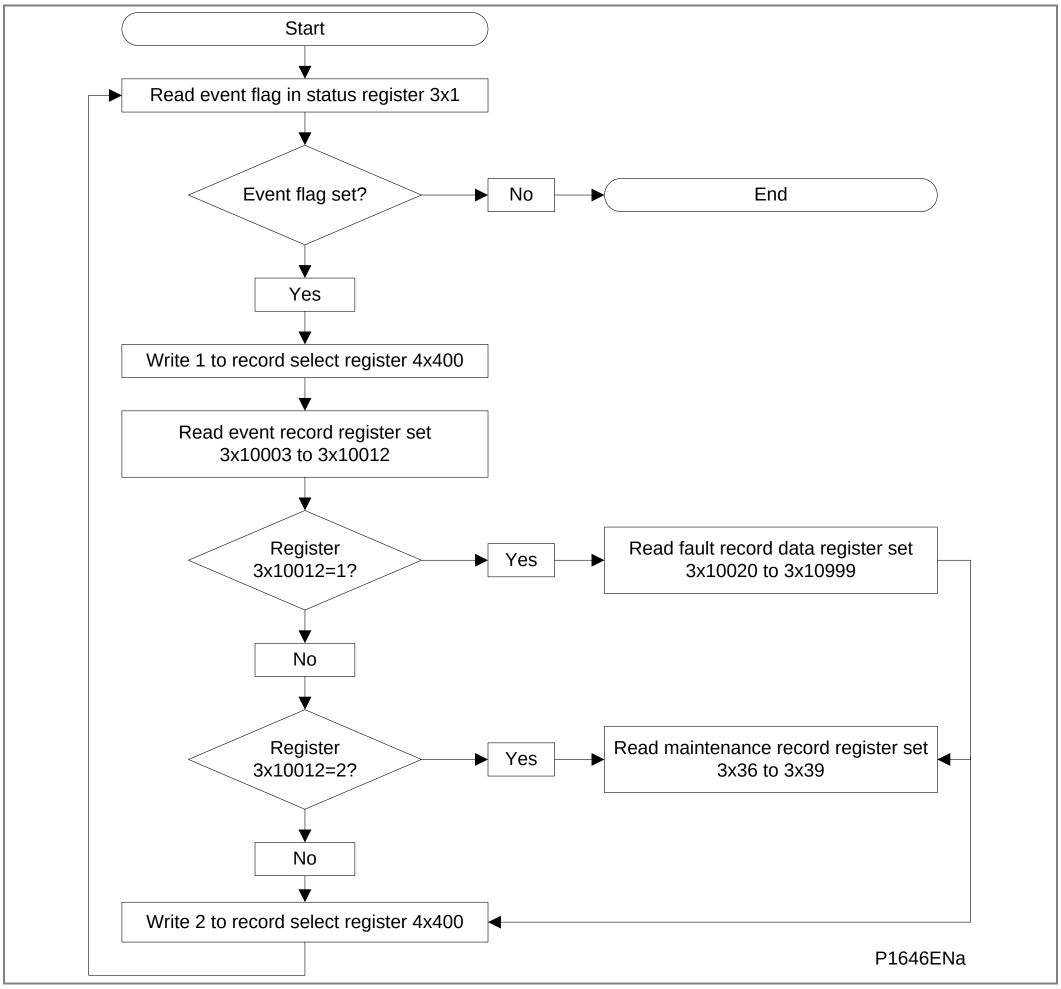


Figure 6 - Automatic event extraction procedure

5.11.3 Record Data

The location and format of the registers used to access the record data is the same whether they have been selected using manual or automatic extraction mechanisms, see the *Manual Extraction Procedure* and *Automatic Extraction Procedure* sections.

Description	Register	Length (registers)	Comments
Time Stamp	3x10003	4	See G12 data type in the Relay Menu Database document, P14x/EN MD.
Event Type	3x10007	1	Indicates the type of the event record. See G13 data type in the Relay Menu Database document, P14x/EN MD (a value of 255 indicates that the end of the event log has been reached).
Event Value	3x10008	2	Contains the associated status register value as a string of binary flags for relay-contact, opto-input, alarm, and protection events. Otherwise it has a value of zero. When a status value is supplied, the value represents the recorded value of the event types associated register pair, as indicated by the Event Origin value (see Note 1).
Event Origin	3x10010	1	The Event Original value indicates the MODBUS Register pair where the change occurred (see Note 2). Possible values are: 30011: Alarm Status 1 event 30013: Alarm Status 2 event 30015: Alarm Status 3 event 30723: Relay contact event (2 registers: DDB 0-31 status) 30725: Status input event (2 registers: DDB 32-63 status) 30727 to 30785: Protection events (Indicates the 32-bit DDB status word that was the origin of the event) For General events, Fault events, and Maintenance events, a value of zero is returned.
Event Index	3x10011	1	The Event Index value is used to distinguish between events with the same Event Type and Event Origin. The registers value depends on the type of the event: For protection events, the value is the ID of the DDB that caused the event. For alarm events, the value is the ID of the alarm that caused the event. In both cases, the value includes the direction of the state transition in the Most Significant Bit. This direction bit is 1 for a 0-1 (low to high) change, and 0 for a 1-0 (high to low) change. For all other types of events, it has a value of zero.
Additional Data Present	3x10012	1	Indicates whether the record has additional data. 0: Indicates that there is no additional data. 1: Indicates that fault record data can be read from 3x10020 to 3x10999 (see Note 3). 2: Indicates that maintenance record data can be read from registers 3x36 to 3x39.

Note 1 *The protection-event status information is the value of the DDB status word that contains the protection DDB that caused the event.*

Note 2 *Subtracting 3000 from the Event Origin value results in the MODBUS 3x memory-page register ID, subtracting one from this results in the MODBUS register address. The resultant register address can be used in a function code 4 MODBUS query.*

Note 3 *The exact number of fault record registers depends on the individual product - see Relay Menu Database, P14x/EN MD.*

Table 9 - Event record extraction registers

If a fault record or maintenance record is directly selected using the manual mechanism, the data can be read from the fault or maintenance data register ranges specified in the *Maintenance record types* table. The event record data in registers 3x10003 to 3x10012 is not valid.

See the *Relay Menu Database document* for the record values for each event.

The general procedure for decoding an event record is to use the value of the **Event Type** field combined with the value of the **Event Index** field to uniquely identify the event. The exceptions to this are event types 4, 5, 7, 8, & 9.

Event types 4 **Relay Contact Output Events** and 5 **Opto-Isolated Status Input Events** only provide the value of the input or output status register (as indicated by the Event Origin value) when the event occurred. If event transition information for each input or output is required, it must be deduced by comparing the event value with the previous event value (for identically-typed events records).

Event type 7 **General Event** events are solely identified by their **Event Value**.

Event types 8 **Fault Record** and 9 **Maintenance Record** require additional registers to be read when the associated additional data is available (see Note). The Fault record registers in the range 3x10020 to 3x10999 (the exact number of registers depends on the individual product) are documented in the 3x register-map in the *Relay Menu Database document*. The two additional 32-bit maintenance record register-pairs consist of a maintenance record type (register pair 3x36/7) and a type-specific error code (register pair 3x38/9). The *Maintenance record types* table lists the different types of maintenance record available from the product.

Note	*As noted at the beginning of the Event Extraction section, it should not be assumed that the additional data is available for fault and maintenance record events.*

Maintenance record	Front panel text	Record type 3x00036
Power on test errors (non-fatal)		
Watchdog 1 failure (fast)	Fast W'Dog Error	0
Battery fail	Battery Failure	1
Battery-backed RAM failure	BBRAM Failure	2
Field voltage failure	Field Volt Fail	3
Ribbon bus check failure	Bus Reset Error	4
Watchdog 2 failure (slow)	Slow W'Dog Error	5
Continuous self-test errors		
SRAM bus failure	SRAM Failure Bus	6
SRAM cell failure	SRAM Failure Blk.	7
Flash EPROM checksum failure	FLASH Failure	8
Program code verify failure	Code Verify Fail	9
Battery-backed RAM failure	BBRAM Failure	10
Battery fail	Battery Failure	11
Field Voltage failure	Field Volt Fail	12
EEPROM failure	EEPROM Failure	13
Fatal software exception	Software Failure	14
Incorrect hardware configuration	H/W Verify Fail	15
Software exception (typically non-fatal)	Non Standard	16
Analog module failure	Ana. Sample Fail	17
Ethernet card error	NIC Soft Error	18

Table 10 - Maintenance record types

5.11.4 Event Record Deletion

It is possible to independently delete ("clear") the stored event, fault, and maintenance record queues. This is done by writing a value of 1, 2, or 3 to register 4x401 (G6 data type), respectively.

Register 4x401 also provides an option to reset the product's front panel indications, which has the same effect as pressing the front panel "Clear" key when viewing alarm indications using the front panel user interface. This is done by writing a value of 4 to register 4x401.

See also the *Disturbance Record Deletion* section for details about deleting disturbance records.

5.11.5 Legacy Event Record Support

Version 57 of P24x and Version 31 of P34x product introduced a new set of 3x registers for the presentation of the event and fault record data. For legacy compatibility, the original registers are supported and are described in this section. They should not be used for new installations and they are correspondingly described as previous MODBUS address in the 3x-register table in the *Relay Menu Database document*.

The *Correspondence of obsolete event record 3x registers with their counterparts* table provides a mapping between the obsolete event record 3x-registers and the registers used in the event record discussions in the previous sub-sections.

The obsolete fault record data between registers 3x113 and 3x199, and 3x490 and 3x499, now exists between registers 3x10020 and 3x10999. In comparison with the obsolete fault record data, the data between registers 3x10020 and 3x10999 is ordered slightly differently and it contains new data values. These new values are not available in the obsolete fault-record register sets.

The maintenance-record registers 3x36 to 3x39 remain unaffected by this evolution.

Description	Obsolete register	Length (registers)	Corresponds to register
Number of stored event records	3x00100	1	3x10100
Number of stored fault records	3x00101	1	3x10101
Number of stored maintenance records	3x00102	1	3x10102
Time Stamp	3x00103	4	3x10103
Event Type	3x00107	1	3x10107
Event Value	3x00108	2	3x10108
Event Origin	3x00110	1	3x10110
Event Index	3x00111	1	3x10111
Additional Data Present	3x00112	1	3x10112

Table 11 - Correspondence of obsolete event record 3x registers with their counterparts

5.12 Disturbance Record Extraction

The product provides facilities for both manual and automatic extraction of disturbance records. The two methods differ only in the mechanism for selecting a disturbance record; the method for extracting the data and the format of the data are identical.

Records extracted are presented in IEEE COMTRADE format. This involves extracting two files: an ASCII text configuration file, and a binary data file.

Each file is extracted by repeatedly reading a data-page until all of the file's data has been transferred. The data-page is made up of 127 registers; providing a maximum of 254 bytes for each register block request.

5.12.1.1 Interface Registers

The following set of registers is presented to the master station to support the extraction of uncompressed disturbance records:

Register	Name	Description
3x00001	Status register	Provides the status of the product as bit flags: b0 Out of service b1 Minor self test failure b2 Event b3 Time synchronization b4 Disturbance b5 Fault b6 Trip b7 Alarm b8 to b15 Unused A '1' in bit "b4" indicates the presence of one or more disturbance records.
3x00800	Number of stored disturbances	Indicates the total number of disturbance records currently stored in the product, both extracted and unextracted.
3x00801	Unique identifier of the oldest disturbance record	Indicates the unique identifier value for the oldest disturbance record stored in the product. This is an integer value used in conjunction with the 'Number of stored disturbances' value to calculate a value for manually selecting records.
4x00250	Manual disturbance record selection register	This register is used to manually select disturbance records. The values written to this cell are an offset of the unique identifier value for the oldest record. The offset value, which ranges from 0 to the No of stored disturbances - 1, is added to the identifier of the oldest record to generate the identifier of the required record.
4x00400	Record selection command register	This register is used during the extraction process and has a number of commands. These are: b0 Select next event b1 Accept event b2 Select next disturbance record b3 Accept disturbance record b4 Select next page of disturbance data b5 Select data file
3x00930 to 3x00933	Record time stamp	These registers return the timestamp of the disturbance record.
3x00802	Number of registers in data page	This register informs the master station of the number of registers in the data page that are populated.
3x00803 to 3x00929	Data page registers	These 127 registers are used to transfer data from the product to the master station.
3x00934	Disturbance record status register	The disturbance record status register is used during the extraction process to indicate to the master station when data is ready for extraction. See next table.
4x00251	Data file format selection	This is used to select the required data file format. This is reserved for future use.

Table 12 - Interface registers

The Disturbance Record status register will report one of the following values:

State		Description
Idle		This will be the state reported when no record is selected; such as after power on or after a record has been marked as extracted.
Busy		The product is currently processing data.
Page ready		The data page has been populated and the master can now safely read the data.
Configuration complete		All of the configuration data has been read without error.
Record complete	4	All of the disturbance data has been extracted.
Disturbance overwritten	5	An error occurred during the extraction process where the disturbance being extracted was overwritten by a new record.
No unextracted disturbances	6	An attempt was made by the master station to automatically select the next oldest unextracted disturbance when all records have been extracted.
Not a valid disturbance	7	An attempt was made by the master station to manually select a record that did not exist in the product.
Command out of sequence	8	The master station issued a command to the product that was not expected during the extraction process.

Table 13 - Disturbance record status register (3x934) values

5.12.2 Extraction Procedure

The following procedure must be used to extract disturbance records from the product. The procedure is split into four sections:

1. Selection of a disturbance, either manually or automatically.
2. Extraction of the configuration file.
3. Extraction of the data file.
4. Accepting the extracted record (automatic extraction only).

5.12.2.1 Manual Extraction Procedure

The procedure used to extract a disturbance manually is shown in the following *Manual selection of a disturbance record* diagram. The manual method of extraction does not allow for the acceptance of disturbance records.

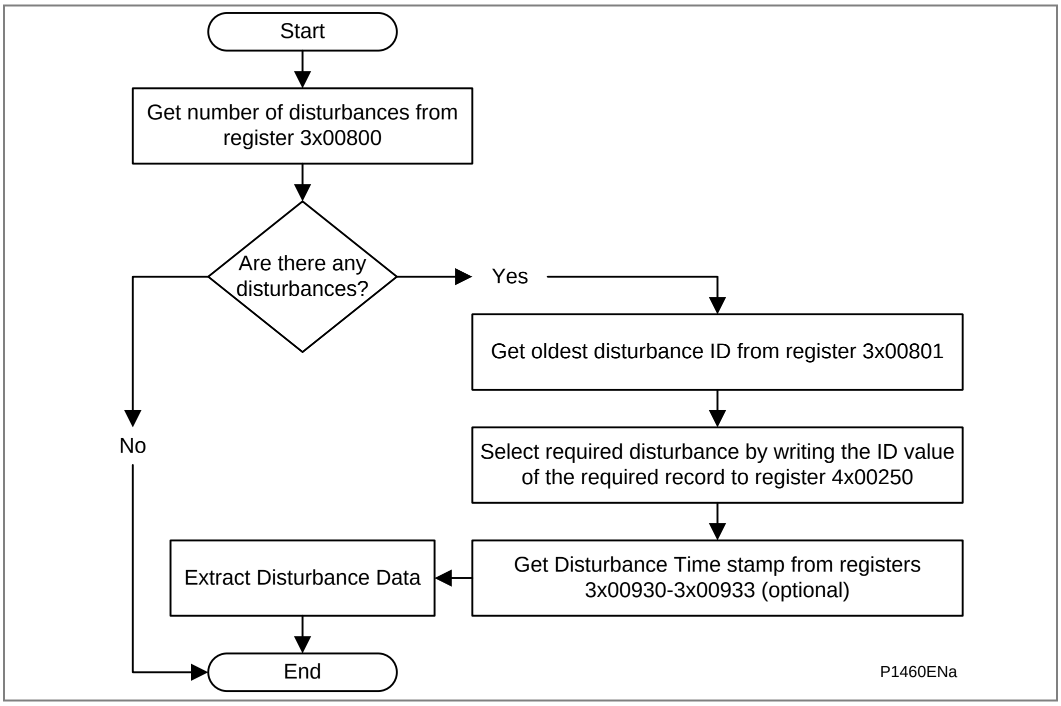


Figure 7 - Manual selection of a disturbance record

5.12.2.2 Automatic Extraction Procedure

There are two methods that can be used for automatically extracting disturbances.

- Option 1 is simpler and is better at extracting single disturbance records, i.e. when the disturbance recorder is polled regularly.
- Option 2, however, is more complex to implement but is more efficient at extracting large quantities of disturbance records. This may be useful when the disturbance recorder is polled only occasionally and hence may have many stored records.

5.12.2.3 Automatic Extraction Procedure – Option 1

There are two methods that can be used for automatically extracting disturbances. The procedure for the first method is shown in the *Automatic selection of a disturbance - option 1* diagram. This also shows the acceptance of the disturbance record once the extraction is complete.

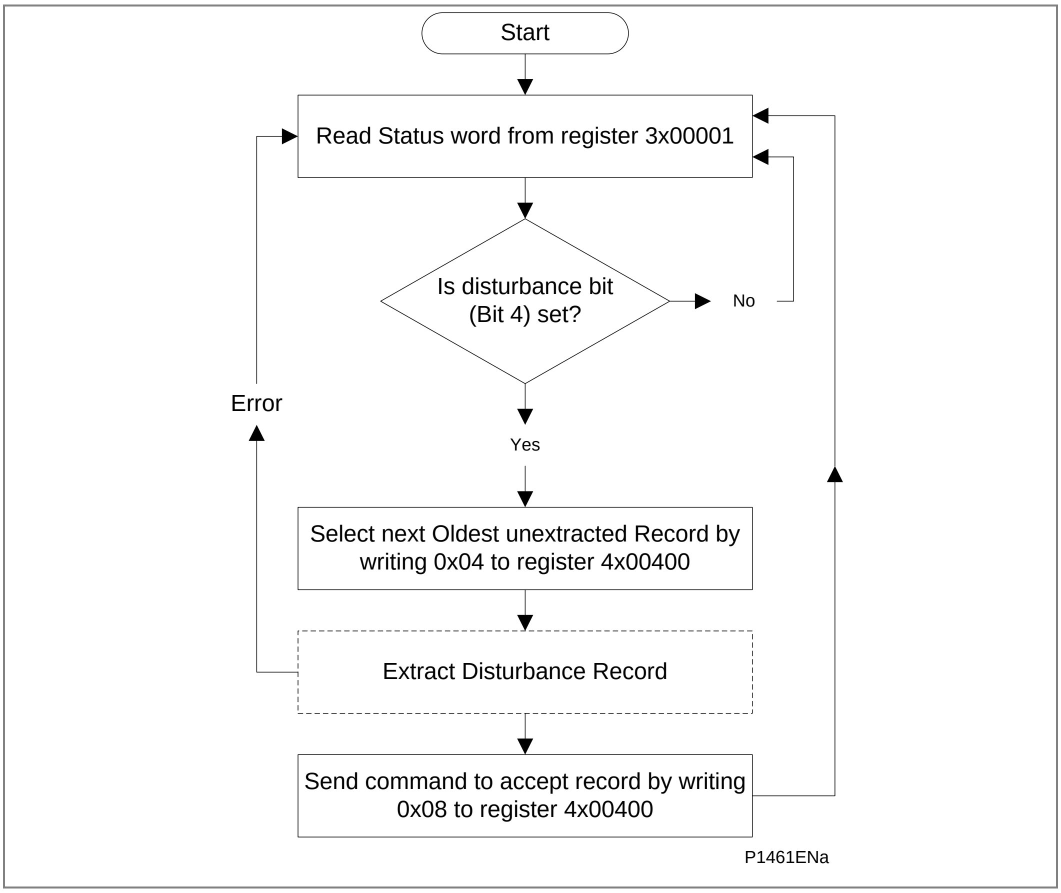


Figure 8 - Automatic selection of a disturbance – option 1

5.12.2.4 Automatic Extraction Procedure – Option 2

The second method that can be used for automatic extraction is shown in the *Automatic selection of a disturbance - option 2* diagram. This also shows the acceptance of the disturbance record once the extraction is complete.

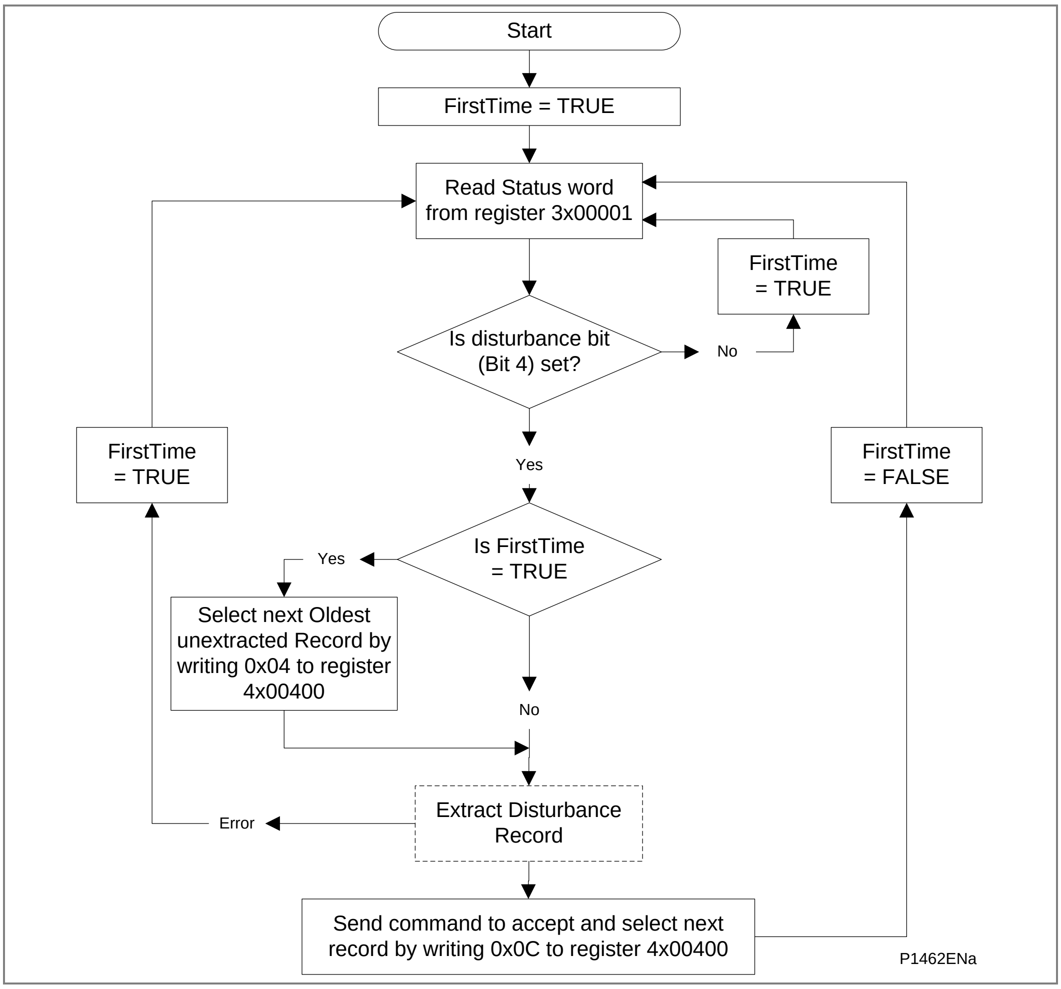


Figure 9 - Automatic selection of a disturbance – option 2

5.12.3 Extracting the Disturbance Data

Extraction of a selected disturbance record is a two-stage process. This involves first reading the configuration file, then the data file. The *Extracting the COMTRADE configuration file* diagram shows how the configuration file is read and *the Extracting the COMTRADE binary data file* diagram shows how the data file is extracted.

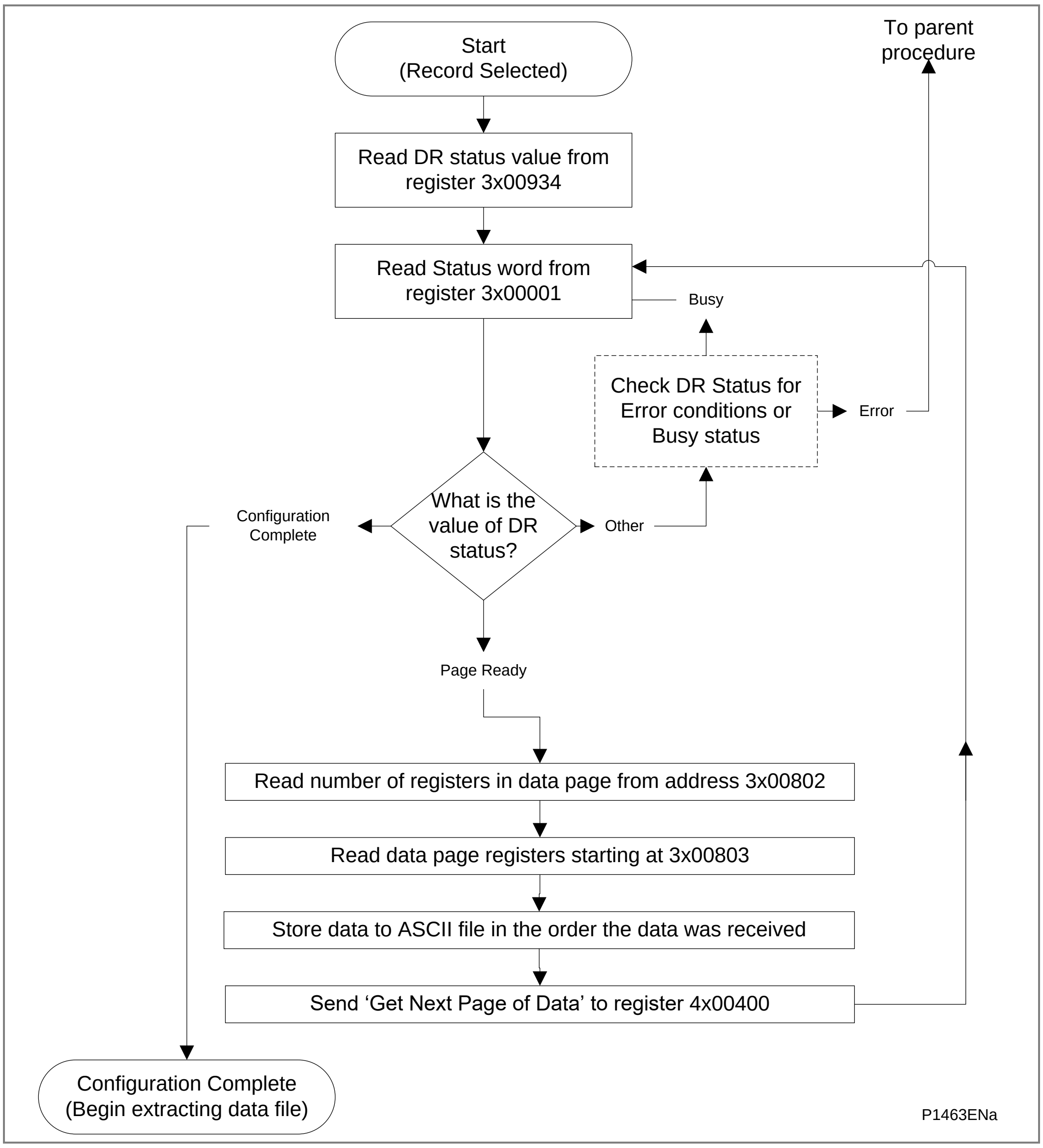


Figure 10 - Extracting the COMTRADE configuration file

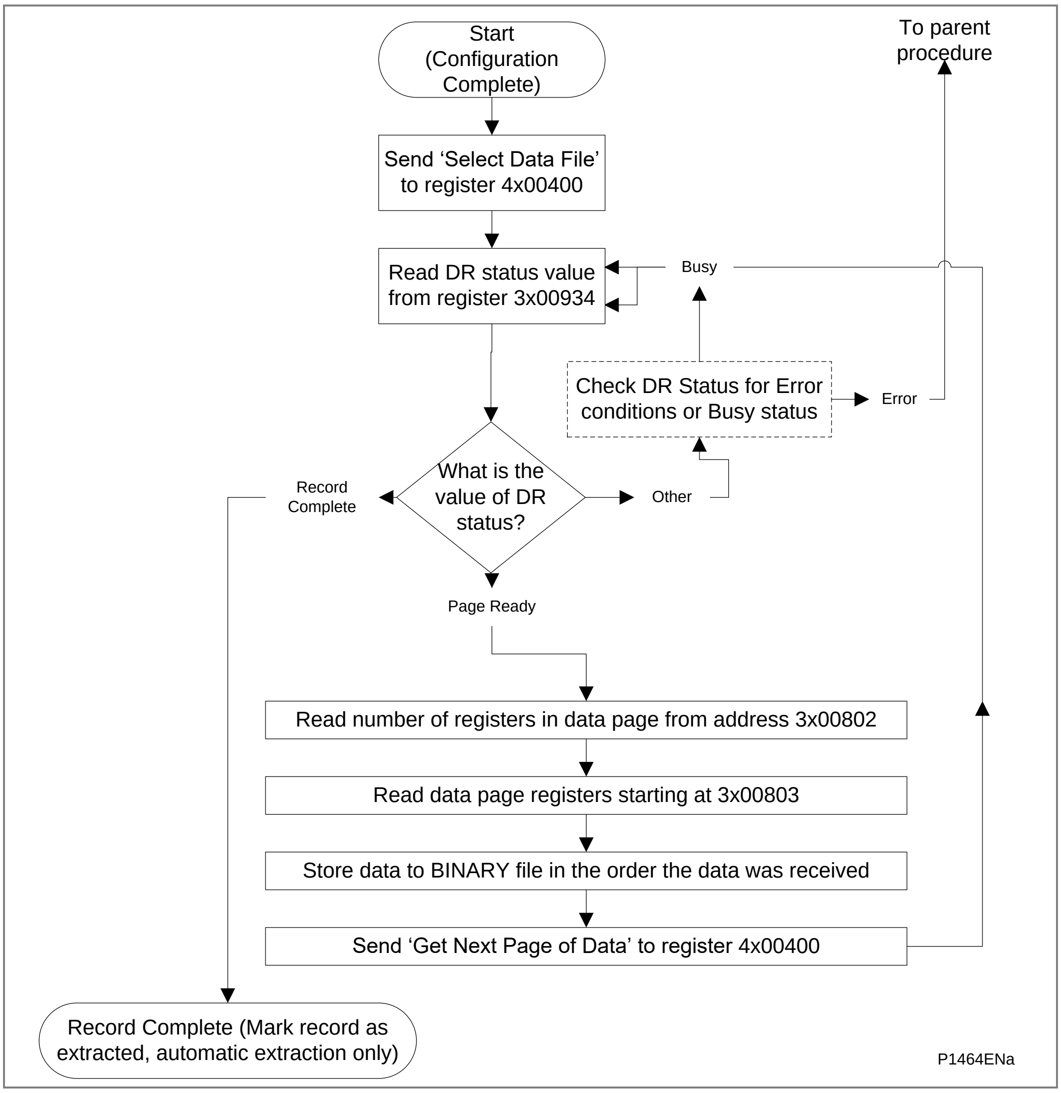


Figure 11 - Extracting the COMTRADE binary data file

During the extraction of a COMTRADE file, an error may occur that is reported in the disturbance record status register, 3x934. This can be caused by the product overwriting the record that is being extracted. It can also be caused by the master issuing a command that is not in the bounds of the extraction procedure.

5.12.4 Storage of Extracted Data

The extracted data needs to be written to two separate files. The first is the configuration file, which is in ASCII text format, and the second is the data file, which is in a binary format.

5.12.4.1 Storing the Configuration File

As the configuration data is extracted from the product, it should be stored to an ASCII text file with a '.cfg' file extension. Each register in the page is a G1 format 16-bit unsigned integer that is transmitted in big-endian byte order. The master must write the configuration file page-data to the file in ascending register order with <u>each register's high order byte written before its low order byte</u>, until all the pages have been processed.

5.12.4.2 Storing the Binary Data File

As the binary data is extracted from the product, it should be stored to a binary file with the same name as the configuration file, but with a '.dat' file extension instead of the '.cfg' extension. Each register in the page is a G1-format 16-bit unsigned integer that is transmitted in big-endian byte order. The master must write the page data to a file in ascending register order with each register's high order byte written before its low order byte until all the pages have been processed.

5.12.5 Disturbance Record Deletion

All of the disturbance records stored in the product can be deleted ("cleared") by writing 5 to the record control register 4x401 (G6 data type). See the *Event Record Deletion* section for details on event record deletion.

5.13 Setting Changes

The relay settings can be split into two categories:

- Control and support settings
- Disturbance record settings and protection setting groups

Changes to settings in the control and support area are executed immediately. Changes to the protection setting groups or the disturbance recorder settings are stored in a temporary 'scratchpad' area and must be confirmed before they are implemented. All the product settings are 4xxxx page registers; see the *Relay Menu Database document*. The following points should be noted when changing settings:

- Settings implemented using multiple registers must be written to using a multi-register write operation. The product does not support write access to sub-parts of multi-register data types.
- The first address for a multi-register write must be a valid address. If there are unmapped addresses in the range that is written to, the data associated with these addresses are discarded.
- If a write operation is performed with values that are out of range, an "illegal data" response code is produced. Valid setting values in the same write operation are executed.
- If a write operation is performed attempting to change registers that require a higher level of password access than is currently enabled, all setting changes in the write operation are discarded.

5.13.1 Password Protection

Access to the product's settings is subject to authentication of a user who has the correct role. The authentication needed to change a setting is shown in the 4x register-map table in the *Relay Menu Database document, P64x/EN MD*.

5.13.2 Control and Support Settings

Control and support settings are committed immediately when a value is written to such a register. The MODBUS registers in this category are:

- 4x00000-4x00599
- 4x00700-4x00999
- 4x02049-4x02052
- 4x10000-4x10999

5.13.2.1 Time Synchronization

The value of the product’s real time clock can be set by writing the desired time (see the *Date and Time Format (Data Type G12)* section) to registers 4x02049 through 4x02052. These registers are standard to Schneider Electric MiCOM products, which makes it easier to broadcast a time synchronization packet, being a block write to the time setting registers sent to slave address zero.

When the product’s time has been set using these registers, the Time Synchronized flag in the MODBUS Status Register (3x1: type G26) is set. The product automatically clears this flag if more than five minutes has elapsed since these registers were last written to.

A “Time synchronization” event is logged if the new time value is more than two seconds different to the current value.

5.13.3 Disturbance Recorder Configuration Settings

Disturbance recorder configuration-settings are written to a scratchpad memory area. A confirmation procedure is required to commit the contents of the scratchpad to the disturbance recorder's set-up, which ensures that the recorders configuration is consistent at all times. The contents of the scratchpad memory can be discarded with the abort procedure. The scratchpad confirmation and abort procedures are described in the *Scratchpad Management* section.

The disturbance recorder configuration registers are in the range:

- 4x00600-4x00699

5.13.4 Protection Settings

Protection configuration-settings are written to a scratchpad memory area. A confirmation procedure is required to commit the contents of the scratchpad to the product’s protection functions, which ensures that their configuration is consistent at all times. The contents of the scratchpad memory can be discarded with the abort procedure. The scratchpad confirmation and abort procedures are described in the *Scratchpad Management* section.

The product supports four groups of protection settings. One protection-group is active and the other three are either dormant or disabled. The active protection-group can be selected by writing to register 4x00404. An illegal data response is returned if an attempt is made to set the active group to one that has been disabled.

The MODBUS registers for each of the four groups are repeated in the following ranges:

- Group 1 4x01000-4x02999, (see note) 4x11000-4x12999
- Group 2 4x03000-4x04999, 4x13000-4x14999
- Group 3 4x05000-4x06999, 4x15000-4x16999
- Group 4 4x07000-4x08999, 4x17000-4x18999

Note	*Registers 4x02049 to 4x02052 are not part of protection setting group #1 so they do not repeat in any of the other protection setting groups. These registers are for time synchronization purposes and are standard for most Schneider Electric products. See the Time Synchronization section.*

5.13.5 Scratchpad Management

Register 4x00405 can be used to either confirm or abort the setting changes in the scratchpad area. In addition to the basic editing of the protection setting groups, these functions are provided:

- Default values can be restored to a setting group or to all of the product settings by writing to register 4x00402.
- It is possible to copy the contents of one setting group to another by writing the source group to register 4x00406 and the target group to 4x00407.
- The setting changes performed by either of these two operations are made to the scratchpad area. These changes must be confirmed by writing to register 4x00405.

5.14 Register Data Types

The product maps one or more MODBUS registers to data-typed information contained in an internal database. These data-types are referred to as G-Types since they have a 'G' prefixed identifier. The *Relay Menu Database document* gives a complete definition of the all of the G-Types used in the product.

Generally the data types are transmitted in high byte to low byte order, also known as "Big Endian format". This may require the MODBUS master to reorder the received bytes into a format that complies with its byte order and register order (for multi-register G-Types) conventions. Most MODBUS masters provide byte-swap and register-swap device (or data point) configuration to cope with the wide range of implementations.

The product's data types cannot be broken into smaller parts. Therefore multi-register data types cannot be read from or written to on an individual register basis. All of the registers for a multi-register data-typed item must be read from or written to with a single block read or write command. The following subsections provide some additional notes for a few of the more complex G-Types.

5.15 Numeric Setting (Data Types G2 & G35)

Numeric settings are integer representations of real (non-integer) values. The register value is the number of setting increments (or steps) that the real value is away from the real minimum value. This is expressed by this formula:

$S_{real} = S_{min.} + (S_{inc.} \times S_{numeric})$

Where:

S_{real} Setting real value

$S_{min.}$ Setting real minimum value

$S_{inc.}$ Setting real increment (step) value

$S_{numeric}$ Setting numeric (register) value

For example, a setting with a real value setting range of 0.01 to 10 in steps of 0.01 would have the following numeric setting values:

Real value (S_{real})	Numeric value ($S_{numeric}$)
0.01	0
0.02	1
1.00	99

Table 14 - Real and numeric values

The G2 numeric data type uses 1 register as an unsigned 16-bit integer, whereas the G35 numeric data type uses 2 registers as an unsigned 32-bit integer. The G2 data type therefore provides a maximum setting range of $2^{16} \times S_{inc}$. Similarly the G35 data type provides a maximum setting range of $2^{32} \times S_{inc}$.

5.16 Date and Time Format (Data Type G12)

The date-time data type G12 allows real date and time information to be conveyed down to a resolution of 1 ms. The data-type is used for record time-stamps and for time synchronization (see the *Time Synchronization* section).

The structure of the data type is shown in the following table and complies with the IEC60870-5-4 Binary Time 2a format.

Byte	Bit Position							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
1	m^7	m^6	m^5	m^4	m^3	m^2	m^1	m^0
2	m^{15}	m^{14}	m^{13}	m^{12}	m^{11}	m^{10}	m^9	m^8
3	IV	R	I^5	I^4	I^3	I^2	I^1	I^0
4	SU	R	R	H^4	H^3	H^2	H^1	H^0
5	W^2	W^1	W^0	D^4	D^3	D^2	D^1	D^0
6	R	R	R	R	M^3	M^2	M^1	M^0
7	R	Y^6	Y^5	Y^4	Y^3	Y^2	Y^1	Y^0

Where:

m	=	0…59,999ms	Y	=	0…99 Years (year of century)
I	=	0…59 minutes	R	=	Reserved bit = 0
H	=	0…23 Hours	SU	=	Summertime: 0=standard time, 1=summer time
W	=	1…7 Day of week; Monday to Sunday, 0 for not calculated	IV	=	Invalid value: 0=valid, 1=invalid
D	=	1…31 Day of Month			
M	=	1…12 Month of year; January to December	range	=	0ms…99 years

Table 15 - G12 date & time data type structure

The seven bytes of the structure are packed into four 16-bit registers. Two packing formats are provided: standard and reverse. The prevailing format is selected by the G238 setting in the **Date and Time** menu column or by register 4x306 (Modbus IEC Time).

The standard packing format is the default and complies with the IEC60870-5-4 requirement that byte 1 is transmitted first. This is followed by byte 2 through to byte 7, followed by a null (zero) byte to make eight bytes in total. Since register data is usually transmitted in big-endian format (high-order byte followed by low-order byte), byte 1 is in the high-order byte position followed by byte 2 in the low-order position for the first register. The last register contains just byte 7 in the high-order position and the low-order byte has a value of zero.

The reverse packing format is the exact byte transmission order reverse of the standard format. The null (zero) byte is sent as the high-order byte of the first register and byte 7 as the register’s low-order byte. The second register’s high-order byte contains byte 6 and byte 5 in its low order byte.

Both packing formats are fully documented in the *Relay Menu Database document* for the G12 type.

The principal application of the reverse format is for date-time packet format consistency when a mixture of MiCOM Px20, Px30, and Px40 series products are being used. This is especially true when there is a requirement for broadcast time synchronization with a mixture of such MiCOM products.

The data type provides only the value for the year of the century. The century must be deduced. The century could be imposed as 20 for applications not dealing with dates stored in this format from the previous (20th) century. Alternatively, the century can be calculated as the one that produces the nearest time value to the current date. For example: 30-12-99 is 30-12-1999 when received in 1999 & 2000, but is 30-12-2099 when received in 2050. This technique allows 2-digit years to be accurately converted to 4 digits in a ±50 year window around the current datum.

The invalid bit has two applications:

- It can indicate that the date-time information is considered inaccurate, but is the best information available.
- Date-time information is not available.

The summertime bit is used to indicate that summertime (day light saving) is being used and, more importantly, to resolve the alias and time discontinuity which occurs when summertime starts and ends. This is important for the correct time correlation of time stamped records.

Note	*The value of the summertime bit does not affect the time displayed by the product.*

The day of the week field is optional and if not calculated is set to zero.

This data type (and therefore the product) does not cater for time zones so the end user must determine the time zone used by the product. UTC (universal co-ordinated time) is commonly used and avoids the complications of daylight saving timestamps.

5.17 Power and Energy Measurement Data Formats (G29 & G125)

The power and energy measurements are available in two data formats, G29 integer format and G125 IEEE754 floating point format. The G125 format is preferred over the older G29 format.

For historical reasons the registers listed in the main part of the "**Measurements 2**" column of the *Menu Database* are of the G29 format. The floating point, G125, versions appear at the end of the column.

5.17.1 Data Type G29

Data type G29 consists of three registers. The first register is the per-unit power or energy measurement and is of type G28, which is a signed 16-bit quantity. The second and third registers contain a multiplier to convert the per-unit value to a real value.

The multiplier is of type G27, which is an unsigned 32-bit quantity. Therefore the overall value conveyed by the G29 data type must be calculated as G29 = G28 × G27.

The product calculates the G28 per unit power or energy value as

G28 = ((measured secondary quantity) / (CT secondary) × (110 V / (VT secondary)).

Since data type G28 is a signed 16-bit integer, its dynamic range is constrained to ±32768. This limitation should be borne in mind for the energy measurements, as the G29 value saturates a long time before the equivalent G125.

The associated G27 multiplier is calculated as

G27 = (CT primary) × (VT primary / 110 V)
when primary value measurements are selected,
and as
G27 = (CT secondary) × (VT secondary / 110 V)
when secondary value measurements are selected.

Due to the required truncations from floating point values to integer values in the calculations of the G29 component parts and its limited dynamic range, the use of the G29 values is only recommended when the MODBUS master cannot deal with the G125 IEEE754 floating point equivalents.

Note	*The G29 values must be read in whole multiples of three registers. It is not possible to read the G28 and G27 parts with separate read commands.*

Example:

For A-Phase Power (Watts) (registers 3x00300 - 3x00302) for a 110 V nominal,
In = 1 A, VT ratio = 110 V:110 V and CT ratio = 1 A : 1 A.

Applying A-phase 1A @ 63.51V

A-phase Watts = ((63.51 V × 1 A) / In=1 A) × (110/Vn=110 V) = 63.51 Watts

The G28 part of the value is the truncated per unit quantity, which is equal to 64 (40h).

The multiplier is derived from the VT and CT ratios set in the product, with the equation ((CT Primary) × (VT Primary) / 110 V)). Therefore the G27 part of the value equals 1 and the overall value of the G29 register set is 64×1 = 64 W.

The registers would contain:

3x00300 - 0040h
3x00301 - 0000h
3x00302 - 0001h

Using the previous example with a VT ratio = 110,000 V:110 V and CT ratio = 10,000 A : 1 A the G27 multiplier would be 10,000 A × 110,000 V / 110 = 10,000,000. The overall value of the G29 register set is 64 × 10,000,000 = 640 MW. (Note that there is an actual error of 49 MW in this calculation due to loss of resolution).

The registers would contain:

3x00300 - 0040h
3x00301 - 0098h
3x00302 - 9680h

5.17.2 Data Type G125

Data type G125 is a short float IEEE754 floating point format, which occupies 32 bits in two consecutive registers. The most significant 16 bits of the format are in the first (low order) register and the least significant 16 bits in the second register.

The value of the G125 measurement is as accurate as the product's ability to resolve the measurement after it has applied the secondary or primary scaling factors as required. It does not suffer from the truncation errors or dynamic range limitations associated with the G29 data format.

6 IEC60870-5-103 INTERFACE

The IEC60870-5-103 interface is a master/slave interface with the relay as the slave device. The relay conforms to compatibility level 2; compatibility level 3 is not supported.

These IEC60870-5-103 facilities are supported by this interface:

- Initialization (Reset)
- Time Synchronization
- Event Record Extraction
- General Interrogation
- Cyclic Measurements
- General Commands
- Disturbance Record Extraction
- Private Codes

6.1 Physical Connection and Link Layer

Two connection options are available for IEC60870-5-103, either the rear EIA(RS)-485 port or an optional rear fiber optic port. If the fiber optic port is fitted, the active port can be selected using the front panel menu or the front Courier port. However the selection is only effective following the next relay power up.

For either of the two connection modes, both the relay address and baud rate can be selected using the front panel menu or the front Courier port. Following a change to either of these two settings a reset command is required to re-establish communications, see the description of the reset command in the *Initialization* section.

6.2 Initialization

Whenever the relay has been powered up, or if the communication parameters have been changed, a reset command is required to initialize the communications. The relay responds to either of the two reset commands (Reset CU or Reset FCB). However, the Reset CU clears any unsent messages in the relay's transmit buffer.

The relay responds to the reset command with an identification message ASDU 5. The Cause Of Transmission (COT) of this response is either Reset CU or Reset FCB depending on the nature of the reset command. For information on the content of ASDU 5 see *section IEC60870-5-103 in the Relay Menu Database document*.

In addition to the ASDU 5 identification message, if the relay has been powered up it also produces a power-up event.

6.3 Time Synchronization

The relay time and date can be set using the time synchronization feature of the IEC60870-5-103 protocol. The relay corrects for the transmission delay as specified in IEC60870-5-103. If the time synchronization message is sent as a send / confirm message, the relay responds with a confirm. Whether the time-synchronization message is sent as a send / confirm or a broadcast (send / no reply) message, a time synchronization Class 1 event is generated.

If the relay clock is synchronised using the IRIG-B input, it is not possible to set the relay time using the IEC60870-5-103 interface. If the time is set using the interface, the relay creates an event using the current date and time from the internal clock, which is synchronised to IRIG-B.

6.4 Spontaneous Events

Events are categorized using the following information:

- Function Type
- Information Number

The IEC60870-5-103 profile in the *Relay Menu Database document*, contains a complete listing of all events produced by the relay.

6.5 General Interrogation

The General Interrogation (GI) request can be used to read the status of the relay, the function numbers, and information numbers that are returned during the GI cycle. See the IEC60870-5-103 profile in the *Relay Menu Database document*.

6.6 Cyclic Measurements

The relay produces measured values using ASDU 9 cyclically. This can be read from the relay using a Class 2 poll (note ADSU 3 is not used). The rate at which the relay produces new measured values can be controlled using the Measurement Period setting. This setting can be edited from the front panel menu or the front Courier port and is active immediately following a change.

The measurands transmitted by the relay are sent as a proportion of 2.4 times the rated value of the analog value.

6.7 Commands

A list of the supported commands is contained in the *Relay Menu Database document*. The relay responds to other commands with an ASDU 1, with a Cause of Transmission (COT) indicating ‘negative acknowledgement’.

6.8 Test Mode

The **Test Mode** menu cell (in the **COMMISSION TESTS** column) is used to allow secondary injection testing to be performed on the relay.

To select test mode set the Test Mode menu cell to ‘**Test Mode**’. It causes an alarm condition to be recorded, the yellow ALARM LED to light and an alarm message ‘**Test Mode Alm**’ to be generated.

Test Mode freezes any information stored in the **CB CONDITION** column and (in IEC60870-5-103 builds) changes the Cause Of Transmission (COT) to Test Mode. For relays supporting IEC 61850 Edition 2, the test bit for data quality attribute shall set to TRUE, and the Logical Device Mode will set to test.

Test mode can also be enabled by energizing an opto mapped to the **Test Mode** signal.

To enable testing of output contacts set the **Test Mode** cell to **Contacts Blocked**. It causes an alarm condition to be recorded, the yellow ALARM LED to light and an alarm message ‘**Contacts Blk Alm**’ to be generated.

In **Contact Blocked** mode, the protection function still works but the contacts will not operate. Also the **test pattern** and contact test functions are visible, which can be used to manually operate the output contacts. For relays supporting IEC 61850 Edition 2, the test bit for data quality attribute shall set to TRUE, and the Logical Device Mode will set to test/blocked.

Contacts Blocked can also be enabled by energizing an opto mapped to the **Contacts Blocked** signal.

Once testing is complete the cell must be set back to ‘**Disabled**’ to restore the relay back to service.

WARNING **If you use or enable Test Mode, you must disable Test Mode before putting the relay back into active service. IT IS POTENTIALLY EXTREMELY UNSAFE TO ATTEMPT TO USE ANY RELAY WHICH IS STILL IN TEST MODE IN ACTIVE SERVICE.**

6.9 Disturbance Records

The disturbance records are stored in uncompressed format and can be extracted using the standard mechanisms described in IEC60870-5-103.

Note IEC60870-5-103 only supports up to 8 records.

6.10 Blocking of Monitor Direction

The relay supports a facility to block messages in the Monitor direction and in the Command direction. Messages can be blocked in the Monitor and Command directions using the menu commands, Communications - CS103 Blocking -
Disabled / Monitor Blocking / Command Blocking or DDB signals Monitor Blocked and Command Blocked.

6.11 Setting Changes through IEC103 Protocol

The IEC 870-5-103 Standard suggests using the generic services for read/write operations on the proprietary data of different manufacture protection equipments, the directory structure specified by the standard for accessing the generic data is the same as the Px40 setting structure. With the generic services selected in the Platform Software full access to the relay’s database is possible over the first rear communications port using the IEC608070-5-103 protocol with Level 3 compatibility.

Each cell in the database has an attribute that defines whether it is included in the list of cells that are subject to a General Interrogation of Generic data.

The following Group 1,2,3 and 4 settings will be included in the GGI:

- Overcurrent, Neg Seq O/C, Broken Conductor, Earth Fault 1 and 2,
- SEF/REF Prot'n, Residual O/V NVD, Thermal Overload, NEG Sequence O/V,
- Cold Load Pickup, Selective Logic, Admit Protection, Power Protection,
- Volt Protection, Freq Protection, CB FAIL & I<, Supervision,
- Fault Locator, System Checks, Autoreclose, ADV.Frequency.

7 DNP3.0 INTERFACE

7.1 DNP3.0 Protocol

The DNP3.0 protocol is defined and administered by the DNP Users Group. For information on the user group, DNP3.0 in general and the protocol specifications, see www.dnp.org

The descriptions given there are intended to accompany the device profile document that is included in the *Relay Menu Database document.* The DNP3.0 protocol is not described here, please refer to the documentation available from the user group. The device profile document specifies the full details of the DNP3.0 implementation for the relay. This is the standard format DNP3.0 document that specifies which objects; variations and qualifiers are supported. The device profile document also specifies what data is available from the relay using DNP3.0. The relay operates as a DNP3.0 slave and supports subset level 2 of the protocol, plus some of the features from level 3.

DNP3.0 communication uses the EIA(RS)-485 communication port at the rear of the relay. The data format is 1 start bit, 8 data bits, an optional parity bit and 1 stop bit. Parity is configurable (see menu settings below).

7.2 DNP3.0 Menu Setting

The following settings are in the DNP3.0 menu in the ***Communications*** column.

Settings	Range	Description
Remote Address	0 - 65519	DNP3.0 address of relay (decimal)
Baud Rate	1200, 2400, 4800, 9600, 19200, 38400	Selectable baud rate for DNP3.0 serial communication
Parity	None, Odd, Even	Parity setting
DNP Time Sync	Disabled, Enabled	If set to 'Enabled' the DNP3.0 master station can be used to synchronize the time on the IED. If set to 'Disabled' either the internet free running clock, or IRIG-B input are used.
Meas Scaling	Primary, Secondary or Normalised	Setting to report analog values in terms of primary, secondary or normalized (with respect to the CT/VT ratio setting) values.
Message Gap (ms)	0-50	DNP3.0 versions only. This setting allows the master station to have an interframe gap.
DNP Need Time	1 - 30 mins	The length of time waited before requesting another time sync from the master.
DNP App Fragment	100 - 2048 bytes	The maximum message length (application fragment size) transmitted by the relay.
DNP App Timeout	1 - 120 s	The length of time waited after sending a message fragment and waiting for a confirmation from the master.
DNP SBO Timeout	1 - 10 s	The length of time waited after receiving a select command and waiting for an operate confirmation from the master.
DNP Link Timeout	0 - 120 s	The length of time the relay waits for a Data Link Confirm from the master. A value of 0 means data link support disabled and 1 to 120 seconds is the timeout setting.

Table 16 - DNP3.0 Menu Settings

7.3 Object 1 Binary Inputs

Object 1, binary inputs, contains information describing the state of signals in the relay, which mostly form part of the Digital Data Bus (DDB). In general, these include the state of the output contacts and input optos, alarm signals and protection start and trip signals. The 'DDB number' column in the device profile document provides the DDB numbers for the DNP3.0 point data. These can be used to cross-reference to the DDB definition list. See the *Relay Menu Database document*. The binary input points can also be read as change events using object 2 and object 60 for class 1-3 event data.

7.4 Object 10 Binary Outputs

Object 10, binary outputs, contains commands that can be operated using DNP3.0. Therefore the points accept commands of type pulse on [null, trip, close] and latch on/off as detailed in the device profile in the *Relay Menu Database document* and execute the command once for either command. The other fields are ignored (queue, clear, trip/close, in time and off time).

There is an additional image of the control inputs. Described as alias control inputs, they reflect the state of the control input, but with a dynamic nature.

- If the Control Input DDB signal is already SET and a new DNP SET command is sent to the Control Input, the Control Input DDB signal goes momentarily to RESET and then back to SET.
- If the Control Input DDB signal is already RESET and a new DNP RESET command is sent to the Control Input, the Control Input DDB signal goes momentarily to SET and then back to RESET.

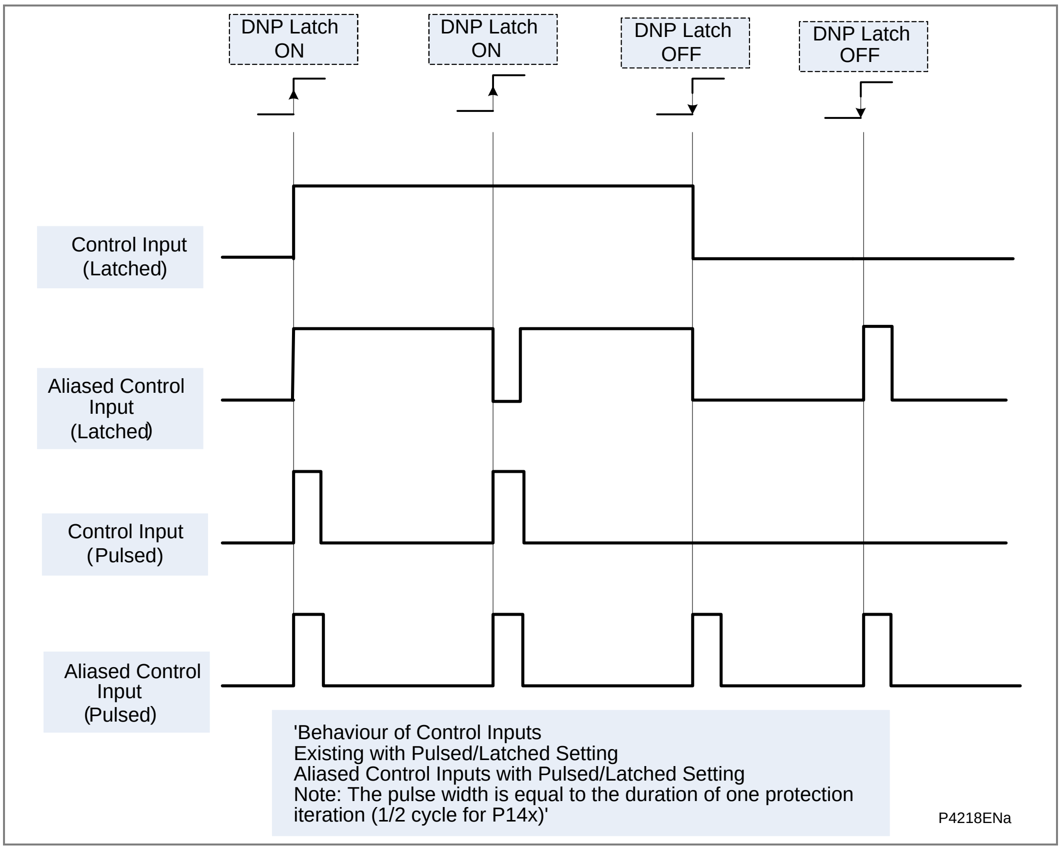


Figure 12 - Behavior when control input is set to pulsed or latched

Many of the relay's functions are configurable so some of the object 10 commands described in the following sections may not be available. A read from object 10 reports the point as off-line and an operate command to object 12 generates an error response.

Examples of object 10 points that maybe reported as off-line are:

- Activate setting groups — Ensure setting groups are enabled
- CB trip/close — Ensure remote CB control is enabled
- Reset NPS thermal — Ensure NPS thermal protection is enabled
- Reset thermal O/L — Ensure thermal overload protection is enabled
- Reset RTD flags — Ensure RTD Inputs is enabled
- Control inputs — Ensure control inputs are enabled

7.5 Object 20 Binary Counters

Object 20, binary counters, contains cumulative counters and measurements. The binary counters can be read as their present 'running' value from object 20, or as a 'frozen' value from object 21. The running counters of object 20 accept the read, freeze and clear functions. The freeze function takes the current value of the object 20 running counter and stores it in the corresponding object 21 frozen counter. The freeze and clear function resets the object 20 running counter to zero after freezing its value.

Binary counter and frozen counter change event values are available for reporting from object 22 and object 23 respectively. Counter change events (object 22) only report the most recent change, so the maximum number of events supported is the same as the total number of counters. Frozen counter change events (object 23) are generated whenever a freeze operation is performed and a change has occurred since the previous freeze command. The frozen counter event queues store the points for up to two freeze operations.

7.6 Object 30 Analog Input

Object 30, analog inputs, contains information from the relay's measurements columns in the menu. All Object 30 points can be reported as 16 or 32-bit integer values with flag, 16 or 32-bit integer values without flag, as well as short floating point values.

Analogue values can be reported to the master station as primary, secondary or normalized values (which takes into account the relay's CT and VT ratios) and this is settable in the DNP3.0 Communications Column in the relay. Corresponding deadband settings can be displayed in terms of a primary, secondary or normalized value. Deadband point values can be reported and written using Object 34 variations.

The deadband is the setting used to determine whether a change event should be generated for each point. The change events can be read using Object 32 or Object 60. These events are generated for any point which has a value changed by more than the deadband setting since the last time the data value was reported.

Any analog measurement that is unavailable when it is read is reported as offline. For example, the frequency when the current and voltage frequency is outside the tracking range of the relay or the thermal state when the thermal protection is disabled in the configuration column. All Object 30 points are reported as secondary values in DNP3.0 (with respect to CT and VT ratios).

Beside the measurements described above, the latest fault record can also be retrieved and mapped over DNP3.0 protocol in serial and Ethernet connections:

The fault data defined in Object 30 table are:

- Fault voltages, Fault currents and Fault Location
- Operating time of relay and Operating time of breaker
- Fault time, Fault data, etc.

The following fault data can be mapped in DNP3.0 protocol in serial and Ethernet connections:

- Fault voltages
- Fault currents
- Fault location
- Operating time of relay
- Operating time of breaker
- Fault time
- Fault date

The latest fault records only will be retrieved over DNP3.0.

7.7 Object 40 Analog Output

The conversion to fixed-point format requires the use of a scaling factor, which is configurable for the various types of data within the relay such as current, voltage, and phase angle. All Object 40 points report the integer scaling values and Object 41 is available to configure integer scaling quantities.

7.8 DNP3.0 Configuration using Easergy Studio

DNP3.0 over Ethernet includes support for unsolicited responses. For the Unsolicited Responses configuration of DNP over Ethernet, please refer to this table:

Setting Name	Explanation
unsolAllowed	Determines whether unsolicited responses are allowed. If unsolAllowed is set to disabled, no unsolicited responses will be generated. Requests to enable or disable unsolicited responses will fail and the master station will reply indicating bad function information. If it is configured to allow unsolicited mode (enabled), the relay will be able to send event data in an unsolicited response after it receives a request from the master station containing function code ENABLE_UNSOLICITED(0x14) that enables some or all points to initiate unsolicited responses.
unsolMaxRetries	Specify the maximum number of unsolicited retries before changing to the 'offline' retry period (30 seconds).
unsolRetryDelay	Specifies the time, in seconds, to delay after an unsolicited confirm timeout before retrying the unsolicited response.
unsolClass1MaxDelay unsolClass2MaxDelay unsolClass3MaxDelay	If unsolicited responses are enabled, unsolClassXMaxDelay specifies the maximum amount of time in seconds after an event in the corresponding class is received before an unsolicited response will be generated. A configured value of 0 indicates that responses are not delayed.
unsolClass1MaxEvents unsolClass2MaxEvents unsolClass3MaxEvents	If unsolicited responses are enabled, unsolClassXMaxEvents specifies the maximum number of events in the corresponding class to be allowed before an unsolicited response will be generated.

Important	***At most 8 clients are supported to connect to device at the same time in DNP3.0 over Ethernet protocol.***

7.8.1 DNP3.0 over Ethernet runs concurrently with IEC61850

DNP3.0 over Ethernet can run concurrently with IEC61850 if DNP3.0 over Ethernet plus IEC61850 option is chosen. Below table describes the different cases of the usage of DNP3.0 over Ethernet service and IEC61850 service. IEC61850 service will always run under this situation, but DNPoE service only runs when certain requirements are met.

Board Type	Dual or PRP/HSR	Configuration file	Interface 1		Interface 2		Invalid DNPoE IP Alarm
			IP address	DNP3oE	IP address	DNP3oE	
Q or R	Doesn't matter	Default IEC61850 configuration No DNP setting or IP_DNP is 0.0.0.0	DEF_IP_1	Disabled	DEF_IP_2	Disabled	No
	Dual	Default IEC61850 configuration Customized DNP setting with valid IP_DNP	IP_DNP	Run	DEF_IP_2	N/A	No
	PRP/HSR		DEF_IP_1	N/A	IP_DNP	Run	No
	Doesn't matter	Customized IEC61850 configuration No DNPoE setting or IP_DNP is 0.0.0.0	IP_1	Disabled	IP_2	Disabled	No
	Doesn't matter	Customized IEC61850 configuration Customized DNPoE setting where IP_DNP = IP_1	IP_1	Run	IP_2	N/A	No
	Doesn't matter	Customized IEC61850 configuration Customized DNPoE setting where IP_DNP = IP_2	IP_1	N/A	IP_2	Run	No
	Doesn't matter	Customized IEC61850 configuration Customized DNPoE setting where IP_DNP ≠ IP_1 and IP_DNP ≠ IP_2	IP_1	Disabled	IP_2	Disabled	Yes
S	N/A	Default IEC61850 configuration No DNPoE setting or IP_DNP is 0.0.0.0	DEF_IP_1	Disabled	N/A	N/A	No
	N/A	Default IEC61850 configuration Customized DNPoE setting with valid IP_DNP	IP_DNP	Run	N/A	N/A	No
	N/A	Customized IEC61850 configuration No DNPoE setting or IP_DNP is 0.0.0.0	IP_1	Disabled	N/A	N/A	No
	N/A	Customized IEC61850 configuration Customized DNPoE setting where IP_DNP = IP_1	IP_1	Run	N/A	N/A	No
	N/A	Customized IEC61850 configuration Customized DNPoE setting where IP_DNP ≠ IP_1	IP_1	Disabled	N/A	N/A	Yes

Note *For detailed information about different interfaces please refer to the* ***Dual IP in MiCOM*** *section in the Dual Redundant Ethernet Board (DREB) chapter.*

Table 17 – Protocol running options for different board types

For these IP abbreviations please refer to this table:

Abbreviation	Description
DEF_IP_1	Default IP of interface 1 with default IEC61850 configuration
DEF_IP_2	Default IP of interface 2 with default IEC61850 configuration
IP_1	IP of interface 1 configured in a IEC61850 configuration file
IP_2	IP of interface 2 configured in a IEC61850 configuration file
IP_DNP	IP configured in DNP over Ethernet setting

Table 18 – Abbreviations of Different IP

Note *Running DNP3.0 serial and DNP3.0 over Ethernet concurrently is not recommended.*

8 IEC61850 ETHERNET INTERFACE

8.1 Introduction

IEC 61850 is the international standard for Ethernet-based communication in substations. It enables integration of all protection, control, measurement and monitoring functions in a substation, and provides the means for interlocking and inter-tripping. It combines the convenience of Ethernet with the security which is essential in substations today.

The MiCOM protection relays can integrate with the PACiS substation control systems, to complete Schneider Electric's offer of a full IEC 61850 solution for the substation. The majority of MiCOM Px3x and Px4x relay types can be supplied with Ethernet, in addition to traditional serial protocols. Relays which have already been delivered with UCA2.0 on Ethernet can be easily upgraded to IEC 61850.

8.2 What is IEC 61850?

IEC 61850 is a 14-part international standard, which defines a communication architecture for substations. It is more than just a protocol and provides:

- Standardized models for IEDs and other equipment in the substation
- Standardized communication services (the methods used to access and exchange data)
- Standardized formats for configuration files
- Peer-to-peer (for example, relay to relay) communication

The standard includes mapping of data onto Ethernet. Using Ethernet in the substation offers many advantages, most significantly including:

- High-speed data rates (currently 100 Mbits/s, rather than tens of kbits/s or less used by most serial protocols)
- Multiple masters (called “clients”)
- Ethernet is an open standard in every-day use

Schneider Electric has been involved in the Working Groups which formed the standard, building on experience gained with UCA2.0, the predecessor of IEC 61850.

8.2.1 Interoperability

A major benefit of IEC 61850 is interoperability. IEC 61850 standardizes the data model of substation IEDs which simplifies integration of different vendors’ products. Data is accessed in the same way in all IEDs, regardless of the vendor, even though the protection algorithms of different vendors’ relays may be different.

IEC 61850-compliant devices are not interchangeable, you cannot replace one device with another (although they are interoperable). However, the terminology is predefined and anyone with knowledge of IEC 61850 can quickly integrate a new device without mapping all of the new data. IEC 61850 improves substation communications and interoperability at a lower cost to the end user.

8.2.2 Data Model

To ease understanding, the data model of any IEC 61850 IED can be viewed as a hierarchy of information. The categories and naming of this information is standardized in the IEC 61850 specification.

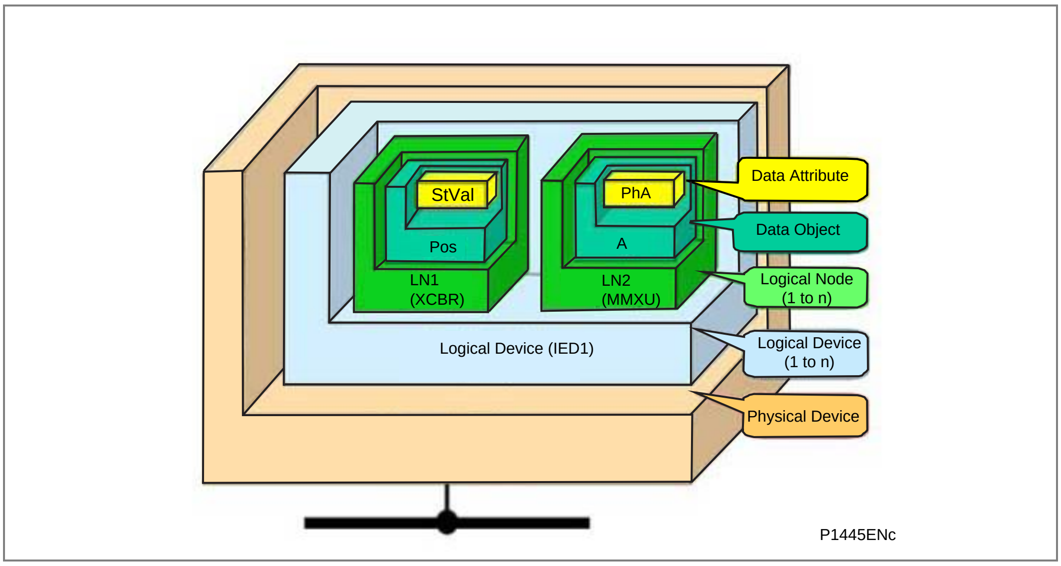


Figure 13 - Data model layers in IEC 61850

The levels of this hierarchy can be described as follows:

- Physical Device — Identifies the actual IED in a system. Typically the device's name or IP address can be used (for example **Feeder_1** or **10.0.0.2**).
- Logical Device — Identifies groups of related Logical Nodes inthe Physical Device. For the MiCOM relays, five Logical Devices exist: **Control, Measurements, Protection, Records, System**.
- Wrapper/Logical Node Instance
  Identifies the major functional areas in the IEC 61850 data model. Either 3 or 6 characters are used as a prefix to define the functional group (wrapper) while the actual functionality is identified by a 4 character Logical Node name, suffixed by an instance number. For example, XCBR1 (circuit breaker), MMXU1 (measurements), FrqPTOF2 (overfrequency protection, stage 2).
- Data Object — This next layer is used to identify the type of data presented. For example, **Pos** (position) of Logical Node type **XCBR**.
- Data Attribute — This is the actual data (such as measurement value, status, and description). For example, **stVal** (status value) indicates the actual position of the circuit breaker for Data Object type **Pos** of Logical Node type **XCBR**.

8.3 IEC 61850 in MiCOM Relays

IEC 61850 is implemented in MiCOM relays by use of a separate Ethernet card. This card manages the majority of the IEC 61850 implementation and data transfer to avoid any impact on the performance of the protection.

To communicate with an IEC 61850 IED on Ethernet, it is necessary only to know its IP address. This can then be configured into either:

- An IEC 61850 **client** (or **master**), for example a PACiS computer (MiCOM C264) or HMI, or
- An **MMS browser**, with which the full data model can be retrieved from the IED, without any prior knowledge

8.3.1 Capability

The IEC 61850 interface provides these capabilities:

- Read access to measurements

  All measurands are presented using the measurement Logical Nodes, in the **Measurements** Logical Device. Reported measurement values are refreshed by the relay once per second, in line with the relay user interface.

The following fault data have been mapped in LN RFLO1 of LD Records of IEC61850 data model:

- Fault voltages, Fault currents and Fault location
- Operating time of relay and Operating time of breaker
- Fault time, Fault date, etc…

Only the latest fault record can be retrieved over IEC61850.

- Generation of unbuffered reports on change of status/measurement

  Unbuffered reports, when enabled, report any change of state in statuses and measurements (according to deadband settings).
- Support for time synchronization over an Ethernet link

  Time synchronization is supported using SNTP (Simple Network Time Protocol). This protocol is used to synchronize the internal real time clock of the relays.
- GOOSE peer-to-peer communication
  GOOSE communications of statuses are included as part of the IEC 61850 implementation. See *Peer-to-Peer (GSE) Communications* for more details.
- Disturbance record extraction
  Disturbance records can be extracted from MiCOM relays by file transfer, as ASCII format COMTRADE files.
- Controls
  The following control services are available:
  - Direct Control
  - Direct Control with enhanced security
  - Select Before Operate (SBO) with enhanced security
  - Controls are applied to open and close circuit breakers using XCBR.Pos and DDB signals ‘Control Trip’ and ‘Control Close’.
  - System/LLN0. LLN0.LEDRs are used to reset any trip LED indications.
- Reports
  Reports only include data objects that have changed and not the complete dataset. The exceptions to this are a General Interrogation request and integrity reports.
- Buffered Reports
  Eight Buffered Report Control Blocks, (BRCB), are provided in SYSTEM/LLN0 in Logical Device ‘System’.
  Buffered reports are configurable to use any configurable dataset located in the same Logical device as the BRCB (SYSTEM/LLN0).
- Unbuffered Reports
  Sixteen Unbuffered Report Control Blocks (URCB) are provided in SYSTEM/LLN0 in Logical Device ‘System’.
  Unbuffered reports are configurable to use any configurable dataset located in the same Logical device as the URCB (SYSTEM/LLN0).

- Configurable Data Sets
  It is possible to create and configure datasets in any Logical Node using the IED Configurator. The maximum number of datasets will be specified in an IED's ICD file. An IED is capable of handling 100 datasets.
- Published GOOSE message
  Eight GOCBs are provided in SYSTEM/LLN0.
- Uniqueness of control
  The Uniqueness of control mechanism is implemented to be consistent with the PACiS mechanism. This requires the relay to subscribe to the OrdRun signal from all devices in the system and be able to publish such a signal in a GOOSE message.
- Select Active Setting Group
  Functional protection groups can be enabled or disabled using private mod/beh attributes in the Protection/LLN0.OcpMod object. Setting groups are selectable using the Setting Group Control Block class, (SGCB). The Active Setting Group can be selected using the System/LLN0.SP.SGCB.ActSG data attribute in Logical Device 'System'.
- Quality for GOOSE
  It is possible to process the quality attributes of any Data Object in an incoming GOOSE message. Devices that do not support IEC61850 quality flags send quality attributes as all zeros. The supported quality attributes for outgoing GOOSE messages are described in the Protocol Implementation eXtra Information for Testing (PIXIT) document.
- Address List
  An Address List document (to be titled ADL) is produced for each IED which shows the mapping between the IEC61850 data model and the internal data model of the IED. It includes a mapping in the reverse direction, which may be more useful. This document is separate from the PICS/MICS document.
- Originator of Control
  Originator of control mechanism is implemented for operate response message and in the data model on the ST of the related control object, consistent with the PACiS mechanism.
- Metering
  MMTR (metering) logical node is implemented in P14x products. All metered values in the MMTR logical node are of type BCR. The actVal attribute of the BCR class is of type INT128, but this type is not supported by the SISCO MMSLite library. Instead, an INT64 value will be encoded for transmission.
  A SPC data object named MTTRs has been included in the MMTR logical node. This control will reset the demand measurements. A SPC data object named MTTRs is also included in the PTTR logical node. This control will reset the thermal measurements.
- Scaled Measurements
  The Unit definition, as per IEC specifies an SI unit and an optional multiplier for each measurement. This allows a magnitude of measurement to be specified e.g. mA, A, kA, MA.

The multiplier will always be included in the Unit definition and will be configurable in SCL, but not settable at runtime. It will apply to the magnitude, rangeC.min & rangeC.max attributes. rangeC.min & rangeC.max will not be settable at runtime to be more consistent with Px30 and to reduce configuration problems regarding deadbands.

Setting changes, such as changes to protection settings, are done using Easergy Studio. These changes can also be done using the relay's front port serial connection or the relay's Ethernet link, and is known as "tunneling".

8.3.2 IEC 61850 Configuration

One of the main objectives of IEC 61850 is to allow IEDs to be directly configured from a configuration file generated at system configuration time. At the system configuration level, the capabilities of the IED are determined from an IED capability description file (ICD), which is provided with the product. Using a collection of these ICD files from different products, the entire protection of a substation can be designed, configured and tested (using simulation tools) before the product is even installed into the substation.

To help this process, the Easergy Studio Support Software provides an IEC61850 IED Configurator tool. Select **Tools > IEC61850 IED Configurator**. This tool allows the preconfigured IEC 61850 configuration file (SCD or CID) to be imported and transferred to the IED. The configuration files for MiCOM relays can also be created manually, based on their original IED Capability Description (ICD) file.

Other features include the extraction of configuration data for viewing and editing, and a sophisticated error-checking sequence. The error checking ensures the configuration data is valid for sending to the IED and ensures the IED functions correctly in the substation.

To help the user, some configuration data is available in the **IED CONFIGURATOR** column of the relay user interface, allowing read-only access to basic configuration data.

8.3.2.1 Configuration Banks

To promote version management and minimize down-time during system upgrades and maintenance, the MiCOM relays have incorporated a mechanism consisting of multiple configuration banks. These configuration banks are categorized as:

- Active Configuration Bank
- Inactive Configuration Bank

Any new configuration sent to the relay is automatically stored in the inactive configuration bank, therefore not immediately affecting the current configuration. Both active and inactive configuration banks can be extracted at any time.

When the upgrade or maintenance stage is complete, the IED Configurator tool can be used to transmit a command to a single IED. This command authorizes the activation of the new configuration contained in the inactive configuration bank, by switching the active and inactive configuration banks. This technique ensures that the system down-time is minimized to the start-up time of the new configuration. The capability to switch the configuration banks is also available using the **IED CONFIGURATOR** column.

For version management, data is available in the **IED CONFIGURATOR** column in the relay user interface, displaying the SCL Name and Revision attributes of both configuration banks.

8.3.2.2 Network Connectivity

Note	*This section presumes a prior knowledge of IP addressing and related topics. Further details on this topic may be found on the Internet (search for IP Configuration) and in numerous relevant books.*

Configuration of the relay IP parameters (IP Address, Subnet Mask, Gateway) and SNTP time synchronization parameters (SNTP Server 1, SNTP Server 2) is performed by the IED Configurator tool. If these parameters are not available using an SCL file, they must be configured manually.

If the assigned IP address is duplicated elsewhere on the same network, the remote communications do not operate in a fixed way. However, the relay checks for a conflict at power up and every time the IP configuration is changed. An alarm is raised if an IP conflict is detected.

Use the **Gateway** setting to configure the relay to accept data from networks other than the local network.

8.4 Data Model of MiCOM Relays

The data model naming adopted in the Px30 and Px40 relays has been standardized for consistency. The Logical Nodes are allocated to one of the five Logical Devices, as appropriate, and the wrapper names used to instantiate Logical Nodes are consistent between Px30 and Px40 relays.

The data model is described in the Model Implementation Conformance Statement (MICS) document, which is available separately. The MICS document provides lists of Logical Device definitions, Logical Node definitions, Common Data Class and Attribute definitions, Enumeration definitions, and MMS data type conversions. It generally follows the format used in Parts 7-3 and 7-4 of the IEC 61850 standard.

8.5 Communication Services of MiCOM Relays

The IEC 61850 communication services which are implemented in the Px30 and Px40 relays are described in the Protocol Implementation Conformance Statement (PICS) document, which is available separately. The PICS document provides the Abstract Communication Service Interface (ACSI) conformance statements as defined in Annex A of Part 7-2 of the IEC 61850 standard.

8.6 Peer-to-Peer (GSE) Communications

The implementation of IEC 61850 Generic Object Oriented Substation Event (GOOSE) sets the way for cheaper and faster inter-relay communications. The generic substation event model provides fast and reliable system-wide distribution of input and output data values. The generic substation event model is based on autonomous decentralization This provides an efficient method of allowing simultaneous delivery of the same generic substation event information to more than one physical device, by using multicast services.

The use of multicast messaging means that IEC 61850 GOOSE uses a publisher-subscriber system to transfer information around the network*. When a device detects a change in one of its monitored status points, it publishes (sends) a new message. Any device that is interested in the information subscribes (listens) to the data message.

*Note**	*Multicast messages cannot be routed across networks without specialized equipment.*

Each new message is retransmitted at user-configurable intervals until the maximum interval is reached, to overcome possible corruption due to interference and collisions. In practice, the parameters which control the message transmission cannot be calculated. Time must be allocated to the testing of GOOSE schemes before or during commissioning; in just the same way a hardwired scheme must be tested.

8.6.1 Scope

A maximum of 128 virtual inputs are available within the PSL which can be mapped directly to a published dataset in a GOOSE message (Configurable dataset is supported).

Each GOOSE signal contained in a subscribed GOOSE message can be mapped to any of the 128 virtual inputs within the PSL. The virtual inputs allow the mapping to internal logic functions for protection control, directly to output contacts or LEDs for monitoring.

The MiCOM relay also can subscribe to analogue GOOSE messages with Float32 data type. The received analogue values can not apply to any application function, these values will be stored only on the IEC 61850 data mode.

The MiCOM relay also can subscribe to analogue GOOSE messages with Float32 data type. The received analogue values can not apply to any application function, these values will be stored only on the IEC 61850 data mode.

8.6.2 Simulation GOOSE Configuration

From Easergy Studio select Tools > IEC 61850 IED Configurator (Ed.2). Make sure the configuration is correct as this ensures efficient GOOSE scheme operation.

The relay can be set to publish/subscribe simulation/test GOOSE; it is important that this setting is returned to publish/receive normal GOOSE messages after testing to permit normal operation of the application and GOOSE messaging.

The relay provides a single setting to receive Simulated GOOSE, however it manages each subscribed GOOSE signal independently when the setting is set to simulated GOOSE. Each subscription (virtual input) will continue to respond to GOOSE messages without the simulation flag set; however once the relay receives a GOOSE for a subscription with the simulation flag set, it will respond to this and ignore messages without the simulation flag set. Other subscriptions (virtual inputs) which have not received a GOOSE message with the simulation flag will continue to operate as before. When the setting is reset back to normal GOOSE messaging the relay will ignore all GOOSE messages with the simulation flag set and act on GOOSE messages without the simulation flag.

WARNING	**If you set the GOOSE in Simulation Mode, you MUST set it back to normal GOOSE after testing. IT IS POTENTIALLY EXTREMELY UNSAFE TO ATTEMPT TO USE ANY RELAY WHICH IS STILL IN GOOSE SIMULATION MODE.**

8.6.3 High Performance GOOSE

In addition, the Px40 device is designed to provide maximum performance through an optimized publishing mechanism. This optimized mechanism is enabled so that the published GOOSE message is mapped using only the data attributes rather than mapping a complete data object. If data objects are mapped, the GOOSE messaging will operate correctly; but without the benefit of the optimized mechanism.

A pre-configured dataset named as "HighPerformGOOSE" is available in Ed.2 ICD template, which include all data attributes of all virtual outputs. We recommend using this dataset to get the benefit of better GOOSE performance. The optimized mechanism also applies to Ed.1 but without such a pre-configured dataset.

8.7 Ethernet Functionality

8.7.1 Ethernet Disconnection

IEC 61850 ‘Associations’ are unique and made to the relay between the client (master) and server (IEC 61850 device). If the Ethernet is disconnected, such associations are lost and must be re-established by the client. The TCP_KEEPALIVE function is implemented in the relay to monitor each association and terminate any which are no longer active.

8.7.2 Loss of Power

If the relay's power is removed, the relay allows the client to re-establish associations without a negative impact on the relay’s operation. As the relay acts as a server in this process, the client must request the association. Uncommitted settings are cancelled when power is lost. Reports requested by connected clients are reset and must be re-enabled by the client when the client next creates the new association to the relay.

8.7.3 Courier Tunneling via Secure Ethernet Communications

8.7.3.1 Introduction

When the IED and Easergy Studio are connected via the Ethernet port they will communicate securely using TLS.

The benefits of secure communication are:

- Help in the prevention of unwanted eavesdropping between Easergy Studio and the IED
- Help in the prevention of modification of data between Easergy Studio and the IED
- Ensure integrity of data
- Prevent replay of data at a later data

Note	*The communication will be done using port 4422, ensure this port is left unblocked on your network.*

8.7.3.2 Setting up a Connection

As a quick guide, you need to do the following:

1. In Easergy Studio, click the Quick Connect… button
2. Select the relevant Device Type in the Quick Connect dialog box.
3. Select Ethernet port
4. Enter the relevant data i.e. IP address of IED
5. Click Finish
6. Easergy Studio will attempt to communicate with the device

Note	*When attempting to connect to the IED via Ethernet, Easergy Studio will first try to communicate with the IED via secure communication. If this is not possible, it will use open communication with no encryption.* *For secure communication, please ensure port 4422 is left unblocked on the firewalls on which Easergy Studio is running.*

Notes:

INSTALLATION

CHAPTER 16

Date (month/year):	11/2016			
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.			
Hardware suffix:	P141/P142/P143 P145 P241 P242/P243 P342 P343/P344/P345 P391 P445 P44x (P441/P442/P444) P44x (P442/P444)	J/L J/M J K J K A J/L J/K M	P44y (P443/P446) P547 P54x (P543/P544/P545/P546) P642 P643 P645 P74x (P741/P742/P743) P746 P841 P849	K/M K K/M J/L K/M K/M J/K K/M K/M K/M
Software version:	P14x (P141/P142/P143/P145) P24x (P241/P242/P243): P342/P343/P344/P345/P391 P445 P44x (P441/P442/P444) P44x (P442/P444)	43/44/46/ B0/B1/B2 57 36 35/36/J4 C7.x/D4.x/ D5.x/D6.x/ E0/E1	P44y (P443/P446) P547 P54x (P543/P544/P545/P546) P64x (P642/P643/P645) P74x (P741/P742/P743) P746 P841 P849	55/H4 57 45/55/H4 04/A0/B1/B2 51/A0/B1 A0/B1/B2/B3/ C1/C2/C3 45/55/G4/H4 A0/B1
Connection diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P445: 10P445xx (xx = 01 to 04) P44x (P441, P442 & P444): 10P44101 (SH 1 & 2) 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)		P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 1 to 10) 10P643xx (xx = 1 to 6) 10P645xx (xx = 1 to 9) P74x (P741, P742 & P743): 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)	

CONTENTS

Page (IN) 16-

TABLES

FIGURES

1 INTRODUCTION TO MICOM RANGE

About MiCOM Range

MiCOM is a comprehensive solution capable of meeting all electricity supply requirements. It comprises a range of components, systems and services from Schneider Electric.

Central to the MiCOM concept is flexibility. MiCOM provides the ability to define an application solution and, through extensive communication capabilities, integrate it with your power supply control system.

The components within MiCOM are:

- P range protection relays
- C range control products
- M range measurement products for accurate metering and monitoring
- S range versatile PC support and substation control packages

MiCOM products include extensive facilities for recording information on the state and behaviour of the power system using disturbance and fault records. They can also provide measurements of the system at regular intervals to a control centre enabling remote monitoring and control to take place.

For up-to-date information, please see:

www.schneider-electric.com

MiCOM Px4x Products

The MiCOM Px4x series of protection devices provide a wide range of protection and control functions and meet the requirements of a wide market segment.

Different parts of the Px4x range provide different functions. These include:

- **P14x** **Feeder Management** relay suitable for MV and HV systems
- **P24x** **Motors** and rotating machine management relay for use on a wide range of synchronous and induction machines
- **P34x** **Generator Protection** for small to sophisticated generator systems and interconnection protection
- **P445** Full scheme **Distance Protection** relays for MV, HV and EHV systems
- **P44x** Full scheme **Distance Protection** relays for MV, HV and EHV systems
- **P44y** Full scheme **Distance Protection** relays for MV, HV and EHV systems
- **P54x** **Line Differential** protection relays for HV/EHV systems with multiple communication options and phase comparison protection for use with PLC
- **P547** **Line Differential** protection relays for HV/EHV systems with multiple communication options and phase comparison protection for use with PLC
- **P64x** **Transformer Protection Relays**
- **P74x** **Numerical Busbar Protection** for use on MV, HV and EHV busbars
- **P746** **Numerical Busbar Protection** for use on MV, HV and EHV busbars
- **P84x** **Breaker Failure** protection relays

Note	*During 2011, the International Electrotechnical Commission classified the voltages into different levels (IEC 60038). The IEC defined LV, MV, HV and EHV as follows: LV is up to 1000V. MV is from 1000V up to 35 kV. HV is from 110 kV or 230 kV. EHV is above 230 KV.* *There is still ambiguity about where each band starts and ends. A voltage level defined as LV in one country or sector, may be described as MV in a different country or sector. Accordingly, LV, MV, HV and EHV suggests a possible range, rather than a fixed band. Please refer to your local Schneider Electric office for more guidance.*

2 RECEIPT, HANDLING, STORAGE AND UNPACKING RELAYS

2.1 Receipt of Relays

Protective relays, although generally of robust construction, require careful treatment prior to installation on site.

Upon receipt, relays should be examined immediately to ensure no external damage has been sustained in transit. If damage has been sustained, a claim should be made to the transport contractor and Schneider Electric should be promptly notified.

Relays that are supplied unmounted and not intended for immediate installation should be returned to their protective polythene bags and delivery carton. See the *Storage* section for more information about the storage of relays.

2.2 Handling of Electronic Equipment

Warning	**Before carrying out any work on the equipment, you should be familiar with the contents of the Safety Information chapter/Safety Guide SFTY/5L M/L11 or later issue, the Technical Data chapter and the ratings on the equipment rating label.**

A person's normal movements can easily generate electrostatic potentials of several thousand volts. Discharge of these voltages into semiconductor devices when handling electronic circuits can cause serious damage which, although not always immediately apparent, will reduce the reliability of the circuit. This is particularly important to consider where the circuits use Complementary Metal Oxide Semiconductors (CMOS), as is the case with these relays.

The electronic circuits inside the relay are protected from electrostatic discharge when housed in the case. Do not expose them to risk by removing the front panel or Printed Circuit Boards (PCBs) unnecessarily.

Each PCB incorporates the highest practicable protection for its semiconductor devices. However, if it becomes necessary to remove a PCB, the following precautions should be taken to preserve the high reliability and long life for which the relay has been designed and manufactured.

- Before removing a PCB, ensure that you are at the same electrostatic potential as the equipment by touching the case.
- Handle analogue input modules by the front panel, frame or edges of the circuit boards. PCBs should only be handled by their edges. Avoid touching the electronic components, printed circuit tracks or connectors.
- Do not pass the module to another person without first ensuring you are both at the same electrostatic potential. Shaking hands achieves equipotential.
- Place the module on an anti-static surface, or on a conducting surface which is at the same potential as yourself.
- If it is necessary to store or transport printed circuit boards removed from the case, place them individually in electrically conducting anti-static bags.

In the unlikely event that you are making measurements on the internal electronic circuitry of a relay in service, it is preferable that you are earthed to the case with a conductive wrist strap. Wrist straps should have a resistance to ground between 500kΩ to 10MΩ. If a wrist strap is not available you should maintain regular contact with the case to prevent a build-up of electrostatic potential. Instrumentation which may be used for making measurements should also be earthed to the case whenever possible.

More information on safe working procedures for all electronic equipment can be found in IEC 61340-5-1. It is strongly recommended that detailed investigations on electronic circuitry or modification work should be carried out in a special handling area such as described in the aforementioned Standard document.

2.3 Storage

If relays are not to be installed immediately upon receipt, they should be stored in a place free from dust and moisture in their original cartons. Where de-humidifier bags have been included in the packing they should be retained. The action of the de-humidifier crystals will be impaired if the bag is exposed to ambient conditions and may be restored by gently heating the bag for about an hour prior to replacing it in the carton.

To prevent battery drain during transportation and storage a battery isolation strip is fitted during manufacture. With the lower access cover open, presence of the battery isolation strip can be checked by a red tab protruding from the positive side.

Care should be taken on subsequent unpacking that any dust which has collected on the carton does not fall inside. In locations of high humidity the carton and packing may become impregnated with moisture and the de-humidifier crystals will lose their efficiency.

Prior to installation, relays should be stored at a temperature of between -40°C to +70°C (-13°F to +158°F).

2.4 Unpacking

Care must be taken when unpacking and installing the relays so that none of the parts are damaged and additional components are not accidentally left in the packing or lost. Make sure that any user’s CDROM or technical documentation is NOT discarded, and accompanies the relay to its destination substation.

Note	*With the lower access cover open, the red tab of the battery isolation strip will be seen protruding from the positive side of the battery compartment. Do not remove this strip because it prevents battery drain during transportation and storage and will be removed as part of the commissioning tests.*

Relays must only be handled by skilled persons.

The site should be well lit to facilitate inspection, clean, dry and reasonably free from dust and excessive vibration. This particularly applies to installations which are being carried out at the same time as construction work.

3 RELAY MOUNTING

MiCOM relays are dispatched either individually or as part of a panel/rack assembly. Individual relays are normally supplied with an outline diagram showing the dimensions for panel cut-outs and hole centres. This information can also be found in the product publication.

Secondary front covers can also be supplied as an option item to prevent unauthorised changing of settings and alarm status. They are available in sizes 40TE and 60TE. The 60TE cover also fits the 80TE case size of the relay.

The old GN0037/GN0038 part numbers are now obsolete.

They have been replaced by the GN0242/GN0243 versions as shown below.

Product	Size	Part No (obsolete)	Replacement Part No
P40	**40TE** **60TE / 80TE**	**GN0037 001** **GN0038 001**	**GN0242 001** **GN0243 001**
P14x	40TE 60TE / 80TE	GN0037 001 GN0038 001	GN0242 001 GN0243 001
P24xxxxxxxxxxxA P24xxxxxxxxxxxC	40TE 60TE / 80TE	GN0037 001 GN0038 001	GN0242 001 GN0243 001
P24xxxxxxxxxxxJ P24xxxxxxxxxxxK	40TE 60TE / 80TE		GN0242 001 GN0243 001
P34xxxxxxxxxxxA P34xxxxxxxxxxxC	40TE 60TE / 80TE	GN0037 001 GN0038 001	GN0242 001 GN0243 001
P34xxxxxxxxxxxJ P34xxxxxxxxxxxK	40TE 60TE / 80TE		GN0242 001 GN0243 001
P44x	40TE 60TE / 80TE	GN0037 001 GN0038 001	GN0242 001 GN0243 001
P44y	60TE / 80TE	GN0038 001	GN0243 001
P445	40TE 60TE / 80TE	GN0037 001 GN0038 001	GN0242 001 GN0243 001
P54x	60TE / 80TE	GN0038 001	GN0243 001
P547	60TE / 80TE	GN0038 001	GN0243 001
P64xxxxxxxxxxxA/B/C	40TE 60TE / 80TE	GN0037 001 GN0038 001	GN0242 001 GN0243 001
P64xxxxxxxxxxxJ/K	40TE 60TE / 80TE		GN0242 001 GN0243 001
P74x P74x	40TE 60TE	GN0037 001 GN0038 001	GN0242 001 GN0243 001
P746	80TE	GN0038 001	GN0243 001
P841	60TE / 80TE	GN0038 001	GN0243 001
P849	80TE	GN0038 001	GN0243 001

Note *Part Numbers suitable for rack-mounting have an "N" as the 10th digit.*
Part Numbers suitable for panel-mounting have an "M" as the 10th digit.
Size 40TE may be GN0242 001 and 60TE/80TE as GN0243 001.

Table 1 - Products, sizes and part numbers

The design of the relay is such that the fixing holes in the mounting flanges are only accessible when the access covers are open and hidden from sight when the covers are closed.

If a MiCOM P991 or Easergy test block is to be included with the relays, we recommend you position the test block on the right-hand side of the associated relays (when viewed from the front). This minimises the wiring between the relay and test block, and allows the correct test block to be easily identified during commissioning and maintenance tests.

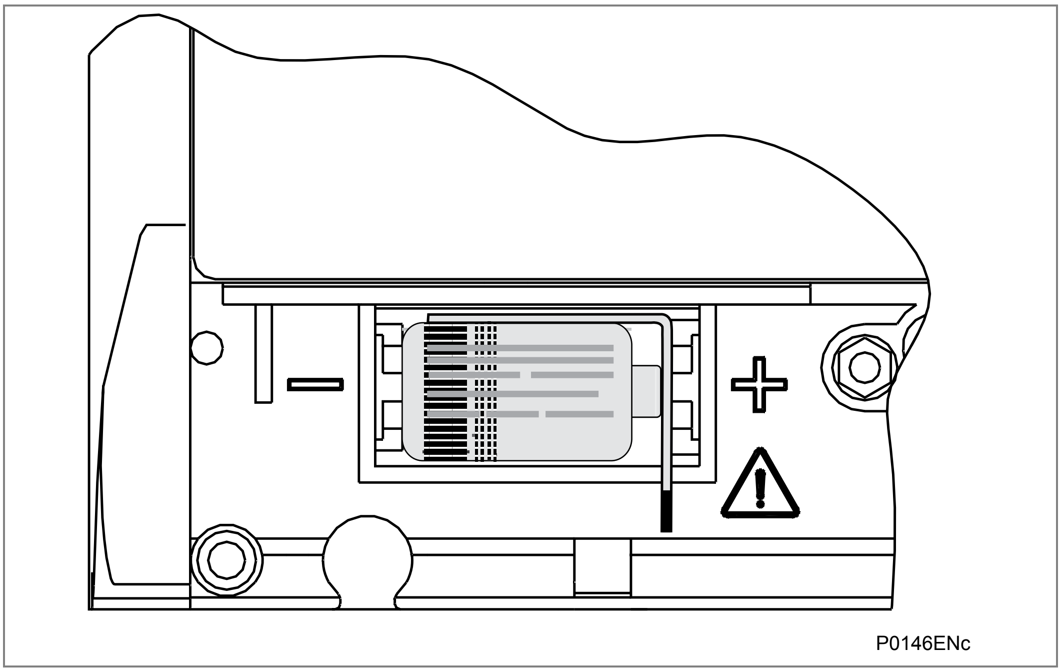


Figure 1 - Location of battery isolation strip

If you need to test correct relay operation during the installation, the battery isolation strip can be removed but should be replaced if commissioning of the scheme is not imminent. This will prevent unnecessary battery drain during transportation to site and installation. The red tab of the isolation strip can be seen protruding from the positive side of the battery compartment when the lower access cover is open. To remove the isolation strip, pull the red tab whilst lightly pressing the battery to prevent it falling out of the compartment. When replacing the battery isolation strip, ensure that the strip is refitted as shown in the *Location of battery isolation strip* diagram, i.e. with the strip behind the battery with the red tab protruding.

3.1 Rack Mounting

Virtually all MiCOM relays can be rack mounted using single tier rack frames (part number FX0021 101), see the ***Rack mounting of relays*** diagram below. These frames have dimensions in accordance with IEC 60297 and are supplied pre-assembled ready to use. On a standard 483 mm rack this enables combinations of case widths up to a total equivalent of size 80TE to be mounted side-by-side.

The two horizontal rails of the rack frame have holes drilled at approximately 26 mm intervals and the relays are attached via their mounting flanges using M4 Taptite self-tapping screws with captive 3 mm thick washers (also known as a SEMS unit). These fastenings are available in packs of 5 (part number ZA0005 104).

Warning	**Risk of damage to the front cover moulding. Do not use conventional self-tapping screws, including those supplied for mounting other relays because they have slightly larger heads.**

Once the tier is complete, the frames are fastened into the racks using mounting angles at each end of the tier.

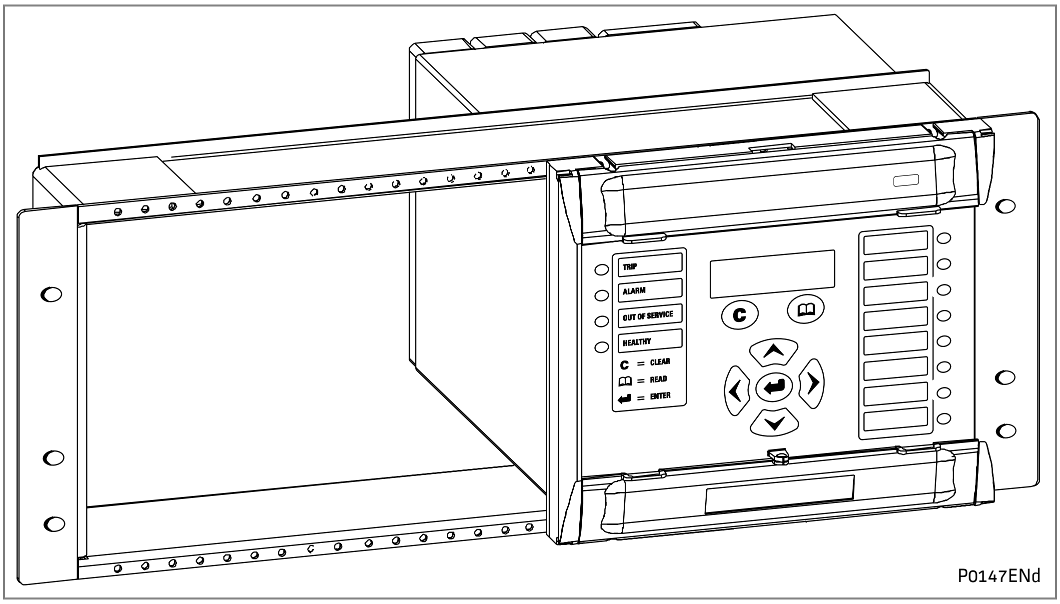


Figure 2 - Rack mounting of relays

Relays can be mechanically grouped into single tier (4U) or multi-tier arrangements by the rack frame. This enables schemes using MiCOM products to be pre-wired together prior to mounting.

Use blanking plates if there are empty spaces. The spaces may be for future installation of relays or because the total size is less than 80TE on any tier. Blanking plates can also be used to mount ancillary components. The following ***Blanking plates*** table shows the sizes that can be ordered.

Note	*Blanking plates are only available in grey.*

Case size summation	Blanking plate part number
10TE	GJ2028 102
20TE	GJ2028 104
30TE	GJ2028 106
40TE	GJ2028 108

Table 2 - Blanking plates

3.2 Panel Mounting

The relays can be flush mounted into panels using M4 SEMS Taptite self-tapping screws with captive 3 mm thick washers (also known as a SEMS unit). These fastenings are available in packs of 5 (part number ZA0005 104).

Warning	**Risk of damage to the front cover moulding. Do not use conventional self-tapping screws, including those supplied for mounting other relays because they have slightly larger heads.**

Alternatively tapped holes can be used if the panel has a minimum thickness of 2.5 mm. If several relays are mounted in a single cut-out in the panel, mechanically group them together horizontally or vertically to form rigid assemblies prior to mounting in the panel.

Note	*Fastening MiCOM relays with pop rivets is not advised because this does not allow easy removal if repair is necessary.*

Rack-mounting panel-mounted versions: it is possible to rack-mount some relay versions which have been designed to be panel-mounted. The relay is mounted on a single-tier rack frame, which occupies the full width of the rack. To make sure a panel-mounted relay assembly complies with BS EN60529 IP52, fit a metallic sealing strip between adjoining relays (Part No GN2044 001) and a sealing ring from the following ***IP52 sealing rings*** table around the complete assembly.

Width	Single tier	Double tier
40TE	GJ9018 008	GJ9018 024
45TE	GJ9018 009	GJ9018 025
50TE	GJ9018 010	GJ9018 026
55TE	GJ9018 011	GJ9018 027
60TE	GJ9018 012	GJ9018 028
65TE	GJ9018 013	GJ9018 029
70TE	GJ9018 014	GJ9018 030
75TE	GJ9018 015	GJ9018 031
80TE	GJ9018 016	GJ9018 032

Table 3 - IP52 sealing rings

4 RELAY WIRING

This section serves as a guide to selecting the appropriate cable and connector type for each terminal on the MiCOM relay.

Warning	**Before carrying out any work on the equipment, you should be familiar with the contents of the Safety Information chapter/Safety Guide SFTY/5L M/L11 or later issue, the Technical Data chapter and the ratings on the equipment rating label.**

4.1 Medium and Heavy Duty Terminal Block Connections

Key:

Heavy duty terminal block: CT and VT circuits, terminals with “C”,“D”,“E” or “F” prefix (depending on the relay)

Medium duty: All other terminal blocks (grey color)

Loose relays are supplied with sufficient M4 screws for making connections to the rear mounted terminal blocks using ring terminals, with a recommended maximum of two ring terminals per relay terminal.

If required, Schneider Electric can supply M4 90° crimp ring terminals in three different sizes depending on wire size (see the *M4 90° crimp ring terminals* table). Each type is available in bags of 100.

Part number	Wire size	Insulation colour
ZB9124 901	0.25 – 1.65mm^2 (22 – 16AWG)	Red
ZB9124 900	1.04 – 2.63mm^2 (16 – 14AWG)	Blue
ZB9124 904	2.53 – 6.64mm^2 (12 – 10AWG)	Uninsulated*

Note — ** To maintain the terminal block insulation requirements for safety, fit an insulating sleeve over the ring terminal after crimping.*

Table 4 - M4 90° crimp ring terminals

The following minimum wire sizes are recommended:

- Current Transformers 2.5mm^2
- Auxiliary Supply Vx 1.5mm^2
- RS485 Port See separate section
- Rotor winding to P391 1.0mm^2
- Other circuits 1.0mm^2

Due to the limitations of the ring terminal, the maximum wire size that can be used for any of the medium or heavy duty terminals is 6.0mm^2 using ring terminals that are not pre-insulated. Where it required to only use pre-insulated ring terminals, the maximum wire size that can be used is reduced to 2.63mm^2 per ring terminal. If a larger wire size is required, two wires should be used in parallel, each terminated in a separate ring terminal at the relay.

The wire used for all connections to the medium and heavy duty terminal blocks, except the RS485 port, should have a minimum voltage rating of 300Vrms.

It is recommended that the auxiliary supply wiring should be protected by a 16A maximum High Rupture Capacity (HRC) fuse of type NIT or TIA. For safety reasons, current transformer circuits must never be fused. Other circuits should be appropriately fused to protect the wire used.

Note — *The high-break contacts optional fitted to P44y (P443/P446) and P54x relays are polarity sensitive. External wiring must respect the polarity requirements which are shown on the external connection diagram to ensure correct operation.*

Each opto input has selectable filtering. This allows use of a pre-set filter of ½ cycle which renders the input immune to induced noise on the wiring: although this method is secure it can be slow, particularly for intertripping. This can be improved by switching off the ½ cycle filter in which case one of the following methods to reduce ac noise should be considered. The first method is to use double pole switching on the input, the second is to use screened twisted cable on the input circuit. The recognition time of the opto inputs without the filtering is <2 ms and with the filtering is <12 ms.

4.2 EIA(RS)485 Port

Connections to the first rear EIA(RS)485 port use ring terminals. 2-core screened cable is recommended with a maximum total length of 1000m or 200nF total cable capacitance. A typical cable specification would be:

Each core:	16/0.2mm copper conductors. PVC insulated
Nominal conductor area:	0.5mm^2 per core
Screen:	Overall braid, PVC sheathed

See the SCADA Communications chapter for details of setting up an EIA(RS)485 bus.

4.3 Current Loop Input Output (CLIO) Connections (if applicable)

Where current loop inputs and outputs are available on a MiCOM relay, the connections are made using screw clamp connectors, as per the RTD inputs, on the rear of the relay which can accept wire sizes between 0.1 mm^2 and 1.5 mm^2. It is recommended that connections between the relay and the current loop inputs and outputs are made using a screened cable. The wire should have a minimum voltage rating of 300 Vrms.

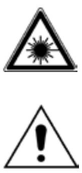
4.4 IRIG-B Connections (if applicable)

The IRIG-B input and BNC connector have a characteristic impedance of 50Ω. It is recommended that connections between the IRIG-B equipment and the relay are made using coaxial cable of type RG59LSF with a halogen free, fire retardant sheath.

4.5 EIA(RS)232 Port

Short term connections to the RS232 port, located behind the bottom access cover, can be made using a screened multi-core communication cable up to 15m long, or a total capacitance of 2500pF. The cable should be terminated at the relay end with a 9-way, metal shelled, D-type male plug. The Getting Started chapter of this manual details the pin allocations.

4.6 Optical Fiber Connectors (when applicable)



Warning **LASER LIGHT RAYS: Where fibre optic communication devices are fitted, never look into the end of a fiber optic due to the risk of causing serious damage to the eye. Optical power meters should be used to determine the operation or signal level of the device. Non-observance of this rule could possibly result in personal injury.**

If electrical to optical converters are used, they must have management of character idle state capability (for when the fibre optic cable interface is "Light off").
Specific care should be taken with the bend radius of the fibres, and the use of optical shunts is not recommended as these can degrade the transmission path over time.
The relay uses 1310nm multi mode 100BaseFx and BFOC 2.5 - (ST/LC according to the MiCOM model) connectors (one Tx – optical emitter, one Rx – optical receiver).

4.7 Ethernet Port for IEC 61850 and/or DNP3.0 (where applicable)

4.7.1 Fiber Optic (FO) Port

The relays can have 100 Mbps Ethernet port. Fibre Optic (FO) connection is recommended for use in permanent connections in a substation environment. The 100 Mbit port uses a type LC connector (according to the MiCOM model), compatible with fiber multimode 50/125 µm or 62.5/125 µm to 1310 nm.

Note *The new LC fiber optical connector can be used with the Px40 Enhanced Ethernet Board.*

4.7.2 RJ-45 Metallic Port

Due to possibility of noise and interference on this part, it is recommended that this connection type be used for short-term connections and over short distance. Ideally, where the relays and switches are located in the same cubicle.
The connector for the Ethernet port is a shielded RJ-45. The following ***Signals on the Ethernet connector*** table shows the signals and pins on the connector.

Pin	Signal name	Signal definition
1	TXP	Transmit (positive)
2	TXN	Transmit (negative)
3	RXP	Receive (positive)
4	-	Not used
5	-	Not used
6	RXN	Receive (negative)
7	-	Not used
8	-	Not used

Table 5 - Signals on the Ethernet connector

4.8 RTD Connections (if applicable)

Where RTD inputs are available on a MiCOM relay, the connections are made using screw clamp connectors on the rear of the relay that can accept wire sizes between 0.1 mm^2 and 1.5 mm^2. The connections between the relay and the RTDs must be made using a screened 3-core cable with a total resistance less than 10 Ω. The cable should have a minimum voltage rating of 300 Vrms.
A 3-core cable should be used even for 2-wire RTD applications, as it allows for the cable's resistance to be removed from the overall resistance measurement. In such cases the third wire is connected to the second wire at the point the cable is joined to the RTD.
The screen of each cable must only be earthed at one end, preferably at the relay end and must be continuous. Multiple earthing of the screen can cause circulating current to flow along the screen, which induces noise and is unsafe.
It is recommended to minimize noise pick-up in the RTD cables by keeping them close to earthed metal casings and avoiding areas of high electromagnetic and radio interference. The RTD cables should not be run adjacent to or in the same conduit as other high voltage or current cables.
A typical cable specification would be:

Each core: 7/0.2 mm copper conductors heat resistant PVC insulated
Nominal conductor area: 0.22 mm^2 per core
Screen: Nickel-plated copper wire braid heat resistant PVC sheathed

The extract below may be useful in defining cable recommendations for the RTDs:

Noise pick-up by cables can be categorized in to three types:

- Resistive
- Capacitive
- Inductive

Resistive coupling requires there to be an electrical connection to the noise source. So assuming that the wire and cable insulation is sound and that the junctions are clean then this can be dismissed.

Capacitive coupling requires there to be sufficient capacitance for the impedance path to the noise source to be small enough to allow for significant coupling. This is a function of the dielectric strength between the signal cable on the noise source and the potential (i.e. power) of the noise source.

Inductive coupling occurs when the signal cable is adjacent to a cable/wire carrying the noise or it is exposed to a radiated EMF.

Standard screened cable is normally used to protect against capacitively coupled noise, but in order for it to be effective the screen must only be bonded to the system ground at one point, otherwise a current could flow and the noise would be coupled in to the signal wires of the cable. There are different types of screening available, but basically there are two types: aluminum foil wrap and tin-copper braid.

Foil screens are good for low to medium frequencies and braid is good for high frequencies. High-fidelity screen cables provide both types.

Protection against magnetic inductive coupling requires very careful cable routing and magnetic shielding. The latter can be achieved with steel-armored cable and the use of steel cable trays. It is important that the armor of the cable is grounded at both ends so that the EMF of the induced current cancels the field of the noise source and hence shields the cables conductors from it. (However, the design of the system ground must be considered and care taken to not bridge two isolated ground systems since this could be hazardous and defeat the objectives of the original ground design). The cable should be laid in the cable trays as close as possible to the metal of the tray and under no circumstance should any power cable be in or near to the tray. (Power cables should only cross the signal cables at 90 degrees and never be adjacent to them).

Both the capacitive and inductive screens must be contiguous from the RTD probes to the relay terminals.

The best types of cable are those provided by the RTD manufactures. These tend to be three conductors (a so-called "triad") which are screened with foil. Such triad cables are available in armored forms as well as multi-triad armored forms.

4.9 Download/Monitor Port

Short term connections to the download/monitor port, located behind the bottom access cover, can be made using a screened 25-core communication cable up to 4m long. The cable should be terminated at the relay end with a 25-way, metal shelled, D-type male plug.

The Getting Started and Commissioning chapters this manual details the pin allocations.

4.10 Second EIA(RS)232/485 Port

Relays with Courier, MODBUS, IEC 60870-5-103 or DNP3 protocol on the first rear communications port have the option of a second rear port, running Courier protocol. The second rear communications port can be used over one of three physical links:

- twisted pair K-Bus (non-polarity sensitive),
- twisted pair EIA(RS)485 (connection polarity sensitive) or
- EIA(RS)232. This EIA(RS)232 port is actually compliant to EIA(RS)574; the 9-pin version of EIA(RS)232, see www.tiaonline.org.

4.10.1 Connection to the Second Rear Port

The second rear Courier port connects via a 9-way female D-type connector (SK4) in the middle of the card end plate (in between IRIG-B connector and lower D-type). The connection is compliant to EIA(RS)574.

4.10.1.1 For IEC 60870-5-2 over EIA(RS)232/574

Pin	Connection
1	No Connection
2	RxD
3	TxD
4	DTR#
5	Ground
6	No Connection
7	RTS #
8	CTS #
9	No Connection
# - These pins are control lines for use with a modem.	

Table 6 - Pin connections for IEC 60870-5-2 over EIA(RS)232/574

Connections to the second rear port configured for EIA(RS)232 operation can be made using a screened multi-core communication cable up to 15 m long, or a total capacitance of 2500 pF. The cable should be terminated at the relay end with a 9-way, metal shelled, D-type male plug. The table above details the pin allocations.

4.10.1.2 For K-bus or IEC 60870-5-2 over EIA(RS)485

Pin*	Connection
4	EIA(RS)485 - 1 (+ ve)
7	EIA(RS)485 - 2 (- ve)
* - All other pins unconnected.	

> *Note* *Connector pins 4 and 7 are used by both the EIA(RS)232/574 and EIA(RS)485 physical layers, but for different purposes. Therefore, the cables should be removed during configuration switches.*
> *For the EIA(RS)485 protocol an EIA(RS)485 to EIA(RS)232/574 converter will be required to connect a modem or PC running MiCOM S1 Studio, to the relay. A Schneider Electric CK222 is recommended.*
> *EIA(RS)485 is polarity sensitive, with pin 4 positive (+) and pin 7 negative (-).*
> *The K-Bus protocol can be connected to a PC via a KITZ101 or 102.*
> *It is recommended that a 2-core screened cable be used. To avoid exceeding the second communications port flash clearances it is recommended that the length of cable between the port and the communications equipment should be less than 300 m. This length can be increased to 1000 m or 200nF total cable capacitance if the communications cable is not laid in close proximity to high current carrying conductors. The cable screen should be earthed at one end only.*

Table 7 - Pin connections for K-bus or IEC 60870-5-2 over EIA(RS)485

A typical cable specification would be:

Each core:	16/0.2mm copper conductors. PVC insulated
Nominal conductor area:	0.5mm^2 per core
Screen:	Overall braid, PVC sheathed

4.11 Earth Connection (Protective Conductor)

Every relay must be connected to the local earth bar using the M4 earth studs in the bottom left hand corner of the relay case. The minimum recommended wire size is 2.5mm^2 and should have a ring terminal at the relay end.

Due to the limitations of the ring terminal, the maximum wire size that can be used for any of the medium or heavy duty terminals is 6.0mm^2 per wire. If a greater cross-sectional area is required, two parallel connected wires, each terminated in a separate ring terminal at the relay, or a metal earth bar could be used.

Note	*To prevent any possibility of electrolytic action between brass or copper earth conductors and the rear panel of the relay, precautions should be taken to isolate them from one another. This could be achieved in a number of ways, including placing a nickel-plated or insulating washer between the conductor and the relay case, or using tinned ring terminals.*

Warning	**Before carrying out any work on the equipment, you should be familiar with the contents of the Safety Information chapter/Safety Guide SFTY/5L M/L11 or later issue, the Technical Data chapter and the ratings on the equipment rating label.**

4.12 P391 Rotor Earth Fault Unit (REFU) Mounting

Under rotor earth fault conditions, DC currents of up to 29mA can appear in the earth circuit. Accordingly, the P391 must be permanently connected to the local earth via the protective conductor terminal provided.

This section serves as a guide to selecting the appropriate cable and connector type for each terminal on the P391 unit.

Caution	**You must be familiar with all safety statements listed in the Commissioning chapter and the Safety Information section SFTY/4LM/G11 (or later issue) before undertaking any work on the P391.**

Caution	**Under no circumstances should the high voltage DC rotor winding supply be connected via Easergy or P99x test blocks. Both Easergy and P990 test blocks are not rated for continuous working voltages greater than 300 Vrms. These test blocks are not designed to withstand the inductive EMF voltages which will be experienced on disconnection or de-energization of the DC rotor winding supply.**

4.12.1 Medium Duty Terminal Block Connections

Information about the medium duty terminal block connections is described in the ***Medium and Heavy Duty Terminal Block Connections*** section.

> **Caution** **Wiring between the DC rotor winding and the P391 must be suitably rated to withstand at least twice the rotor winding supply voltage to earth. This is to ensure that the wiring insulation can withstand the inductive Electro Motive Force (EMF) voltage which will be experienced on disconnection or de-energization of the DC rotor winding supply.**

Due to the limitations of the ring terminal, the maximum wire size that can be used for any of the medium terminals is 6.0 mm^2 using ring terminals that are not pre-insulated (protective conductor terminal (PCT) only). All P391 terminals, except PCT shall be pre-insulated ring terminals, the maximum wire size that can be used is reduced to 2.63 mm^2 per ring terminal.

Wiring between the DC rotor winding and the P391 shall be suitably rated to withstand at least twice the rotor winding supply voltage to earth. The wire used for other P391 connections to the medium duty terminal blocks should have a minimum voltage rating of 300 Vrms.

The dielectric withstand of P391 injection resistor connections (A16, B16, A8, B8) to earth is 5.8 kV rms, 1 minute.

It is recommended that the auxiliary supply wiring should be protected by a High Rupture Capacity (HRC) fuse of type NIT or TIA, rated between 2 A and 16 A. Other circuits should be appropriately fused to protect the wire used.

5 CASE DIMENSIONS

The MiCOM range of products are available in a series of different case sizes.
The case sizes available for each product are shown here:

Range	Case Size		
	40TE	**60TE**	**80TE**
P14x	P141, P142	P143, P145	P143
P24x	P241	P242	P243
P34x	P341, P342	P341, P342, P343	P343, P344, P345
P441	P441		
P44x		P442	P444
P44y			P443, P446
P445	P445	P445	
P541	P541		
P542		P542	
P54x		P543, P544	P545, P546
P547			P547
P64x	P642	P643, P645	P645
P74x	P742	P743	P741
P746			P746
P841		P841	P841
P849			P849

Table 8 - Products and case sizes

5.1 40TE Case Dimensions

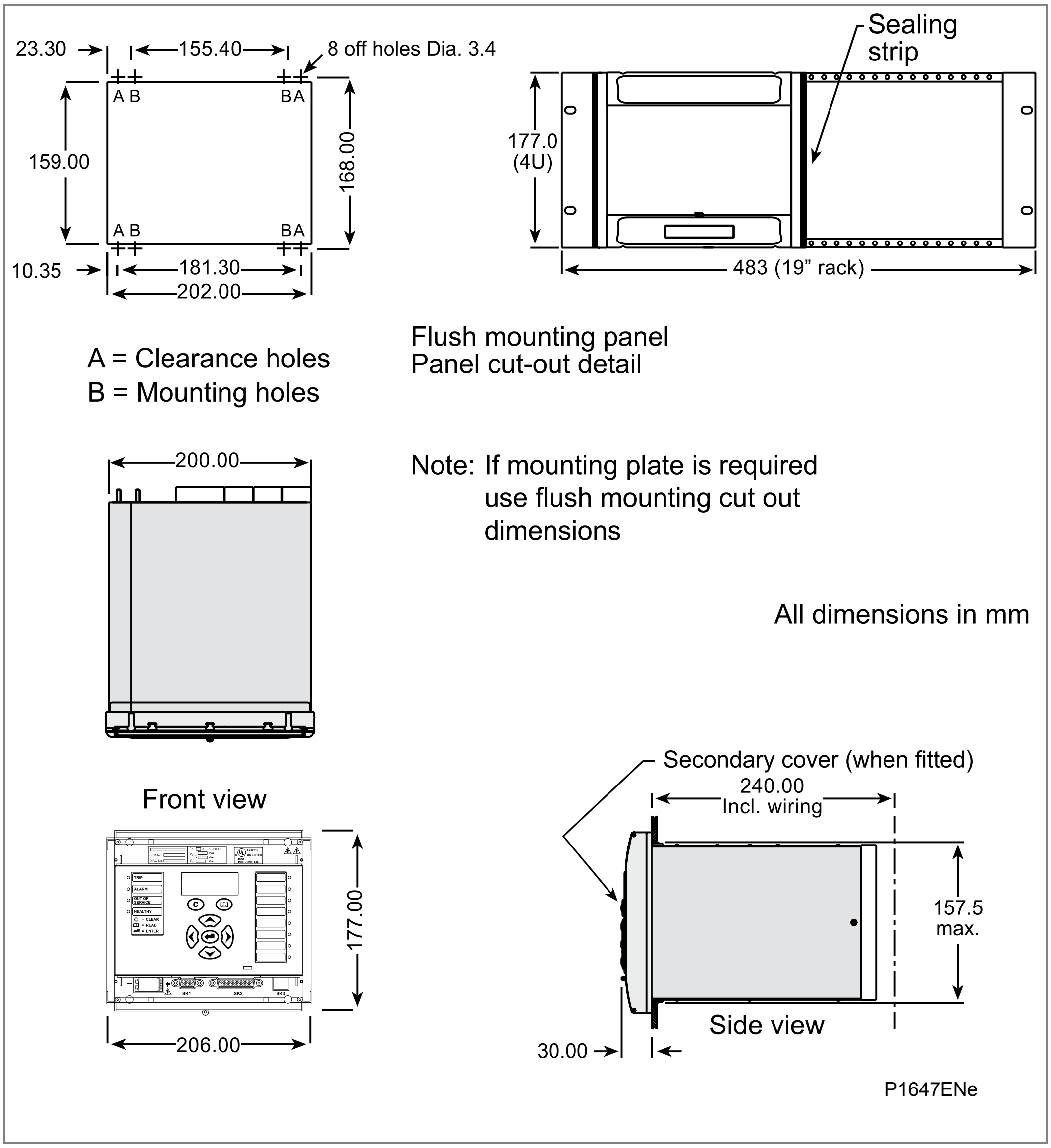


Figure 3 - 40TE Case Dimensions

5.2 60TE Case Dimensions

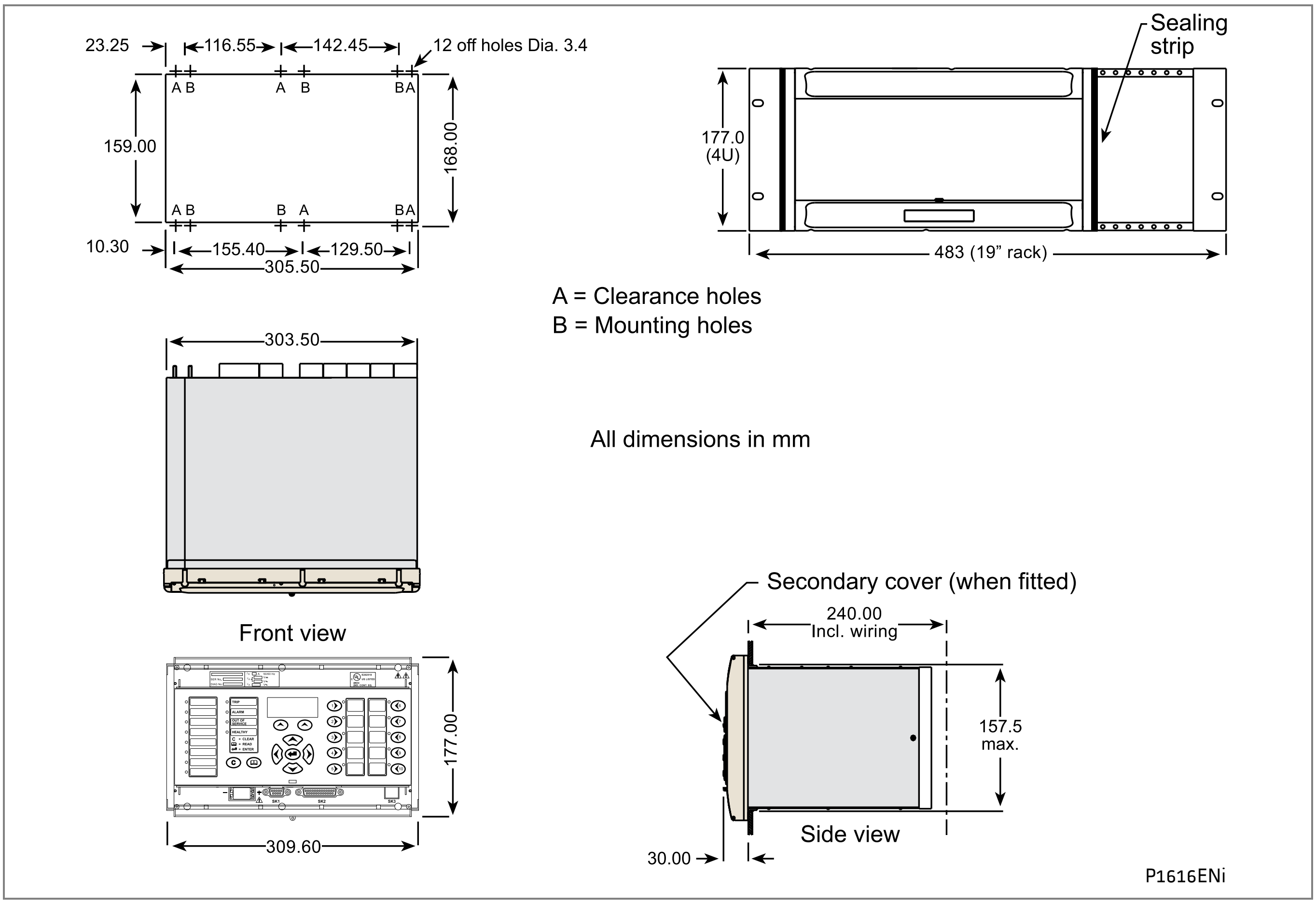


Figure 4 - 60TE Case Dimensions

5.3 80TE Case Dimensions

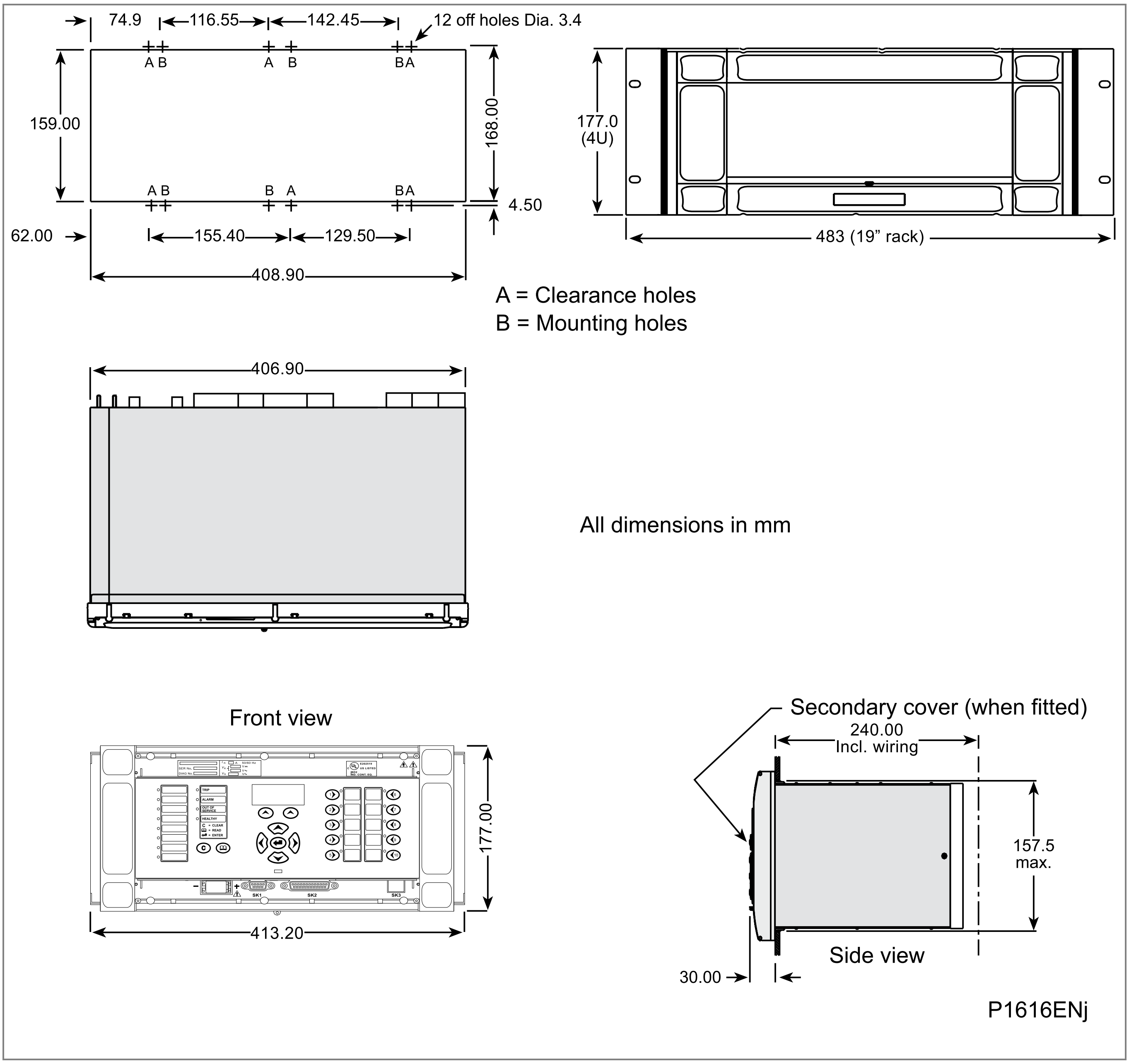


Figure 5 - 80TE Case Dimensions

CONNECTION DIAGRAMS

CHAPTER 17

Date:	07/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142 & P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

CONTENTS

FIGURES

1 INTRODUCTION TO THE CONNECTION DIAGRAMS

The Installation chapter contains general information about the MiCOM unit. The Installation chapter covers many MiCOM P40 products. It includes items such as:

- Receiving, Handling, Storing and Unpacking the Relays
- Mounting the Relay
- Wiring the Relay
- Case Dimensions

This Connection Diagrams chapter is specific to this particular relay, and includes the detailed wiring diagrams which relate only to this particular relay.

Important	***You must be familiar with the contents of the Installation chapter, before using the information in this Connection Diagrams chapter.***

2 COMMUNICATION OPTIONS MICOM PX40 PLATFORM

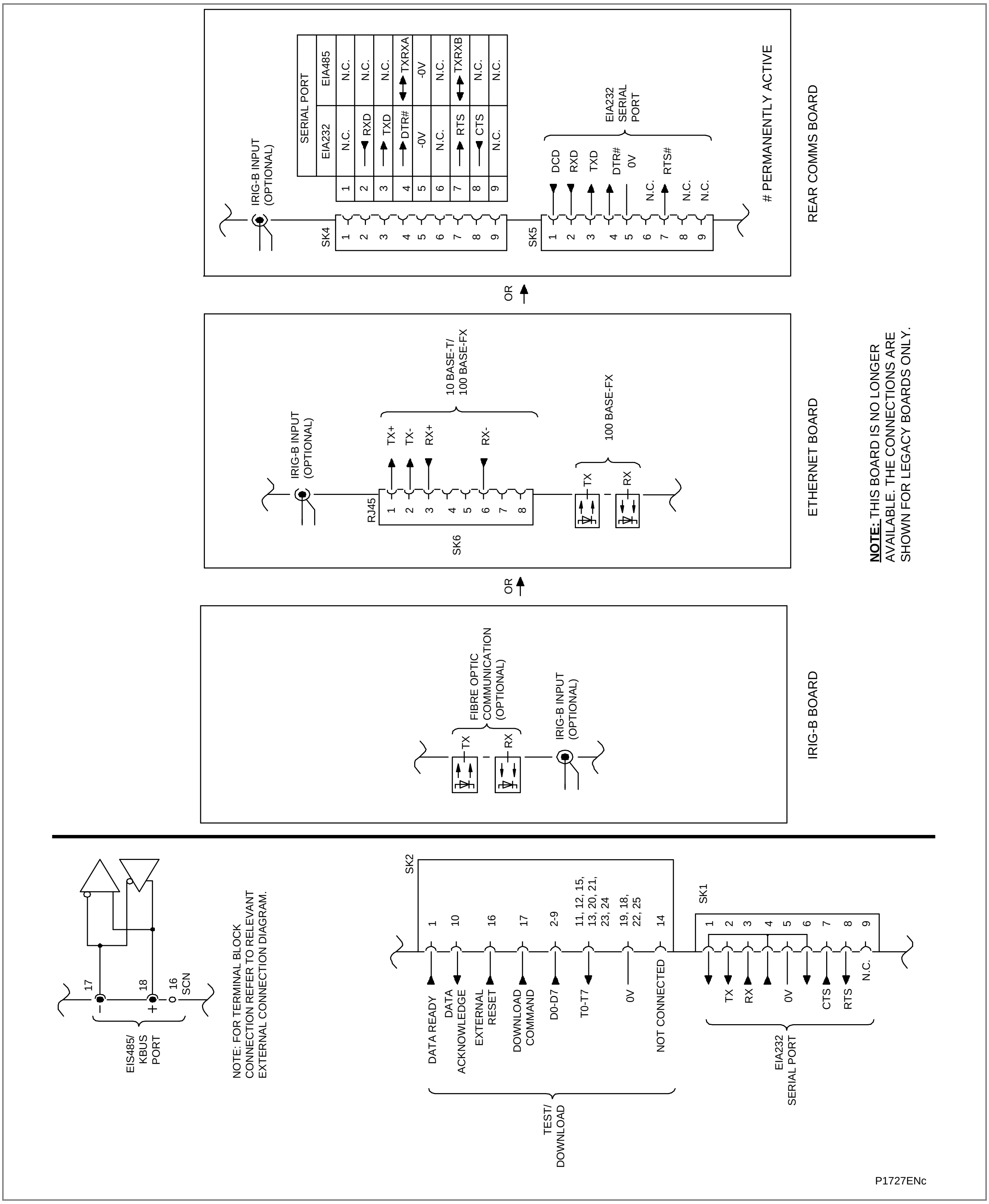


Figure 1 – Serial Communications Options MiCOM Px40 platform

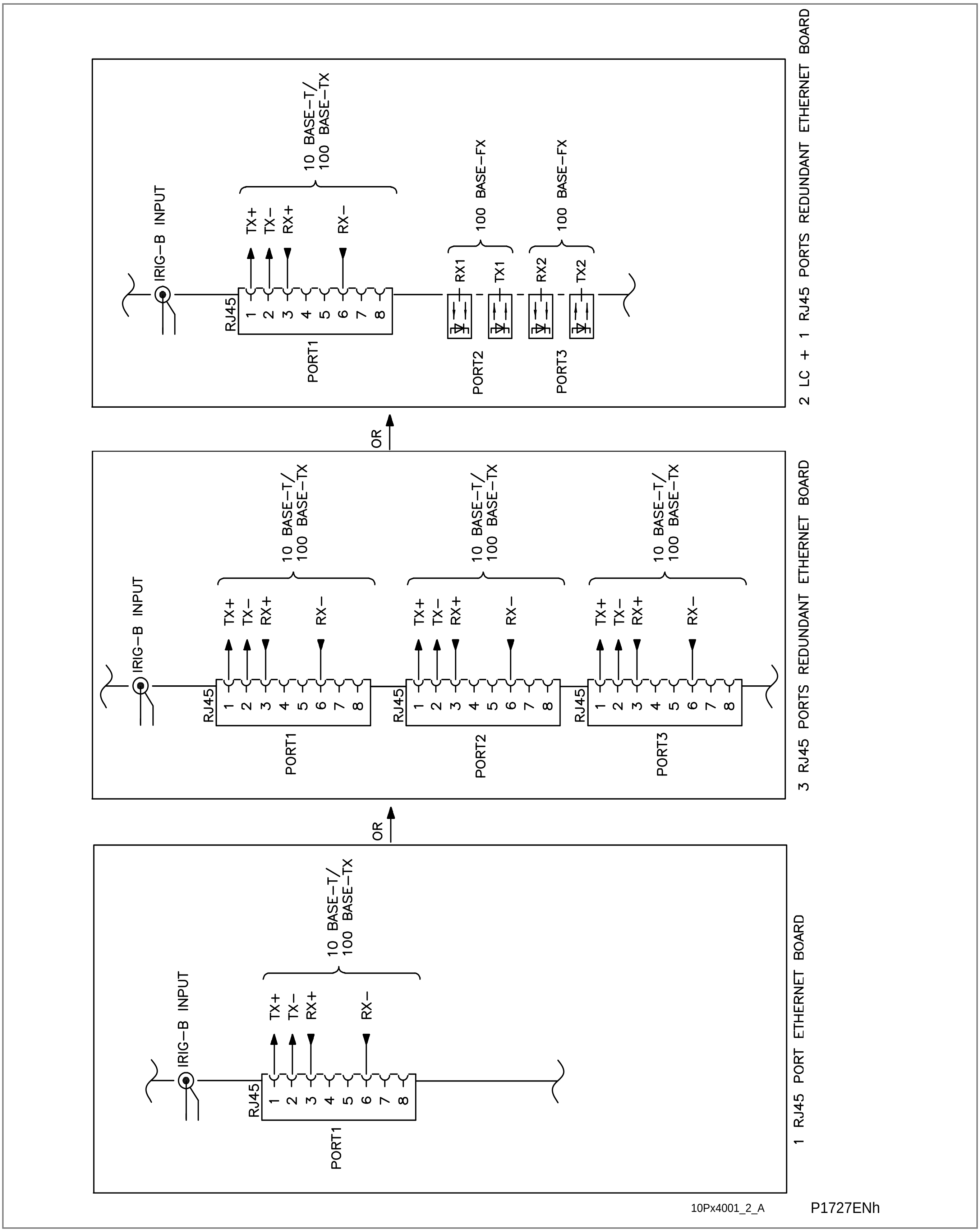


Figure 2 - Ethernet Communications Options MiCOM Px40 platform

3 EXTERNAL CONNECTION DIAGRAMS

In this section, the figure captions use these abbreviations:

- D/P = Directional Phase
- O/C = Overcurrent
- EF = Earth Fault
- SEF = Sensitive Earth Fault
- AR = Auto-reclose
- CS = Check Synchronizing
- RVI = Residual Voltage Input

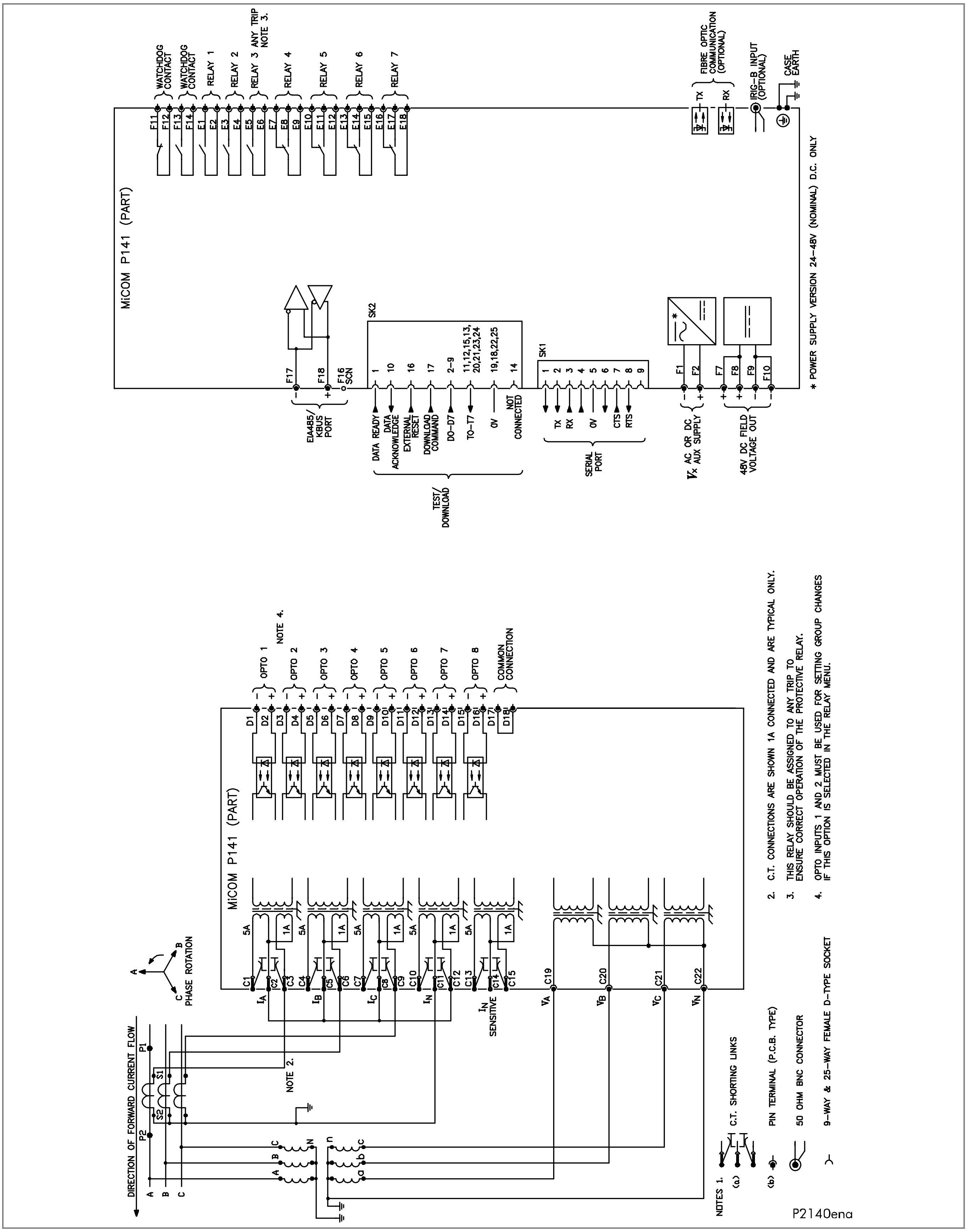


Figure 3 - P141 - D/P O/C and EF (8 I/P & 7 O/P)

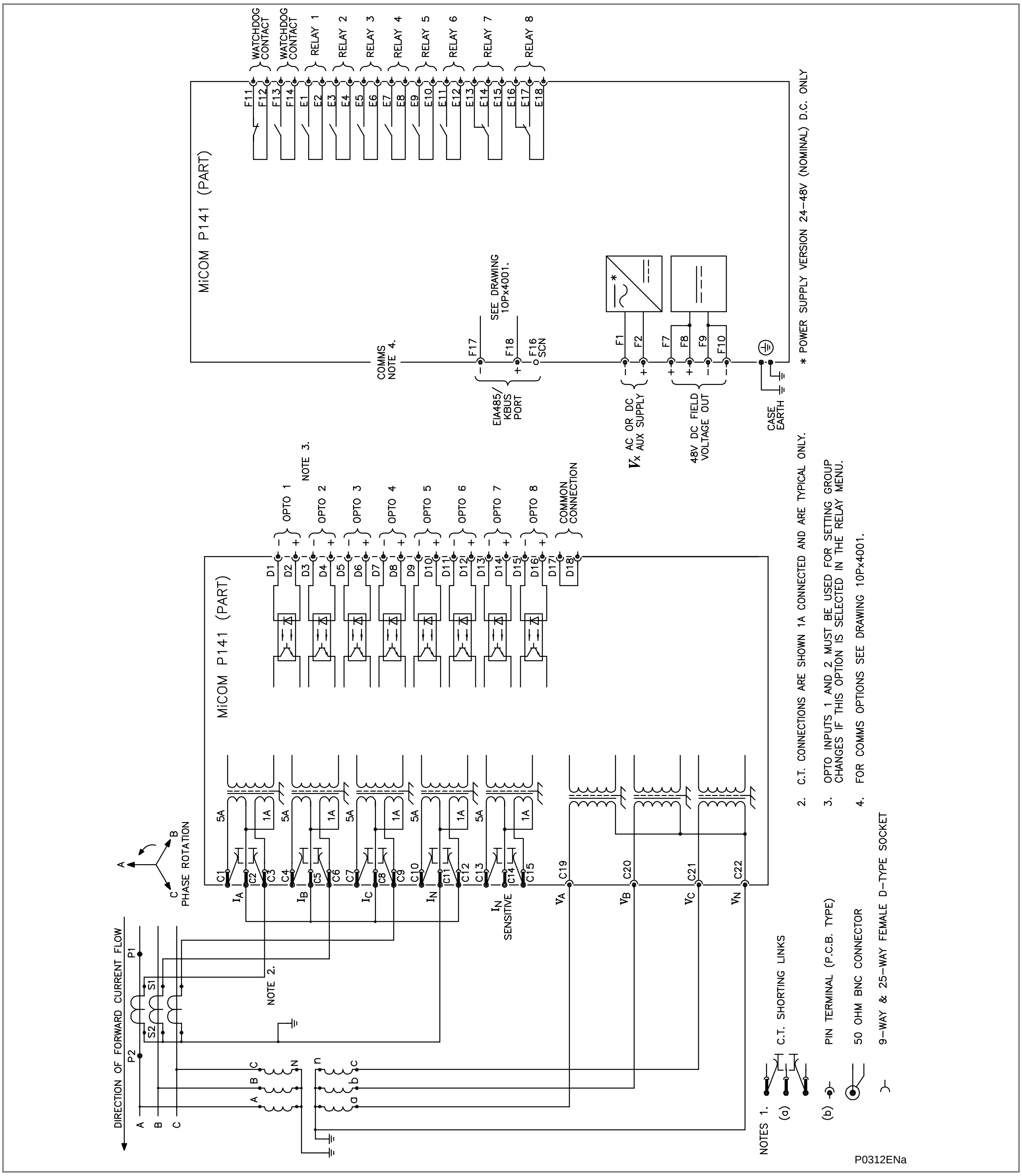


Figure 4 - P141 - D/P O/C and EF (8 I/P & 8 O/P)

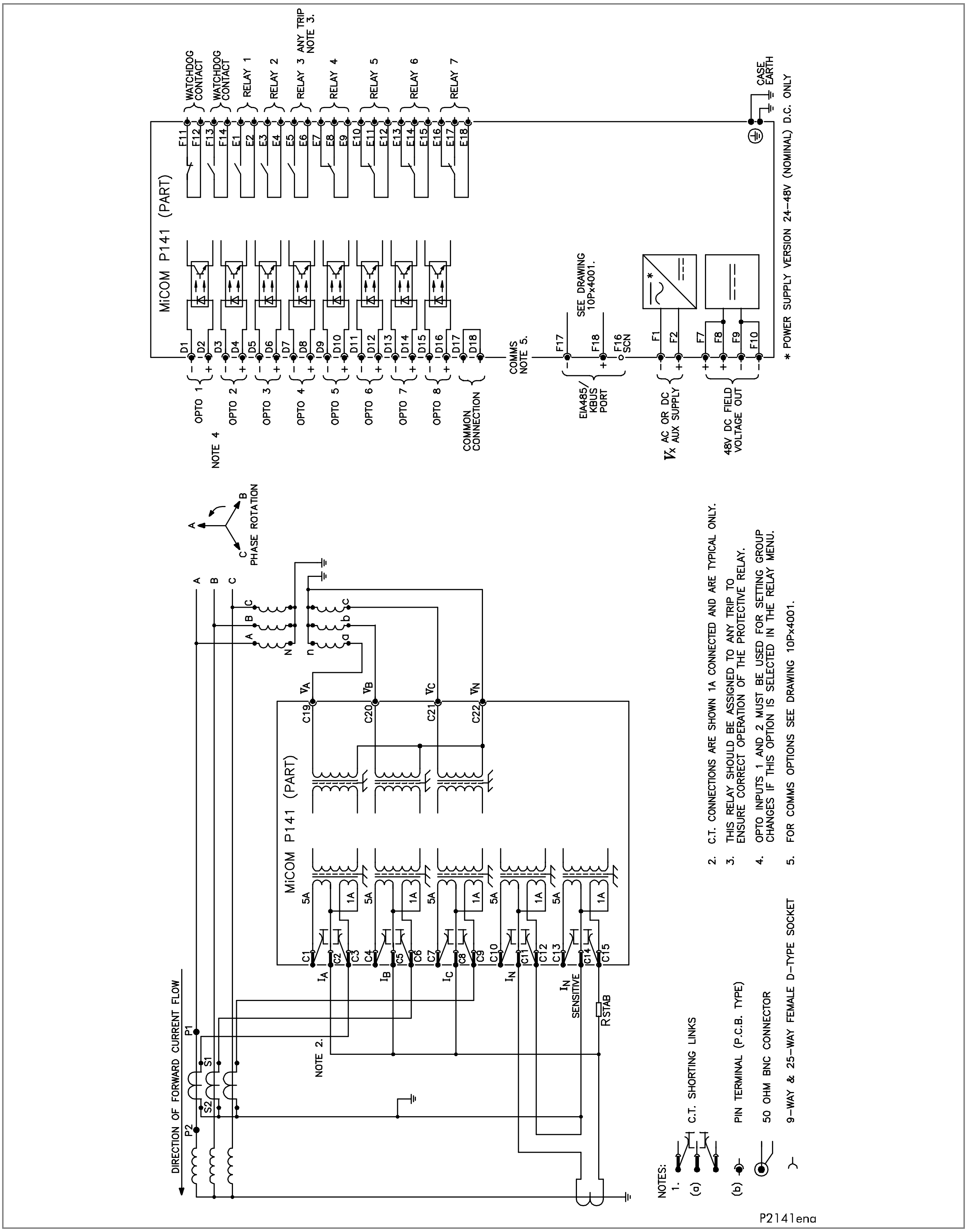


Figure 5 - P141 - D/P O/C and EF with High Impedance REF (8 I/P & 7 O/P)

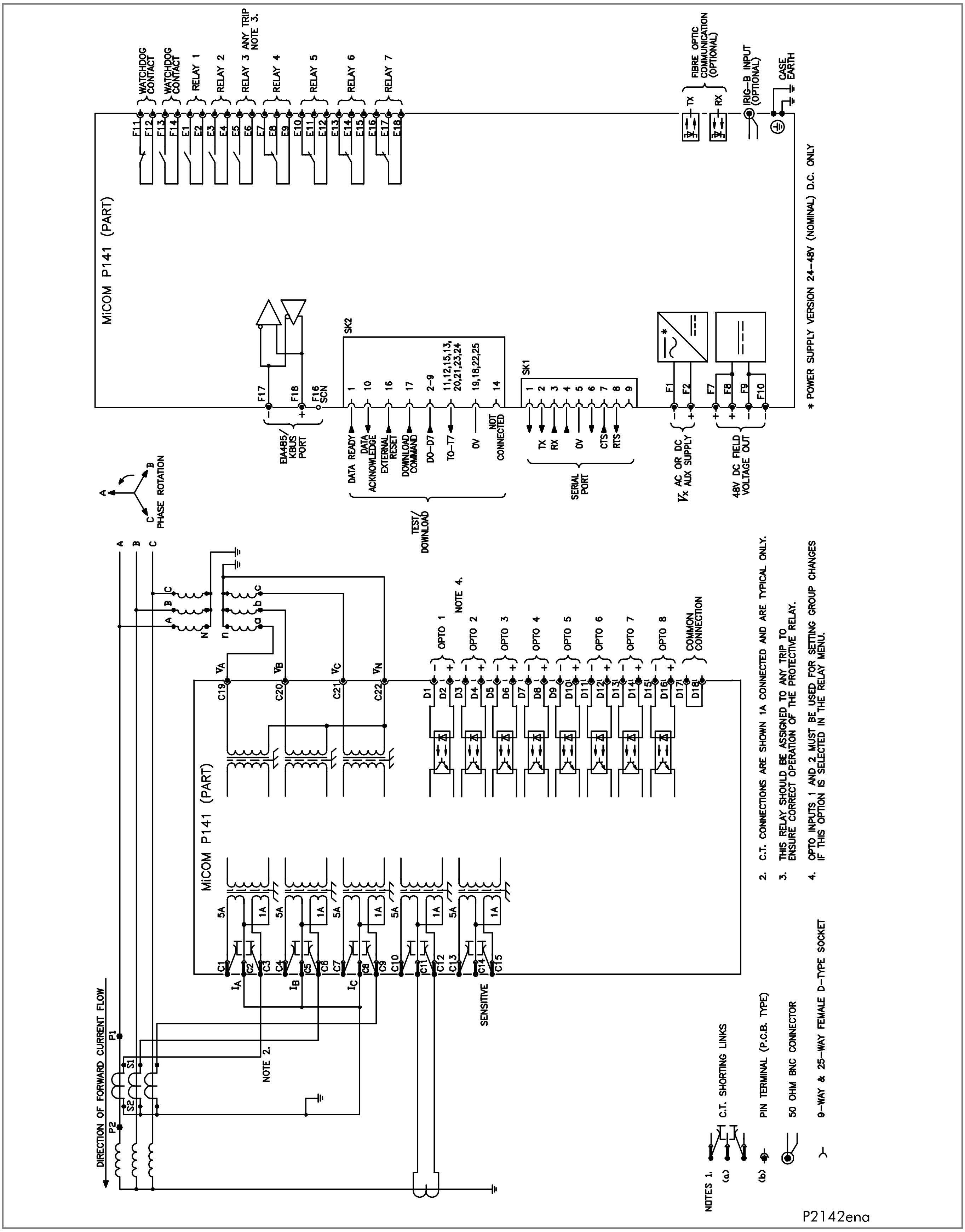


Figure 6 - P141 - D/P O/C and EF with Low Impedance REF (8 I/P & 7 O/P)

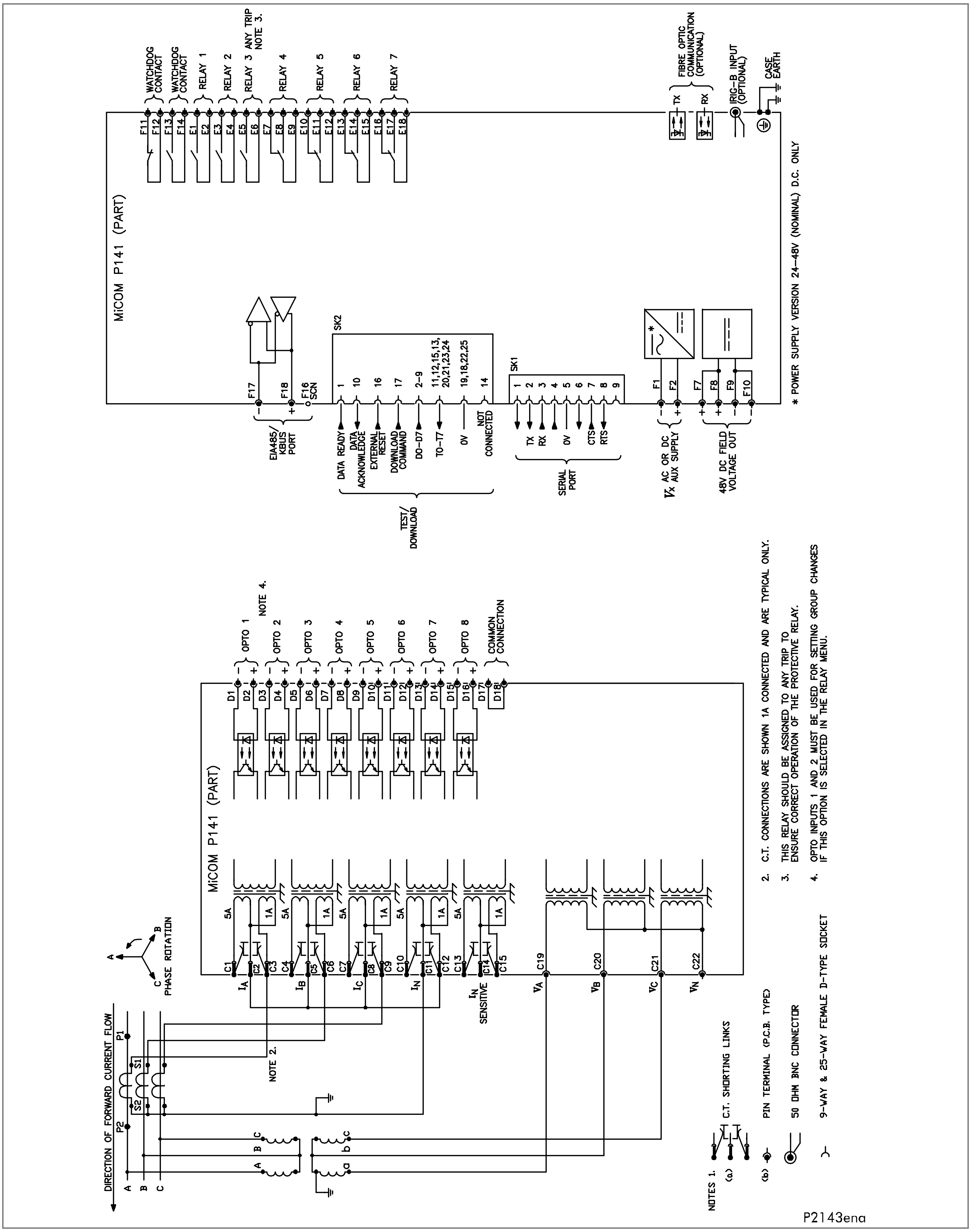


Figure 7 - P141 - Directional and Directional EF with VEE Connected VT (8 I/P & 7 O/P)

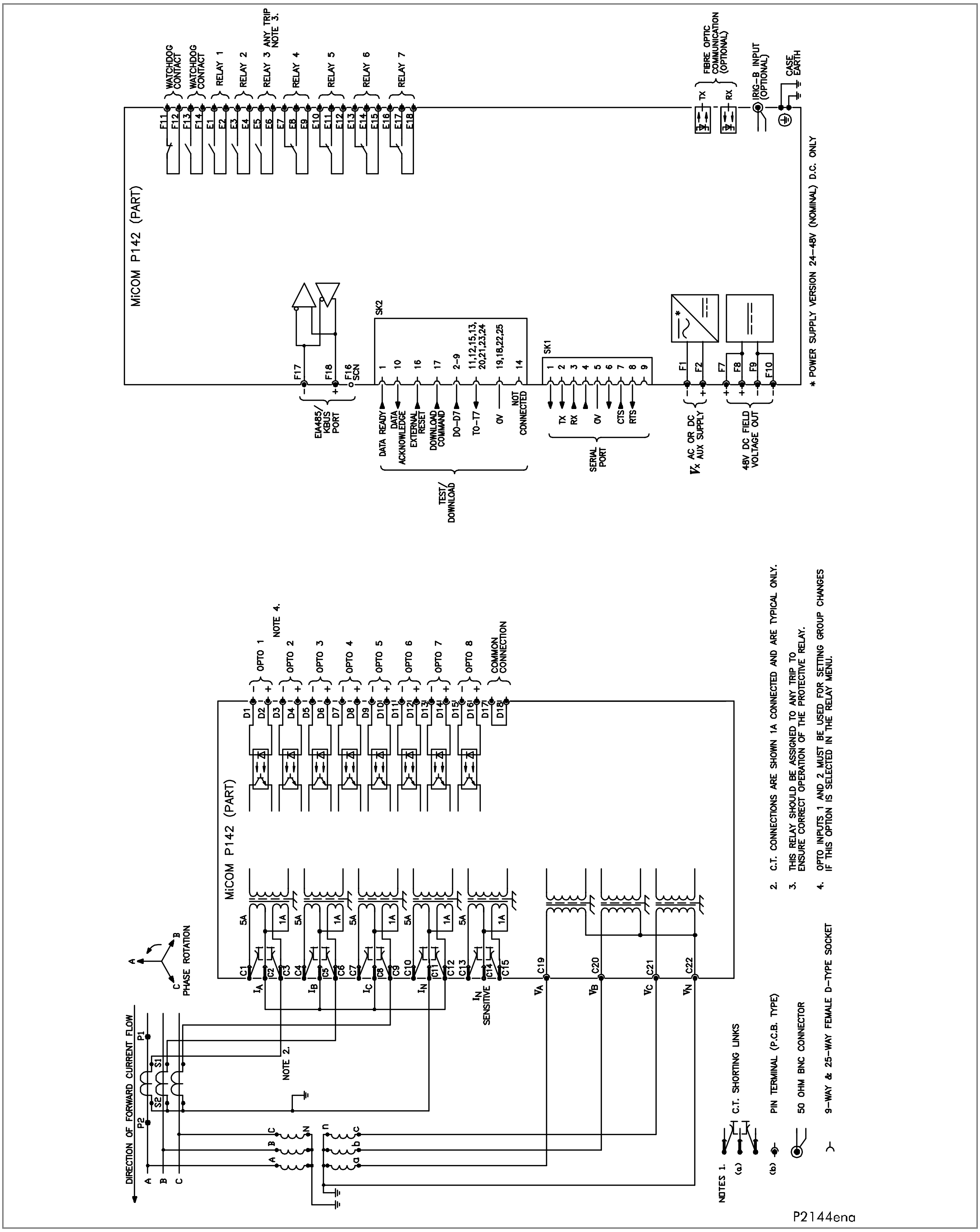


Figure 8 - P142 - D/P O/C and EF with AR (8 I/P & 7 O/P)

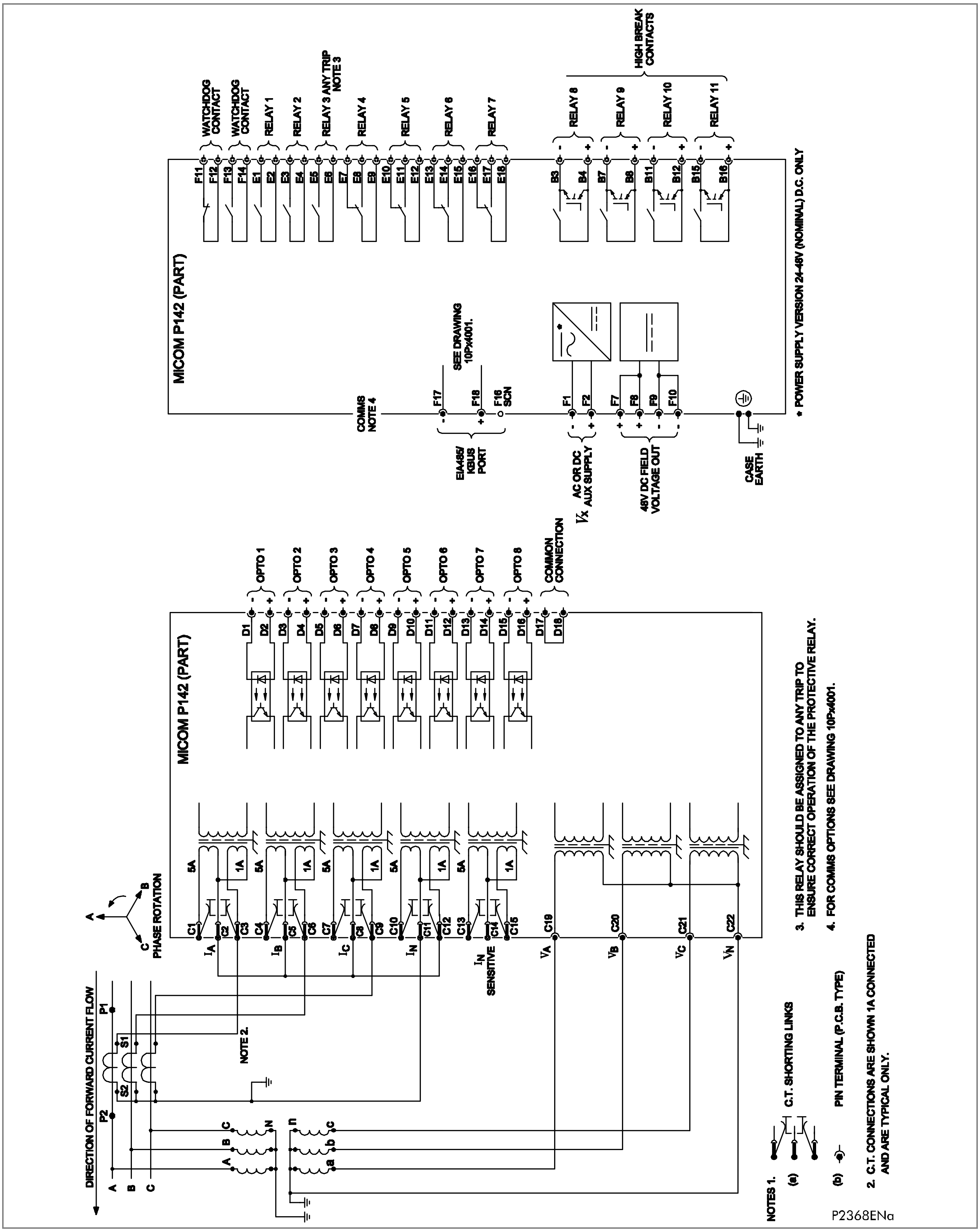


Figure 9 - P142 - D/P O/C and EF with AR (8 I/P & 11 O/P with 4 High Break Contacts)

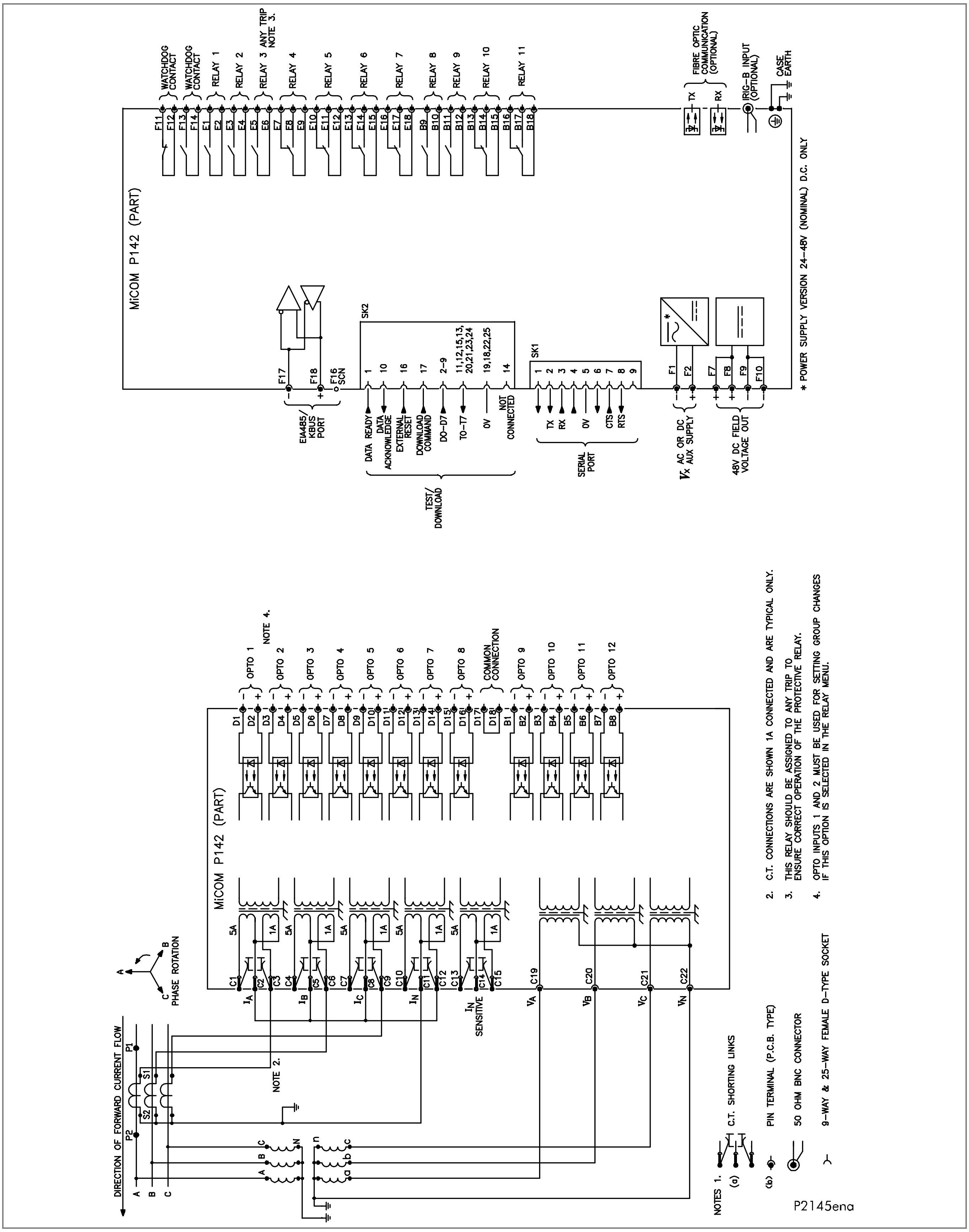


Figure 10 - P142 - D/P O/C and EF with AR (12 I/P & 11 O/P)

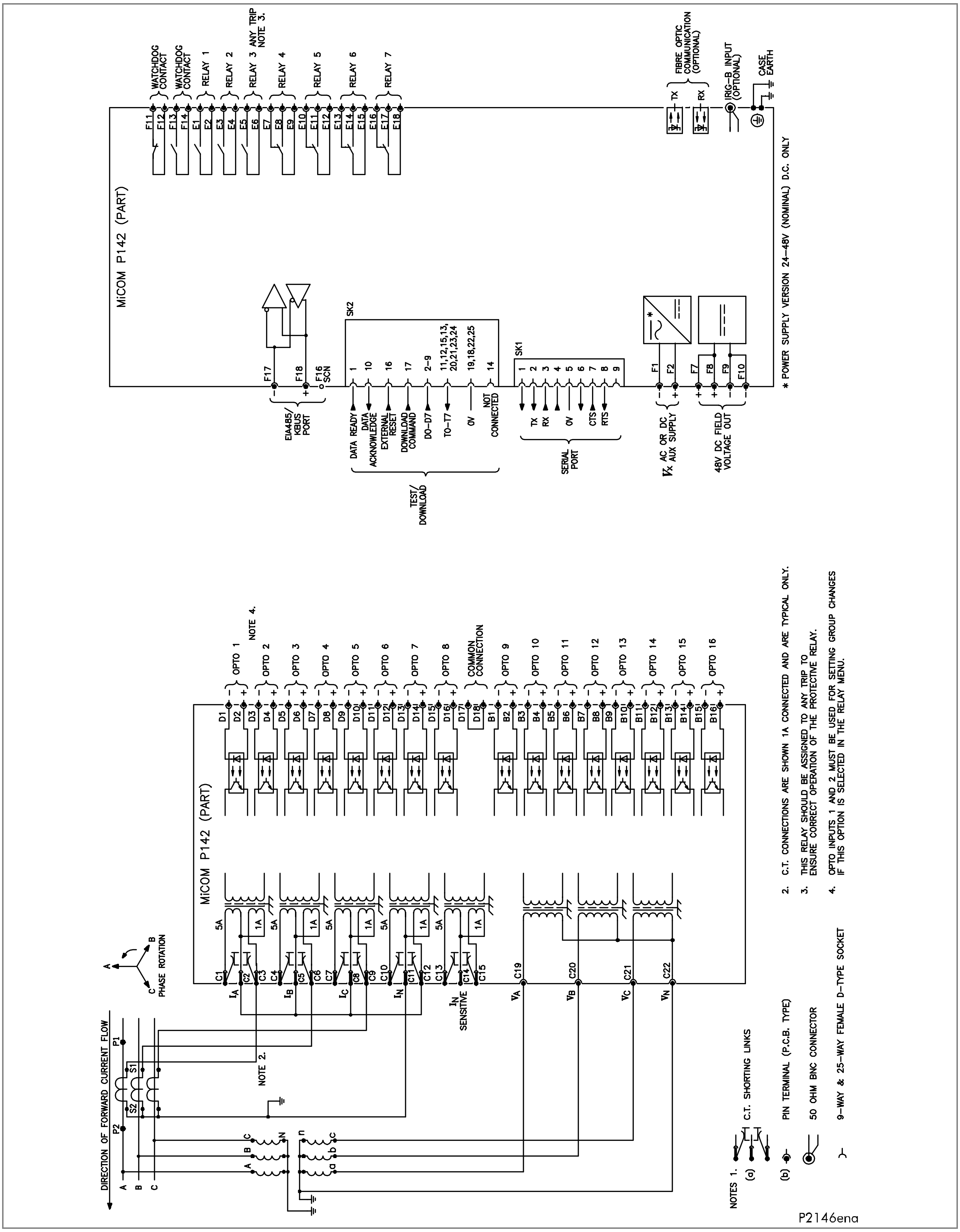


Figure 11 - P142 - D/P O/C and EF with AR (16 I/P & 7 O/P)

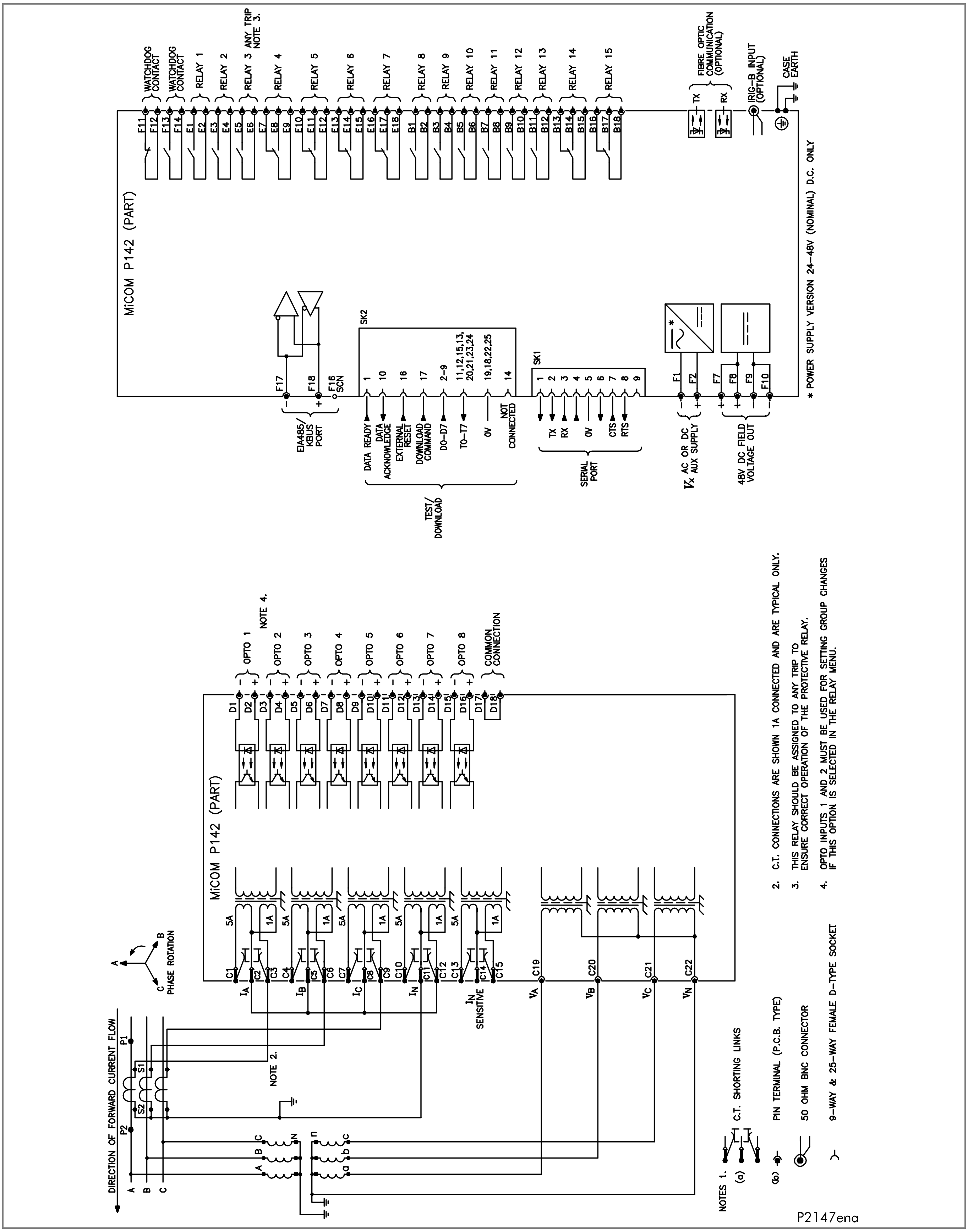


Figure 12 - P142 - D/P O/C and EF with AR (8 I/P & 15 O/P)

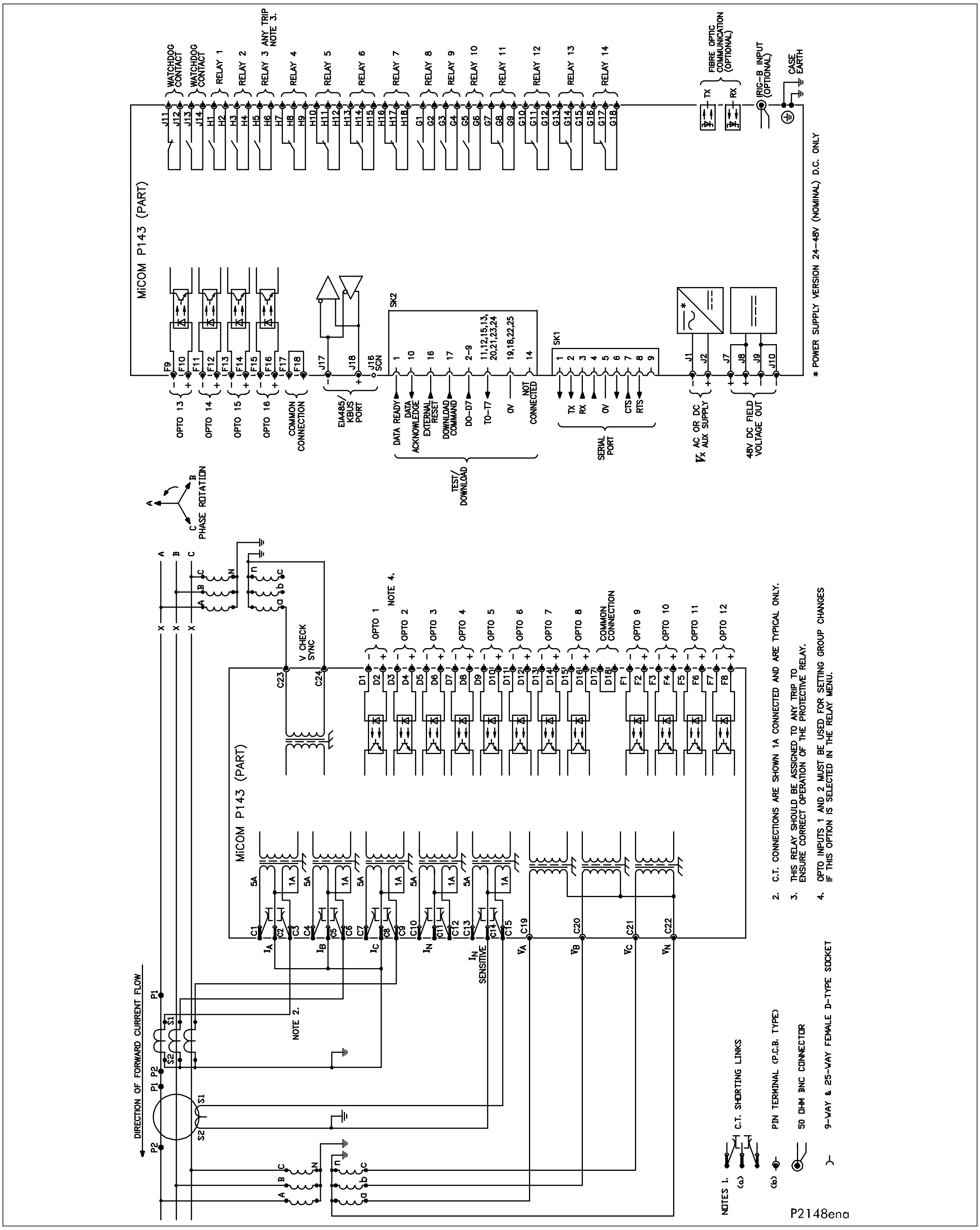


Figure 13 - P143 - D/P O/C and SEF with AR and CS (16 I/P & 14 O/P)

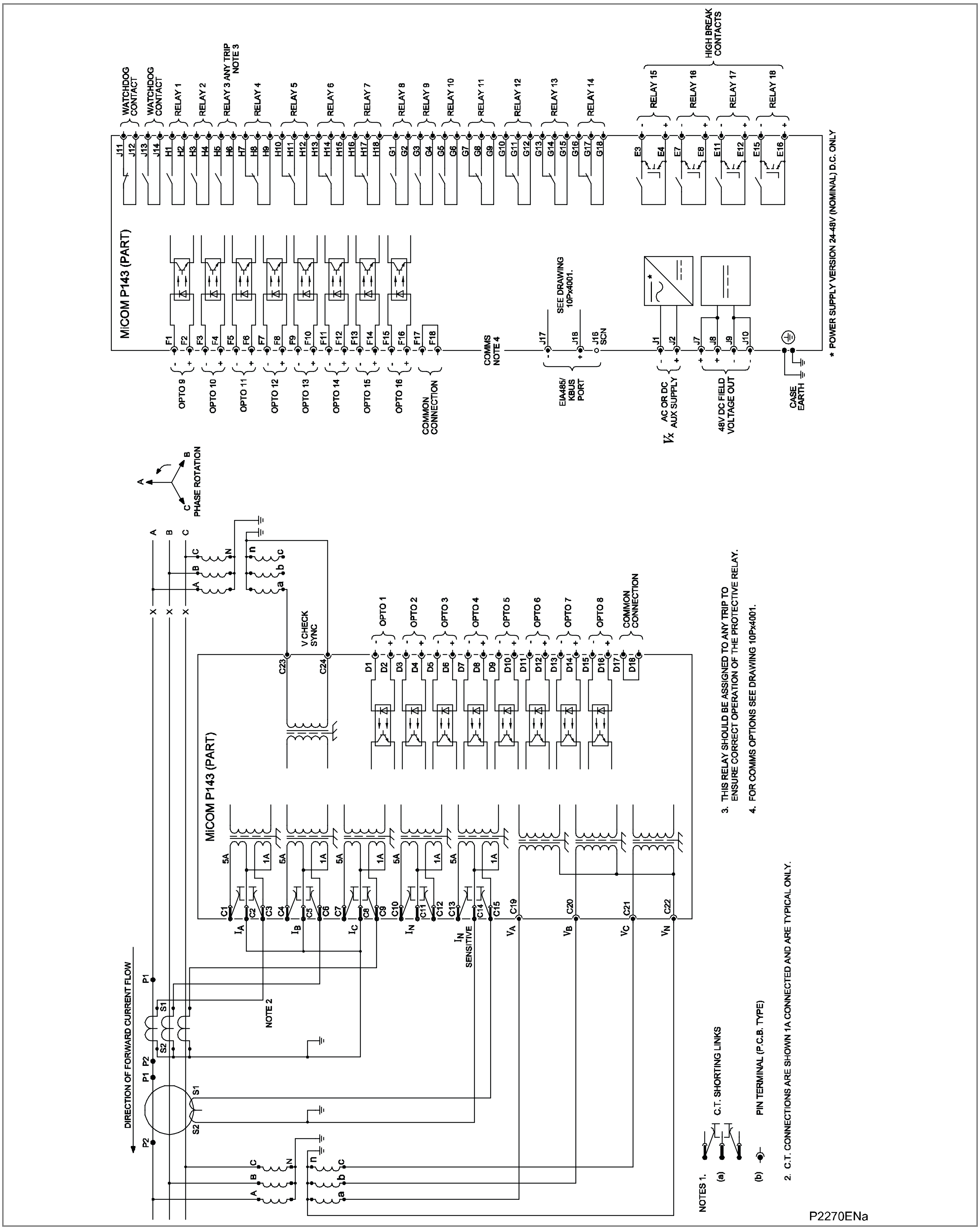


Figure 14 - P143 - D/P O/C and SEF with AR and CS (16 I/P & 18 O/P with 4 High Break Outputs)

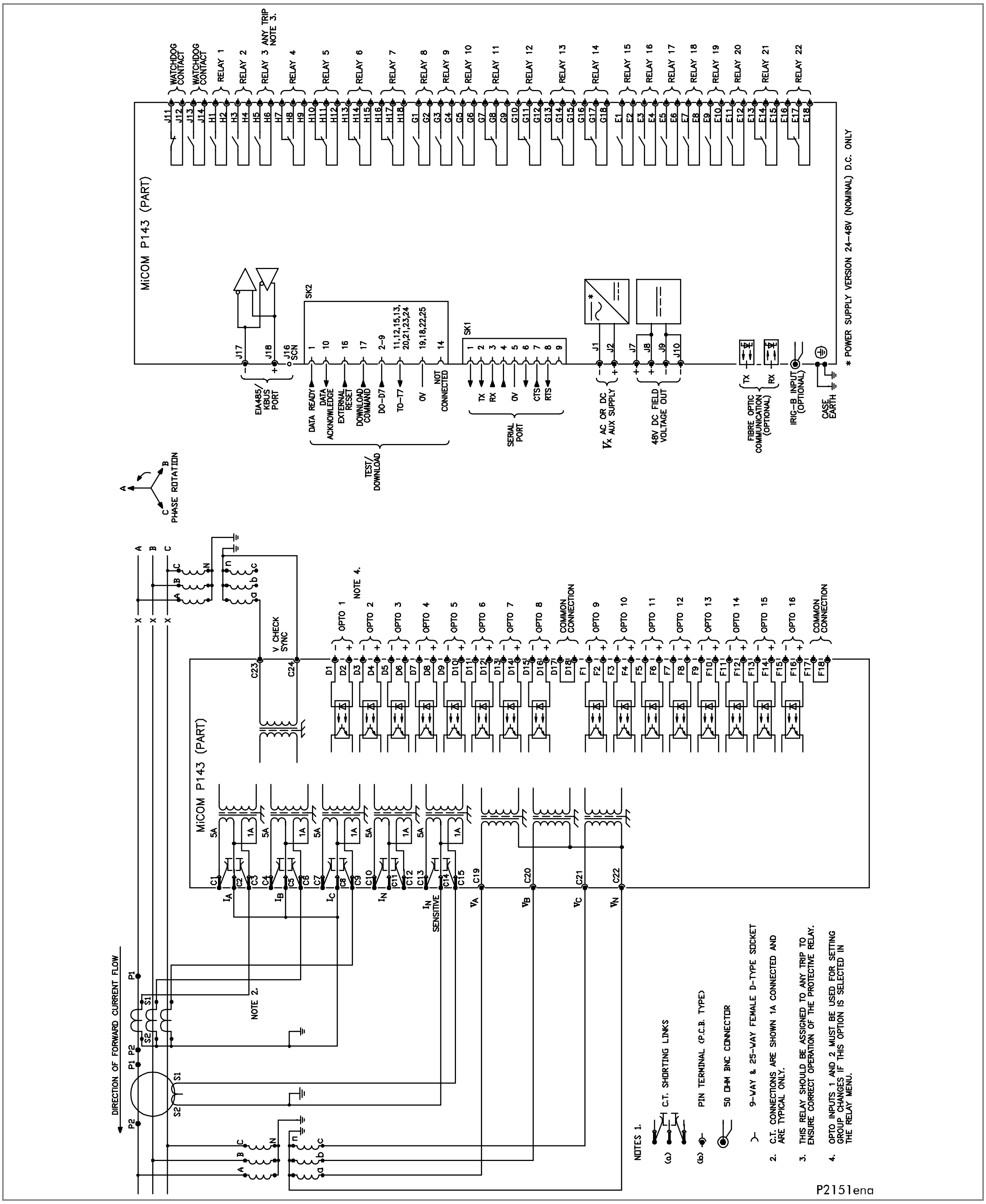


Figure 15 - P143 - D/P O/C and SEF with AR and CS (16 I/P & 22 O/P)

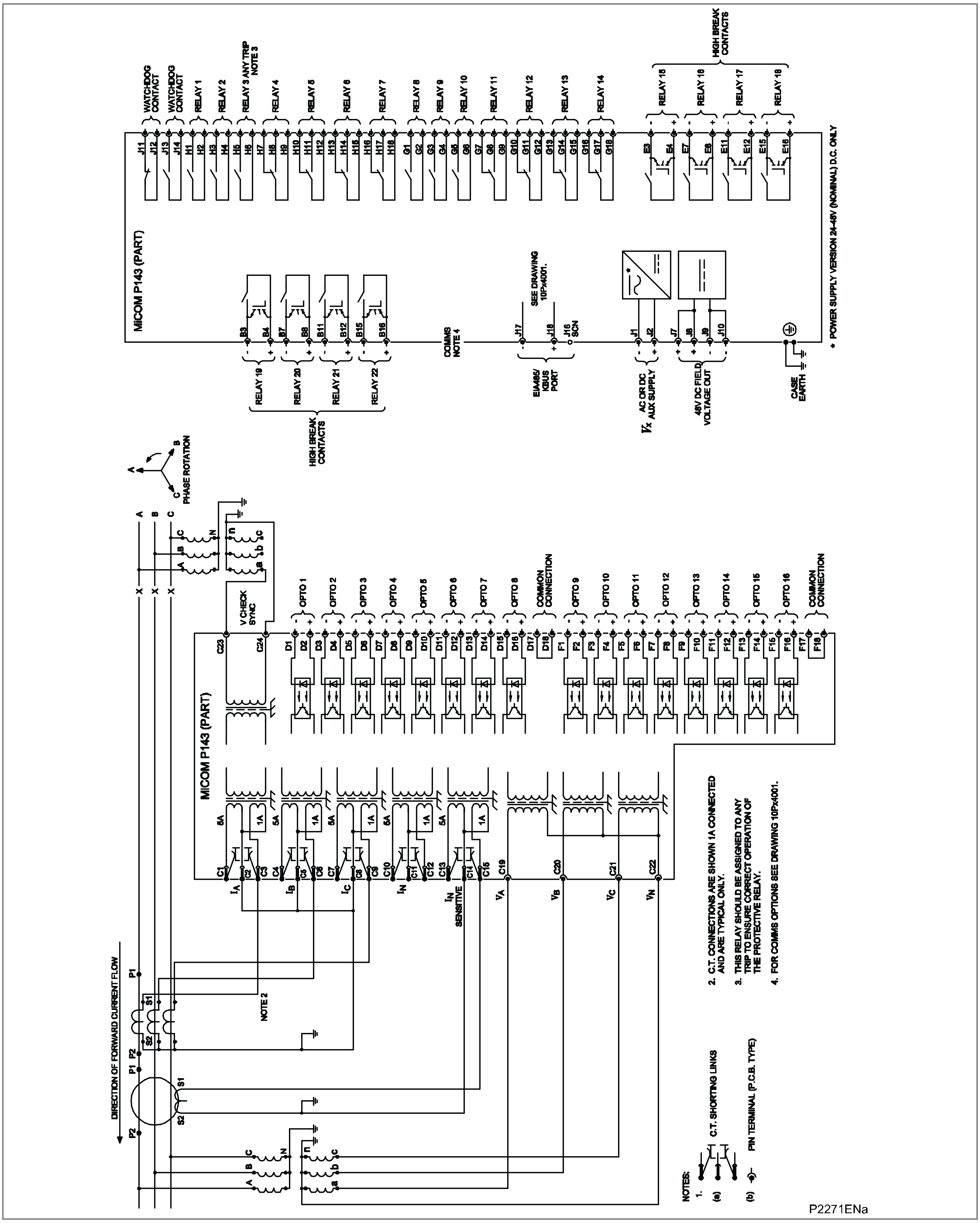


Figure 16 - P143 - D/P O/C and SEF with AR and CS (16 I/P & 22 O/P with 8 High Break Contacts)

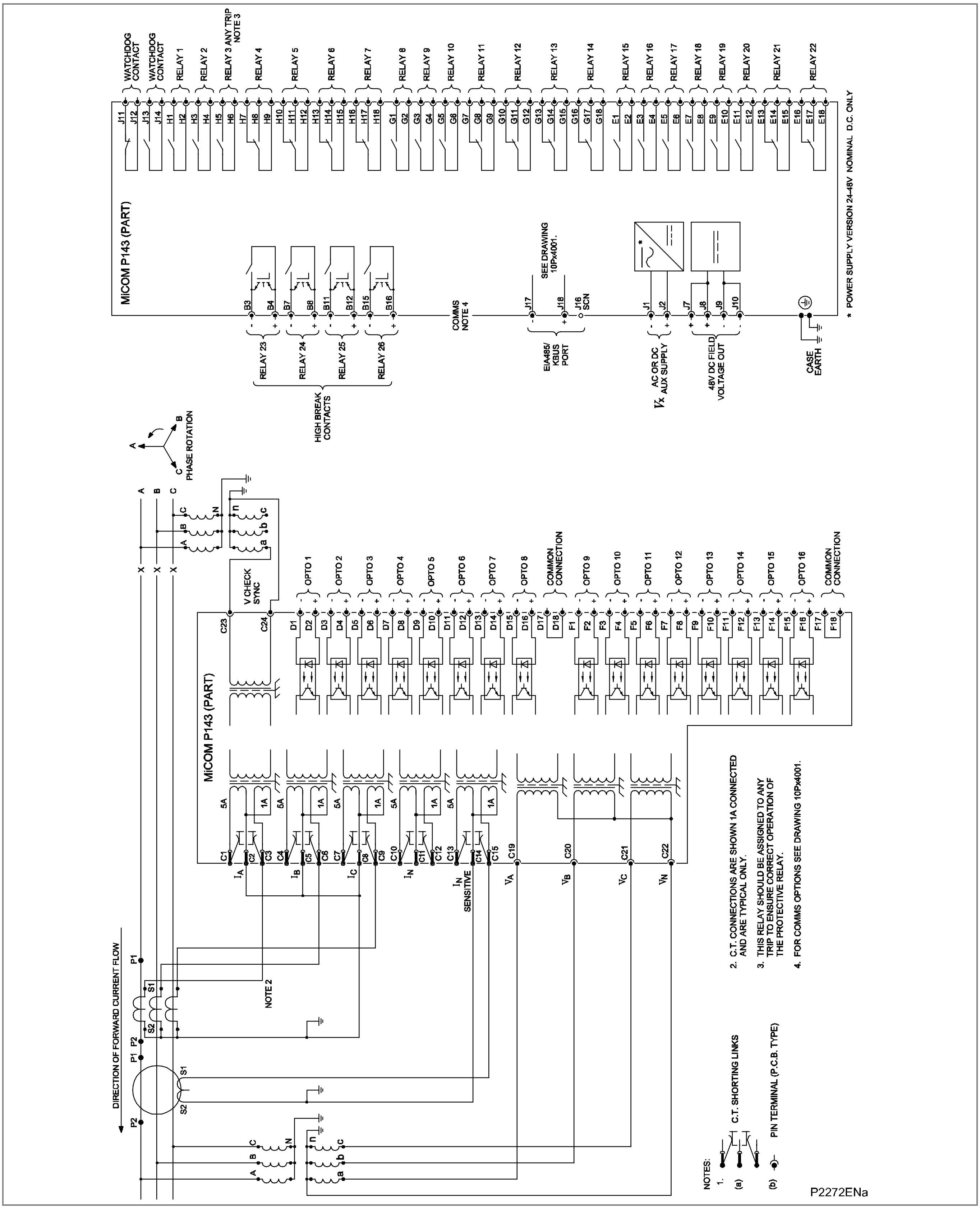


Figure 17 - P143 - D/P O/C and SEF with AR and CS (16 I/P & 26 O/P with 4 High Break Contacts)

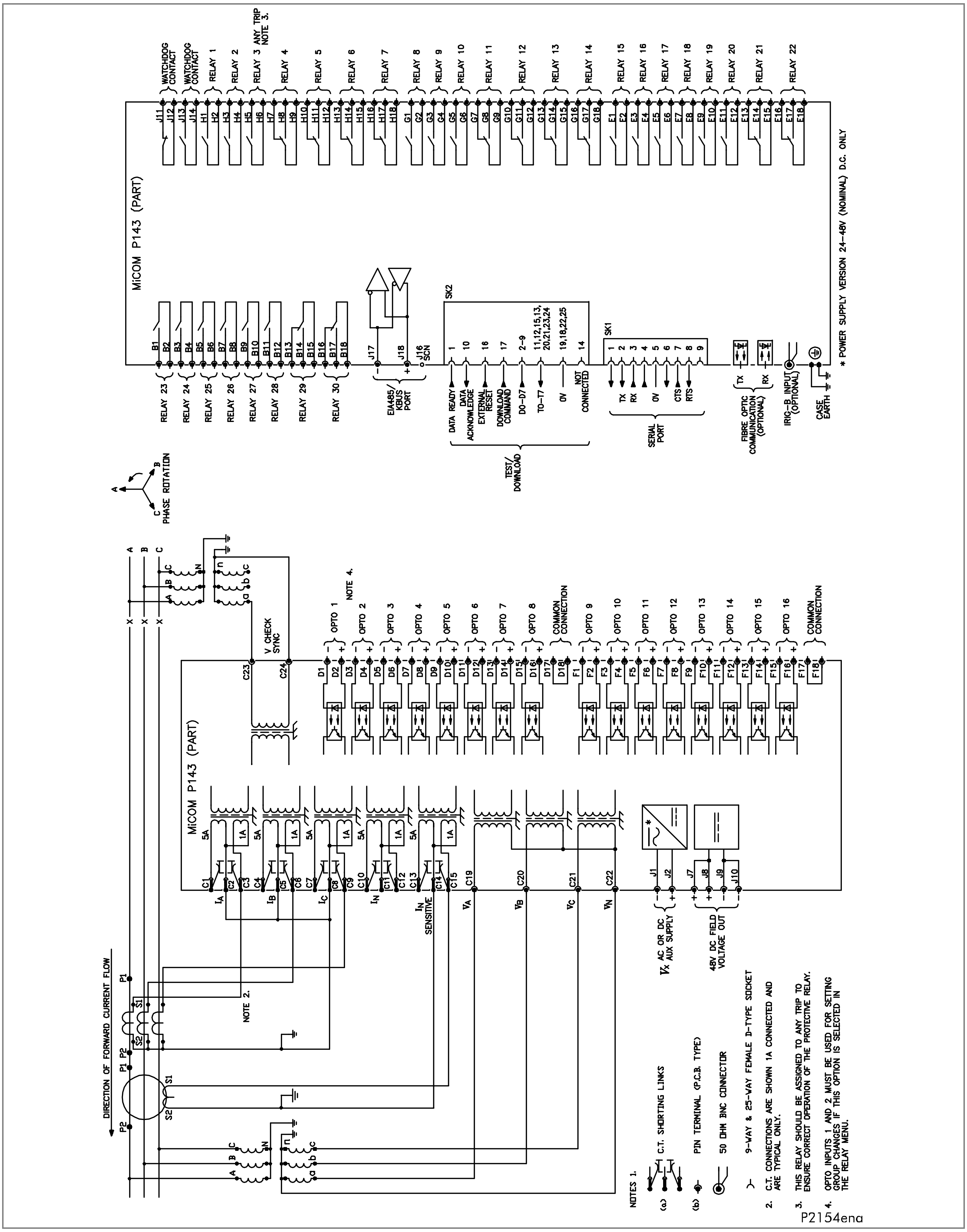


Figure 18 - P143 - D/P O/C and SEF with AR and CS (16 I/P & 30 O/P)

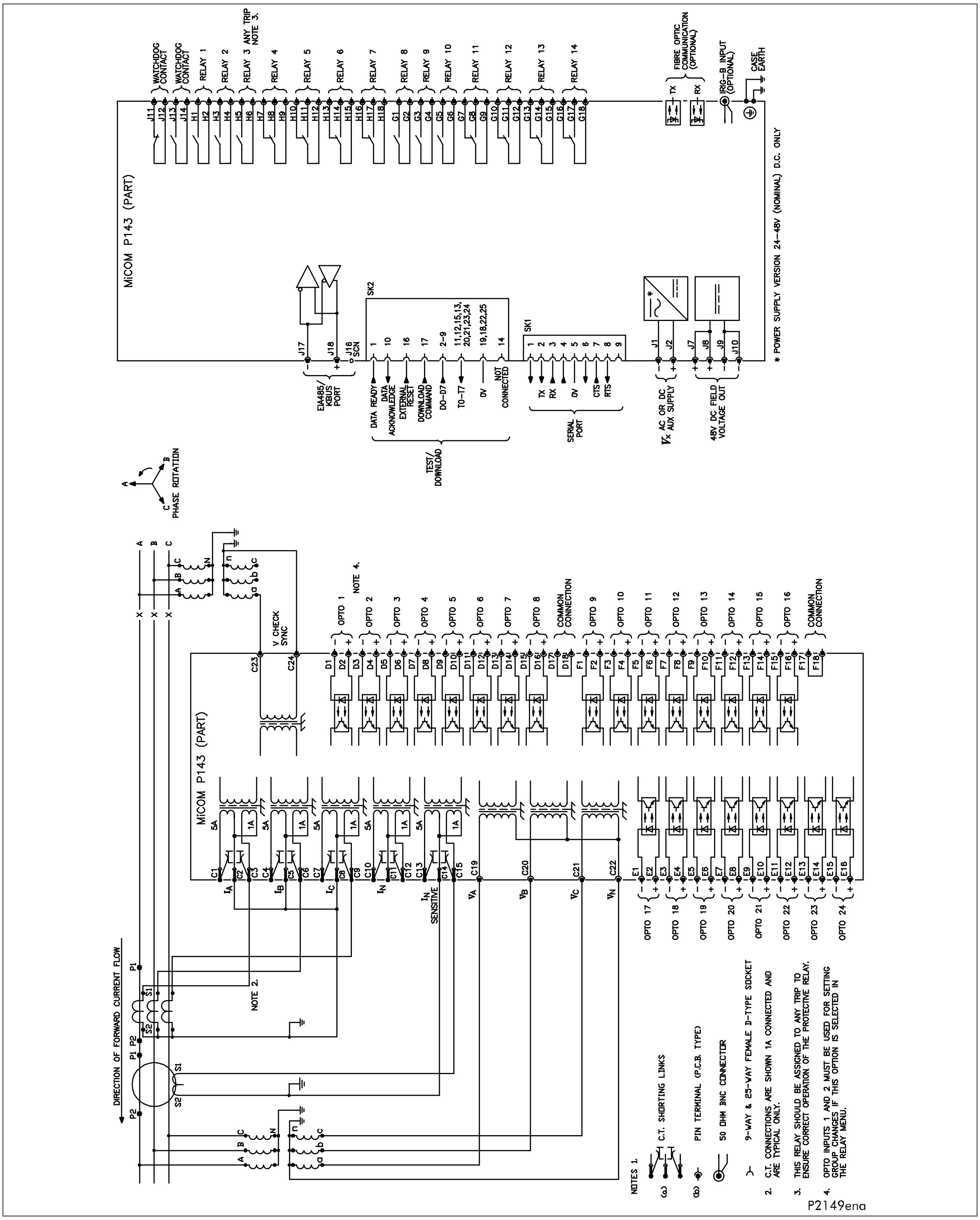


Figure 19 - P143 - D/P O/C and SEF with AR and CS (24 I/P & 14 O/P)

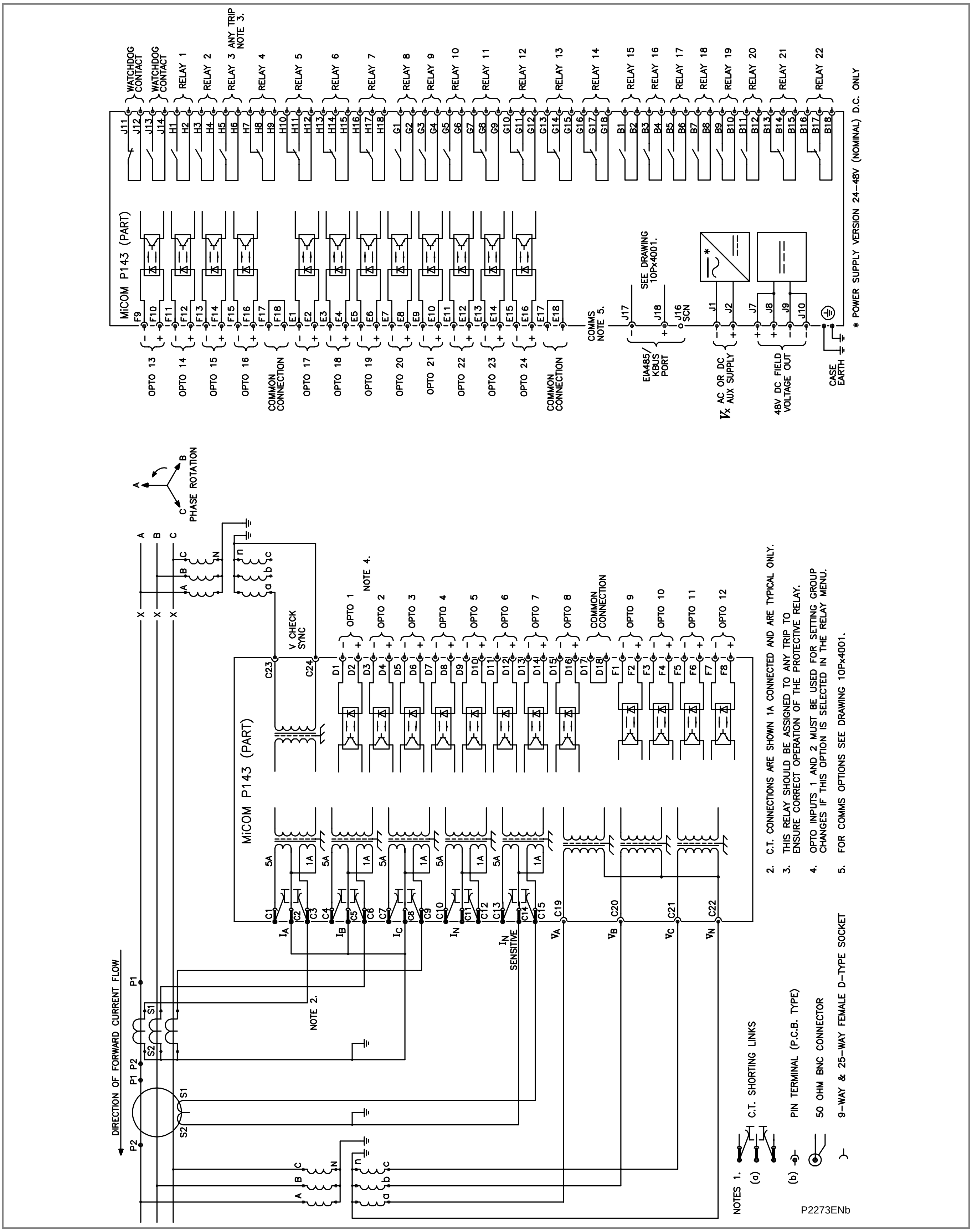


Figure 20 - P143 - D/P O/C and SEF with AR and CS (24 I/P & 22 O/P)

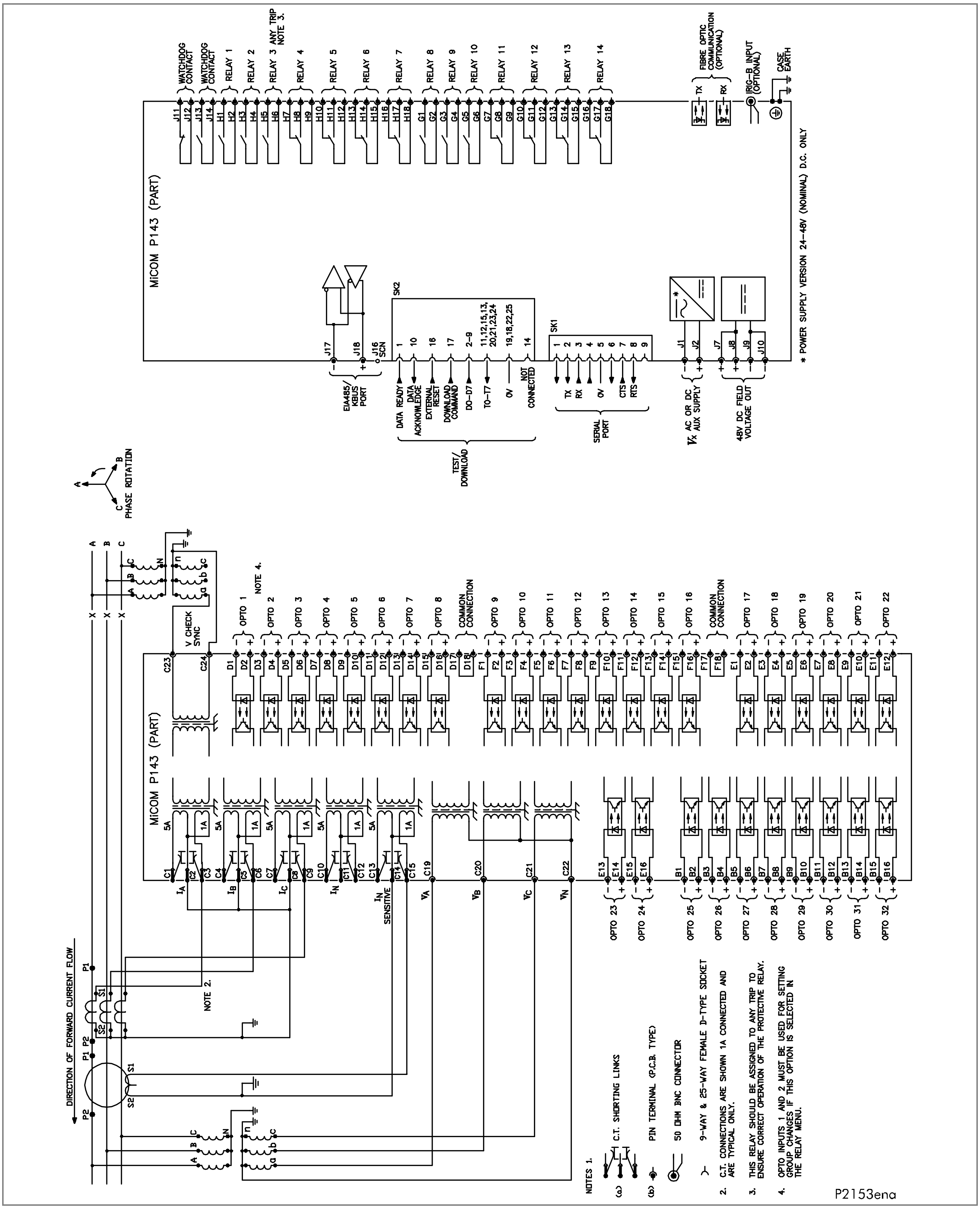


Figure 21 - P143 - D/P O/C and SEF with AR and CS (32 I/P & 14 O/P)

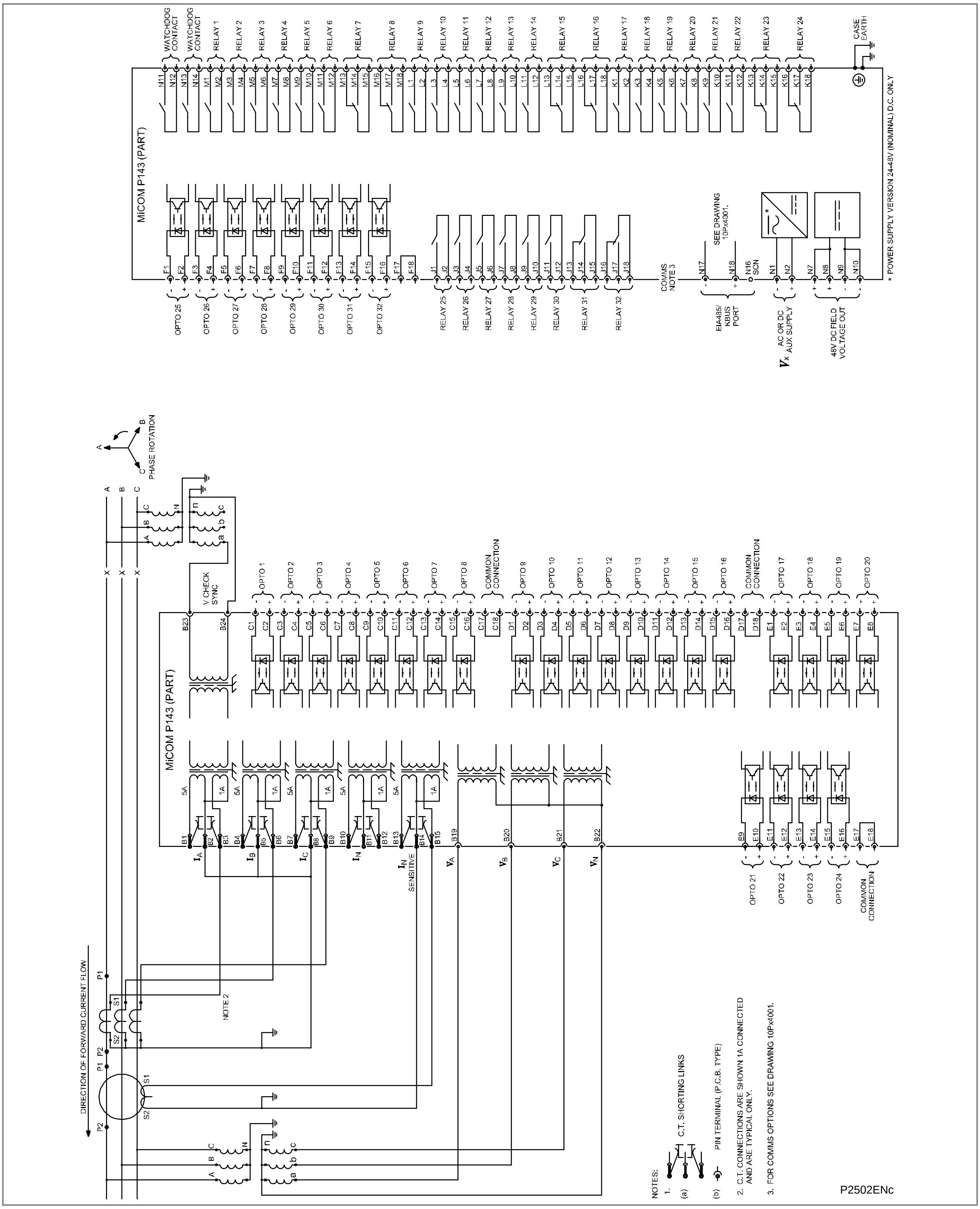


Figure 22 - P143 - D/P O/C and SEF with AR and CS (32 I/P & 32 O/P)

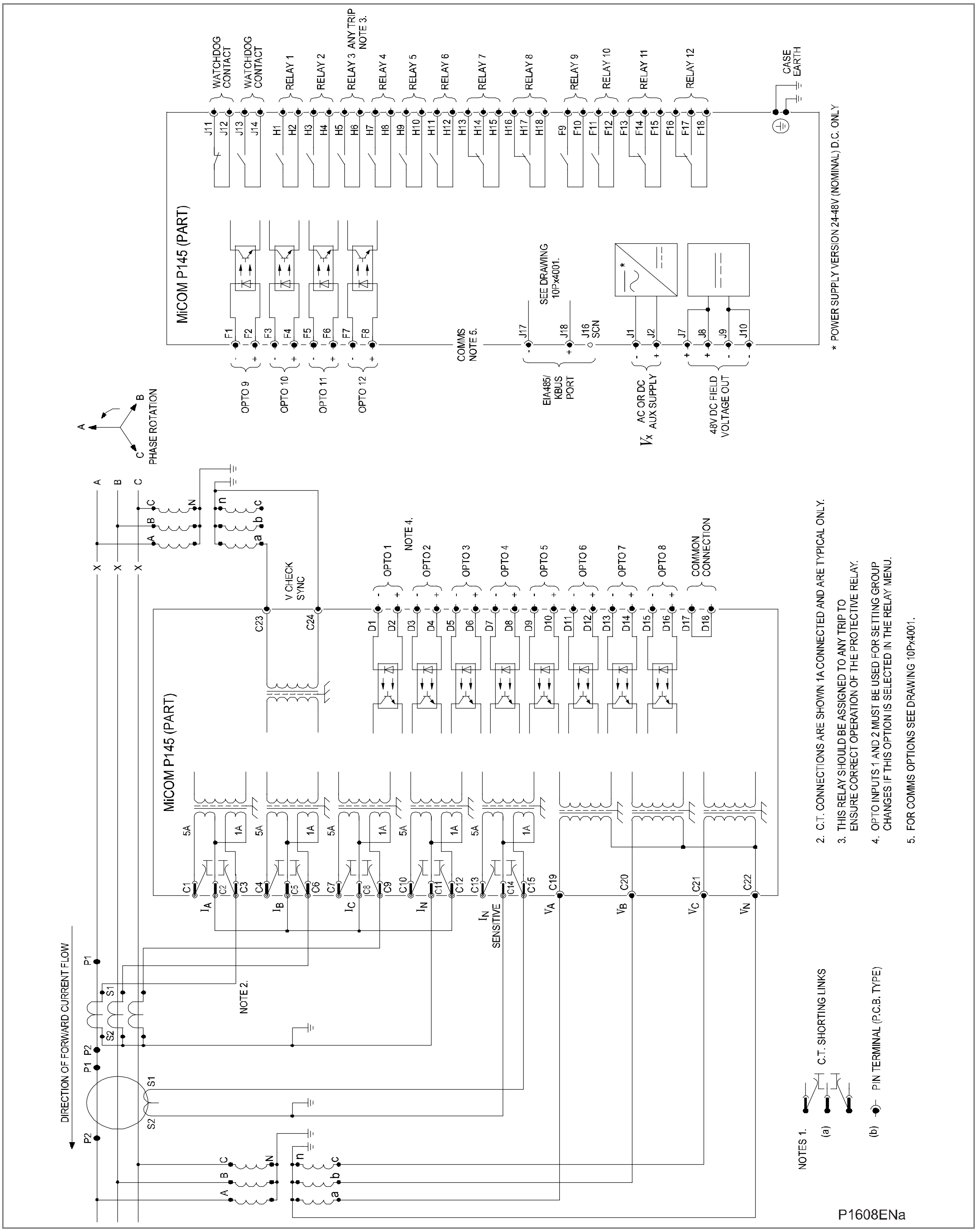


Figure 23 - P145 - D/P O/C and SEF with AR and CS (12 I/P & 12 O/P)

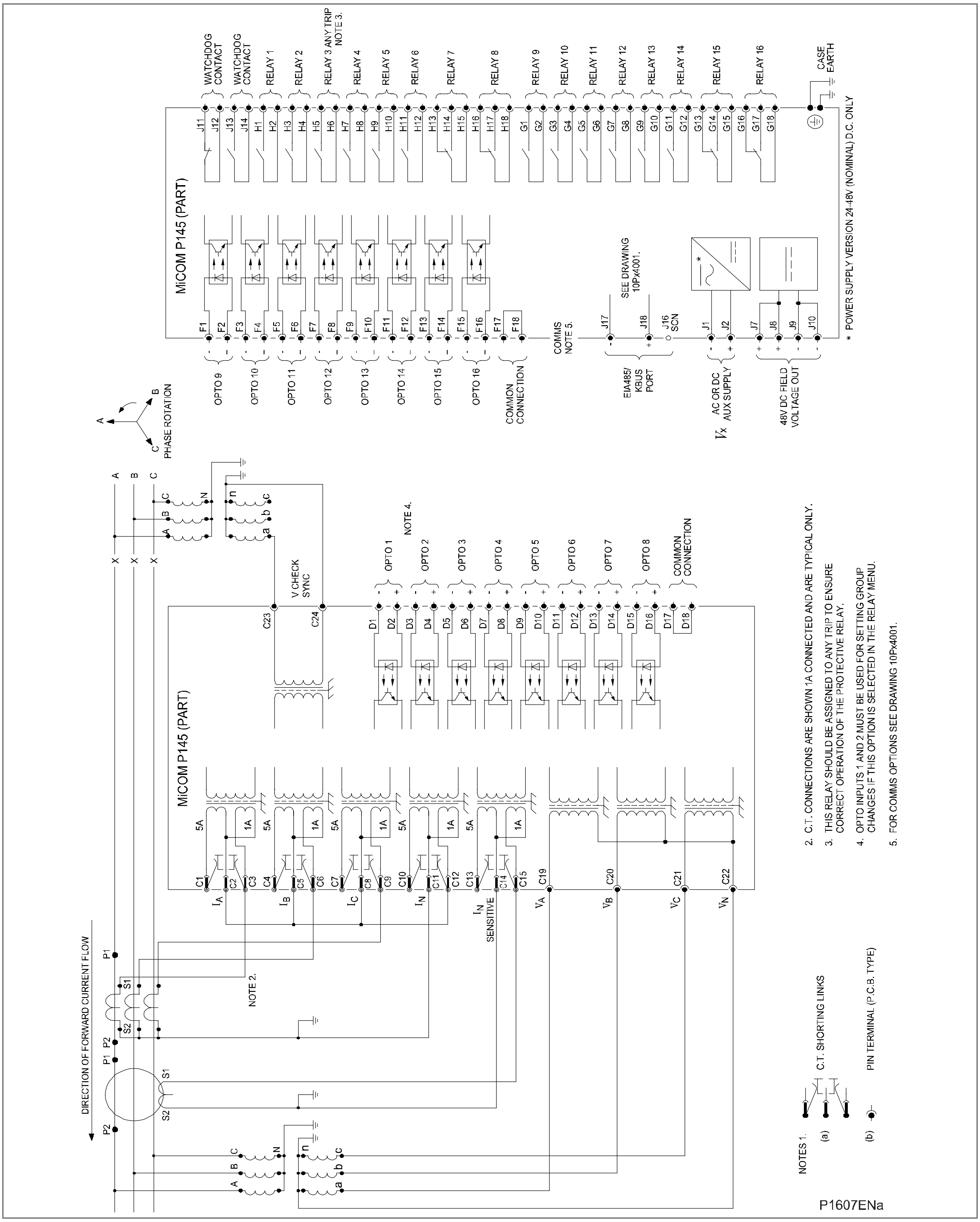


Figure 24 - P145 - D/P O/C and SEF with AR and CS (16 I/P & 16 O/P)

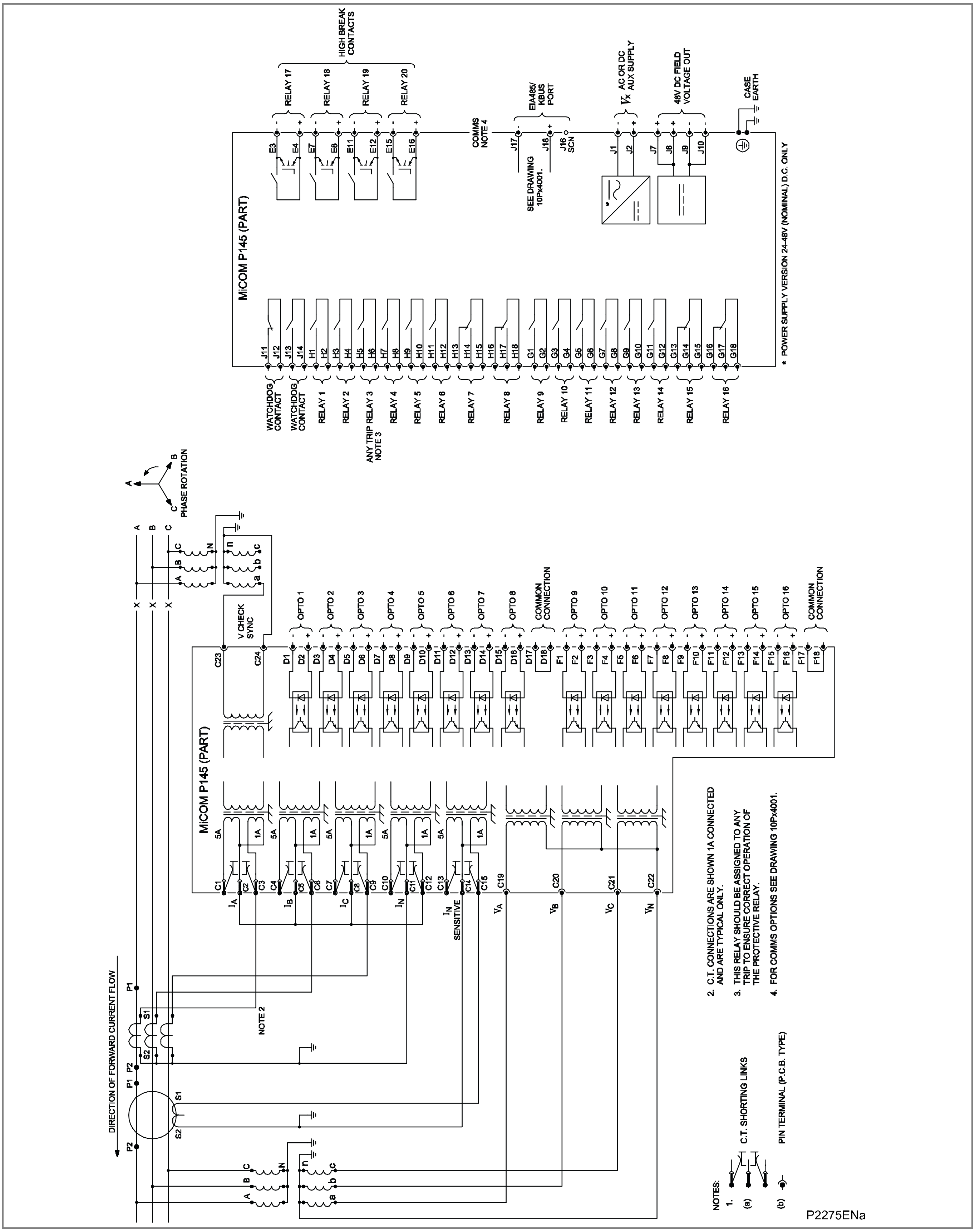


Figure 25 - P145 - D/P O/C and SEF with AR and CS (16 I/P & 20 O/P with 4 High Break Contacts)

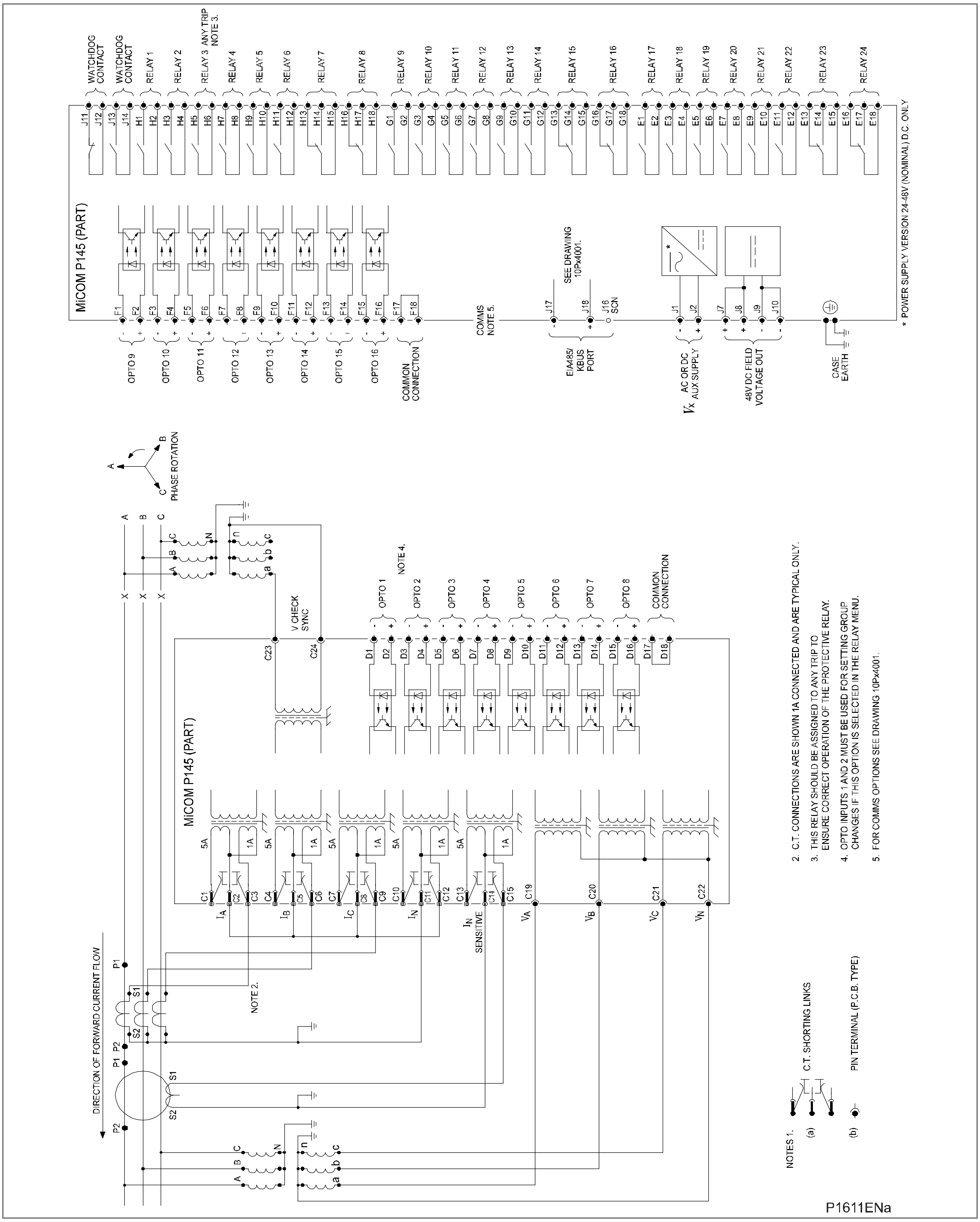


Figure 26 - P145 - D/P O/C and SEF with AR and CS (16 I/P & 24 O/P)

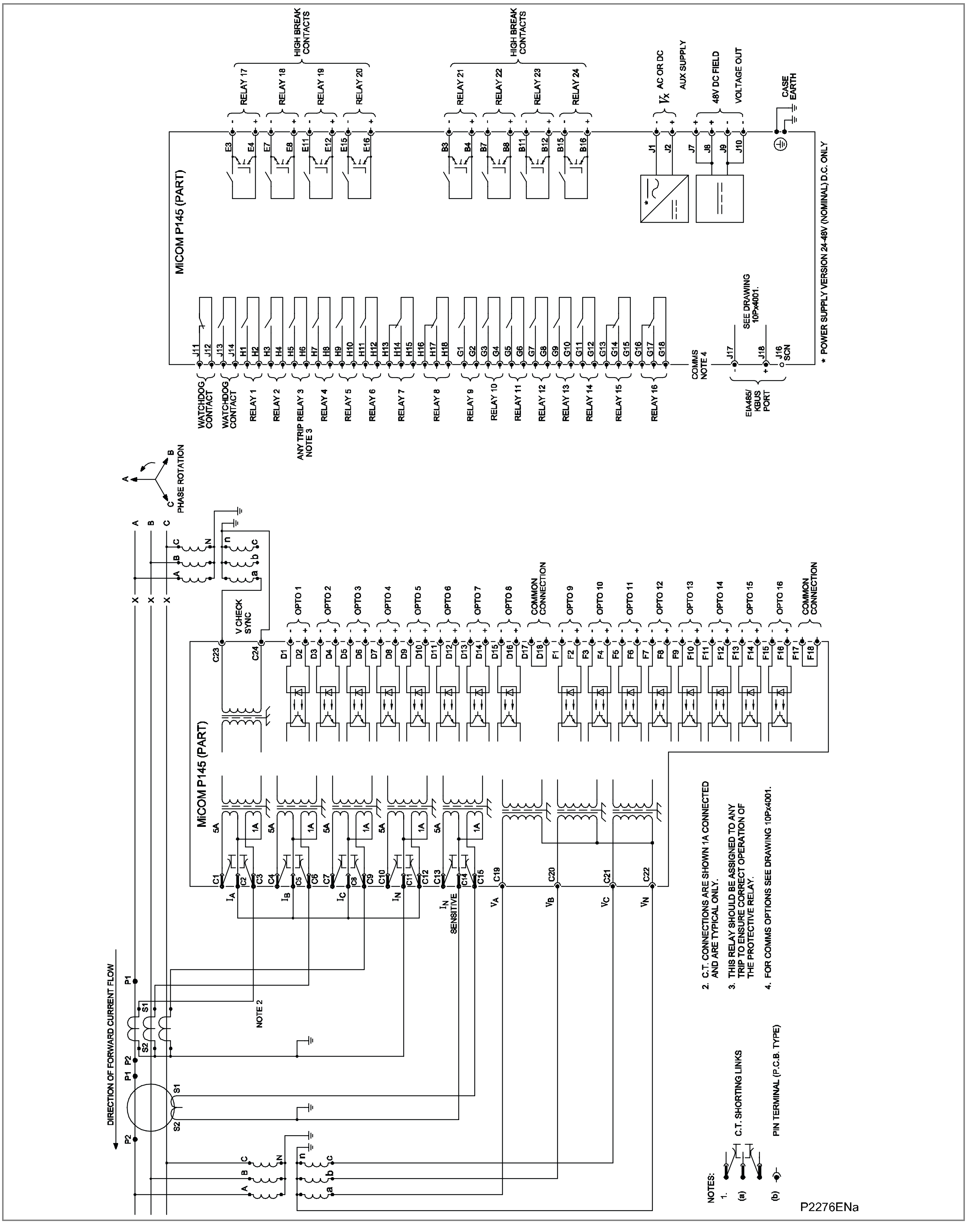


Figure 27 - P145 - D/P O/C and SEF with AR and CS (16 I/P & 24 O/P with 8 High Break Contacts)

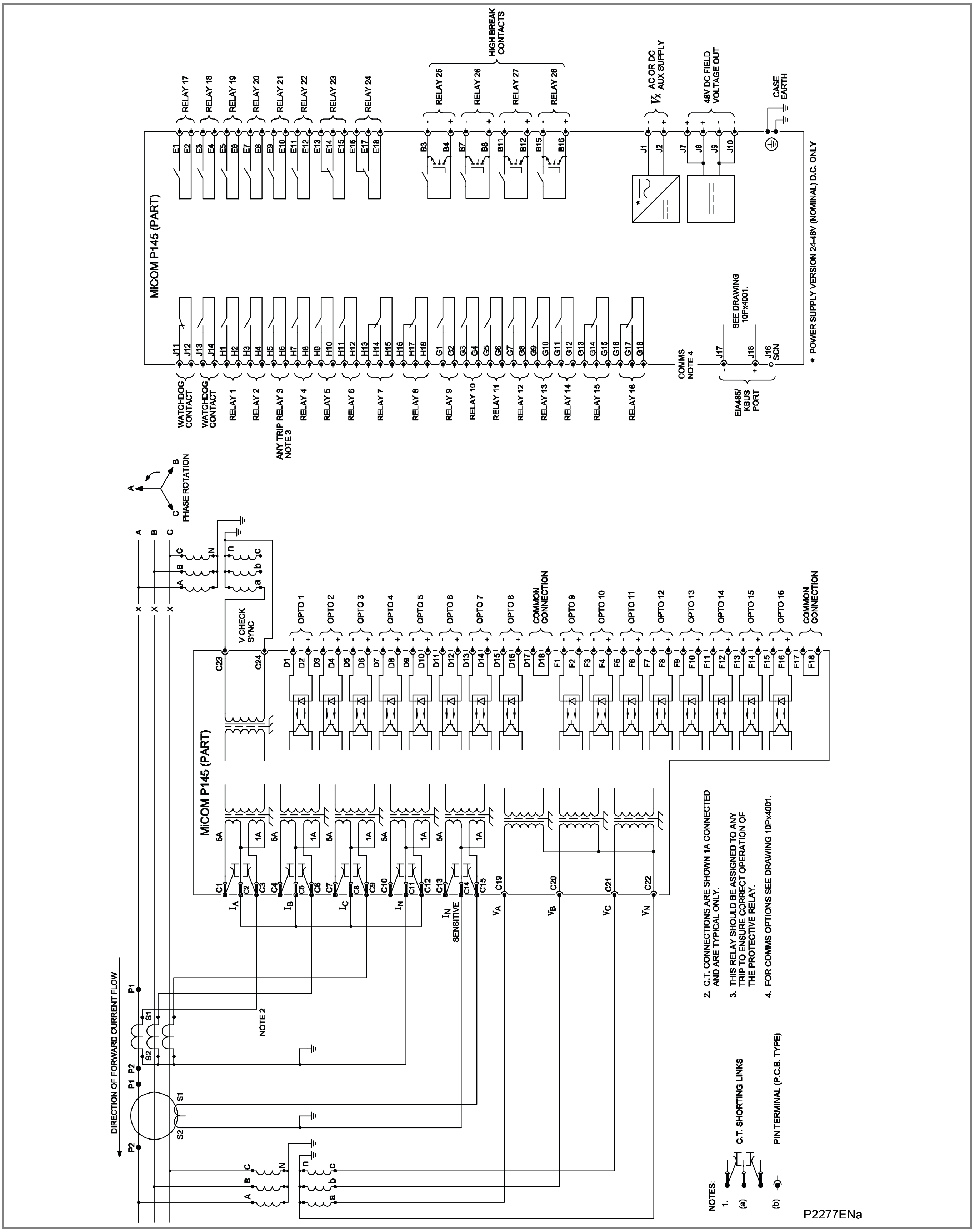


Figure 28 - P145 - D/P O/C and SEF with AR and CS (16 I/P & 28 O/P with 4 High Break Contacts)

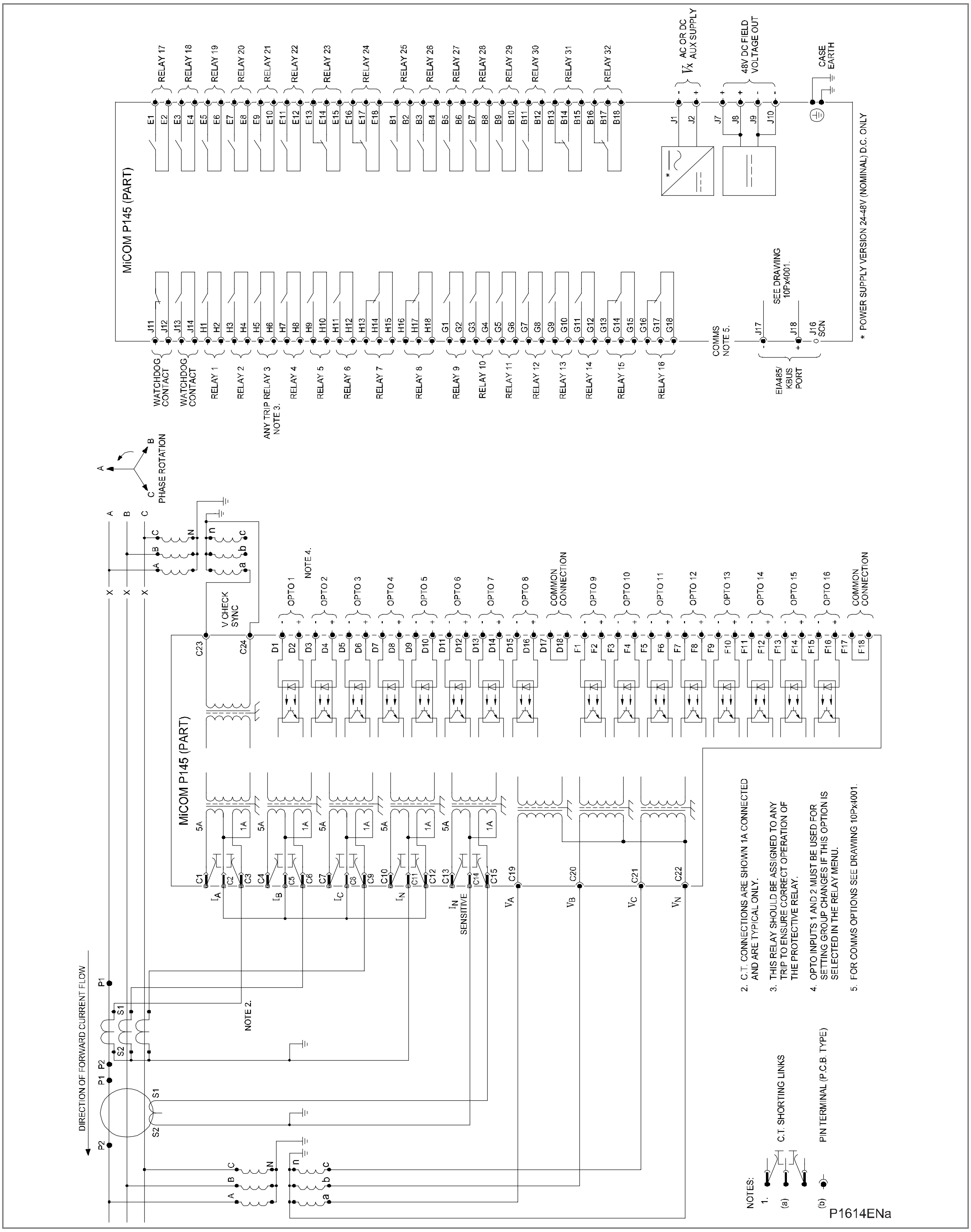


Figure 29 - P145 - D/P O/C and SEF with AR and CS (16 I/P & 32 O/P)

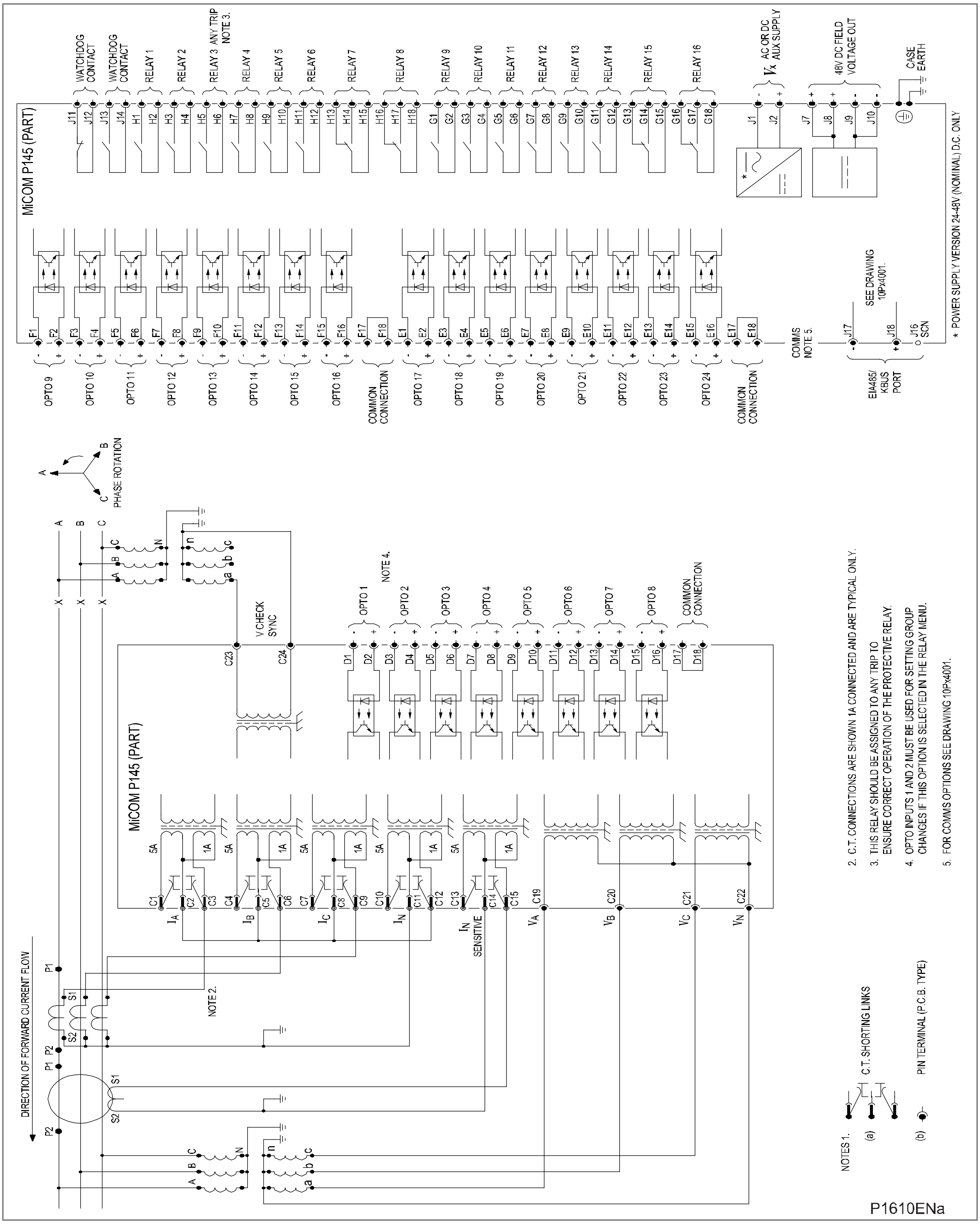


Figure 30 - P145 - D/P O/C and SEF with AR and CS (24 I/P & 16 O/P)

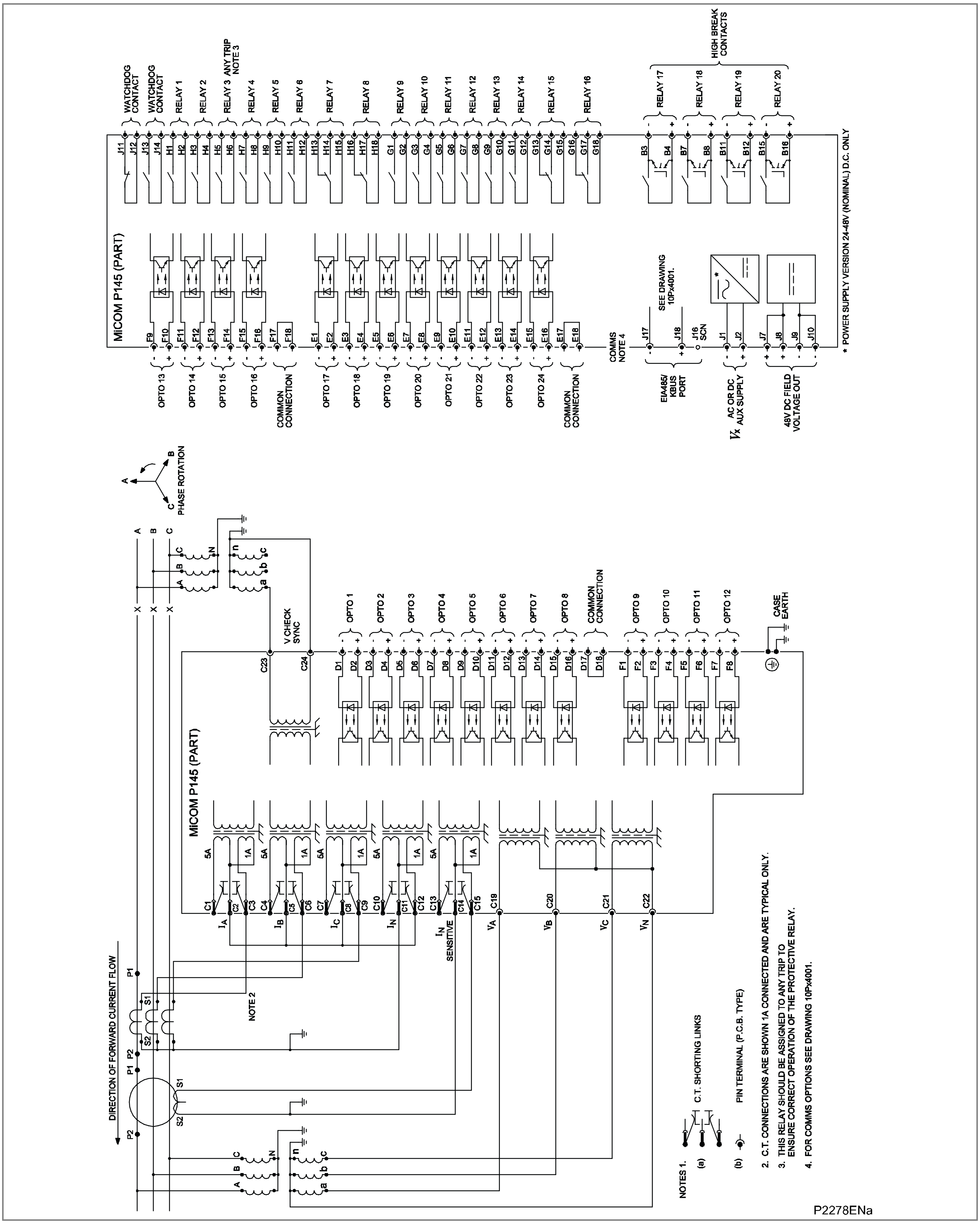


Figure 31 - P145 - D/P O/C and SEF with AR and CS (24 I/P & 20 O/P with 4 High Break Contacts)

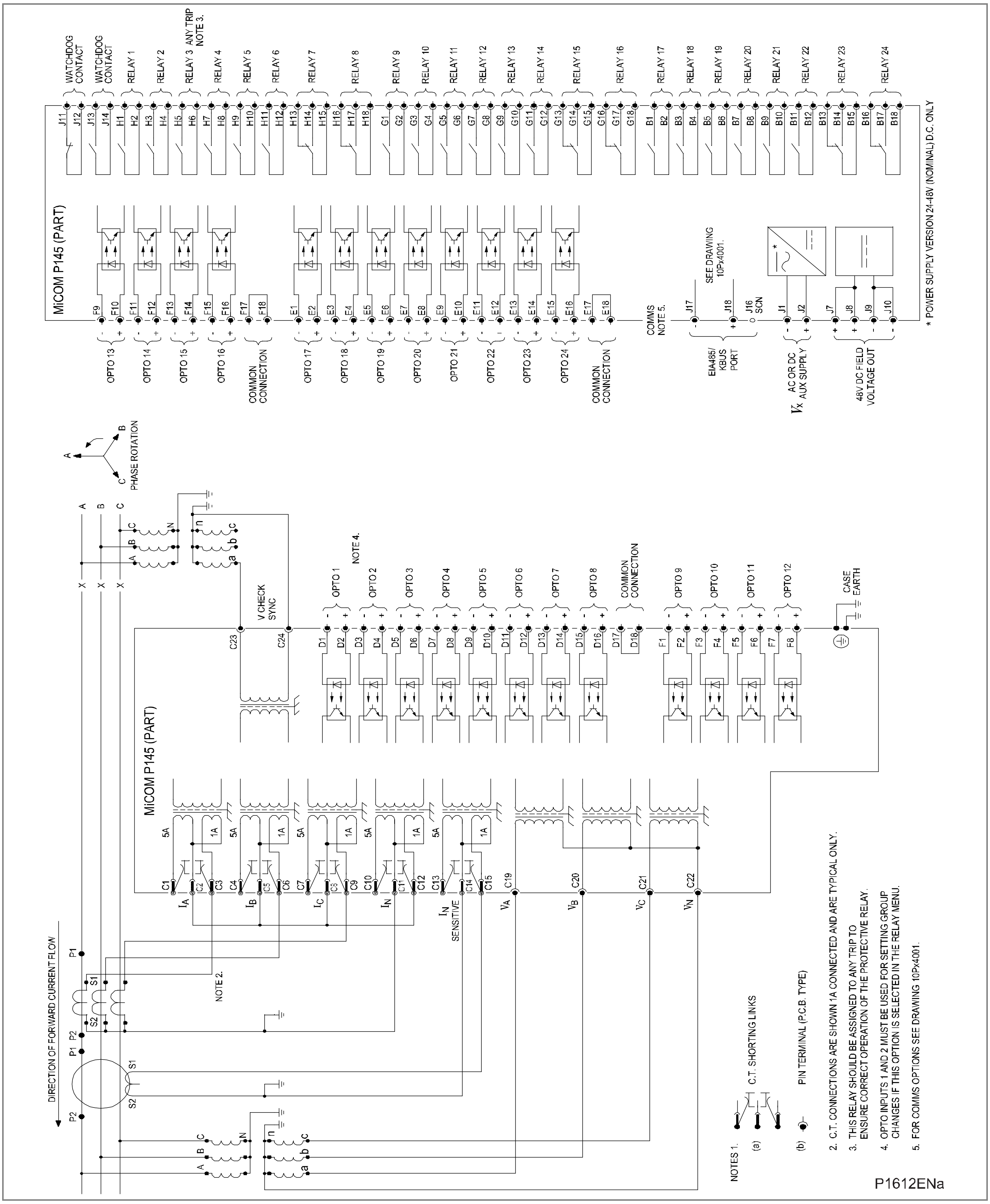


Figure 32 - P145 - D/P O/C and SEF with AR and CS (24 I/P & 24 O/P)

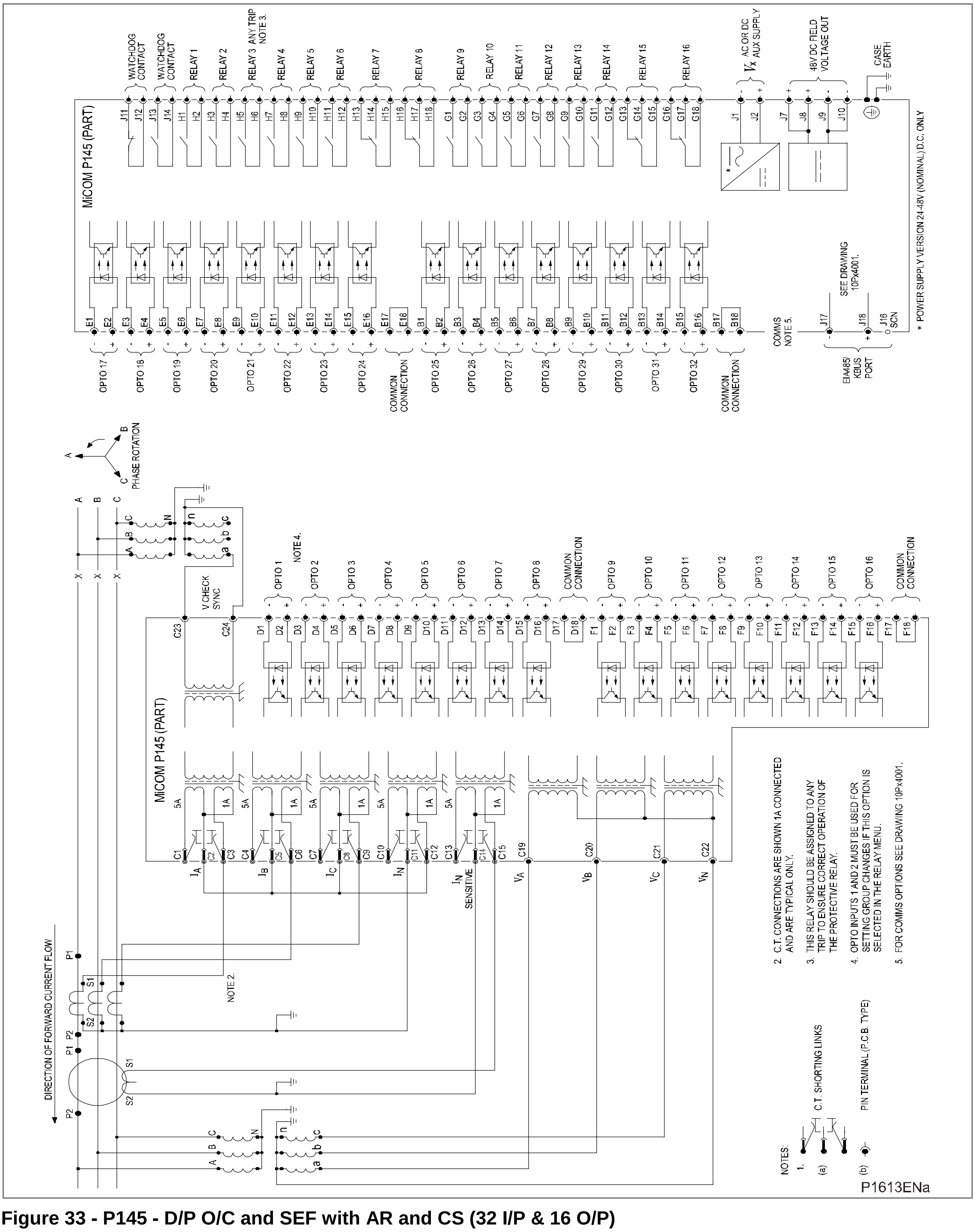


Figure 33 - P145 - D/P O/C and SEF with AR and CS (32 I/P & 16 O/P)

Notes:

CYBER SECURITY

CHAPTER 18

<table>
<tr><td>Date (month/year):</td><td colspan="2">02/2018</td></tr>
<tr><td>Products covered by this chapter:</td><td colspan="2">This chapter covers the specific versions of the MiCOM products listed below. This includes only the following combinations of Software Version and Hardware Suffix.</td></tr>
<tr><td>Hardware Suffix:</td><td>P445 L
P44y (P443/P446) M</td><td>P54x (P543/P544/P545/P546) M
P841A (one circuit breaker) M
P841B (two circuit breakers) M</td></tr>
<tr><td>Software Version:</td><td>P445 J8
P44y (P443/P446) H8</td><td>P54x (P543/P544/P545/P546) H8
P841A (one circuit breaker) G8
P841B (two circuit breakers) H8</td></tr>
<tr><td>Connection Diagrams:</td><td>P14x (P141, P142, P143 & P145):
10P141xx (xx = 01 to 02)
10P142xx (xx = 01 to 05)
10P143xx (xx = 01 to 11)
10P145xx (xx = 01 to 11)
P445:
10P445xx (xx = 01 to 04)
P44x (P442 & P444):
10P44201 (SH 1 & 2)
10P44202 (SH 1)
10P44203 (SH 1 & 2)
10P44401 (SH 1)
10P44402 (SH 1)
10P44403 (SH 1 & 2)
10P44404 (SH 1)
10P44405 (SH 1)
10P44407 (SH 1 & 2)
P44y (P443 & P446):
10P44303 (SH 01 and 03)
10P44304 (SH 01 and 03)
10P44305 (SH 01 and 03)
10P44306 (SH 01 and 03)
10P44600
10P44601 (SH 1 to 2)
10P44602 (SH 1 to 2)
10P44603 (SH 1 to 2)</td><td>P54x (P543, P544, P545 & P546):
10P54302 (SH 1 to 2)
10P54303 (SH 1 to 2)
10P54400
10P54404 (SH 1 to 2)
10P54405 (SH 1 to 2)
10P54502 (SH 1 to 2)
10P54503 (SH 1 to 2)
10P54600
10P54604 (SH 1 to 2)
10P54605 (SH 1 to 2)
10P54606 (SH 1 to 2)
P64x (P642, P643 & P645):
10P642xx (xx = 01 to 10)
10P643xx (xx = 01 to 06)
10P645xx (xx = 01 to 09)
P746:
10P746xx (xx = 00 to 21)
P841:
10P84100
10P84101 (SH 1 to 2)
10P84102 (SH 1 to 2)
10P84103 (SH 1 to 2)
10P84104 (SH 1 to 2)
10P84105 (SH 1 to 2)
P849:
10P849xx (xx = 01 to 06)</td></tr>
<tr><td></td><td colspan="2">Note   This chapter covers the combinations of Products, Software Versions and Hardware Suffixes identified here. If you are using earlier software or hardware, please refer to the Schneider Electric Customer Care Centre (www.schneider-electric.com/ccc) for details of which version of this chapter to refer to.</td></tr>
</table>

CONTENTS

Page (CS) 18-

TABLES

FIGURES

1 OVERVIEW

1.1 Definition

Cyber security is a domain that addresses attacks on or by computer systems and through computer networks that can result in accidental or intentional disruptions. Cyber security addresses not only deliberate attacks, such as from disgruntled employees, industrial espionage, and terrorists, but also inadvertent compromises of the information infrastructure due to user errors, equipment failures, and natural disasters.

1.2 Introduction to Cyber Security

The objective of cyber security is to provide increased levels of protection for information and physical assets from theft, corruption, misuse, or accidents while maintaining access for their intended users.

To achieve this objective the owner of the grid must take into account Cyber Security at every level of his organization by the management of an ongoing process that encompasses procedures, policies, technical (software, and hardware asset) and regulatory constraints.

The following diagram outlines some of the associated topics.

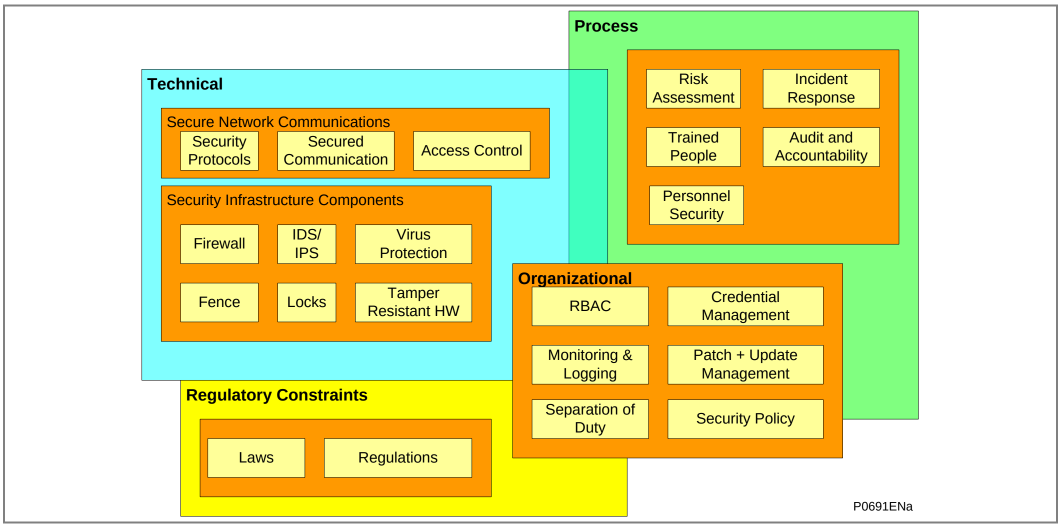


Figure 1 - Associated topics

The asset owner needs to run a continuous improvement process as outlined here:

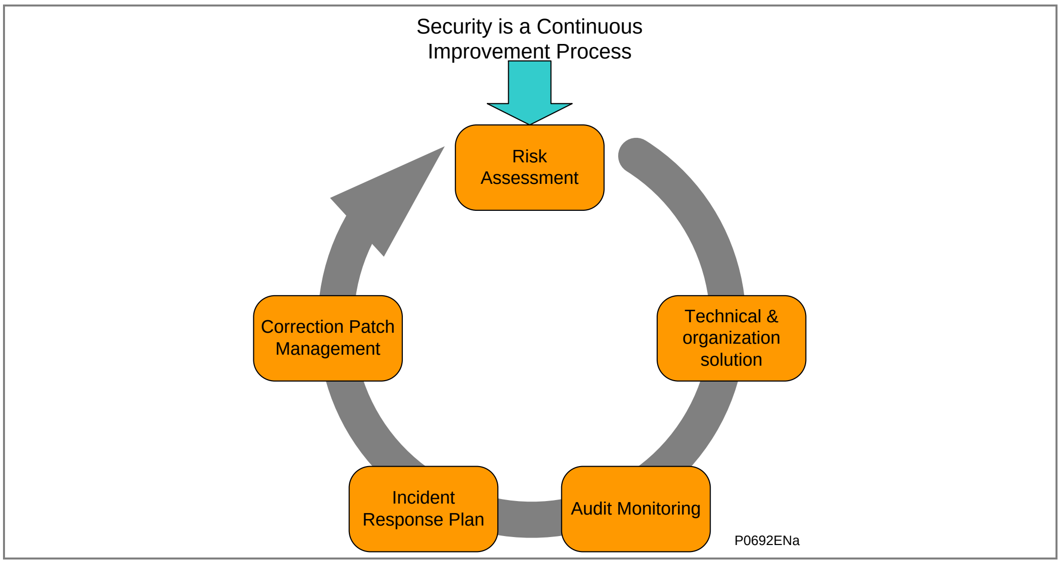


Figure 2 - Continuous improvement process

No single solution can provide adequate protection against all cyber attacks on the control network. Schneider Electric recommends employing a "defense in depth" approach using multiple security techniques to help mitigate risk.

A secured system is to offer:

- Detective controls: Monitor and record specific types of events: Security logs, Intrusion, detection systems, Video Surveillance etc.
- Preventive controls: Help blocking or controlling specific event : Antivirus, White listing, Firewall etc.
- Recovery controls: Help achieve Business continuity and Disaster recovery planning objectives in case of an incident: Backup and Restore solution.

As protective relay vendor, Schneider Electric helps the grid owner to achieve by providing technical features inside the IED, described in the next chapters.

Important	**This product contains a cyber-security function, which manages the encryption of the data exchanged through some of the communication channels. The aim is to protect the data (configuration and process data) from any corruption, malice, attack. Subsequently, this product might be subject to control from customs authorities. It might be necessary to request special authorization from these customs authorities before any export/import operation. For any technical question relating to the characteristics of this encryption please contact your Customer Care Centre - www.schneider-electric.com/ccc.**

1.3 Roles, Rights and relationship between IEC62351 and MiCOM Px4x

1.3.1 Role Based Access Control (RBAC)

The Role Based Access Control (RBAC) is a method to restrict resource access to authorized users. RBAC is an alternative to traditional Mandatory Access Control (MAC) and Discretionary Access Control (DAC).

A key feature of RBAC model is that all access is through roles. A role is essentially a collection of permissions, and all users receive permissions only through the roles to which they are assigned, or through roles they inherit through the role hierarchy.

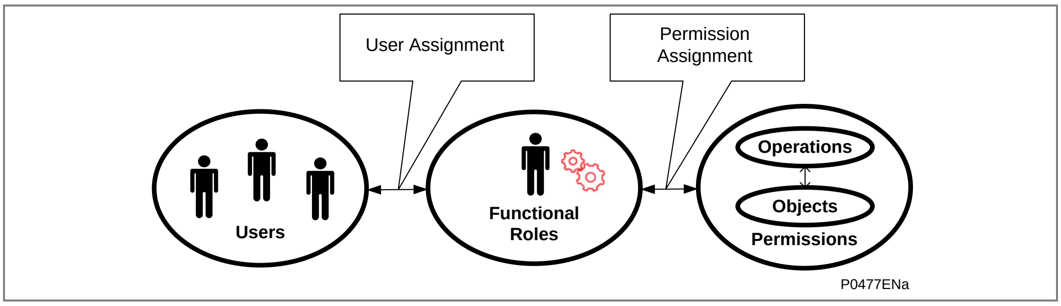


Figure 3 - RBAC Role structure

Roles are created for various job activities. The ***Permissions***, to perform certain operations, are assigned to specific roles. ***Users*** are assigned particular roles, and through those role assignments acquire the computer permissions to perform particular computer-system functions. Since ***users*** are not assigned permissions directly, but only acquire them through their role (or roles), management of individual user rights becomes a matter of simply assigning appropriate roles to the user's account; this simplifies common operations, such as adding a user, or changing user's account.

RBAC defines four different concepts:

RBAC Standard Definition	Description
Object	An ***object*** can represent information containers (e.g. files, directories in an operating system, tables and views in a database management system) or device resources, such as IEDs.
Subject	A ***subject*** is a user of the system. Note that a subject can be a person, or an automated agent / device.
Right	A ***right*** is the ability to access an object in order to perform certain operations (e.g. setting a data or reading a file)
Role	A ***role*** defines a certain authority level in the system. Rights are assigned to roles.

Table 1 – RBAC object, subject, rights and roles definitions

RBAC defines three primary rules:

RBAC Rule	Description
Role assignment	A subject can exercise a permission only if the subject has selected or been assigned a role.
Role authorization	A subject's active role must be authorized for the subject. With rule 1 above, this rule ensures that users can take on only roles for which they are authorized.
Permission authorization	A subject can exercise permission only if the permission is authorized for the subject's active role. With rules 1 and 2, this rule ensures that users can exercise only permissions for which they are authorized.

Table 2 – RBAC permission and authorization rules

1.3.2 User Roles

Different named roles are associated with different access rights. Roles and Rights are setup in a pre-defined arrangement, according to the IEC62351 standard, but customized to the MiCOM Px4x equipment.

When the user tries to access an IED, they need to login using their own username and their own password. The username/password combination is then checked against the records stored on the IED. If they are allowed to login, a message appears which shows them what Role they have been assigned to. It is the role that defines their access to the relevant parts of the system.

The default user roles for MiCOM Px4x are shown here:

Role	Description
VIEWER	Can View what objects are present within a Logical-Device by presenting the type ID of those objects.
OPERATOR	An Operator can view what objects and values are present within a Logical-Device by presenting the type ID of those objects as well as perform control actions.
ENGINEER	An Engineer can view what objects and values are present within a Logical-Device by presenting the type ID of those objects. Moreover, an engineer has full access to Datasets and Files and can configure the server locally or remotely.
SECADM	Security Administrator can change subject-to-role assignments (outside the device) and role-to-right assignment (inside the device) and security policy setting; change security setting such as certificates for subject authentication and access token verification.
SECAUD	Security Auditor can view audit logs

Table 3 – Default user roles summary for MiCOM Px4x

Each authorized user must be placed into at least ONE of these roles that most suits their job description. It is possible to assign a user into a different role; and/or to change the rights associated with a particular role. This means that the administrator can change the access rights for one role; and this will affect ALL the users who are assigned to that role.

It is possible for MiCOM Px4x to create the customized user roles.

1.3.3 Rights

In a similar way in which a set of pre-defined Roles have been created, a pre-defined set of Rights have been created.

These Rights give different permissions to look at what devices may be present, what those devices may contain, manage data within those devices (directly or by using files) and configure rights for other people.

A list of the pre-defined Rights for IEC 62351-8 is given here:

Right	Description
VIEW	Allows the subject/role to discover what objects are present within a Logical-Device by presenting the type ID of those objects. If this right is not granted to a subject/role, the Logical-Device for which the View right has not been granted shall not appear
READ	Allows the subject/role to obtain all or some of the values in addition to the type and ID of objects that are present within a Logical-Device;
DATASET	Allows the subject/role to have full management rights for both permanent and non-permanent Datasets;
REPORTING	Allows a subject/role to use buffered reporting as well as un-buffered reporting;
FILEREAD	Allows the subject/role to have read rights for file objects;
FILEWRITE	Allows the subject/role to have write rights for file objects. This right includes the FILEREAD right
CONTROL	Allows a subject to perform control operations;
CONFIG	Allows a subject to locally or remotely configure certain aspects of the server;
SETTINGGROUP	Allows a subject to remotely configure Settings Groups;
FILEMNGT	Allows the role to transfer files to the Logical-Device, as well as delete existing files on the Logical-Device;
SECURITY	Allows a subject/role to perform security functions at both a Server/Service Access Point and Logical-Device basis. To add Information about the concept of Rights.

Table 4 – Pre-defined rights for IEC 62351-8

The specific Rights for MiCOM Px4x are listed below. These are dependent on the IED data type. Please refer to each product MD file (Menu Database) for the IED data type.

Rights	Authorized Actions to IED	IED_DESC	IED_DATA	DISPLAY	IED_CONFIG	PROT_CONFIG	IEC_COMMAND	AUDIT	IED_FN_KEY	IED_CLEAR
Read Only (SAT default_access_right)	Read	x	x	x	x		x			
	Write	x								
IED Configuration (SAT configuration_right)	Read/write/upload/download				x					
HMI Display Settings (SAT display_action_right)	Read/write/select			x						
Protection Configuration (SAT protection_configuration_right)	Read/write					x				
IED Commands (SAT control_right)	Read/write/clear/reset/select						x			
Reading of Records & Events (SAT audit_read_right)	Read/select/upload							x		
Extraction of Records and Events (SAT audit_write_right)	Send/accept							x		
IED Function Key (SAT fn_key_access_right)	Write								x	
IED Records Clear (SAT clear_right)	Read/write/clear									x

Table 5 – Specific rights for MiCOM Px4x

1.3.4 Roles and their Access Rights

A complete list of the Roles and their access Rights is shown in this table:

Rights \ Roles		VIEWER	OPERATOR	ENGINEER	SECADM	SECAUD
Pre-defined Rights for IEC 62351	VIEW	X	X	X	X	X
	READ		X	X	X	X
	DATASET			X		
	REPORTING	X	X	X		X
	FILEREAD					X
	FILEWRITE			X	X	
	FILEMNGT			X	X	
	CONTROL		X		X	
	CONFIG			X	X	
	SETTINGGROUP				X	
	LOGS				X	X
	SECURITY				X	
Specific Rights for MiCOM Px4x	Read Only	X	X	X		X
	IED Configuration			X		
	HMI Display Settings		X	X		
	Protection Configuration			X		
	IED Commands		X	X		
	Reading of Records and Events	X	X	X		X
	Extraction of Records and Events		X	X		X
	IED Function Key		X	X		
	IED Clear			X		

Table 6 – Pre-defined roles (and rights) for IEC 62351-8 and MiCOM Px4x

Important	**The reason why these are described as Default, is that it is possible to change the definitions of Roles and Rights, using the full version of the SAT software. Depending on the work done by the system administrator, it is possible that your own situation may vary from these initial recommendations.**

1.4 Security Administration Tool (SAT) Software

Important	**This can only be used with Px4x relays with cyber security CSL1 features.**

Important	**For Dual Ethernet cards the SAT functionality is available from communication interface 1. The connection to the SAT would be available from interface 2 only when interface 1 is disconnected from the network.**

The Security Administration Tool (SAT) is the security configuration tool of MiCOM Px4x equipment. It allows the security administrator to define the security policy to the IEDs.

The Security Administrator manages RBAC and security policies data. Security Administrator defines needs to protect devices in accordance with user privileges. Thus, the system security can be configured easily and precisely.

The SAT is used by the Security Administrator to manage the system's security database and deploys security configurations to IED(s).

The SAT allows to Manage User Accounts, Roles, Permission, Elements to Secure (ETS) and Security Server parameters without connection with devices. Information is store on the MS SQL database. This is the Offline mode. SAT allows devices management connected on network. This is the online mode.

The Role Based Access Control (RBAC) is a method to restrict resource access to authorized users. Please refer to this documentation on section "*System RBAC Management*" for more details.

The following table contains the main user main functions of the SAT:

Category	User Function	Note
Offline General Administration	User Accounts Management	User Account Functions: * Creation * Edition * Suppress * Viewing * Sorting * Filtering
	Server Configuration	
	Users Accounts & Roles association Management	Associate a role to the user account
Offline Advanced Administration	Roles Management	Roles Functions: * Creation * Edition * Suppress * Viewing * Sorting
	Element To Secure (ETS) Management	Define ETS which are in fact the PACiS assets present in the project (C264, PACiS Gateway, ECOSUI, IED and SAM). Add, Suppress and Sort permissions associated with the ETS.
	Global Security Management	The Global Security allows scope(s) and associate or disassociate role(s) management for each user account. The security administrator manages the current scope by the Roles: * View Roles List, User Account List and associations User-Roles or Role-Users * Associate / dissociate role(s) for each User Account * Add / Suppress User account(s) for each Role
	Permission access	Define parameters: * Password validity * Inactivity period * Automatic logout period * Maximum attempts of login and lockout period
Communication	Refresh IED list	
	Display IED Logs	
	Display SAM Logs	
	Push RBAC and Security Policies	Send Security Configuration to all Devices integrating Security features.

Table 7 – Main SAT user functions

The details of how to use the SAT are provided in the SAT documentation:

SAT (Security Administration Tool) Documentation - User Guide

This is available from the Schneider Electric website: www.schneider-electric.com.

2 MICOM PX4X CYBER SECURITY IMPLEMENTATION

Schneider Electric MiCOM Px4x IEDs have always been and will continue to be equipped with state-of-the-art security measures. Due to the ever-evolving communication technology and new threats to security, this requirement is not static. Hardware and software security measures are continuously being developed and implemented to mitigate the associated threats and risks.

Considered some users may not want to use the cyber security, Schneider Electric offers MiCOM Px4x relays with CSL0 and CSL1 as below:

CSL0: Simple password management, No SAT required.

CSL1: Advanced cyber security, SAT required.

This depends on the model number, as CSL1 is depend on the Ethernet communication. Hence if the IED if supports only legacy protocol this will be CLS0 default as. The digit position number 9 (protocol options) in the Cortec / model number is used to distinguish it.

Protocol Option Number	Protocol options	Cyber Security options
1	K-Bus/Courier	CSL0
2	Modbus	CSL0
3	IEC 60870 -5 - 103	CSL0
4	DNP3.0	CSL0
6	IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485	CSL0
7	IEC 61850 Edition 1 / 2 and CS103 via rear port RS485	CSL0
B	IEC 61850 Edition 1 / 2 and DNP3oE and DNP Serial	CSL0
G	IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485	CSL1
H	IEC 61850 Edition 1 / 2 and CS103 via rear port RS485	CSL1
L	IEC 61850 Edition 1 / 2 and DNP3oE and DNP3 serial	CSL1

Table 8 – MiCOM Px4x protocol options for cyber security options

2.1 MiCOM Px4x with CSL1 - Advanced Cyber Security

For MiCOM Px4x IEDs which support CSL1, this means the IED supports advanced user account right management. Moreover, the IED supports security logs/events and secure administration capability.

If you want to use cyber security, you need to order the IED that supports CSL1. In this case, the Security Administration Tool (SAT) is required for RBAC configuration.

At the IED level, these cyber security features have been implemented:

- Passwords management (via the SAT)
- RBAC Management (via the SAT)
- User Locking
- Inactivity Timer
- RBAC recovery
- Port Disablement (via Easergy Studio or the front panel)
- Security Logs

2.1.1 Password Management (via the SAT)

For the IED if CSL1 supported, there are two types of password possible for the IED access: alphanumeric password or Arrow Key password.

The alphanumeric password is only settable via the SAT:

- Passwords may be any length between 1 and 32 characters long
- Passwords may contain any ASCII character in the range ASCII code 33 (21 Hex) to ASCII code 122 (7A Hex) inclusive
- Passwords may or may not be NERC/IEEE 1686 compliant
- The alphanumeric password will used for courier client access

For more details about NERC/IEEE 1686 password compliant, please check the standard.

The Arrow Key password is only settable via the SAT:

- The Arrow Key password is a combination of the four arrow keys on the front panel
- The Arrow Key password may be any length between 1 and 8 of arrow keys long
- The Arrow Key password can only used in the front panel
- The user also can disable the Arrow Key password by not setting it

Important	**If the Arrow Key password is not configured, the alphanumeric password will be used for the front panel access. In this case, alphanumeric passwords longer than 16 characters are not allowed.** **Easergy Studio and the front panel are not allowed to change the password.**

2.1.2 RBAC Management (via the SAT)

By default, the IED includes a factory RBAC which has three users, and for each user, the Rights depend on the user Role. Please refer to the *Roles and their Access Rights* section for more details.

Username	Role	Default password
SecurityAdmin	SECADM	AAAAAAAA
EngineerLevel	ENGINEER	AAAA
OperatorLevel	OPERATOR	AAAA

Table 9 – Factory RBAC

A Local Default Access function also available for the default RBAC, with the VIEWER role, which allows everyone login the IED in the front panel with VIEWER role. For more details about the Local Default Access function, please refer to the *Local Default Access* section.

For more information about how the SAT management the RBAC and cyber security policies, please see the *Security Administration Tool (SAT)* section.

2.1.3 User Locking

The user is locked out temporarily, after a defined number of failed password entry attempts.

Important	**If a user is locked out, the block is applied to that named user and to the all IED interfaces. The blocking of one user, does not apply blocks to others. If the user entry is blocked, recover the RBAC or push a new RBAC will not reset the blocked user entry, but IED reboot will reset the blocking time and attempts count, so the user entry will be unblocked.**

An invalid password entry will display a 'Login Failed PW Incorrect' message for 2s. It also reduces the Attempts Remaining Counter (Attempts Remain) by 1 and it remains at this level until the interface inactivity timer expires (CSL0 models) or until the Password Attempts Timer configured in SAT expires (CSL1 models) or another password entry is made. If Attempts Remain equals 1 then a '1 Attempt Left' warning will also be issued for 2s. When Attempts Remain equals 0 then a 'USER LOCKED OUT' warning is displayed for 2s and access for that user is blocked. If the Blocking Timer expires, or the correct password is entered before Attempts Remain reaches zero, then the Attempts Remain is reset to the Attempts Limit.

Once the user entry is blocked, the Blocking Timer is initiated. If the locked out user is selected whilst the Attempts Remain is zero a 'USER LOCKED OUT' error message is displayed.

2.1.4 Inactivity Timer

The MiCOM device runs an inactivity timer, which means that it records the last time an action was taken by a user who was logged in.

If the user does not perform an action within a pre-defined interval, the user will be logged off. This is to reduce the risk that a device can accidentally be left open to access by unauthorized people.

The inactivity timer is separate for each interface.

The inactivity timer is configurable by using the SAT.

Important	**In case of a connection through an Ethernet interface, the actual inactive time depends on the setting value of both "Minimum inactivity period" & "[0E A7] ETH Tunl Timeout", the smaller value of both timers will be applied.**

Refer to the Table 12 for more details about the settings.

2.1.5 RBAC Recovery

RBAC recovery is the means by which the device can be reset to the factory RBAC settings if required. To obtain the recovery password, the customer must go to www.schneider-electric.com/ccc to raise a recovery password request and supply the IED *Security Code*.

Caution	**The "recovery" password gives you access to the Factory RBAC Configuration. This action deletes all existing users (and their passwords), and restores to Factory RBAC Configuration. Recover the RBAC does not affect relay proper settings and does not provoke reboot of the relay - the protection functions of the relay are always maintained.**

2.1.5.1 Generate Security Code

The security code is a 16-character ASCII string. It is a read-only parameter. The IED generates its own random security code. This is when a new code is generated:

- On power up
- On expiry of validity timer (see below)
- When the recovery password is entered

As soon as the security code is ***first*** displayed on the LCD display, a validity timer is started. This validity timer is set to 120 hours and is not configurable. The validity timer is not reset if you request a subsequent code within the 120 hour period.

To prevent accidental reading of the IED security code the cell will initially display a warning message on the front panel of the IED:

```
PRESS ENTER TO
READ SEC. CODE
```

The security code will be displayed on confirmation, whereupon the validity timer will be started. Note that the security code can only be read from the front panel.

Important	**The recover password will be invalid once the new Security Code is generated, so please make sure the IED is always powered on before you get the reover password, and make sure you input the recover password within 120 hours.**

2.1.5.2 Entry of the Recovery Password

The "recovery" password is intended for recovery only. It is not a replacement password that can be used continually. It can only be used once – for password recovery.

Entry of the recovery password is done at the local front panel and it causes the IED to reset the RBAC back to default.

On this action, the following message is displayed on the front panel of the IED:

```
RBAC reset done
Press any key
```

2.1.6 Port Disabling (Equipment Hardening)

The availability of unused ports could provide a security risk. Hence, unused ports can be disabled (also known as equipment hardening) – either via the front panel or by Easergy Studio software. An Engineer role is needed to perform this action.

These physical ports and logical ports can be enabled/disabled:

Port types	Menu text	Col	Row	Default Setting	Available Value
Physical Ports	Front port	25	05	Enable	Enable/Disable
	Rear Port 1	25	06	Enable	Enable/Disable
	Rear Port 2	25	07	Enable	Enable/Disable
	Ethernet Port 1	25	08	Enable	Enable/Disable
	Ethernet Port 1/2	25	09	Enable	Enable/Disable
	Ethernet Port 2/3	25	0A	Enable	Enable/Disable
	Ethernet Port 3	25	0B	Enable	Enable/Disable
Logical Ports	Courier Tunnel	25	0C	Enable	Enable/Disable
	IEC61850	25	0D	Enable	Enable/Disable
	DNP3oE	25	0E	Enable	Enable/Disable

Table 10 - Port hardening settings

Note	*The port disabling setting cells are not provided in the settings file. In addition, it is not possible to disable simultaneously more than one physical port or Logical port.* *New redundant Ethernet boards have three physical ports but total two interfaces. The actual disabled physical port is depended on the redundant communication mode (PRP, HSR, RSTP or Dual IP). Refer to the Dual Redundant Ethernet Board (Upgrade) (DREB) chapter (Px4x/EN EB) for more details.*

When the Ethernet board related physical ports or logical ports are disabled or enabled, the Ethernet card will reboot. The status of the ports will be available after reboot of the Ethernet board.

For more details about how to disable/enable the unused ports, please see sections:

- How to Disable a Physical Port
- How to Disable a Logical Port

2.1.7 Security Logs

The Security Logs needs to store logs from each item of equipment. These logs are generated by the system, and cannot be edited by the user. A variety of different items are recorded, including: bad/faulty access attempts, login attempts, authentication errors, changes to roles, users and access control lists, network backup and configuration changes, communication failures and so on.

Security logs emissions depend on the security standards that are configurable by the SAT.

The security logs will push to a Syslog server if the Syslog server IP address and Syslog server IP port are configured and connected.

SAT also can be used to explore the security logs but Easergy studio is not supported.

The settings for the security log standards and Syslog server IP address and ports are listed in the *Configurable cyber security settings* table. For more detail about the security log configuration, please refer to the SAT documentation.

Note	*The Security logs time stamp may be time shifted by several milliseconds compared with local event log.* *The security logs will not be generated if the Ethernet card is starting up.* *If the Syslog server is unavailable, the new logs will be stored and overwriting the oldest logs.*

This table lists the security logs categories available for each standard.

Log ID	Additional field	Explanation	Level	Standards					
				BDEW	E3	NERC CIP	IEEE 1686	IEC 62351	CS Phase 1
CONNECTION_SUCCESS	The additional field will contain the issuer of the connection: LOCAL or NETWORK	Successful connection	INFO	x	x	x	x		x
CONNECTION_FAILURE		Failed connection (wrong credentials)	WARNING	x	x	x	x		x
CONNECTION_FAILURE_ AND_BLOCK		Failed connection (wrong credentials) triggering the blocking of the account on the IED	DANGER	x	x	x	x		x
CONNECTION_FAILURE_ ALREADY_BLOCKED		Failed connection because of a blocked userID on this IED	DANGER	x	x	x	x		x
DISCONNECTION		Disconnection triggered by the peer /user	INFO	x	x	x	x		x
DISCONNECTION_TIMEOUT		Disconnection triggered by a timeout	INFO	x	x	x	x		x
CONTROL_OPERATION	Type & Data associated to the control	Trace and control / override of real data from a peer	INFO				x		
CONFIGURATION_ DOWNLOAD	Version	Download of the configuration file from the device - Files include PSL, Courier setting, DNP setting, MCL/CID and user curves (crv)	INFO				x		
CONFIGURATION_UPLOAD	Version	Upload of a new configuration file into the device - Files include PSL, Courier setting, DNP setting, MCL and user curves (crv)	INFO				x		
RBAC_UPDATE	Version	Update of the RBAC cache in the IED	INFO				x		x
SEC_LOGS_RETRIEVAL	Version	Retrieval of the security logs of the IED	INFO				x		
TIME_CHANGE	New & Old time	Modification of the time of the IED	INFO				x		
REBOOT_ORDER	None	Reboot order sent to the IED / IED start up	DANGER				x		x
PORT_MANAGEMENT	Port, action (enable / disable)	Any comms port enabled / disabled	INFO						x
AUTHORIZATION_REQ	Action, object	Any authorization request sent to the CS brick	INFO			x		x	x

Table 11 – Security logs recorded

2.1.8 Common Cyber Security Settings

The System Administrator can customize the cyber security settings at the SAT. The following table shows the common cyber security settings. Parts of settings also are visible on the IED with specific Courier cells but not editable in IED or Easergy Studio. These are shown in the right-hand columns of this table:

Setting in SAT	Default Setting	Available Value	Menu in IED	Col	Row
Minimum inactivity period	15	1 to 99 Minutes	-	-	-
If the user does not perform any action within this interval, the user will be logged off.					
Allow user locking	Yes	Yes/No	-	-	-
Option allows user account locking					
Maximum login attempts	5	1 to 99	Attempts Limit	25	02
The maximum failed password entry attempts, the user will lock once the attempts reached.					
Password attempts timer	3	1 to 30 Minutes	Attempts timer	25	03
The time for reset the attempts count to 0. The user got to maximum login attempts.					
Automatic user account unlocking	Yes	Yes/No	-	-	-
Enable/disable the attempts times aromatic reset function.					
Locking period duration	240	1 to 86400 Seconds	Blocking timer	25	04
The Locking period duration (seconds)					
Password Complexity	None	None / IEEE1686/ NERC	-	-	-
Set the password compliant standard.					
Log and monitoring standard	BDEW	BDEW / E3 /NERC-CIP / IEE1686 / IEC62351/ CS_PH1	-	-	-
Setup security log emission standard					
Syslog server IP address	0.0.0.0		-	-	-
Syslog server IP address					
Syslog server IP port	601	1 to 65535	-	-	-
Syslog server IP port					

Table 12 – Configurable cyber security settings

These settings show some common information about cyber security, which are not configurable whether by SAT, or Easergy Studio or the front panel.

Menu in IED	Col	Row	Description
User Banner	25	01	Show user banner information: ACCESS ONLY FOR AUTHORITY USERS
Attempts remain	25	11	Show the remains attempt times for user login.
Blk time remain	25	12	Show the remains time for blocked user to unlock
User Name	25	21~2F	Configured user name (in SAT)
Security Code	25	FE	The security code used to recovery the password.
RBAC Password	25	FF	Enter 16 characters recover password to recovery password

Table 13 – Un-configurable cyber security settings

2.1.9 Local Default Access

Local Default Access function can be disabled/enabled in the SAT.
The intention for Local Default Access function is to allow the user easy to access the IED from the front panel and without any authorization required. This means if the Local Default Access function is enabled, everyone will be authorized to access the front panel with associated Rights.
By default, the Local Default Access has the VIEWER role, it is also possible to associate the other Roles to the Local Default Access, which is configurable in the SAT.
Local Default Access function is only available in the front panel.
The Local Default Access login/logout process is invisible for the user.

2.2 MiCOM Px4x with CSL0- Simple Password Management

For MiCOM Px4x IED with CSL0, as the Security Administration Tool (SAT) is not supported, all the cyber security features which need SAT support will not be available.

This section describes the different implementations by comparing with CLS1.

The cyber security features that are not mentioned in this section will default to be the same as CSL1.

2.2.1 Password Management

For MiCOM Px4x IED with CSL0, SAT is not supported for the configuration, so only the alphanumeric password can be used.

- The alphanumeric password is settable via Easergy Studio and the Front panel
- Passwords may be any length between 1 and 16 characters long
- Passwords may contain any ASCII character in the range ASCII code 33 (21 Hex) to ASCII code 122 (7A Hex) inclusive
- No password compliance is required
- The alphanumeric password will used for Courier access and the front panel access

Arrow key password is not available for IED with CLS0.

2.2.2 Fixed Factory RBAC

For MiCOM Px4x IED with CSL0, the user list and its role/right will be fixed as factory RBAC and not configurable. Refer to the *Factory RBAC* table for more details.

2.2.3 Security Logs Services

The security logs services are not available for MiCOM Px4x IED with CSL0.

2.2.4 Cyber Security Settings

For MiCOM Px4x IED with CSL0, all cyber security settings are fixed as default setting and un-configurable. Refer to the *Configurable cyber security settings* table for the default settings.

2.2.5 Disable/Blank Password

For MiCOM Px4x IED with CSL0, it is possible to remove the user password. In MiCOM S1 Studio, this is achieved by click the BOX “Disable the password”. In the IED, this is achieved by setting the password as blank.

Once the password is disabled/blank, the user can login to the IED directly and there is no need to enter the password.

3 HOW TO USE CYBER SECURITY FEATURES

These sections shows the most common tasks associated with Cyber Security features.

For many of these tasks, the steps you take are the same as you have performed previously; with the main changes being in the steps you use to login and/or logout.

3.1 How to Login

3.1.1 Local Default Access

If the Local Default Access is enabled, the user may login to the front panel with associated roles.

See Table 14 for the applied cases.

3.1.2 Auto Login

Auto login means the user will login the IED automatically and no need to select the user name and enter the password. In this case, the user will be authorized with relevant rights. The auto login will be applied in these cases:

CS Version	Interface	RBAC/PW Cases	Login Process
CSL1	Front panel	Factory RBAC	Auto login with **EngineerLevel**
		Customized RBAC	Local Default Access Enabled: Login with **Local Default Access** Local Default Access Disabled: Login with **Prompt User List**
	Courier Interface	All cases	Login with **Prompt User List**
CSL0	Front panel	Factory RBAC	Auto login with **EngineerLevel**
		Password changed	**EngineerLevel** password is “AAAA” or is disabled/blank: Auto login with **EngineerLevel** **OperatorLevel** password is “AAAA” or is disabled/blank: Auto login with **OperatorLevel** **EngineerLevel** and **OperatorLevel** password changed: Auto login with **ViewerLevel Access**
	Courier Interface	Factory RBAC	Auto login with **EngineerLevel**
		Password changed	**EngineerLevel** password is “AAAA” or is disabled/blank: Auto login with **EngineerLevel** **OperatorLevel** password is “AAAA” or is disabled/blank: Auto login with **OperatorLevel** **EngineerLevel** and **OperatorLevel** password changed: Login with **Prompt User List**

Table 14 – Auto Login process

For more details about the Factory RBAC, please refer to Table 9.

3.1.3 Login with Prompt User List

This login process will happen if:

- The Auto login process is not applied.
- Or high authorization is required for the current operation.

In this case, the IED will prompt the user list, and the user needs to select proper user name and enter the password to login.

3.2 How to Logout

3.2.1 How to Logout at the IED

For security consideration, it would be better to “logout' the IED once the configuration done. You can do this by going up to the default display. When you are at the default display and you press the ‘Cancel’ button, you may be prompted to log out with the following display:

```
ENTER TO LOGOUT
CLEAR TO CANCEL
```

You will be asked this question if you are logged in.

If you confirm, the following message is displayed for 2 seconds:

```
LOGGED OUT
User Name
```

If you decide not to log out (i.e. you cancel), the following message is displayed for 2 seconds.

```
LOGOUT CANCELLED
User Name
```

Note	*The MiCOM IED runs a timer, which logs the user out after a period of inactivity. For more details, refer to the Inactivity Timer section.*

3.2.2 How to Logout at Easergy Studio

- Right-click on the device name and select Log Off.
- In the Log Off confirmation dialog click Yes.

3.3 How to Disable a Physical Port

Using Easergy Studio or the front panel it is possible to disable unused physical ports. This can not be done by the SAT. By default, an Engineer-role is needed to perform this action.

To prevent accidental disabling of a port, a warning message is displayed according to whichever port is required to be disabled. For example if rear port 1 is to be disabled, the following message appears:

```
REAR PORT 1 TO BE
DISABLED.CONFIRM
```

There are between two and four ports eligible for disablement:

- Front port
- Rear port 1
- Rear port 2 (available in the specific models)
- Ethernet port (available in the specific models)

Important	**It is not possible to disable a port from which the disabling port command originates.**

3.4 How to Disable a Logical Port

Using Easergy Studio or the front panel it is possible to disable unused logical ports. This can’t be done by the SAT. An Engineer-role is needed to perform this action.

Caution **Disabling the Ethernet port will disable all Ethernet based communications.**

If it is not desirable to disable the Ethernet port, it is possible to disable selected protocols on the Ethernet card and leave others functioning.

These protocols can be disabled:

- IEC61850 (available in the specific models)
- Courier Tunnelling (available in the specific models)
- IEC61850 + DNPoE (available in the specific models)

3.5 How to Secure a Function Key (When Available)

In cyber security implementation, this function has been linked to the front panel authorization.

- When the function key pressed, if there is no user login in the front panel or the logged- in user is not authorized, a prompt message will be raised in the front panel to ask the user to login. Once the user is logged-in, they need to press the function key again to execute the command.
- If the user is already logged in and the authorization is OK, the command will be executed immediately.
- By default, the OPERATOR or ENGINEER Roles are able to operate the function keys.
- The function key will be executed immediately if the auto login process is applied and the user is authorized.
- If unauthorized users press the Function Key during the setting change, they need to commit the changes first then login with authorized user to operate the function key.

4 GLOSSARY FOR CYBER SECURITY

Term	Meaning
CIP Standards	Critical Infrastructure Protection standards. NERC CIP standards have been given the force of law by the Federal Energy Regulatory Commission (FERC)
DCS	Distributed Control System
HMI	Human Machine Interface
IED	Intelligent Electronic Device. It is a power industry term to describe microprocessor-based controllers of power system equipments (e.g. Circuit breaker, transformer, etc)
LOGS	All the operations related to the security (connection, configuration…) are automatically caught in events that are logged in order to provide a good visibility of the previous actions to the security administrators.
MIB	Management Information Base
NERC	North American Electric Reliability Corporation
RBAC	Role Based Access Control. Authentication and authorization mechanism based on roles granted to a user. Roles are made of rights, themselves being actions that can be applied on objects. Each user's action is authorized or not based on his roles
Roles	A role is a logical representation of a person activity. This activity authorizes or forbids operations within the tool suite thanks to permissions that are associated to the role. A role needs to be attached to a user account to have a real purpose.
SAM	Security Administration Module. Device in charge of security management on an IP-over-Ethernet network.
SAT	Security Administration Tool TSF based application used to define and create security configuration
Secured IED	Devices embedding security mechanisms defined in the security architecture document
Security Administrator	A user of the system granted to manage its security
TAT	Transfer Administration Tool
Unsecured IED	Relay/IEDs with no security mechanisms.

Table 15 – Glossary for cyber security

DUAL REDUNDANT ETHERNET BOARD (DREB)

CHAPTER 19

Date (month/year):	07/2018			
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.			
Hardware Suffix:	P141/P142/P143 P145 P445 P44x (P442/P444) P44y (P443/P446)	L M L M M	P54x (P543/P544/P545/P546) P642 P643/P645 P746 P841A (one circuit breaker) P841B (two circuit breakers)	M L M M M M
Software Version:	P14x (P141/P142/P143/P145) P445 P44x (P442/P444) P44y (P443/P446)	B4 J9 E3 H9	P54x (P543/P544/P545/P546) P64x (P642/P643/P645) P746 P841A P841B	H9 B4 B5/C5 G9 H9
Connection Diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P44x (P442 & P444): 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2) P445: 10P445xx (xx = 01 to 04)		P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 01 to 10) 10P643xx (xx = 01 to 06) 10P645xx (xx = 01 to 09) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2)	

CONTENTS

Page (EB) 19-

FIGURES

TABLES

1 INTRODUCTION

The redundant Ethernet board assures redundancy at IED level. It is fitted into the following MiCOM IEDs from Schneider Electric.

- P14x = P141, P142, P143, P145
- P24x = P241, P242, P243
- P34x = P341, P342, P343, P344, P345
- P44x = P442, P444
- P44y = P443, P446
- P445
- P54x = P543, P544, P545, P546
- P547
- P64x = P642, P643, P645
- P74x = P741, P743, P746
- P841
- P849

1.1 Standard Safety Statements

For safety information please see the Safety Information chapter of the relevant Px4x Technical Manual.

2 HARDWARE DESCRIPTION

IEC 61850 works over Ethernet. Three boards are available:

- 1RJ45 Port Ethernet Board
- 3RJ45 Ports Redundant Ethernet Board
- 2LC+1RJ45 Ports Redundant Ethernet Board.

All are required for communications but 3RJ45 Ports and 2LC+1RJ45 Ports Redundant Ethernet Board allow an alternative path to be always available, providing bumpless redundancy.

Industrial network failure can be disastrous. Redundancy provides increased security and reliability, but also devices can be added to or removed from the network without network downtime.

The following list shows Schneider Electric's implementation of Ethernet redundancy, which has two variants with embedded IEC 61850 over Ethernet, plus PRP, HSR and RSTP redundancy protocols.

- Parallel Redundancy Protocol (PRP)/High-availability Seamless Redundancy (HSR)/Rapid Spanning Tree Protocol (RSTP) with 1310 nm multi mode 100BaseFx fiber optic Ethernet ports (LC connector) and modulated/un- modulated IRIG-B input. Part number 2072069A01.

Note	*The board offers compatibility with any PRP/HSR/RSTP device.*

- Parallel Redundancy Protocol (PRP)/High-availability Seamless Redundancy (HSR)/Rapid Spanning Tree Protocol (RSTP) with 100BaseTx Ethernet ports (RJ45) and modulated/un- modulated IRIG-B input. Part number 2072071A01.

Note	*The board offers compatibility with any PRP/HSR/RSTP device.*

The redundant Ethernet board is fitted into Slot A of the IED, which is the optional communications slot. Each Ethernet board has three MAC addresses for two groups, one group (PORT 1) including one host MAC address, the other group (PORT 2 & 3) used for redundant application, including one host MAC address and one redundant agency device MAC address. Two host MAC addresses of the IED are printed on the rear panel of the IED.

In additional above for HSR/PRP/RSTP redundant protocols, the redundant Ethernet board also can operate on Dual IP mode. In this case, each Ethernet board has two host MAC addresses.

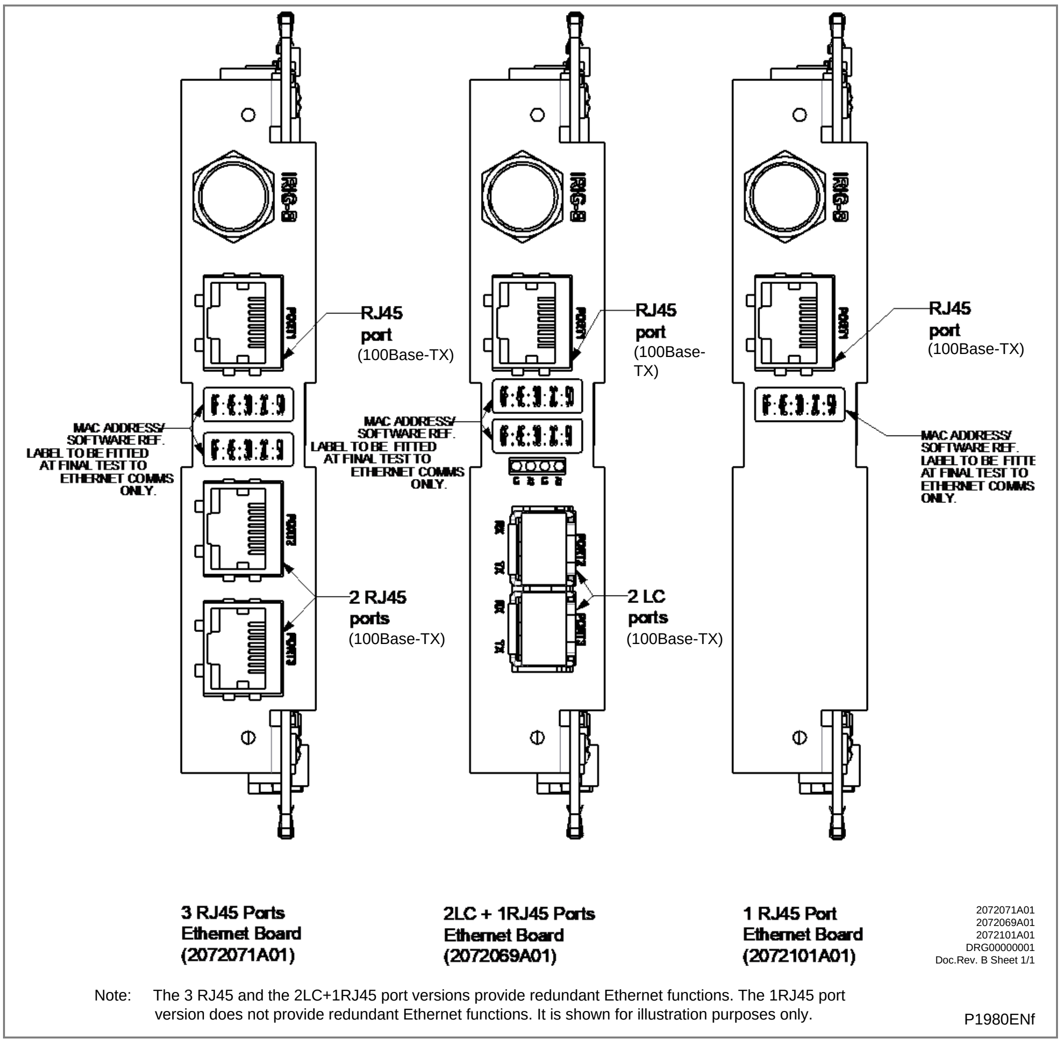


Figure 1 - Ethernet board connectors (3 RJ45 or 2 LC + RJ45 or 1 RJ45)

2.1 IRIG-B Connector

This is available as a modulated/un-modulated input.
See section 6.1.

2.2 LEDs

LED	Function	On	Off	Flashing
Green	Link	Link ok	Link broken	
Yellow	Activity			Traffic activity

Table 1 - LED functionality

2.3 Optical Fiber Connectors

Use 1310 nm multi mode 100BaseFx and LC connectors.
See Figure 1 and section 6.1.

Connector	PRP	HSR	RSTP
2	R_X	R_X	R_X
2	T_X	T_X	T_X
3	R_X	R_X	R_X
3	T_X	T_X	T_X

Table 2 - Optical fiber connector functionality

3 REDUNDANCY PROTOCOLS

There are two redundancy protocols available:

- PRP (Parallel Redundancy Protocol)
- HSR (High-availability Seamless Redundancy)
- RSTP (Rapid Spanning Tree Protocol)

3.1 Parallel Redundancy Protocol (PRP)

When the upper protocol layers send a data packet, the PRP interface creates a “twin packet” from this. The PRP interface then transmits redundant data packet of the twin pair to each participating LAN simultaneously. As they are transmitted via different LANs, the data packets may have different run times.
The receiving PRP interface forwards the first packet of a pair towards the upper protocol layers and discards the second packet. When viewed from the application, a PRP interface functions like a standard Ethernet interface.
The PRP interface or a Redundancy Box (RedBox) injects a Redundancy Control Trailer (RCT) into each packet. The RCT is a 48-bit identification field and is responsible for the identification of duplicates. This field contains, LAN identification (LAN A or B), information about the length of the payload, and a 16-bit sequence number. The PRP interface increments the sequence number for each packet sent. Using the unique attributes included in each packet, such as Physical MAC source address and sequence number, the receiving RedBox or Double Attached Node (DAN) interface identifies and discards duplicates.
Depending on the packet size, with PRP it attains a throughput of 93 to 99% of the available bandwidth.

3.1.1 PRP Network Structure

PRP uses two independent LANs. The topology of each of these LANs is arbitrary, and ring, star, bus and meshed topologies are possible.
The main advantage of PRP is loss-free data transmission with an active (transit) LAN. When the terminal device receives no packets from one of the LANs, the second (transit) LAN maintains the connection. As long as 1 (transit) LAN is available, repairs and maintenance on the other (transit) LAN have no impact on the data packet transmission.
The elementary devices of a PRP network are known as RedBox (Redundancy Box) and DANP (Double Attached Node implementing PRP).
Both devices have one connection each to the (transit) LANs.
The devices in the (transit) LAN are conventional switches that do not require any PRP support. The devices transmit PRP data packets transparently, without evaluating the RCT information.
Terminal devices that are connected directly to a device in the (transit) LAN are known as SAN (Single Attached Node). If there is an interruption, these terminal devices cannot be reached via the redundant line. To use the uninterruptible redundancy of the PRP network, you integrate your device into the PRP network via a RedBox.

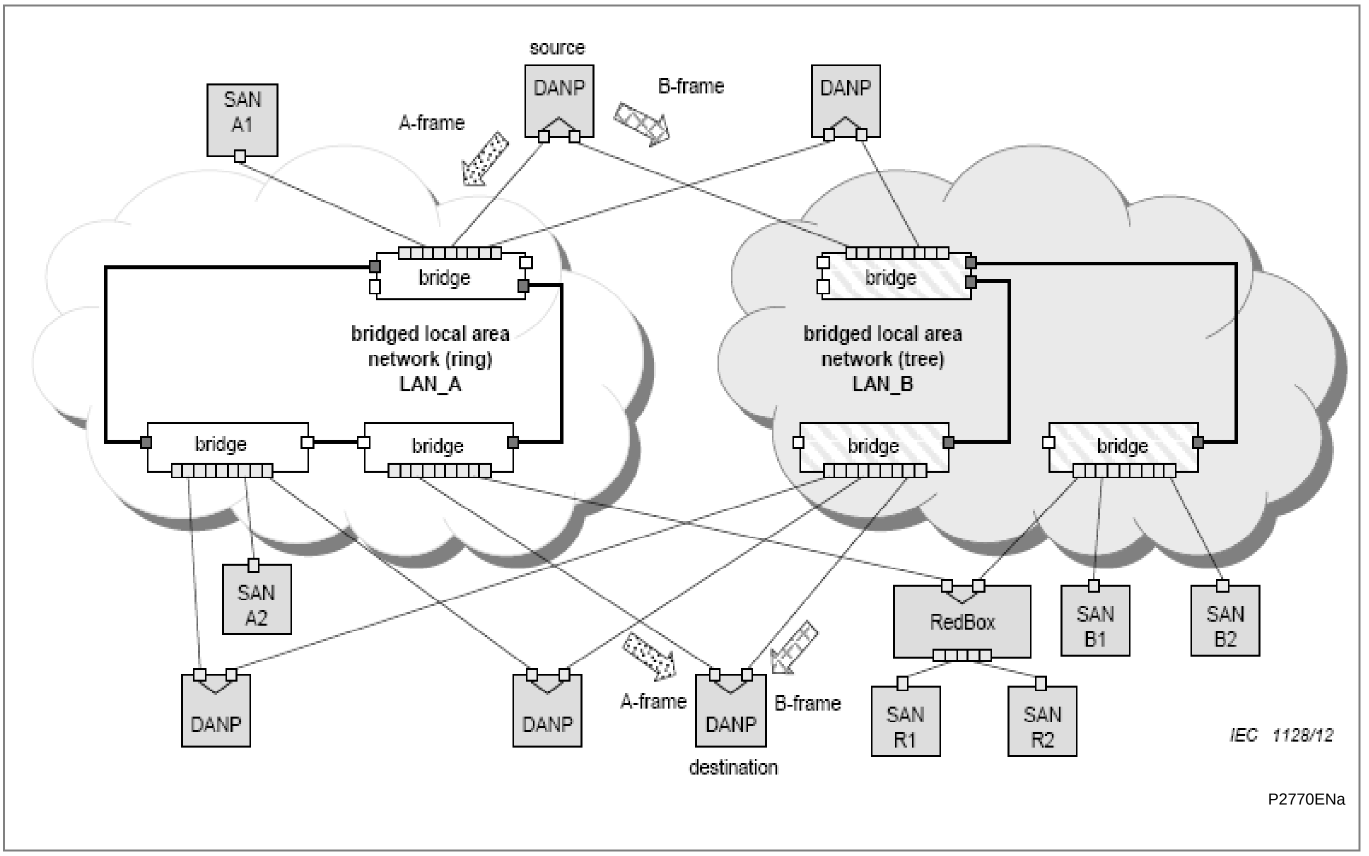


Figure 2 - PRP example of general redundant network

3.1.2 Example Configuration

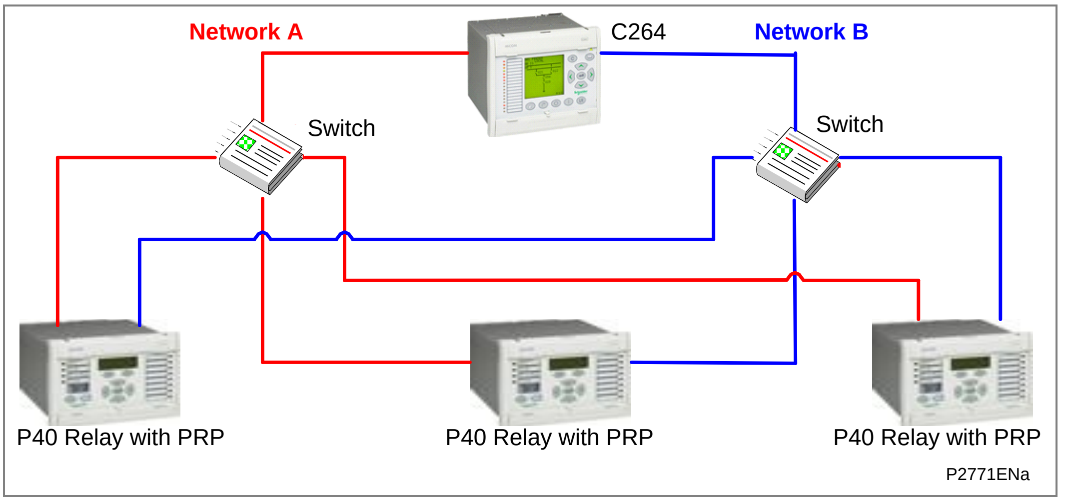


Figure 3 - PRP Relay Configuration

3.2 High-availability Seamless Redundancy (HSR)

High-availability Seamless Redundancy (HSR) can only be used in a ring topology, This section describes the application of the PRP principles (IEC 62439-3- Clause 4) to implement a High-availability Seamless Redundancy (HSR), retaining the PRP property of zero recovery time, applicable to rings. With respect to PRP, HSR allows you to greatly reduce the network infrastructure. With respect to rings based on IEEE 802.1D (RSTP), IEC 62439-2 (MRP), IEC 62439-6 (DRP) or IEC 62439-7 (RRP), the available network bandwidth for network traffic is somewhat reduced depending on the type of traffic. Nodes within the ring are restricted to be HSR-capable bridging nodes, thus avoiding the use of dedicated bridges. Singly Attached Nodes (SANs) such as laptops or printers cannot be attached directly to the ring, but need attachment through a RedBox (redundancy box).

3.2.1 HSR Network Structure

As in PRP, a node has two ports operated in parallel; it is a DANH (Doubly Attached Node with HSR protocol).
A simple HSR network consists of doubly-attached bridging nodes, each having two ring ports, interconnected by full-duplex links, as shown in these examples for a ring topology:

- Figure 4 (multicast)
- Figure 5 (unicast)

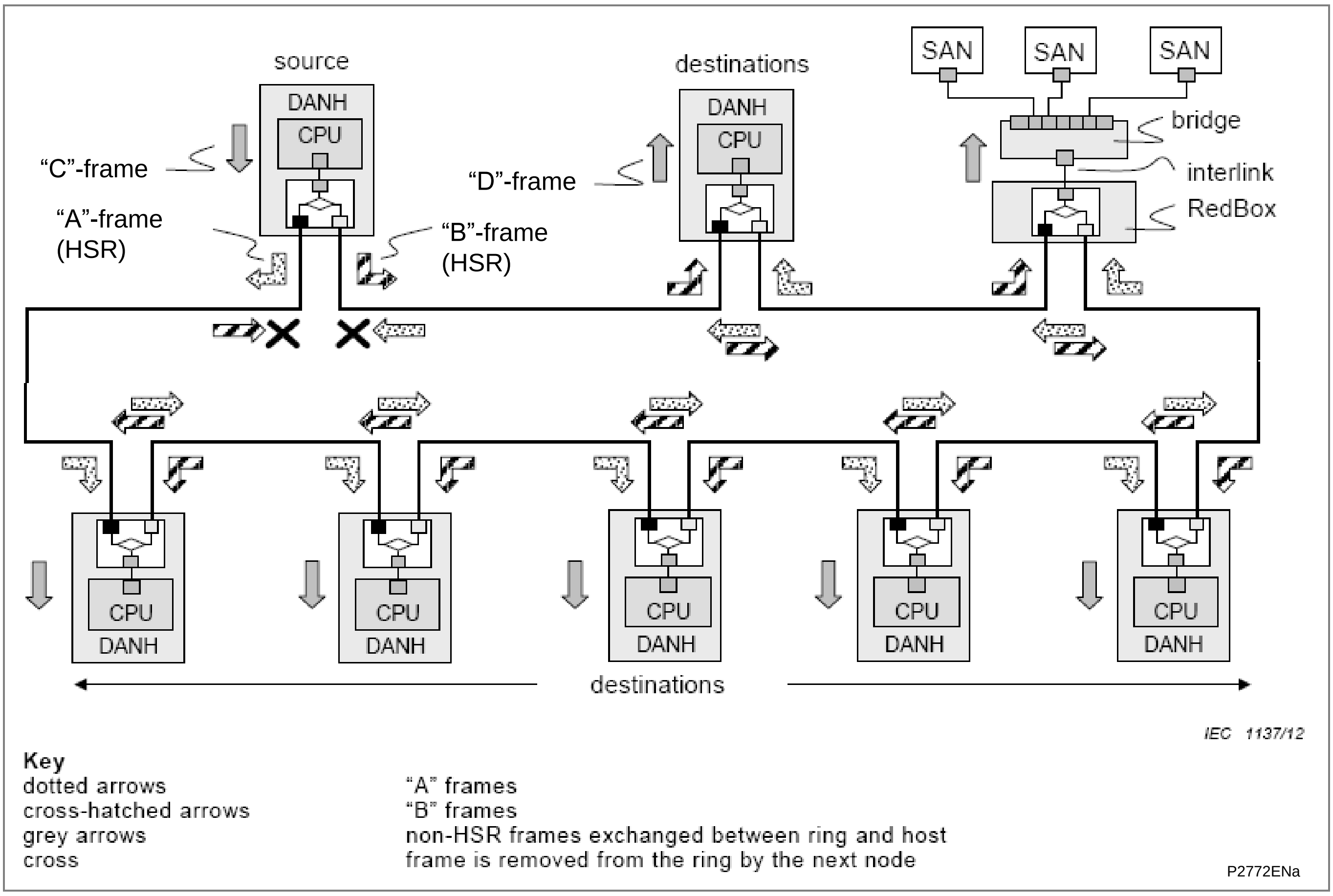


Figure 4 - HSR example of ring configuration for multicast traffic

A source DANH sends a frame passed from its upper layers ("C" frame), prefixes it by an HSR tag to identify frame duplicates and sends the frame over each port ("A"-frame and "B"-frame). A destination DANH receives, in the fault-free state, two identical frames from each port within a certain interval, removes the HSR tag of the first frame before passing it to its upper layers ("D"-frame) and discards any duplicate.

The nodes support the IEEE 802.1D bridge functionality and forward frames from one port to the other, except if they already sent the same frame in that same direction. In particular, the node will not forward a frame that it injected into the ring.

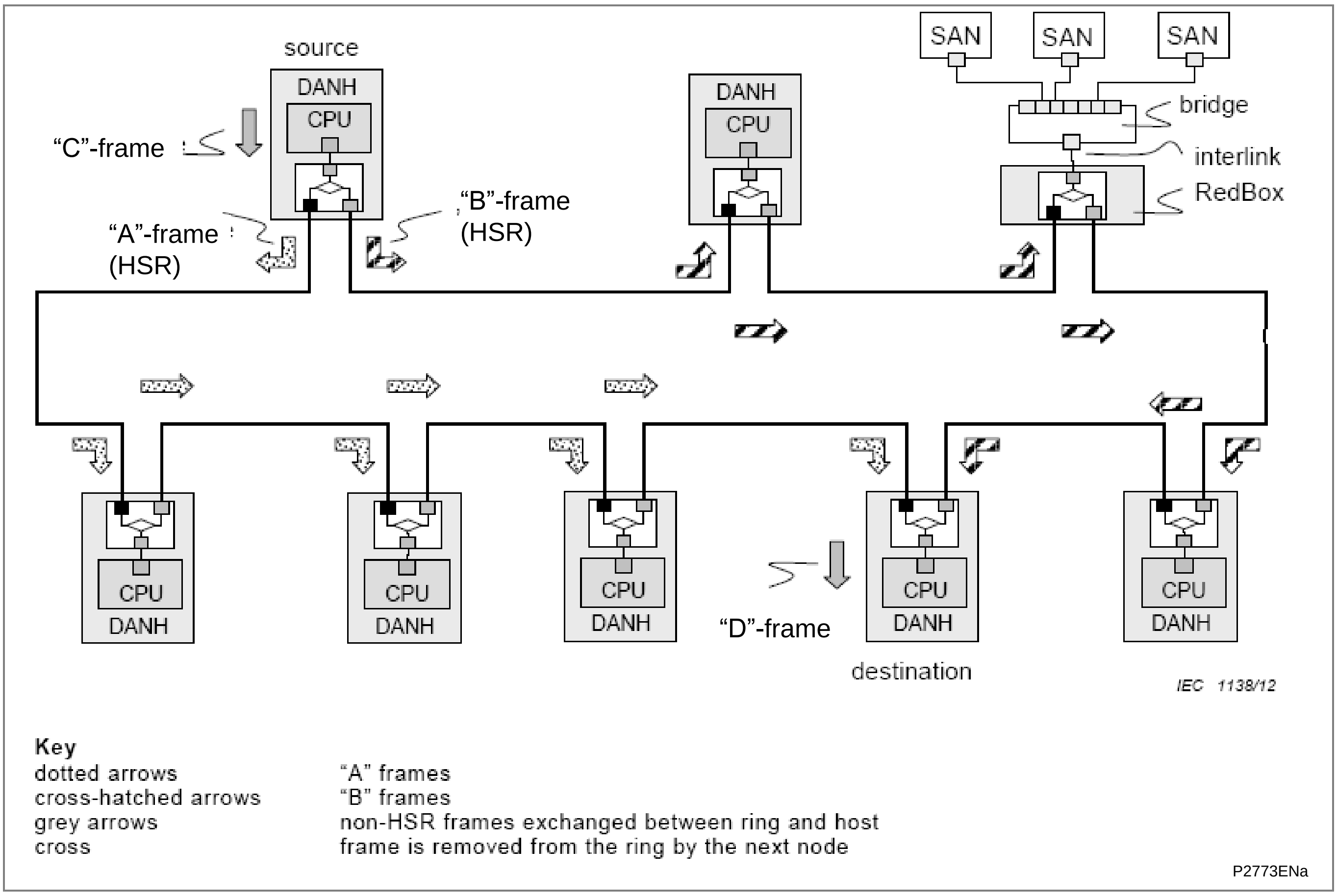


Figure 5 - HSR example of ring configuration for unicast traffic

A destination node of a unicast frame does not forward a frame for which it is the only destination, except for testing.

Frames circulating in the ring carry the HSR tag inserted by the source, which contains a sequence number. The doublet {source MAC address, sequence number} uniquely identifies copies of the same frame.

Singly Attached Nodes (SANs), for instance maintenance laptops or printers cannot be inserted directly into the ring since they have only one port and cannot interpret the HSR tag in the frames. SANs communicate with ring devices through a RedBox (redundancy box) that acts as a proxy for the SANs attached to it, as shown in the diagram.

Connecting non-HSR nodes to ring ports, breaking the ring, is allowed to enable configuration. Non-HSR traffic within the closed ring is supported in an optional mode.

3.2.2 Example Configuration

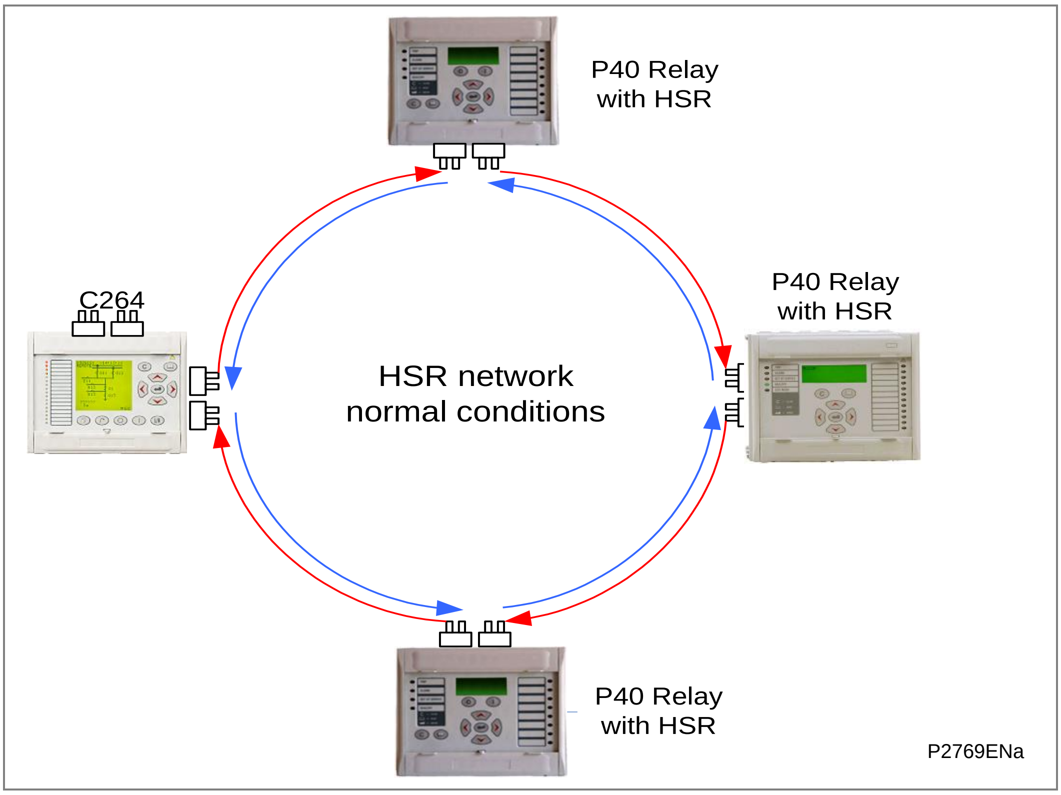


Figure 6 - HSR Relay Configuration

3.3 Rapid Spanning Tree Protocol (RSTP)

3.3.1 RSTP Network Structure

RSTP is a standard used to quickly reconnect a network fault by finding an alternative path, allowing loop-free network topology. Although RSTP can recover network faults quickly, the fault recovery time depends on the number of devices and the topology. The recovery time also depends on the time taken by the devices to determine the root bridge and compute the port roles (discarding, learning, forwarding). The devices do this by exchanging Bridge Protocol Data Units (BPDUs) containing information about bridge IDs and root path costs.

See the IEEE 802.1D 2004 standard for further information.

3.3.2 Example Configuration

The Px4x redundant Ethernet board uses the RSTP protocol (802.1w), so a Px4x can attach onto a network as shown in Figure 7:

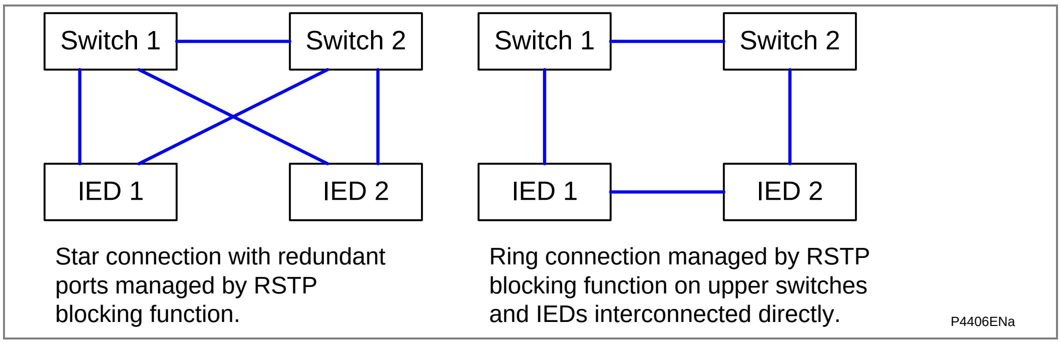


Figure 7 - Px4x attached to a redundant Ethernet star or ring circuit

The RSTP solution is based on open standards. It is therefore compatible with other manufacturers' IEDs that use the RSTP protocol. The RSTP recovery time is typically 300ms but it increases with network size.

3.4 Generic Functions for all Redundant Ethernet Boards

The following apply to the redundant Ethernet protocols (PRP, HSR and RSTP).

3.4.1 Priority Tagging

802.1p priority is enabled on all ports.

3.4.2 Simple Network Time Protocol (SNTP)

Simple Network Time Protocol (SNTP) is supported by both the IED and the redundant Ethernet switch. SNTP is used to synchronize the clocks of computer systems over packet-switched, variable-latency data networks. A jitter buffer is used to reduce the effects of variable latency introduced by queuing in packet switched networks, ensuring a continuous data stream over the network.

The IED receives the synchronization from the SNTP server. This is done using the IP address of the SNTP server entered into the IED from the IED Configurator software.

3.4.3 Dual Ethernet Communication (Dual IPs)

3.4.3.1 Dual IP Introduction

Dual IP means the IED provides two independent IEC 61850 interfaces, and both these interfaces support MMS and GOOSE message.

The IED which supports Dual IP can provide the customer with more flexible network connections: two fully segregated Station BUS networks, or one Station Bus and one Process Bus (for GOOSE message transmission).

Dual IP is not mutually exclusive with PRP/HSR/RSTP - Dual IP is automatically supported even if the IED is operate under HSR/PRP/RSTP mode.

3.4.3.2 Dual IP in MiCOM

Dual IP is only supported for devices with the new Ethernet board assembly. This is shown by the model number, where the 7th digit is either hardware option Q or R. These boards have three Ethernet ports, as shown in Figure 1.

A setting is provided in the HMI to switch the operation mode between PRP / HSR / RSTP / Dual IP.

Operation mode	Port 1	Port 2	Port3
PRP	Interface 1	Interface 2 (PRP)	Interface 2 (PRP)
HSR	Interface 1	Interface 2 (HSR)	Interface 2 (HSR)
RSTP	Interface 1	Interface 2 (RSTP)	Interface 2 (RSTP)
Dual IP	* Interface 1 on Port 1 or Port 2		Interface 2

** Note — In Dual IP mode, interface 1 can be available on port 1 or port 2. If both of port 1 and port 2 are connected, only port 1 will work.*

Table 3 - Ethernet ports operation mode

For each interface, the fully IEC 61850 functions (GOOSE and MMS services) are supported independently.

For outgoing GOOSE messages, you need to configure whether a message is to be transmitted across one or both Ethernet connections. You also need to configure the destination parameters such as multicast MAC address, AppID, VLAN, etc.

Two communication parameters also need to be configured for each interface (IP address, MAC address, subnet mask). For the CID which is exported from SCD file, the second interface communication parameters are not configured. This needs to be done by manually editing in the IED configurator (this being invisible by the SCD file). This process needs to be completed before the exported CID file is downloaded to the IED. (this being invisible by the SCD file).

3.4.3.3 Typical User Cases

Below for Interface 1 and Interface 2, from a functional point of view it is same. The customer has flexibility to define the functionality according their requirements.

- Both for Station Bus to have duplicated network for DCS.
- One for Station Bus and one for process bus (Goose message)

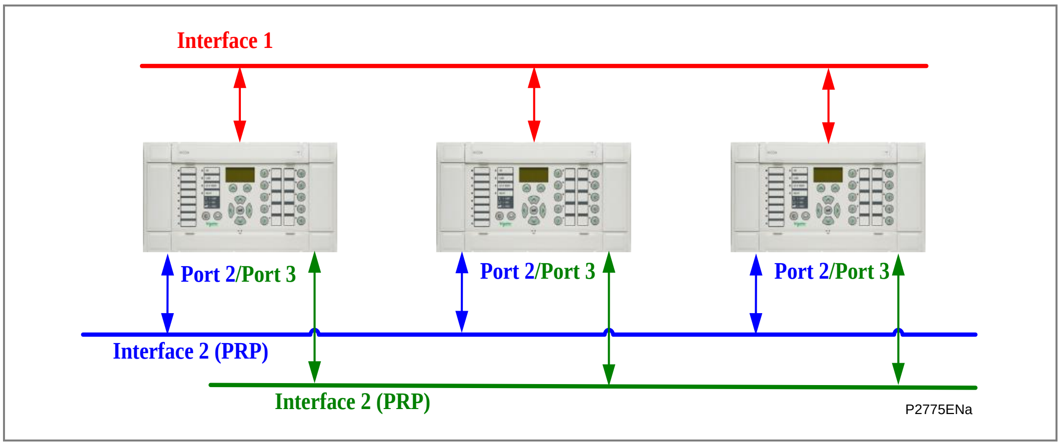


Figure 8 - PRP + Dual IP (Ethernet Mode PRP)

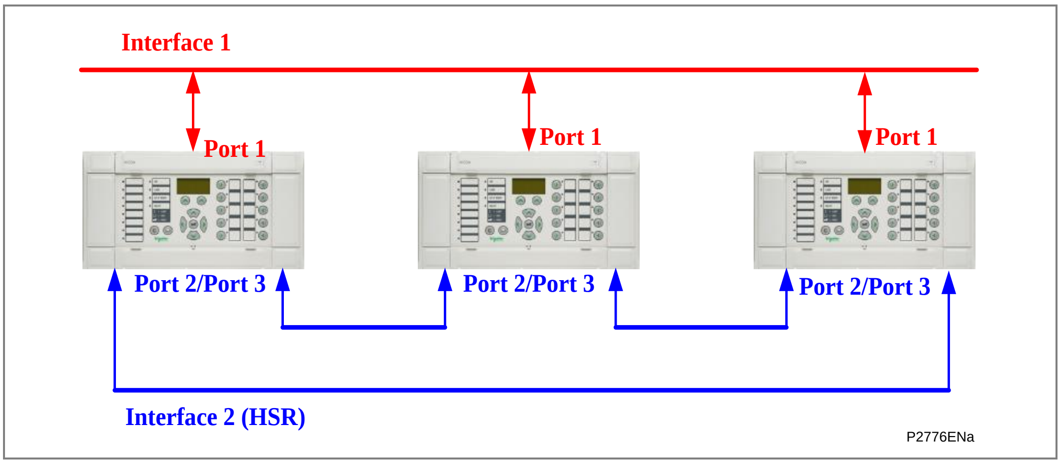


Figure 9 - HSR + Dual IP (Ethernet Mode HSR)

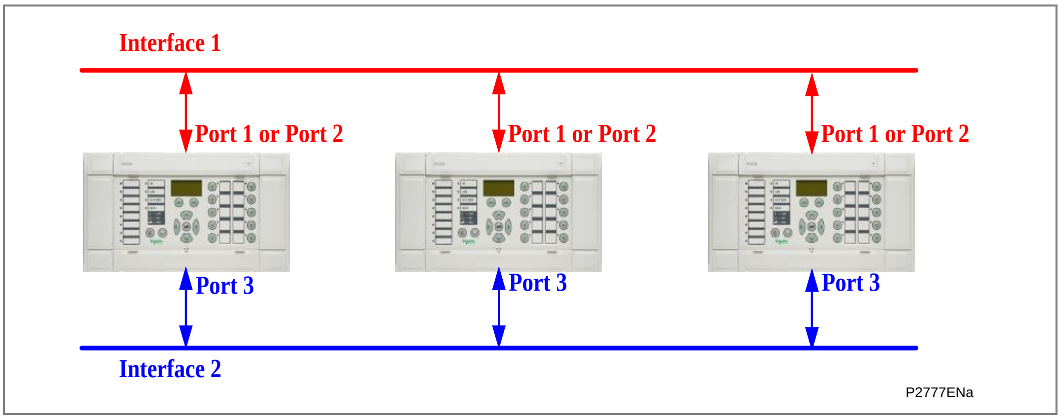


Figure 10 - Dual IP (Ethernet Mode Dual IP)

3.4.4 Precision Time Protocol (PTP)

Precision Time Protocol (PTP) provides higher time accuracy (500us) than IRIG-B.

PTP communication uses the IEEE 802.3 protocol.

3.4.4.1 Introduction to the IEEE1588 Standard

A protocol is provided in this standard that enables precise synchronization of clocks in measurement and control systems implemented with technologies such as network communication, local computing, and distributed objects. The protocol is applicable to systems communicating via packet networks. Heterogeneous systems are enabled that include clocks of various inherent precision, resolution, and stability to synchronize. System-wide synchronization accuracy and precision in the sub-microsecond range are supported with minimal network and local clock computing resources. Simple systems are installed and operated without requiring the management attention of users because the default behaviour of the protocol allows for it.

3.4.4.2 PTP Implementation

PTP implementation is compliant with IEC61850-9-3.

PTP communication is supported in all Ethernet interfaces (redundant ports or single port) with all communication protocols (PRP/HSR/RSTP).

A Slave only Ordinary Clock (OC) is supported by the single port of the Ethernet boards. A Transparent Clock (TC) is supported on the HSR ring.

Peer-to-Peer mode and Best Master Clock algorithm (BMCA) are supported.

The priority of time synchronization is PTP then, if not provided IRIG-B then, if not provided SNTP.

PTP is only supported by the model number, where the 7th digit is Q, R or S.

3.4.4.3 PTP Settings

PTP Settings	Value	Description
DATE AND TIME		
1588 Sync	0: Disabled 1: Interface1 Enabled 2: Interface2 Enabled 3: Interface1&2 Enabled	For Q or R board, the setting value can be 0,1,2,3. For S board, the setting value can be 0, 1. If the setting value is 0, PTP communication is disabled.
1588 DomainNum	[0, 255]	Define the permitted domainNumber of master clock. If the domainNumber in received PTP message header is different from the configuration parameter, the message will be rejected.
1588 PdelInterv	[0, 5]	Define the PDelay interval (2^0~2^5) sent by IED.

PTP is linked with Interface 2 configuration. If there is no IP configured for Interface 2, PTP on interface 2 will not work.

3.4.4.4 IEC61850-9-3 PICS

PICS proforma reference	Capability	Base	Support
CLOCK_TYPE_OC	clock is OC according to this base	m	True
CLOCK_TYPE_TC	clock is TC according to this base	m	True
CLOCK_TYPE_BC	clock is BC according to this base	m	False
NR_PORTS	number of clock ports (total)	m	2

PICS proforma reference	Capability	Base	Support
PORTS_STEP	1: all ports support 1- step on egress 2: all ports support 2- step on egress 3: all ports support both 1 - step and 2.	m	{1 or 2} For PRP/HSR/RSTP mode: Port1 support 2 step on egress. Port2&3 support 1 step on egress For Dual IP mode: Port1&2 support 2 step on egress Port3 support 1 step on egress
SLAVE_ONLY	all ports of the clock are slave - only	m	True
TIME_TRACEABLE	connectable to a time reference outside of PTP (e.g. GPS)	m	
FREQ_TRACEABLE	connectable to a frequency reference outside of PTP (e.g. GPS)	m	
DAC	doubly attached OC	o	True (in HSR, PRP or RSTP mode)
PORTS_PAIRED	paired clock ports for redundancy (e.g. {3-4})	o	{0,1} 0=A, 1=B
REDBOX_DATC	Redbox as TC	o	
REDBOX_SLTC	Redbox as Stateless TC	o	
REDBOX_TWBC	Redbox as three- way BC	o	
REDBOX_DABC	Redbox as DAC BC	o	
MIB_SNMP	supports MIB of IEC 2439-3 :2015, Annex E	m	False
MIB_61850	supports IEC 6 1859- 90- 4 Clock Objects	m	False
MIB_OTHER	clock supports fixed values or a mechanism defined by the manufacturer (If True, this list is appended to this PICS)	m	True Some management requests for time synchronization information are supported in PTP protocol. The following lists the supported datasets. CURRENT_DATA_SET - stepsRemoved - offsetFromMaster - meanPathDelay PORT_DATA_SET - portIdentity - portState - logMinDelayReqInterval - peerMeanPathDelay - logAnnounceInterval - announceReceiptTimeout - logSyncInterval - delayMechanism - logMinPdelayReqInterval - versionNumber

4 CONFIGURATION

The new redundant Ethernet board supports three communication operation modes. These can be achieved by change the setting in HMI. It is not necessary to flash the firmware.

Also for the two interfaces, the communication parameters need to be configured. These include the IP address, MAC address, and subnet mask, etc.

For redundant protocols, the communication parameters for redundant agency device also need to be configured.

4.1 Configuring Ethernet Communication Mode

Menu Text	Cell Add.	Default Setting	Available Setting
ETH COMM Mode	0016	Dual IP	Dual IP, PRP, HSR or RSTP
Sets the redundancy protocol. This setting can only be changed via the UI. The setting is linked with Interface2. If there is no IP configured for Interface 2, the setting is not configurable. By default, this setting is configurable thanks to the default IP.			

Table 4 - Ethernet communication mode setting

4.2 Configuring the IED Communication Parameters

The communication parameter for each interface is configured using the IED Configurator software in MiCOM S1 Studio. **Customers can configure these parameters according to their needs, but the IP address for these two interfaces should not be in the same subnet.**

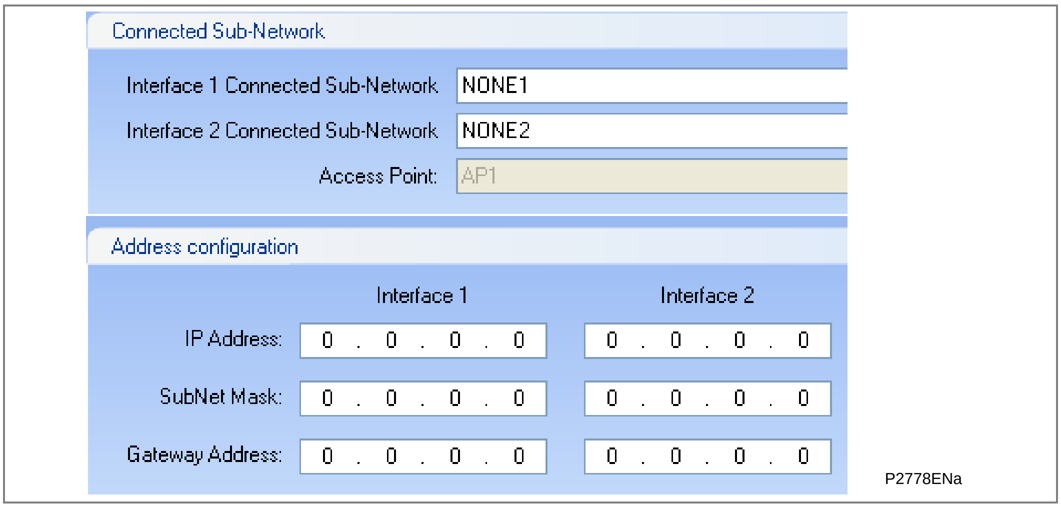


Figure 11 - Communication Parameters for two Interfaces

To use the device configuration with Courier Tunneling, for each interface, a default IP address has been applied. The default IP address for the first three bytes is fixed for each interface as below:

Interface	First three Bytes for IP address
Interface 1	169.254.0.xxx
Interface 2	169.254.1.yyy

Note	*xxx = Mod (the last byte MAC1 address, 128) + 1* *yyy = Mod (the last byte MAC2 address, 128) + 1*

Table 5 - First three bytes for default IP address

The default IP address can be found in the ***IED CONFIGURATOR*** column. Also, you can also calculate it according the MAC address label which is mounted on the rear panel of the Ethernet card.

4.3 Configuring GOOSE Publish Parameters

For outgoing GOOSE messages, you need to configure whether a message is to be transmitted over one or both Ethernet connections. You also need to configure the destination parameters including multicast MAC address, AppID, VLAN, etc.

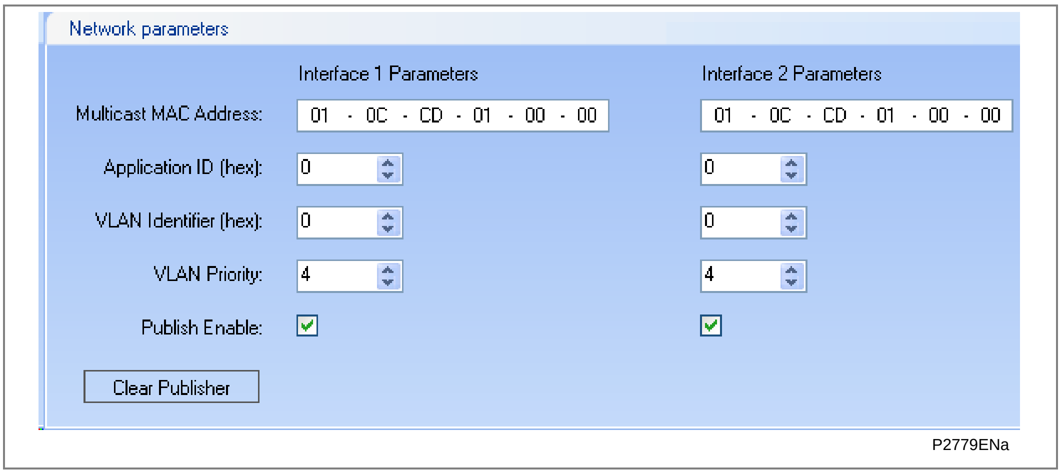


Figure 12 - Goose Publish Parameters for two Interfaces

5 COMMISSIONING

5.1 PRP Star Connection

The following diagram shows the Px4x IEDs with the PRP variant of Redundant Ethernet boards connected in a STAR topology. The STAR topology can have one or more high-end PRP-enabled Ethernet switches to interface with another network. The Ethernet switch is an HSR-enabled switch with a higher number of ports, which should be configured as the root bridge.

The number of IEDs that can be connected in the STAR can be up to 128.

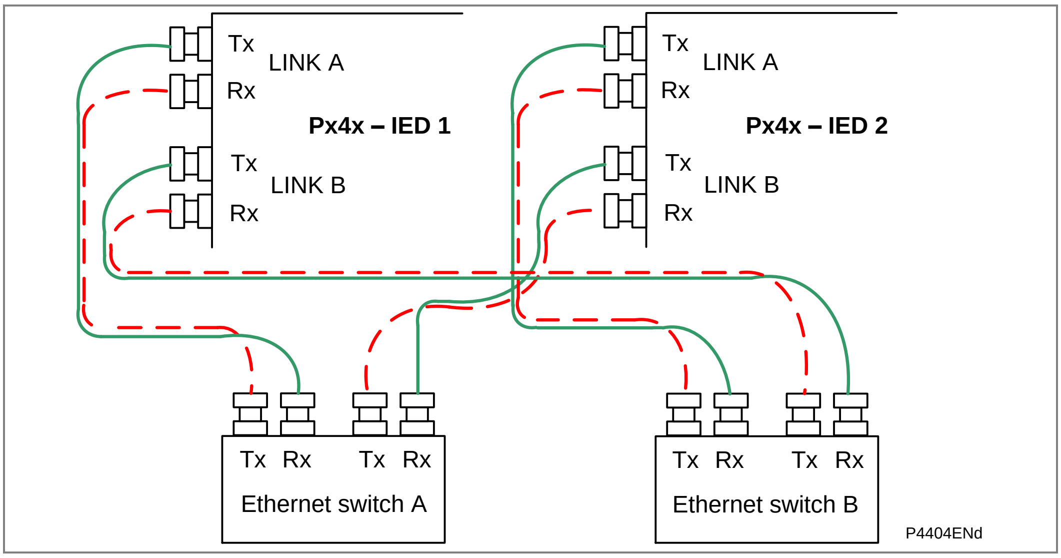


Figure 13 - PRP star connection

5.2 HSR Ring Connection

The following diagram shows the Px4x IEDs (Px4x - IED 1 to IED N) with the HSR variant of redundant Ethernet boards connected in a ring topology. The ring topology can have one or more high-end HSR-enabled Ethernet switches to interface with another network or a control center. The Ethernet switch is an HSR enabled switch with a higher number of ports.

The Ethernet switch, which is connected to the controlling PC, should be configured as the root bridge.

The number of IEDs that can be connected in the ring can be up to 128.

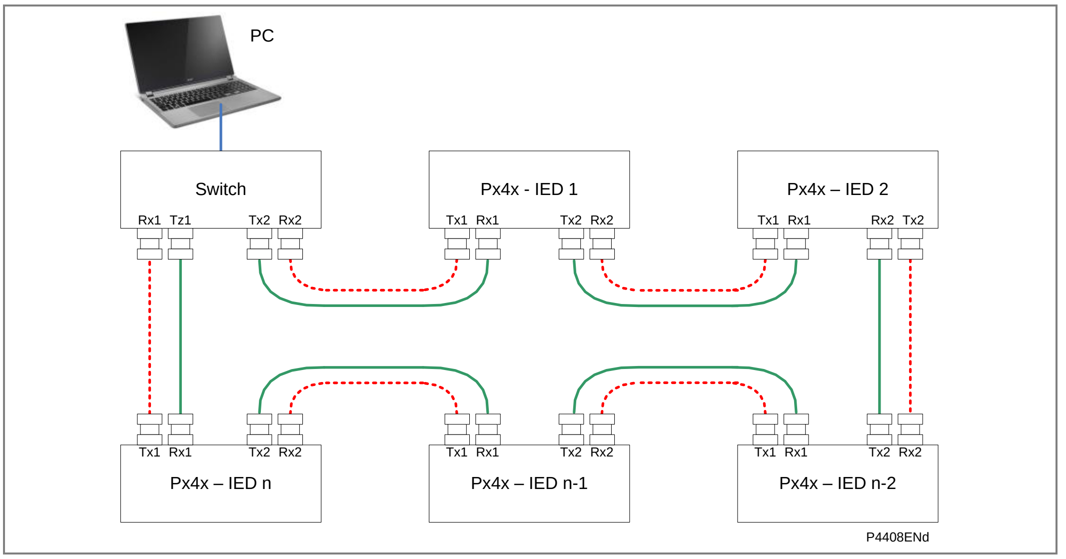


Figure 14 - HSR ring topology

The number of IEDs that can be connected in the ring can be up to 128.

5.3 RSTP Ring Connection

Figure 15 shows the Px4x IEDs (Px4x – IED 1 to IED N) with the RSTP variant of redundant Ethernet boards connected in a ring topology. The ring topology can have one or more high-end RSTP-enabled Ethernet switches to interface with another network or control center.

The Ethernet switch is an RSTP enabled switch with a higher number of ports.

The Ethernet switch, which is connected to the controlling PC, should be configured as the root bridge. The bridge priority of the Ethernet switch should be configured to the minimum value in the network shown in Figure 15.

The maximum number of IEDs that can be connected in the ring network depends on the Max Age parameter configured in the root bridge, see Figure 17.

The Max Age parameter can be varied from 6 to 40 seconds.

If Max Age = 6 seconds, the maximum number of IEDs in the ring is 6 - 1 = 5.

If Max Age = 40 seconds, the maximum number of IEDs in the ring is 40 - 1 = 39.

Therefore, the number of IEDs that can be connected in the ring can vary from 5 to 39.

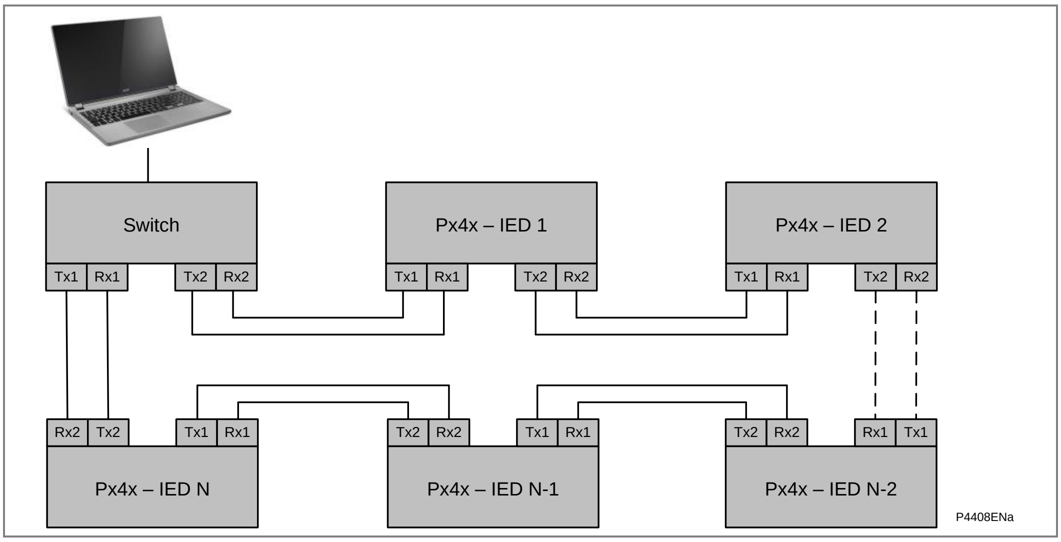


Figure 15 - Dual Ethernet ring topology

5.4 RSTP Star Connection

Figure 16 shows the Px4x IEDs (Px4x – IED 1 to IE D N) with the RSTP variant of redundant

Ethernet boards connected in a star topology. The star topology can have one or more high-end RSTP-enabled Ethernet switches to interface with other networks, control centers, or Px4x IEDs. The Ethernet switch is an RSTP enabled switch with a greater number of ports.

The Ethernet switch, which is connected to the controlling PC, should be configured as the root bridge. The bridge priority of the Ethernet switch should be configured to the minimum value in the network shown in Figure 3.

The Px4x IEDs are placed at two hop distance from the root bridge, therefore the Max Age meter has no impact on star topology.

The maximum number of IEDs that can be connected in the star network depends on the number of ports available in the Ethernet switch, provided that the hop count from the root bridge is less than the Max Age parameter.

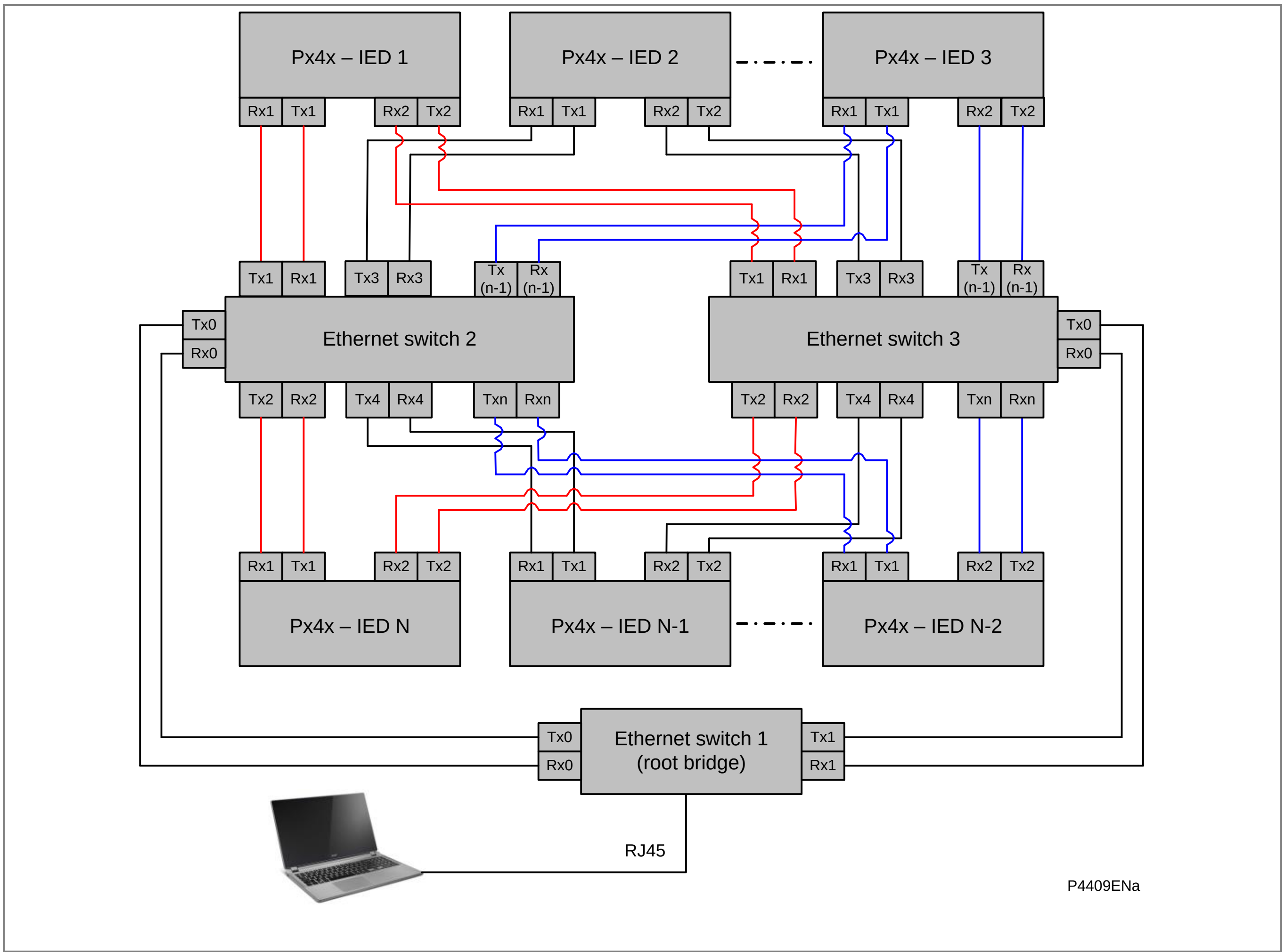


Figure 16 - Dual Ethernet star topology

5.5 Large RSTP Networks combining Star and Ring

Figure 17 shows a star of four rings. Each ring is connected to the root bridge. The root bridge is a high-end RSTP enabled bridge with the maximum number of ports as required.

The devices A1, A2…Anmax, B1, B2…Bnmax, C1, C2…Cnmax, D1, D2…Dnmax, represent the RSTP variant of redundant Ethernet boards.

The maximum number of boards that can be connected in single ring in an RSTP-enabled network depends on the Max Age parameter. The hop count from the root bridge cannot be greater than the Max Age parameter.

The maximum number of RSTP bridges in a ring is given by:

Nmax = (Max Age – 1)

Where:

Nmax = maximum number of devices in a ring
Max Age = Max Age value configured in the root bridge

Assuming the default value of Max Age as 20 seconds in the topology shown 0, the maximum number of devices that can be connected in ring A is 19.

If Max Age is configured as 40 seconds, the maximum number of IEDs that can be connected in the network is (40-1) = 39. According to the IEEE 802.1D 2004 standard, the maximum value for the Max Age parameter is limited to 40. To use the maximum number of IEDs in the ring, the following configuration should be used.

Max Age	40 seconds
Forward Delay	30 seconds
Hello Time	2 seconds
Bridge Priority	As required by the end user

The IEEE 802.1D 2004 standard defines the relation between Max Age and Forward Delay as:

2 * (Forward Delay – 1.0 seconds) >= Max Age

To have the maximum number of nodes in the RSTP network, the number of rings can be increased, depending on the number of ports available in the root bridge.

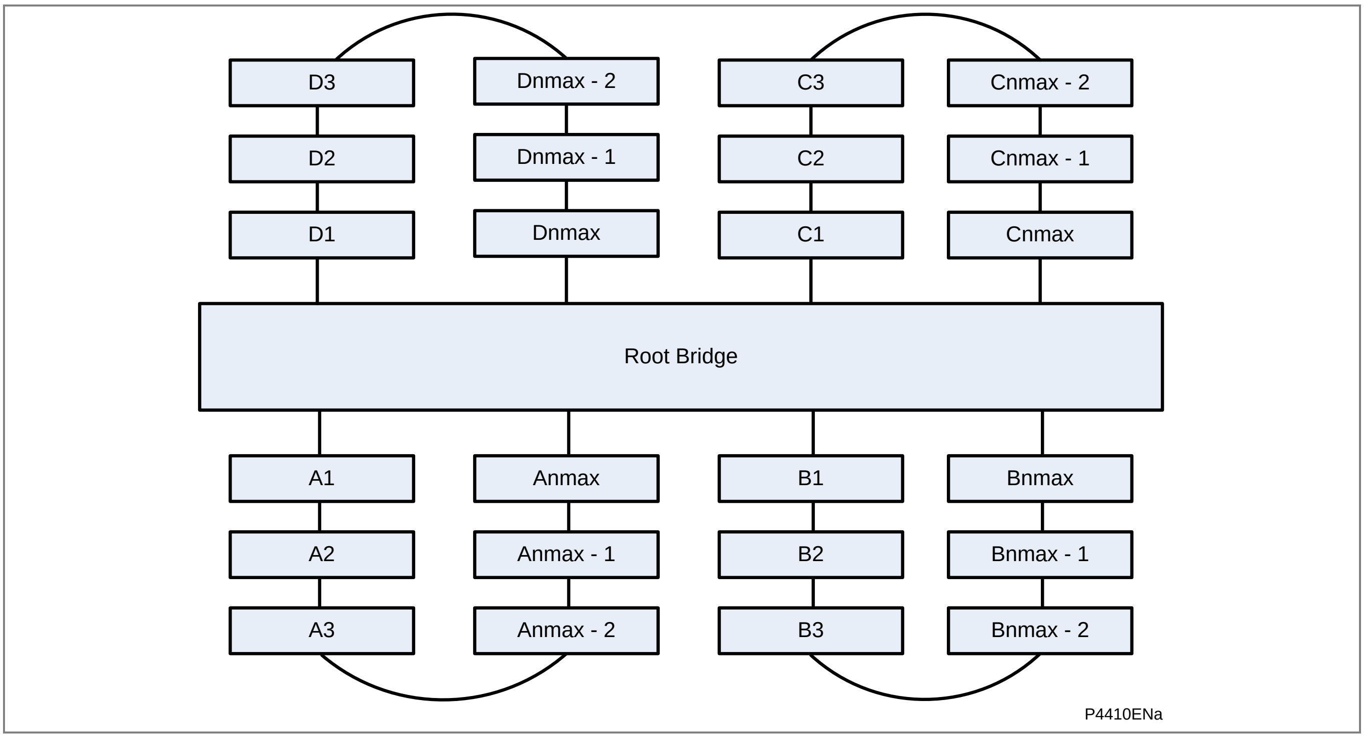


Figure 17 - Combined RSTP star and ring topology

6 TECHNICAL DATA

The technical data applies to a Redundant Ethernet board fitted into these products.

- P14x = P141, P142, P143, P145
- P24x = P241, P242, P243
- P34x = P341, P342, P343, P344, P345
- P44x = P442, P444
- P44y = P443, P446
- P445
- P54x = P543, P544, P545, P546
- P547
- P64x = P642, P643, P645
- P74x = P741, P743, P746
- P841
- P849

6.1 Board Hardware

6.1.1 100 Base TX Communications Interface (in accordance with IEEE802.3 and IEC 61850)

Cable type	Screened Twisted Pair (STP)
Connector type	RJ45
Maximum distance	100m
Full Duplex	100 Mbps

Table 6 - 100 Base TX interface

6.1.2 100 Base FX Communications Interface (in accordance with IEEE802.3 and IEC 61850)

Optical fiber cable	Multi-mode 50/125 µm or 62.5/125 µm
Center wavelength	1310 nm
Connector type	LC
Maximum distance	2 km
Full Duplex	100 Mbps

Table 7 - 100 Base FX interface

6.1.3 Transmitter Optical Characteristics

(TA = -40° C to 85° C)

Parameter	Sym	Min.	Typ.	Max.	Unit
Output Optical Power 62.5/125 µm, NA = 0.275 Fiber	PO	-20	-17.0	-14	dBm avg.
Output Optical Power 50/125 µm, NA = 0.20 Fiber	PO	-23.5	-20.0	-14	dBm avg.
Optical Extinction Ratio				10	dB
Output Optical Power at Logic “0” State	PO (“0”)			-45	dBm avg.

Table 8 - Tx optical characteristics

6.1.4 Receiver Optical Characteristics

(TA = -40° C to 85° C)

Parameter	Sym	Min.	Typ.	Max.	Unit
Input Optical Power	PIN	-31		-14	dBm avg.

Table 9 - Rx optical characteristics

6.1.5 IRIG-B and Real-Time Clock

6.1.5.1 Performance

Year 2000:	Compliant
Real time accuracy:	< ±2 seconds / day
External clock synchronization:	Conforms to IRIG standard 200-98, format B

6.1.5.2 Features

Real time 24 hour clock settable in hours, minutes and seconds
Calendar settable from January 1994 to December 2092
Clock and calendar maintained via battery after loss of auxiliary supply
Internal clock synchronization using IRIG-B Interface for IRIG-B signal is BNC

6.1.5.3 Self-adapted Rear IRIG-B interface (Modulated or Unmodulated)

BNC plug
Isolation to SELV level
50 ohm coaxial cable

6.2 Type Tests

6.2.1 Insulation

Per EN / IEC 60255-27:
Insulation resistance > 100 MΩ at 500 Vdc
(Using only electronic/brushless insulation tester).

6.2.2 Creepage Distances and Clearances

Per EN / IEC 60255-27:
Pollution degree 3, Overvoltage category III,

6.2.3 High Voltage (Dielectric) Withstand

(EIA RS-232 ports excepted and normally-open contacts of output relays excepted).

(i) As for EN / IEC 60255-27:

2 kV rms AC, 1 minute:
 Between all independent circuits.
 Between independent circuits and case earth (ground).
1 kV rms AC for 1 minute, across open watchdog contacts.
1 kV rms AC for 1 minute, across open contacts of changeover output relays.
1 kV rms AC for 1 minute for all D-type EIA(RS)-232 or EIA(RS)-485 ports between the communications port terminals and protective (earth) conductor terminal.
1 kV rms AC for 1 minute between RJ45 ports and the case earth (ground).

(ii) As for ANSI/IEEE C37.90:

1.5 kV rms AC for 1 minute, across open contacts of normally open output relays.
1 kV rms AC for 1 minute, across open watchdog contacts.
1 kV rms AC for 1 minute, across open contacts of changeover output relays.

6.2.4 Impulse Voltage Withstand Test

As for EN / IEC 60255-27:

(i) Front time: 1.2 µs, Time to half-value: 50 µs,
Peak value: 5 kV, 0.5 J
Between all independent circuits.
Between independent circuits and case earth ground.

(ii) Front time: 1.2 µs, Time to half-value: 50 µs,
Peak value: 1.5kV, 0.5 J
Between RJ45 ports and the case earth (ground).
EIA(RS)-232 & EIA(RS)-485 ports and normally open contacts of output relays excepted.

6.3 ElectroMagnetic Compatibility (EMC)

6.3.1 1 MHz Burst High Frequency Disturbance Test

As for EN / IEC 60255-22-1, Class III,

Common-mode test voltage:	2.5 kV,
Differential test voltage:	1.0 kV,
Test duration:	2 s,
Source impedance:	200 Ω

(EIA(RS)-232 ports excepted).

6.3.2 100 kHz and 1MHz Damped Oscillatory Test

EN / IEC 61000-4-18:	Level 3
Common mode test voltage:	2.5 kV
Differential mode test voltage:	1 kV

6.3.3 Immunity to Electrostatic Discharge

As for EN / IEC 60255-22-2, EN / IEC 61000-4-2:

15kV discharge in air to user interface, display, communication ports and exposed metalwork.
6kV contact discharge to the screws on the front of the front communication ports.
8kV point contact discharge to any part of the front of the product.

6.3.4 Electrical Fast Transient or Burst Requirements

As for EN / IEC 60255-22-4, Class B:

±4.0 kV, 5kHz and 100kHz applied to all inputs / outputs excluding communication ports
±2.0 kV, 5kHz and 100kHz applied to all communication ports

As for EN / IEC 61000-4-4, severity level 4:

±2.0 kV, 5kHz and 100kHz applied to all inputs / outputs and communication ports excluding power supply and earth.
±4.0 kV, 5kHz and 100kHz applied to all power supply and earth port

Rise time of one pulse:	5 ns
Impulse duration (50% value):	50 ns
Burst duration:	15 ms or 0.75ms
Burst cycle:	300 ms
Source impedance:	50 Ω

6.3.5 Surge Withstand Capability

As for IEEE/ANSI C37.90.1:
4 kV fast transient and 2.5 kV oscillatory
applied directly across each output contact, optically isolated input, and power supply circuit.

6.3.6 Surge Immunity Test

As for EN / IEC 61000-4-5, EN / IEC 60255-26:
Time to half-value: 1.2 to 50 μs,
Amplitude: 4 kV between all groups and case earth (ground),
Amplitude: 2 kV between terminals of each group.
Amplitude: 1kV for LAN ports

6.3.7 Conducted/Radiated Immunity

For RTDs used for tripping applications the conducted and radiated immunity performance is guaranteed only when using totally shielded RTD cables (twisted leads).

6.3.8 Immunity to Radiated Electromagnetic Energy

Per EN / IEC 61000-4-3 and EN / IEC 60255-22-3, Class 3
Test field strength, frequency band 80 to 1000 MHz and
1.4 GHz to 2.7GHz: 10 V/m,
Test using AM: 1 kHz / 80%
Spot tests at: 80, 160, 450, 900, 1850, 2150 MHz
Per IEEE/ANSI C37.90.2:
80MHz to 1000MHz, zero and 100% square wave modulated.
Field strength of 35V/m.

6.3.9 Radiated Immunity from Digital Communications

As for EN / IEC61000-4-3, Level 4:
Test field strength, frequency band 800 to 960 MHz,
and 1.4 to 2.0 GHz: 30 V/m, Test using AM: 1 kHz/80%.

6.3.10 Radiated Immunity from Digital Radio Telephones

As for EN / IEC 61000-4-3: 10 V/m, 900 MHz and 1.89 GHz.

6.3.11 Immunity to Conducted Disturbances Induced by Radio Frequency Fields

As for EN / IEC 61000-4-6, Level 3, Disturbing test voltage: 10 V.

6.3.12 Power Frequency Magnetic Field Immunity

As for EN / IEC 61000-4-8, Level 5,
100 A/m applied continuously, 1000 A/m applied for 3 s.
As for EN / IEC 61000-4-9, Level 5,
1000 A/m applied in all planes.
As for EN / IEC 61000-4-10, Level 5,
100 A/m applied in all planes at 100 kHz and 1 MHz with a burst duration of 2 s.

6.3.13 Conducted Emissions

As for CISPR 22 Class A:
Power supply:
0.15 - 0.5 MHz, 79 dBμV (quasi peak) 66 dBμV (average)
0.5 - 30 MHz, 73 dBμV (quasi peak) 60 dBμV (average)
Permanently connected communications ports:
0.15 - 0.5MHz, 97dBμV (quasi peak) 84dBμV (average)
0.5 - 30MHz, 87dBμV (quasi peak) 74dBμV (average)

6.3.14 Radiated Emissions

As for CISPR 22 Class A:
30 to 230 MHz, 40 dBμV/m at 10m measurement distance
230 to 1 GHz, 47 dBμV/m at 10 m measurement distance.
1 – 3GHz, 76dBμV/m (peak), 56dBμV/m (average) at 3m measurement distance.
3 – 5GHz, 80dBμV/m (peak), 60dBμV/m (average) at 3m measurement distance.

6.4 Environmental Conditions

6.4.1 Ambient Temperature Range

Per EN 60068-2-1 & EN / IEC 60068-2-2
Operating temperature range: -25°C to +55°C (or -13°F to +131°F)
Storage and transit: -25°C to +70°C (or -13°F to +158°F)

6.4.2 Ambient Humidity Range

Per EN /IEC 60068-2-78:

56 days at 93% relative humidity and +40 °C

Per EN / IEC 60068-2-14

5 cycles, -25°C to +55 °C
1°C / min rate of change

Per EN / IEC 60068-2-30

Damp heat cyclic, six (12 + 12) hour cycles, +25 to +55°C

6.4.3 Corrosive Environments

Per EN / IEC 60068-2-60, Part 2, Test Ke, Method (class) 3
Industrial corrosive environment/poor environmental control, mixed gas flow test.
21 days at 75% relative humidity and +30°C
Exposure to elevated concentrations of H_2S, (100 ppb), NO_2, (200 ppb) & Cl_2 (20 ppb).
Per EN / IEC 60068-2-52 Salt mist (7 days)
Per EN / IEC 60068-2-43 for H_2S (21 days), 15 ppm
Per EN / IEC 60068-2-42 for SO_2 (21 days), 25 ppm

6.5 EU Directives

6.5.1 EMC Compliance

As for 2004/108/EC:

Compliance to the European Commission Directive on EMC is demonstrated using a Technical File. Product Specific Standards were used to establish conformity:
EN 60255-26

6.5.2 Product Safety

Per 2006/95/EC:

Compliance to the European Commission Low Voltage Directive (LVD) is demonstrated using a Technical File. A product-specific standard was used to establish conformity.

CE EN 60255-27

6.5.3 R&TTE Compliance

Radio and Telecommunications Terminal Equipment (R&TTE) directive 99/5/EC.

Compliance demonstrated by compliance to both the EMC directive and the Low voltage directive, down to zero volts.

Applicable to rear communications ports.
Compliance demonstrated by Notified Body certificates of compliance.

6.5.4 Other Approvals

For ATEX Potentially Explosive Atmospheres directive 94/9/EC compliance, consult Schneider Electric.
For other approvals such as UL / CUL / CSA, consult Schneider Electric.

6.6 Mechanical Robustness

6.6.1 Vibration Test

Per EN / IEC 60255-21-1	Response Class 2 Endurance Class 2

6.6.2 Shock and Bump

Per EN / IEC 60255-21-2	Shock response Class 2 Shock withstand Class 1 Bump Class 1

6.6.3 Seismic Test

Per EN / IEC 60255-21-3:	Class 2

7 CORTEC

This is a generic Cortec to cover all IEDs using the **Redundant Ethernet** boards.
It does not necessarily include all the possible options for all products in the MiCOM Px4x range. Likewise, it is possible that options shown in this list, may not be available for all products

Variants / Order Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MiCOM Protection	P														
Application/Platform:															
Feeder Management:		1	4	*											
Motor Protection:		2	4	*											
Generator Protection Relay:		3	4	*											
Distance Protection Relay:		4	4	*											
Current Differential:		5	4	*											
Transformer:		6	4	*											
Busbar:		7	4	*											
Breaker Fail:		8	4	*											
Vx Aux Rating:															
24 - 32 Vdc					9										
48 - 110 Vdc					2										
110 - 250 Vdc (100 - 240 Vac)					3										
In/Vn Rating (model dependent):															
Product Dependent						*									
Hardware Options (model dependent):															
Standard - no options							1								
IRIG-B only (modulated)							2								
Fibre optic converter only							3								
IRIG-B (modulated) & fibre optic converter							4								
Ethernet with 100Mits/s fibre-optic port							6								
Second Rear Comms Port (Courier EIA232/EIA485/k-bus)							7								
Second Rear Comms Port + IRIG-B (modulated) (Courier EIA232/EIA485/k-bus)							8								
InterMiCOM + Courier Rear Port							E								
InterMiCOM + Courier Rear Port + IRIG-B modulated							F								
Redundant Ethernet (100Mbit/s) PRP or HSR or RSTP and Dual IP, 2 LC ports + 1 RJ45 port + Modulated/Un-modulated IRIG-B + 1588							Q								
Redundant Ethernet (100Mbit/s) PRP or HSR or RSTP and Dual IP, 3 RJ45 ports + Modulated/Un-modulated IRIG-B + 1588							R								
Ethernet (100Mbit/s), 1 RJ45 port + Modulated/Un-modulated IRIG-B + 1588							S								
Product Specific Options (model dependent):															
Product Dependent								*							
Protocol Options:															
K-Bus/Courier									1						
Modbus									2						
IEC60870-5-103 (VDEW)									3						
DNP3.0									4						
IEC 61850 over Ethernet and Courier via rear K-Bus/RS485 OR IEC 61850 Edition 1 and Edition 2 and Courier via rear K-Bus/RS485									6						
IEC 61850 over ethernet with CS103 rear port RS485 protocol OR IEC 61850 Edition 1 and Edition 2 and CS103 via rear port RS485									7						
IEC 61850 Edition 1 / 2 and DNPoE and DNP3 Serial with simple password management - (CSL0)									B						
IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required									G						
IEC 61850 Edition 1 / 2 and CS103 via rear port RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required									H						
IEC 61850 Edition 1 / 2 and DNPoE and DNP3 Serial with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required									L						
Mounting Options:															

Flush Panel Mounting	M
Rack Mounting (80TE only)	N
Language Options:	
English, French, German, Spanish	0
English, French, German, Russian	5
Chinese, English or French via HMI, with English or French only via Communications port	C
Software Version:	
	* *
Customisation:	
Default	8
Customer Specific	9
Design Suffix:	
Phase 3 CPU	L
Extended Phase 3 CPU	M

Notes:

PRP NOTES

CHAPTER 20

Date (month/year):	02/2018			
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.			
Hardware Suffix:	P445 P44y (P443/P446)	L M	P54x (P543/P544/P545/P546) P841A (one circuit breaker) P841B (two circuit breakers)	M M M
Software Version:	P445 P44y (P443/P446)	J4/B0/B1/E0/E1 H4	P54x (P543/P544/P545/P546) P841A P841B	H4 G4 H4
Connection Diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P445: 10P445xx (xx = 01 to 04) P44x(P442 & P444): 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)		P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 01 to 10) 10P643xx (xx = 01 to 06) 10P645xx (xx = 01 to 09) P74x (P741, P742 & P743): 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)	

CONTENTS

TABLES

FIGURES

Notes:

1 PARALLEL REDUNDANCY PROTOCOL (PRP) NOTES

1.1 Introduction to PRP

This section gives an introduction to the Parallel Redundancy Protocol (PRP); and how it is implemented on MiCOM-based products manufactured by Schneider Electric.

1.2 Protocols

Industrial real-time Ethernets typically need much better levels of availability and uninterrupted operation than normal office-type Ethernet solutions. For power networks, even a short loss of connectivity may result in a significant loss of functionality or impaired safety. To recover from a network failure, various redundancy schemes have been considered, including: Rapid Spanning Tree Protocol (**RSTP**), Media Redundancy Protocol (**MRP**) and Parallel Redundancy Protocol (**PRP**). The key properties of these are as follows:

RSTP this uses mesh-based topologies or ring topology and computes a tree, based on path costs and priorities. In case of network failure, a typical reset time for RSTP-based system is normally a few seconds.

MRP This uses ring-based topologies. In case of network failure, the network is broken into two separate lines, which are reconnected by de-blocking the previously blocked part. The guaranteed reset time for MRP protocol-based systems is typically around 100ms.

PRP this does not change the active topology as it uses two independent networks. Each message is replicated and sent over both networks. The first network node to receive it acts on it, with all later copies of the message being discarded. Importantly, these details are controlled by the low-level PRP layer of the network architecture, with the two networks being hidden from the higher level layers. Consequently, PRP-based networks are continuously available.

Power networks need to be able to respond to problems very quickly (typically in less than 10ms), and PRP is an available protocol which is robust enough to achieve this. The PRP protocol used in the MiCOM relay/IEDs is defined in the IEC62439-3 (2012) standard and is configured using the existing redundant Ethernet card(s).

1.3 PRP Summary (IEC 62439-3 Clause 4)

A summary of the main PRP features is given below:

- Ethernet redundancy method independent of any Ethernet protocol or topology (tree, ring or mesh)
- Seamless switchover and recovery in case of failure, which supports real-time communication
- Supervises redundancy continuously for better management of network devices
- Suitable for hot swap - 24 hour/365 day operation in substations
- Allows the mixing of devices with single and double network attached nodes on the same Local Area Network (LAN)
- Allows laptops and workstations to be connected to the network with standard Ethernet adapters (on double or single attached nodes)
- Particularly suited for substation automation, high-speed drives and transportation

1.4 Example of a PRP Network

Essentially a PRP network is a pair of similar Local Area Networks (LANs) which can be any topology (tree, ring or mesh). An example of a PRP network is shown in Figure 1:

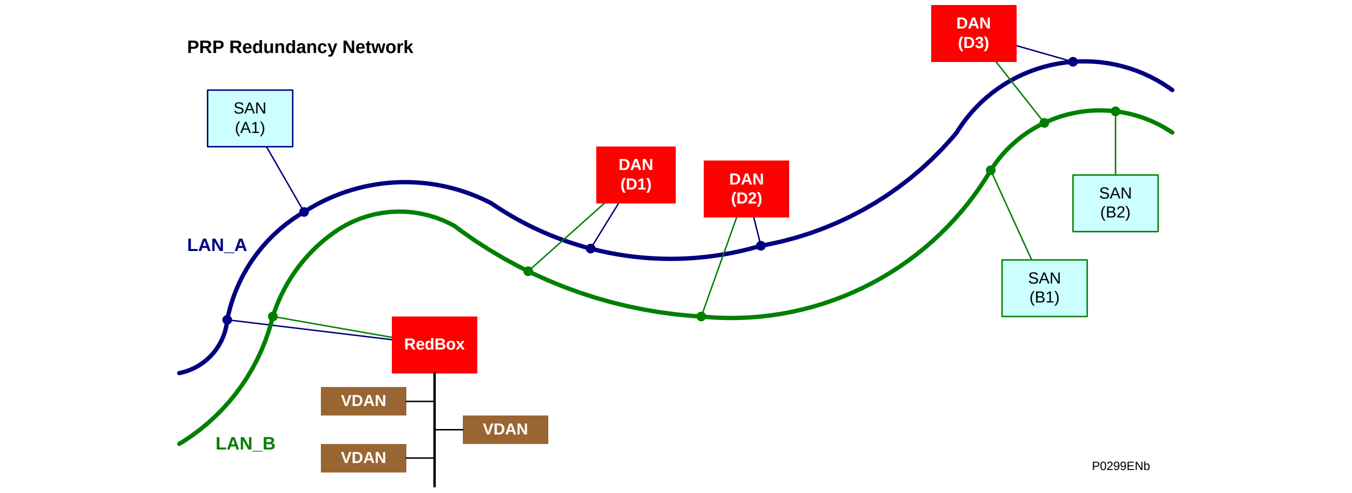


Figure 1 - PRP Redundancy Network

Figure 1 shows two similar Local Area Networks (LANs) which have various Nodes in common. The key features of these networks include:

- With the exception of a RedBox (see below), no direct cable connections can be made between the two LANs.
- Each of these LANs can have one or more Single Attached Nodes (SANs). These are normally non-critical devices that are attached only to a single network. SANs can talk to one another, but only if they are on the same LAN.
- Matched pairs of devices which are critical to the operation of the overall scheme are connected one to each network as Doubly Attached Nodes (DANs).
- To be sure that network messages (also known as frames) are transferred correctly to each DAN, each DAN must have the same Media Access Control (MAC) code and Internet Protocol (IP) address. This will also mean that TCP/IP traffic will automatically communicate with both of the paired devices, so it will be unaware of any two-layer redundancy or frame duplication issues.
- A Redundancy Box (RedBox) is used when a single interface node has to be connected to both networks. The RedBox can talk to all other nodes. So far as other nodes are concerned, the RedBox behaves like a DAN, so a SAN that is connected through a RedBox is also called a Virtual Doubly Attached Node (VDAN). The RedBox must have its own unique IP address.
- Transmission delays can be different between related Nodes of the two LANs.
- Each LAN (i.e. LAN_A and LAN_B) must be powered from a different power source and must be failure independent.

The two LANs can differ in terms of performance and topology. The redundant Ethernet interface can be made using an optical fiber connection with an LC or ST connector type or with RJ45 copper connector type. There is no need for an optical interface away from the relay.

1.5 PRP Network Structure

PRP uses two independent LANs. The topology of each of these LANs is arbitrary, and ring, star, bus and meshed topologies are possible.

The main advantage of PRP is loss-free data transmission with an active (transit) LAN. When the terminal device receives no packets from one of the LANs, the second (transit) LAN maintains the connection. As long as 1 (transit) LAN is available, repairs and maintenance on the other (transit) LAN have no impact on the data packet transmission.

The elementary devices of a PRP network are known as RedBox (Redundancy Box) and DANP (Double Attached Node implementing PRP).

Both devices have one connection each to the (transit) LANs.

The devices in the (transit) LAN are conventional switches that do not require any PRP support. The devices transmit PRP data packets transparently, without evaluating the RCT information.
Terminal devices that are connected directly to a device in the (transit) LAN are known as SAN (Single Attached Node). If there is an interruption, these terminal devices cannot be reached via the redundant line. To use the uninterruptible redundancy of the PRP network, you integrate your device into the PRP network via a RedBox.

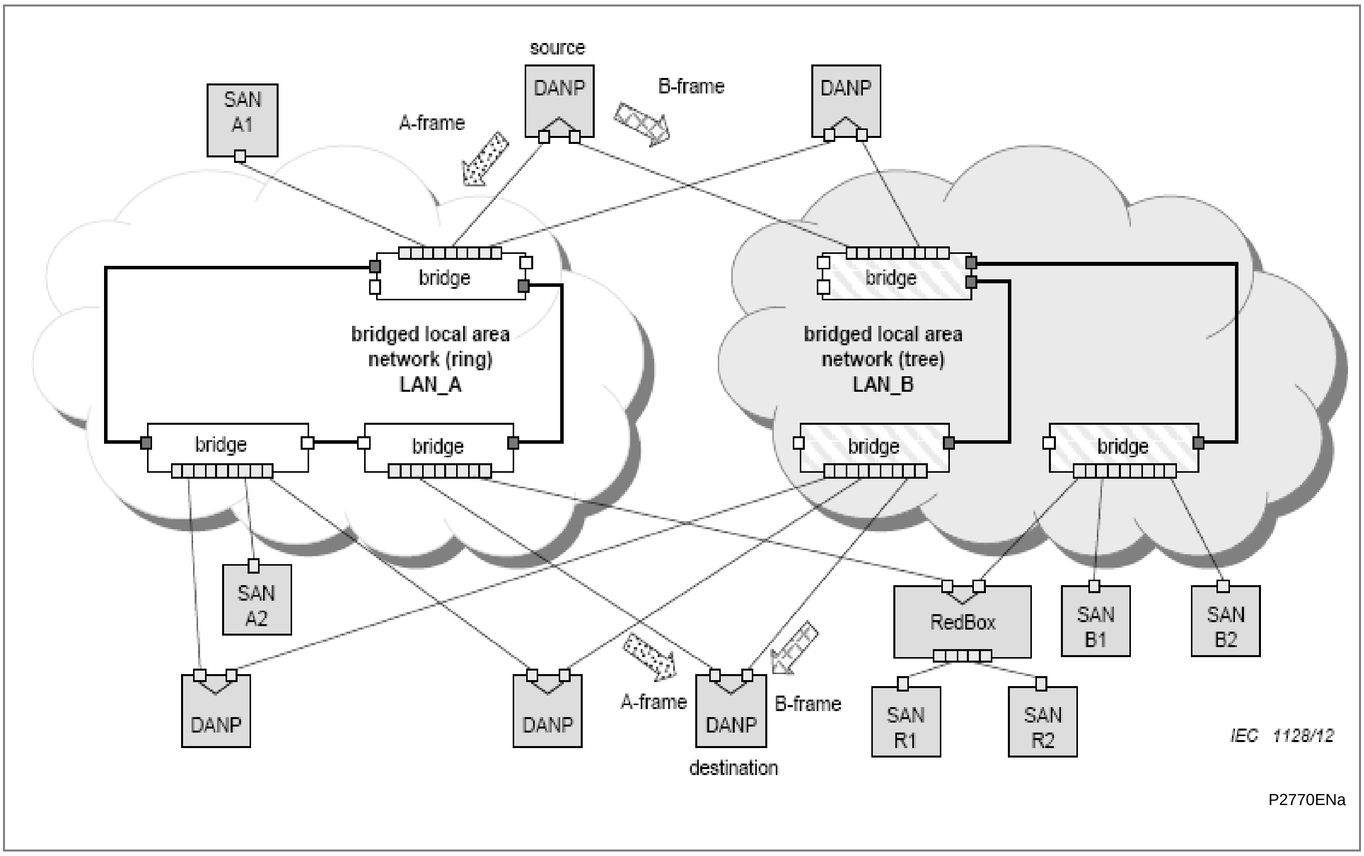


Figure 2 - PRP example of general redundant network

1.6 Structure of a DAN

A MiCOM P40 relay working in PRP Mode works as a DAN within the overall network topology. Each DAN has two ports that operate in parallel. They are attached to the upper layers of the communications stack through the Link Redundancy Entity (LRE) as in Figure 3:

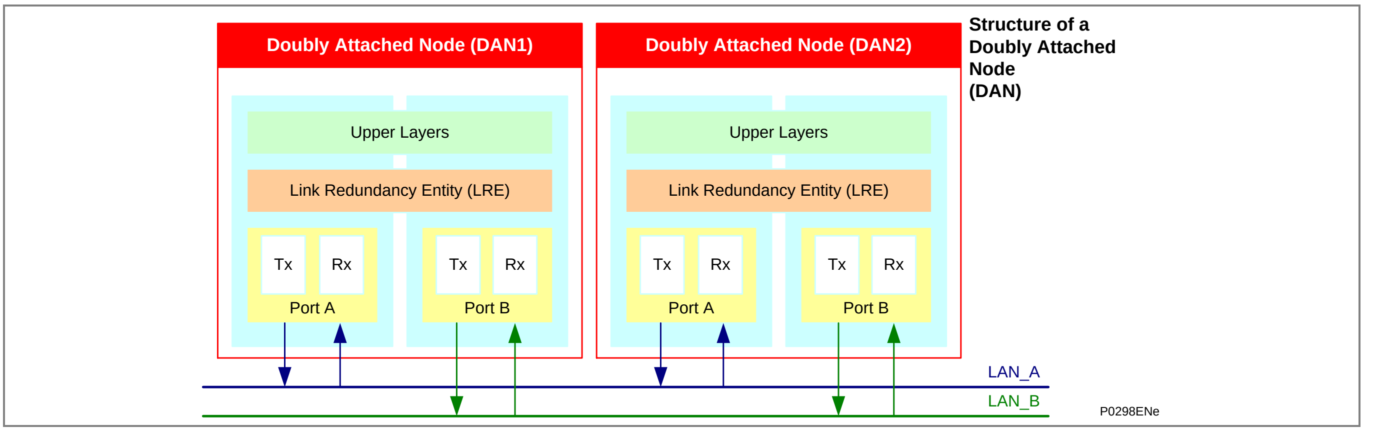


Figure 3 - Communication between two DANs (in PRP)

The LRE has two main tasks:

- handling message frames and
- management of redundancy

When an upper layer sends a frame to the LRE, the LRE replicates the frame and sends it through both its ports at nearly the same time. The two frames move through the two LANs with slightly different delays, ideally arriving at the destination node within a small time window.

When receiving frames, the LRE forwards the first frame it received to its upper layers and then discards the duplicate.

As both DAN nodes have the same MAC and IP addresses, this makes redundancy transparent to the upper layers. This allows the Address Resolution Protocol (ARP) to work in the same way as with a SAN. Accordingly, to the upper layers of a DAN, the LRE layer shows the same interface as the network adapter of a non-redundant adapter.

To manage redundancy, the LRE:

- Adds a 32-bit Redundancy Check Tag (RCT) to each frame it sends and
- Removes the RCT from each frame it receives

1.7 Communication between SANs and DANs

A SAN can be connected to any LAN and can communicate with any other SAN on the same LAN or any DAN. However, a SAN which connected to one LAN can not communicate directly to a SAN which is connected to the other LAN.

A DAN is connected to both LANs and can communicate with any RedBox or any other DANs or any SANs on either network. For communication purposes, a DAN “views” a SAN connected through a RedBox as a VDAN.

When a SAN generates a basic frame, it sends the frame only onto the LAN to which it is connected.

Originating at the SAN, a typical frame contains these parameters:

- dest_addr Destination Address
- src_addr Source Address
- type Type
- data
- fcs Frame Check Sequence (i.e. extra checksum characters added to allow error detection and correction)

The frame from the SAN is then received by the DAN; which sends the frame to its upper layers, which act accordingly.

When a DAN generates a frame, it needs to send the frame onto both of the LANs to which it is connected. When it does this, it extends the frame by adding the 48-bit Redundancy Control Trailer (RCT) into the frame.

The RCT consists of these parameters:

- 16-bit Sequence Number
- 4-bit LAN identifier, 1010 (0xA) for LAN_A and 1011 (0xB) for LAN_B
- 12-bit frame size
- PRP suffix

Note	*The Sequence number is a measure of the number of messages which have been sent since the last system reset. Each time the link layer sends a frame to a particular destination the sender increases the sequence number corresponding to that destination and sends the (nearly) identical frames over both LANs.*

Accordingly, originating at the DAN, a typical frame then contains these parameters:

- dest_addr Destination Address
- src_addr Source Address
- type Type
- lsdu Link Service Data Unit
- Padding if needed
- RCT data:
  - 16-bit sequence number:
    4-bit LAN identifier
    12-bit frame size
  - 16-bit PRP suffix (0X88 0XFB)
- fcs Frame Check Sequence

LSDU	*The Link Service Data Unit (LSDU) data allows PRP frames to be distinguished from none-PRP frames.*
Padding	*After the LSDU data, there may be some data padding. This is added to frames which would otherwise be too short for conventional network traffic (minimum frame size is 64 octets).*

Size	*The frame size will vary depending on the contents of the frame and how it has been tagged by the various SANs and DANs. In VLANs, frame tags may be added or removed during transit through a switch. To make the length field independent of tagging, only the LSDU and the RCT are considered in the size.*

Figure 4 shows the frame types with different types of data.

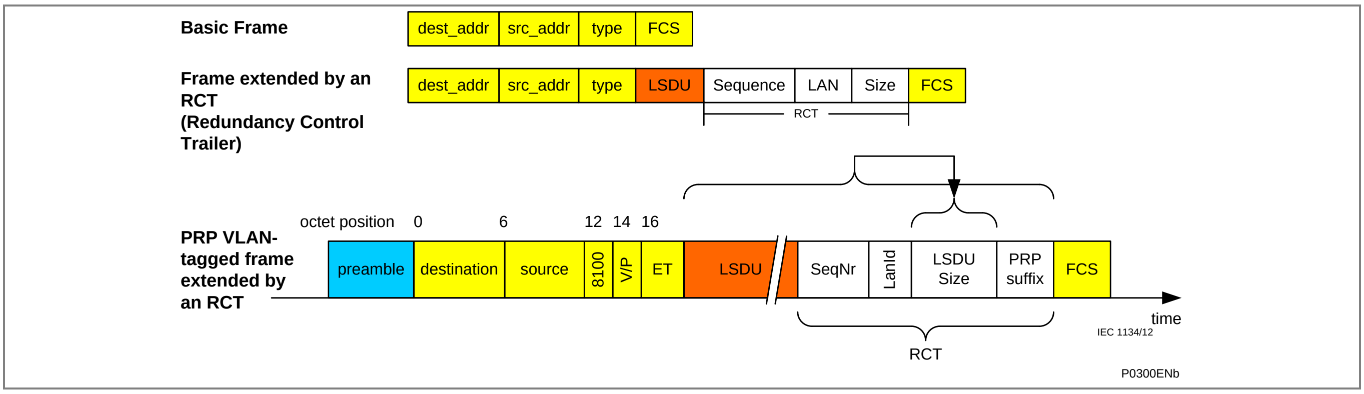


Figure 4 - Frames (basic, extended by an RCT and a VLAN tagged frame extended by RCT)

The key points about these differing frame structures is that:

- SANs do not implement any redundancy features, so they generate basic frames which SANs and DANs can understand.
- SANs can still understand the frames that come from DANs, as SANs ignore the RCT components in frames which come from DANs (a SAN cannot distinguish the RCT from the IEEE802.3 padding)
- If a DAN receives a frame which does not include the RCT component, it sends a single copy of the frame to its upper layers.
- If a DAN receives a frame which does include the RCT component, it does not send a duplicate copy of the frame to its upper layers.
- If a DANP cannot identify that the remote Node is a DAN, it inserts no RCT.

When using a Single Attached Nodes connected to the IED, a redbox is suggested to handle the case when the TPDU size for the client has been set above than 1024.

1.8 PRP Technical Data

- One VLAN tag supported.
- 128 publishers supported per receiver.
- Up to 100Mbit/s full duplex Ethernet.
- Dynamic frame memory allocation (page manager).
- Configurable duplicate detection.
- Wishbone interface for configuration and status registers.
- CPU port interface - Ethernet or Wishbone.
- Support for link-local protocols - CPU may send to specific ports only - CPU knows receive port.
- Configurable frame memory and queue length.
- Duplicate detection with configurable size and aging time.
- MAC address filtering (8 filter masks for interlink, 6 for CPU).
- Support for interfaces with or without Ethernet preamble.

Maximum Transmission Unit

According to the IEC 8802-3, the MTU (Ethernet maximum packet size) is:

- 1518 bytes without VLAN and without PRP
- 1522 bytes with VLAN and without PRP
- 1524 bytes without VLAN and with PRP
- 1528 bytes with VLAN and with PRP

Note: Check that the LAN switches setting for the MTU is at least 1528 bytes

2 PRP AND MICOM FUNCTIONS

2.1 MiCOM Products and PRP

The PRP functions being introduced as part of the overall MiCOM product range provide additional functionality, which is backwards compatible with existing Schneider Electric MiCOM equipment. This means that existing MiCOM relays/IEDS can be used on networks which use PRP functions, with no changes being made to those relays/IEDs.

The new MiCOM products that use the PRP, will interrogate other equipment to determine the equipment model number, and then use the model number to decide (at runtime), whether that particular item of equipment can support PRP or not.

MiCOM models which include the following Ethernet board assembly provide the possibility of PRP function support. This is denoted by Digit 7 where the Hardware option is N, P, Q or R, as shown in Table 1:

Hardware Option	Type	Model No format
"N" at Digit No 7	2 ST ports redundant Ethernet board (Modulated IRIG-B)	Px4xxxNx6Mxxx8K
"P" at Digit No 7	2 ST ports redundant Ethernet board (Un-modulated IRIG-B)	Px4xxxPx6Mxxx8K
"Q" at Digit No 7	2 LC + 1 RJ45 ports redundant Ethernet board (Modulated/ Un-modulated IRIG-B)	Px4xxxQx6Mxxx8M
"R" at Digit No 7	3 RJ45 ports redundant Ethernet board (Modulated/ Un-modulated IRIG-B)	Px4xxxRx6Mxxx8M

Table 1 - MiCOM model numbers for PRP options

The MiCOM relay/IED firmware has been modified to allow the PRP options to be accepted for the power-up tests in addition to the implementation of the supervision frame transmission.

2.2 Easergy Studio Software and the PRP Function

The addition of this function has no impact of the Easergy Studio support files so there is no need to upgrade any Easergy Studio software.

2.3 MiCOM Relay Configuration and the PRP Function

There is no need to change the configuration of any relay (as relays which include support for this function will be able to recognize other devices which support it).

2.4 Hardware Changes for PRP Protocol

This protocol is implemented using the existing redundant Ethernet and dual redundant Ethernet card as a starting point. The Frame management is achieved by re-programming the Field-Programmable Gate Array (FPGA).

The low-level management of the redundant frames is performed within the FPGA; this being defined as the Link Redundancy Entity (LRE). This will involve the addition of the Redundancy Check Tag (RCT) to a frame to be transmitted; this identifies the LAN and the sequence number of the message over the two networks. The FPGA is also responsible for the stripping of the RCT from received frames and discarding the duplicated messages such that only a single application frame is received by the Ethernet processor.

The LRE functionality of the supervision frame transmission is performed by the Ethernet processor card.

2.5 PRP Parameters

The Redundant Ethernet standard (IEC 62439-3:2012) defines several parameters for the PRP protocol; these being fixed at a default value within this release. The following values are set:

Parameter	Value	Description
Supervision Frame Multicast Address	01-15-4E-00-01-00	Target MAC Address for multicast supervision frame
Life Check Interval	2 seconds	Period between transmission of supervision frames
PRP Mode	Duplicate Discard	This is normal PRP mode, Duplicate address will not be supported.
Node Forget Time	60 s	This is the time after which a node entry is cleared.
Entry Forget Time	400 ms	Duration that the received message Sequence number will be held to discard a duplicate message.
Node Reboot Interval	500ms	Duration following reboot for which no PRP frames should be transmitted.

Table 2 - PRP parameter values (for PRP Protocol Version 1)

2.6 Product Implementation Features

Here is a list of the main Product Requirements for MiCOM products which support PRP:

- The MiCOM relay/IED provides two redundant Ethernet ports using PRP.
- The MiCOM relay/IED must be connected to the redundant Ethernet network as a Double Attached Node (DAN) using PRP (DAN using PRP is known as DANP)
- The redundant Ethernet interface can be made using an RJ45 or an optical fibre connection with an LC or ST connector type (Ethernet card dependent).
- The management of the PRP redundancy is transparent to the application data provided via the Ethernet interface.
- The PRP option is available with any of the existing protocol options via the Ethernet Interface (IEC61850 and/or DNPoE)
- Loss of one of the LAN connections to the device does not cause any loss or degradation to the Application data over the Ethernet interface.
- The MiCOM relay/IED supports the transmission of the PRP Supervision frame at a fixed time period (LifeCheckInterval) of 2s (+/- 100ms)
- Each supervision frame includes a sequence number as defined in the IEC 62439-3:2012 specification. This is incremented for each supervision message and the value starts from zero following a system restart.
- The MiCOM relay/IED does not process received supervision frames to provide supervision of the redundant network.
- The MiCOM relay/IED does not provide for the PRP management to be configured (via either the MiCOM relay/IED HMI or the Ethernet interface). Accordingly, the default values (as defined within this document) are used for all PRP parameters.
- The performance of the Ethernet Interface is not degraded by using the PRP interface.

2.6.1 Abbreviations and Acronyms

Abbreviations / Acronyms	Meaning
CRC	Cyclic Redundancy Check
DAN	Doubly Attached Nodes
DANP	Doubly Attached Node implementing PRP
FPGA	Field-Programmable Gate Array
HMI	Human Machine Interface
IED	Intelligent Electronic Devices
IP	Internet Protocol
LAN	Local Area Network
LRE	Link Redundancy Entity
MAC	Media Access Control
MRP	Media Redundancy Protocol
PRP	Parallel Redundancy Protocol
RCT	Redundancy Check Tag
RedBox	Redundancy Box
RSTP	Rapid Spanning Tree Protocol
SAN	Singly Attached Node
TCP	Transmission Control Protocol
VDAN	Virtual Doubly Attached Node

Notes:

HSR NOTES

CHAPTER 21

Date (month/year):	02/2018			
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.			
Hardware Suffix:	P445 P44y (P443/P446)	L M	P54x (P543/P544/P545/P546) P841A (one circuit breaker) P841B (two circuit breakers)	M M M
Software Version:	P445 P44y (P443/P446)	J4/B0/B1/E0/E1 H4	P54x (P543/P544/P545/P546) P841A P841B	H4 G4 H4
Connection Diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P445: 10P445xx (xx = 01 to 04) P44x(P442 & P444): 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)		P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 01 to 10) 10P643xx (xx = 01 to 06) 10P645xx (xx = 01 to 09) P74x (P741, P742 & P743): 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)	

CONTENTS

Page (HS) 21-

TABLES

Page (HS) 21-

FIGURES

Page (HS) 21-

Notes:

1 INTRODUCTION TO HSR

1.1 Introduction to High-availability Seamless Redundancy (HSR)

This section gives an introduction to the High-availability Seamless Redundancy (HSR); and how it is implemented on MiCOM-based products manufactured by Schneider Electric.

1.2 Protocols

Industrial real-time Ethernets typically need much better levels of availability and uninterrupted operation than normal office-type Ethernet solutions. For power networks, even a short loss of connectivity may result in a significant loss of functionality or impaired safety. To recover from a network failure, various redundancy schemes have been considered, including: Rapid Spanning Tree Protocol (**RSTP**), Media Redundancy Protocol (**MRP**), High-availability Seamless Redundancy (**HSR**). The key properties of these are as follows:

RSTP This uses mesh-based topologies or ring topology and computes a tree, based on path costs and priorities. In case of network failure, a typical reset time for RSTP-based system is normally a few seconds.

MRP This uses ring-based topologies. In case of network failure, the network is broken into two separate lines, which are reconnected by de-blocking the previously blocked part. The guaranteed reset time for MRP protocol-based systems is typically around 100ms.

HSR HSR basically uses ring topology, This Clause describes the application of the HSR principles (Clause 5) to implement a High-availability Seamless Redundancy (HSR), retaining the PRP property of zero recovery time, applicable to any topology, in particular rings and rings of rings. With respect to PRP, HSR allows to roughly halve the network infrastructure. With respect to rings based on IEEE 802.1D (RSTP), IEC 62439-2 (MRP), IEC 62439-6 (DRP) or IEC 62439-7 (RRP), the available network bandwidth for network traffic is somewhat reduced depending on the type of traffic. Nodes within the ring are restricted to be HSR-capable bridging nodes, thus avoiding the use of dedicated bridges. Singly Attached Nodes (SANs) such as laptops or printers cannot be attached directly to the ring, but need attachment through a RedBox (redundancy box).

Power networks need to be able to respond to problems very quickly (typically in less than 10ms), and HSR is an available protocol which is robust enough to achieve this. The HSR protocol used in the MiCOM relay/IED is defined in the IEC62439-3 (2012) standard and is configured using the existing redundant Ethernet card(s).

1.3 HSR Summary (IEC 62439-3 Clause 5)

A summary of the main HSR features is given below:

- HSR Ethernet redundancy method independent of any industrial Ethernet protocol and typically used in a ring topology
- Seamless switchover and recovery in case of failure, which supports real-time communication
- Supervises redundancy continuously for better management of network devices
- Suitable for hot swap, 24 hour/365 day operation in substations
- Allows laptops and workstations to be connected to the network with HSR Redbox
- Particularly suited for substation automation, high-speed drives and transportation

1.4 Example of an HSR Network

Essentially a HSR network is a ring topology. An example of a HSR network is shown in Figure 1:

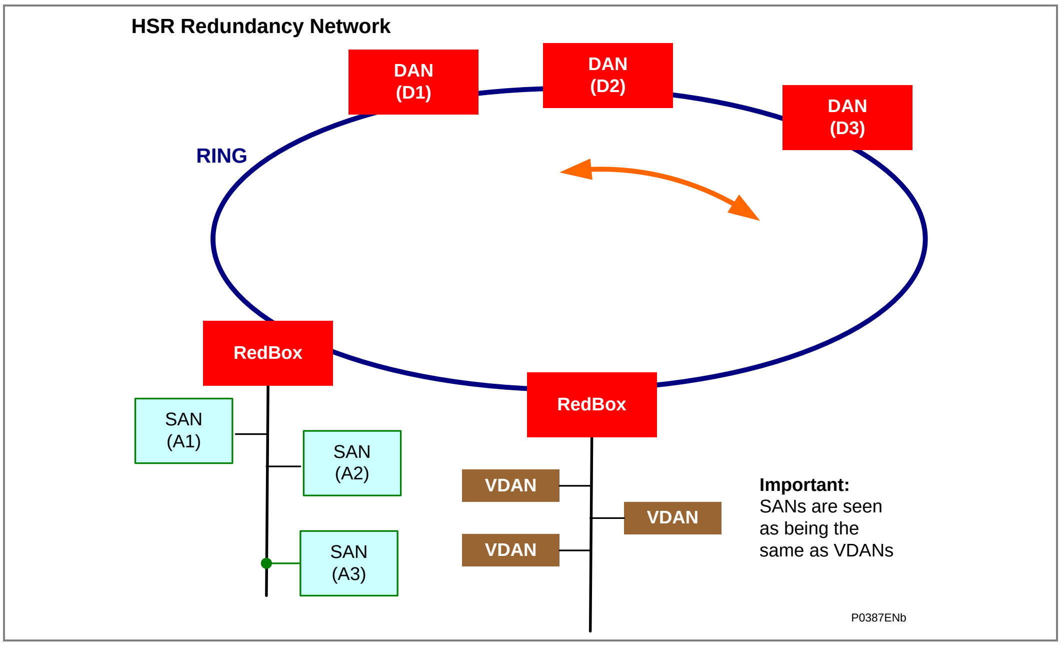


Figure 1 - HSR Redundancy Network

Figure 1 shows typical ring networks that have various Nodes in common.

The key features of the network include:

- Nodes within the ring are restricted to be HSR-capable bridging nodes, thus avoiding the use of dedicated bridges
- Singly Attached Nodes (SANs) such as laptops or printers cannot be attached directly to the ring, but need attachment through a RedBox (redundancy box)
- A simple HSR network consists of doubly attached bridging nodes, each having two ports, interconnected by full-duplex link
- A source DANH sends a frame passed from its upper layers, prefixes it by an HSR tag to identify frame duplicates and sends the frame over each port
- A destination DANH receives, in the fault-free state, two identical frames from each port within a certain interval, if it is a multicast frame, it instantaneously forwards it on the ring*, removes the HSR tag of the first frame before passing it to its upper layers and discards any duplicate.
- *:In particular, the node will not forward a frame that it injected into the ring.
- *:A destination node of a unicast frame does not forward a frame for which it is the only destination, except for testing.

1.5 Structure of a DAN

A MiCOM P40 relay working in HSR Mode works as a DAN within the overall network topology. Each DAN has two ports that operate in parallel. As in Figure 2, The two HSR ports A and B and the device port C are connected by the LRE, which includes a switching matrix allowing to forward frames from one port to the other. The switching matrix allows cut-through bridging. The Link Redundancy Entity (LRE) presents to the higher layers the same interface as a standard Ethernet transceiver would do.

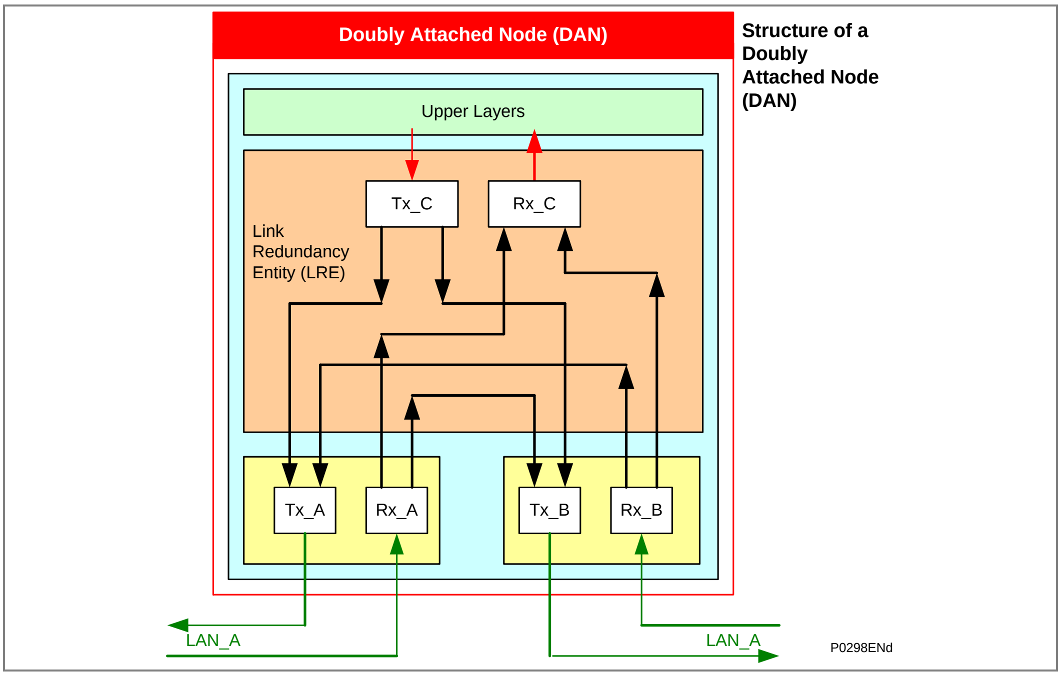


Figure 2 - DAN communication between two paths (in HSR)

DAN node is operable in HSR-tagged forwarding mode, the DAN inserts the HSR tag on behalf of its host and forwards the ring traffic, except for frames sent by the node itself. Duplicate frames and frames where the node is the unicast destination is not forwarded.

1.6 Structure of a RedBox

The RedBox has a LRE that performs the duties of the HSR protocol, in particular:

- forwards the frames received from one HSR port to the other HSR port, unless the frame receives frames addressed to its own upper protocols
- prefixes the frames sent by its own upper layers with the corresponding HSR tag before sending two copies over its HSR ports

The switching logic is incorporated into the RedBox, so interlink becomes an internal connection.

A simple RedBox is present in every node, since the LRE makes a transition to a single non-HSR host. In addition, it is usual to have more than one host in a node, since a port for maintenance often exists.

A node does not send over a port a frame that is a duplicate of a frame previously sent over that port in that same direction.

For the purpose of Duplicate Discard, a frame is identified by:

- its source MAC address;
- its sequence number.

The Duplicate Discard method forgets an entry identified by <Source MAC Address><Sequence number> after a time EntryForgetTime.

1.7 Communication between SANs, DANs and RedBoxs

Singly Attached Nodes (SANs), for instance maintenance laptops or printers cannot be inserted directly into the ring since they have only one port and cannot interpret the HSR tag in the frames. SANs communicate with ring devices through a RedBox (Redundancy Box) that acts as a proxy for the SANs attached to it.

A source DANH sends a frame passed from its upper layers, and prefixes it by an HSR tag to identify frame duplicates and sends the frame over both ports.

A destination DANH receives, in the fault-free state, two identical frames from each port within a certain interval, if it is a multicast frame, it instantaneously forwards it on the ring*,, removes the HSR tag of the first frame before passing it to its upper layers ("D"-frame) and discards any duplicate.

A typical frame contains these parameters:

- dest_addr Destination Address
- src_addr Source Address
- type Type
- data
- fcs Frame Check Sequence (i.e. extra checksum characters added to allow error detection and correction)

HSR frames are identified uniquely by their HSR tag.

The HSR tag consists of these parameters:

- 16-bit Ethertype (HSR_EtherType = 0x892F)
- 4-bit path identifier (PathId), 0000 for both HSR nodes A and B, and 0010-1111 for one of 7 PRP networks (A/B).
- 12-bit frame size (LSDUsize)
- 16-bit Sequence Number (SeqNr)

Note	*The 4-bit PathId field prevents reinjection of frames coming from one PRP network to another PRP network.*

Accordingly, a typical HSR frame then contains these parameters:

- dest_addr Destination Address
- src_addr Source Address
- HSR tag data:
  - 16-bit Ethertype (HSR_EtherType = 0x892F)
  - 4-bit path identifier
  - 12-bit frame size
  - 16-bit sequence number:
- type Type
- payload Payload
- Padding if needed
- fcs Frame Check Sequence

Padding	*After the payload data, there may be some data padding. This is added to frames which would otherwise be too short for conventional network traffic (minimum frame size is 70 octets).*
Size	*The frame size will vary depending on the contents of the frame and how it has been tagged by the various SANs and DANs. In VLANs, frame tags may be added or removed during transit through a switch. To make the length field independent of tagging, only the original LPDU and the HSR tag are considered in the size.*

Figure 3 and Figure 4 shows the frame types with different types of data.

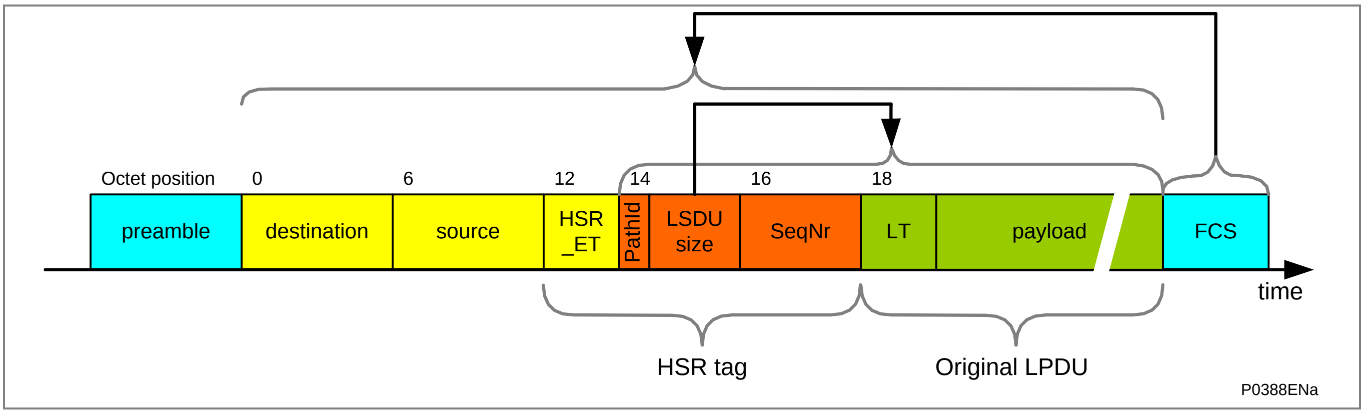


Figure 3 - HSR frame without a VLAN tag

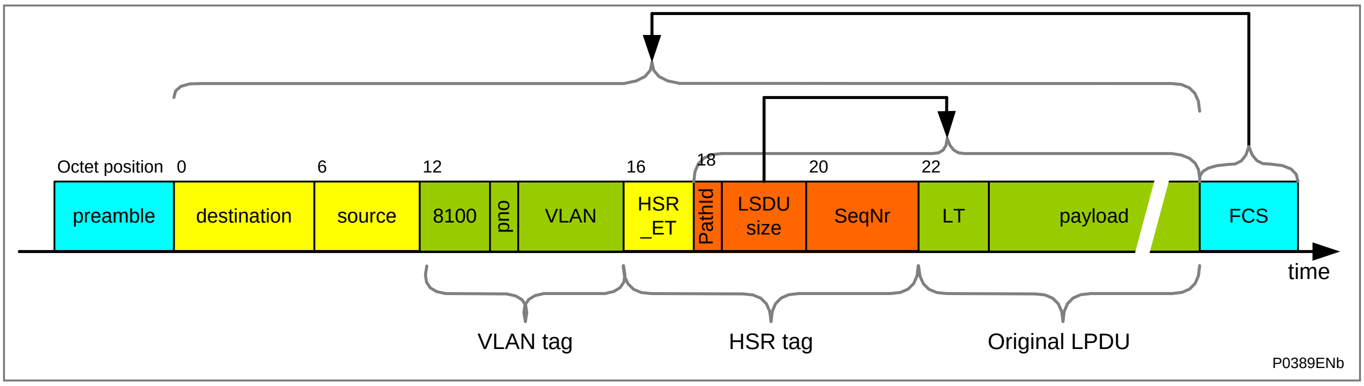


Figure 4 - HSR frame with VLAN tag

The key points about these differing frame structures are that:

- Unlike PRP, SANs cannot be attached directly to such a duplicated network unless they are able to interpret the HSR tag.
- In particular, the node will not forward a frame that it injected into the ring.
- A destination node of a unicast frame does not forward a frame for which it is the only destination, except for testing.
- DANH receiving from an HSR port, if this frame is not HSR-tagged and is a link local traffic, consume the frame and do not forward it.
- DANH receiving from an HSR port, if this frame is HSR-tagged and this node is not a destination, do not pass the frame to the link layer interface.
- A node accepts an HSR tagged frame also if the LanId does not correspond to the PortId and if the LSDUsize does not match the frame size.

1.8 HSR Technical Data

- One VLAN tag supported
- Up to 128 devices supported
- Up to 100Mbit/s full duplex Ethernet
- Dynamic frame memory allocation (page manager)
- Configurable duplicate detection
- Wishbone interface for configuration and status registers
- CPU port interface - Wishbone
- Support for link-local protocols - CPU may send to specific ports only - CPU knows receive port
- Configurable frame memory and queue length
- Duplicate detection with configurable size and aging time
- MAC address filtering (8 filter masks for interlink port, 6 for CPU port)
- Support for interfaces with or without Ethernet preamble

Limitations:

Number of IEDs on a same ring at 100Mbit/s:

Each hop (IED or RedBox) not only carries its own messages but also all the other IED messages thus the bandwidth used is proportional to the number of IEDs.

The maximum number of hops is around 20 when the GOOSE messages are highly used or 40 if the number and importance of GOOSE messages is not high.

When Precision Time Protocol («IEEE1588/IEC 61588») is used:

As the GPS receiver inaccuracy is 200ns and as each hop (IED or RedBox) can add a 50ns inaccuracy, the maximum number of hops is 16 if 1µs accuracy is required (PMU application or Process Bus)

2 HSR AND MICOM FUNCTIONS

2.1 MiCOM Products and HSR

The HSR functions being introduced as part of the overall MiCOM product range provide additional functionality, which is backwards compatible with existing Schneider Electric MiCOM equipment. This means that existing MiCOM relays/IEDS can be used on networks, which use HSR functions, with no changes being made to those relays/IEDs.

The new MiCOM products that use the HSR, will interrogate other equipment to determine the equipment model number, and then use the model number to decide (at runtime), whether that particular item of equipment can support HSR or not.

MiCOM models which include the following Ethernet board assembly provide the possibility of HSR function support. This is denoted by Digit 7 where the Hardware option is Q or R, as shown below:

Hardware Option	Type	Model No format
"Q" at Digit No 7	2 LC + 1 RJ45 ports redundant Ethernet board (Modulated/ Un-modulated IRIG-B)	**Px4xxxQx6Mxxx8M**
"R" at Digit No 7	3 RJ45 ports redundant Ethernet board (Modulated/ Un-modulated IRIG-B)	**Px4xxxRx6Mxxx8M**

Table 1 – Hardware option numbers with HSR functions

The MiCOM relay/IED firmware has been modified to allow the HSR options to be accepted for the power-up tests in addition to the implementation of the supervision frame transmission.

2.2 Easergy Studio Software and the HSR Function

The addition of this function has no impact of the Easergy Studio support files so there is no need to upgrade any Easergy Studio software.

2.3 MiCOM Relay Configuration and the HSR Function

There is no need to change the configuration of any relay (as relays which include support for this function will be able to recognize other devices which support it).

2.4 Hardware Changes for HSR Protocol

This protocol is implemented using the redundant Ethernet card as a starting point. The Frame management is achieved by programming the Field-Programmable Gate Array (FPGA).

The low-level management of the redundant frames is performed within the FPGA; this being defined as the Link Redundancy Entity (LRE). This will add the HSR tag to a frame to be transmitted. The FPGA is also responsible for the stripping of the HSR tag from received frames and discarding the duplicated messages so that only a single application frame is received by the Ethernet processor.

The LRE functionality of the supervision frame transmission is performed by the NIOS II.

The new version of the redundant Ethernet card is based on the 2072069A01 and 2072071A01 (both have modulated and un-modulated IRIG-B).

2.5 HSR Parameters

The Redundant Ethernet standard (IEC 62439-3:2012/FDIS) defines several parameters for the HSR protocol; these being fixed at a default value within this release. The following values are set:

Parameter	Value	Description
Supervision Frame Multicast Address	01-15-4E-00-01-00	Target MAC Address for multicast supervision frame
Life Check Interval	2 seconds	Period between transmission of supervision frames
HSR Mode	Duplicate Discard	This is normal HSR mode, Duplicate address will not be supported.
Node Forget Time	60 s	This is the time after which a node entry is cleared.
Entry Forget Time	400 ms	Duration that the received message Sequence number will be held to discard a duplicate message.
Node Reboot Interval	500ms	Duration following reboot for which no HSR frames should be transmitted.
MulticastFilterSize	16	Number of multicast addresses to be filtered

Table 2 - HSR parameter values

2.6 Product Implementation Features

Here is a list of the main Product Requirements for MiCOM products that support HSR:

- The MiCOM relay/IED provides two redundant Ethernet ports using HSR.
- The MiCOM relay/IED must be connected to the redundant Ethernet network as a Double Attached Node (DAN) using HSR (DAN using HSR is known as DANH)
- The redundant Ethernet interface can be made using an RJ45 or an optical fibre connection with an LC connector type.
- The management of the HSR redundancy is transparent to the application data provided via the Ethernet interface.
- The HSR option is available with any of the existing protocol options via the Ethernet Interface (IEC61850)
- Loss of one of the Node connections to the device does not cause any loss or degradation to the Application data over the Ethernet interface.
- The MiCOM relay/IED supports the transmission of the HSR Supervision frame at a fixed time period (LifeCheckInterval) of 2s (+/- 100ms)
- Each supervision frame includes a sequence number as defined in the IEC 62439-3:2012/FDIS specification. This will be incremented for each supervision message and the value will start from zero following a system restart.
- The MiCOM relay/IED does not provide for the HSR management to be configured (via either the MiCOM relay/IED HMI or the Ethernet interface). Accordingly, the default values (as defined within this document) are used for all HSR parameters.
- The performance of the Ethernet Interface is not degraded by using the HSR interface.

2.6.1 Abbreviations and Acronyms

Abbreviations / Acronyms	Meaning
CRC	Cyclic Redundancy Check
DAN	Doubly Attached Nodes
DANH	Doubly Attached Node implementing HSR
FPGA	Field-Programmable Gate Array
HMI	Human Machine Interface
HSR	High-availability Seamless Redundancy
IED	Intelligent Electronic Devices
IP	Internet Protocol
LAN	Local Area Network
LRE	Link Redundancy Entity
MAC	Media Access Control
MRP	Media Redundancy Protocol
PRP	Parallel Redundancy Protocol
HSR	High-availability Seamless Redundancy
RedBox	Redundancy Box
RSTP	Rapid Spanning Tree Protocol
SAN	Singly Attached Node
TCP	Transmission Control Protocol
VDAN	Virtual Doubly Attached Node

RSTP NOTES

CHAPTER 22

Date (month/year):	02/2018			
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.			
Hardware Suffix:	P141/P142/P143 P145 P445 P44x (P442/P444) P44y (P443/P446)	L M L M M	P54x (P543/P544/P545/P546) P642 P643/P645 P746 P841A (one circuit breaker) P841B (two circuit breakers)	M L M M M M
Software Version:	P14x (P141/P142/P143/P145) P445 P44x (P442/P444) P44y (P443/P446)	B4 J4/B0/B1/E0/E1 E3 H4	P54x (P543/P544/P545/P546) P64x (P642/P643/P645) P746 P841A P841B	H4 B4 B5/C5 G4 H4
Connection Diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P445: 10P445xx (xx = 01 to 04) P44x(P442 & P444): 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)		P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 01 to 10) 10P643xx (xx = 01 to 06) 10P645xx (xx = 01 to 09) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2)	

CONTENTS

TABLES

FIGURES

Notes:

1 RAPID SPANNING TREE PROTOCOL (RSTP) NOTES

1.1 Introduction to RSTP

This section gives an introduction to the Rapid Spanning Tree Protocol (RSTP); and how it is implemented on MiCOM-based products manufactured by Schneider Electric.

1.2 Protocols

Industrial real-time Ethernets typically need much better levels of availability and uninterrupted operation than normal office-type Ethernet solutions. For power networks, even a short loss of connectivity may result in a significant loss of functionality or impaired safety. To recover from a network failure, various redundancy schemes have been considered, including: Rapid Spanning Tree Protocol (**RSTP**), Media Redundancy Protocol (**MRP**), High-availability Seamless Redundancy (**HSR**). The key properties of these are as follows:

RSTP This uses mesh-based topologies or ring topology and computes a tree, based on path costs and priorities. In case of network failure, a typical reset time for RSTP-based system is normally a few seconds.

MRP This uses ring-based topologies. In case of network failure, the network is broken into two separate lines, which are reconnected by de-blocking the previously blocked part. The guaranteed reset time for MRP protocol-based systems is typically around 100ms.

HSR HSR basically uses ring topology, This Clause describes the application of the HSR principles (Clause 5) to implement a High-availability Seamless Redundancy (HSR), retaining the PRP property of zero recovery time, applicable to any topology, in particular rings and rings of rings. With respect to PRP, HSR allows to roughly halve the network infrastructure. With respect to rings based on IEEE 802.1D (RSTP), IEC 62439-2 (MRP), IEC 62439-6 (DRP) or IEC 62439-7 (RRP), the available network bandwidth for network traffic is somewhat reduced depending on the type of traffic. Nodes within the ring are restricted to be HSR-capable bridging nodes, thus avoiding the use of dedicated bridges. Singly Attached Nodes (SANs) such as laptops or printers cannot be attached directly to the ring, but need attachment through a RedBox (redundancy box).

Power networks need to be able to respond to problems very quickly (typically in less than 10ms), and HSR is an available protocol which is robust enough to achieve this. The HSR protocol used in the MiCOM relay/IED is defined in the IEC62439-3 (2012) standard and is configured using the existing redundant Ethernet card(s).

1.3 Example of an RSTP Network

The Px4x Redundant Ethernet board uses the RSTP protocol (802.1w), so a Px4x can attach onto a network as shown in Figure 1:

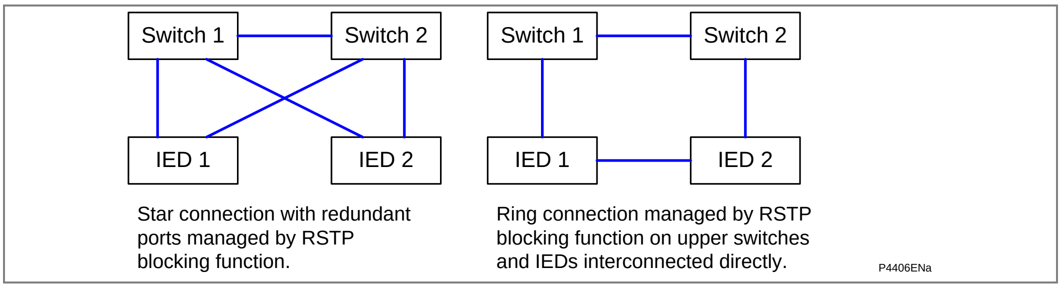


Figure 1 - Px4x attached to a redundant Ethernet star or ring circuit

The RSTP solution is based on open standards. It is therefore compatible with other manufacturers' IEDs that use the RSTP protocol. The RSTP recovery time is typically 300ms but it increases with network size.

2 RSTP AND MICOM FUNCTIONS

2.1 MiCOM Products and RSTP

The RSTP functions being introduced as part of the overall MiCOM product range provide additional functionality, which is backwards compatible with existing Schneider Electric MiCOM equipment. This means that existing MiCOM relays/IEDS can be used on networks, which use RSTP functions, with no changes being made to those relays/IEDs.

The new MiCOM products that use the RSTP, will interrogate other equipment to determine the equipment model number, and then use the model number to decide (at runtime), whether that particular item of equipment can support RSTP or not.

MiCOM models which include the following Ethernet board assembly provide the possibility of HSR function support. This is denoted by Digit 7 where the Hardware option is Q or R, as shown below:

Hardware Option	Type	Model No format
"Q" at Digit No 7	2 LC + 1 RJ45 ports redundant Ethernet board (Modulated/ Un-modulated IRIG-B)	**Px4xxxQx6Mxxx8M**
"R" at Digit No 7	3 RJ45 ports redundant Ethernet board (Modulated/ Un-modulated IRIG-B)	**Px4xxxRx6Mxxx8M**

Table 1 – Hardware option numbers with RSTP functions

The MiCOM relay/IED firmware has been modified to allow the RSTP options to be accepted for the power-up tests in addition to the implementation of the supervision frame transmission.

2.2 Easergy Studio Software and the RSTP Function

The addition of this function has no impact of the Easergy Studio support files so there is no need to upgrade any Easergy Studio software.

2.3 MiCOM Relay Configuration and the RSTP Function

There is no need to change the configuration of any relay (as relays which include support for this function will be able to recognize other devices which support it).

2.4 Hardware Changes for RSTP Protocol

This protocol is implemented using the redundant Ethernet card as a starting point. The Frame management is achieved by programming the Field-Programmable Gate Array (FPGA).

The low-level management of the redundant frames is performed within the FPGA; this being defined as the Link Redundancy Entity (LRE). This will add the RSTP tag to a frame to be transmitted. The FPGA is also responsible for the stripping of the RSTP tag from received frames and discarding the duplicated messages so that only a single application frame is received by the Ethernet processor.

The LRE functionality of the supervision frame transmission is performed by the NIOS II.

The new version of the redundant Ethernet card is based on the 2072069A01 and 2072071A01 (both have modulated and un-modulated IRIG-B).

2.5 RSTP Parameters

You can use the following settings to configure the RSTP function. The IEEE 802.1D 2004 standard defines the relation between Max Age and Forward Delay as:

2 * (Forward Delay – 1.0 seconds) >= Max Age

RSTP Settings

RSTP Settings	Value	Description
COMMUNICATIONS		

RSTP Settings	Value	Description
RSTPPriority	0 to 61440 with step 4096	Bridge Priority
RSTPMaxAge	6.0 to 40.0 with step 0.1	The max age time of RSTP
RSTPForwardDelay	4.0 to 30.0 with step 0.1	The timer of the RSTP forward delay
RSTPHelloTime	1.0 to 2.0 with step 0.1	The RSTP hello time settings

RSTP Status

RSTP Status	Value	Description
COMMUNICATIONS		
RSTPPortAStatus	FORWARDING, DISCARDING, DISABLED	The status RSTP Port A
RSTPPortBStatus	FORWARDING, DISCARDING, DISABLED	The status RSTP Port B

Notes *These two parameters are only visible on front panel (HMI).*
The following relays do not use any independent RSTP Configuration tool:
P14x (Software Version B4 and later)
P44x (Software Version E3 and later)
P445 (Software Version J9 and later)
P44y (Software Version H9 and later)
P54x (Software Version H9 and later)
P841 (Software Version G9 (P841A) & H9 (P841B) and later)
P64x (Software Version B4 and later)
P746 (Software Version B5/C5 and later)
All the RSTP parameters are configured via HMI and Easergy S1 Studio.

2.6 Product Implementation Features

Here is a list of the main Product Requirements for MiCOM products that support RSTP:

- The MiCOM relay/IED provides two redundant Ethernet ports using RSTP.
- The redundant Ethernet interface can be made using an RJ 45 or an optical fibre connection with an LC connector type.
- The management of the RSTP is transparent to the application data provided via the Ethernet interface.
- The RSTP option is available with any of the existing protocol options via the Ethernet Interface (IEC61850 and/or DNPoE)
- Loss of one of the Node connections to the device does not cause any loss or degradation to the Application data over the Ethernet interface.
- The MiCOM relay/IED supports the transmission of the RSTP RST BPDU at a fixed time interval.
- The MiCOM relay/IED provide for the RSTP management to be configured and RSTP status to be monitored via either the MiCOM relay or IED HMI.
- The performance of the Ethernet Interface is not degraded by using the RSTP interface.

2.7 Abbreviations and Acronyms

Abbreviations / Acronyms	Meaning
CRC	Cyclic Redundancy Check
DAN	Doubly Attached Nodes
DANP	Doubly Attached Node implementing PRP
FPGA	Field-Programmable Gate Array
HMI	Human Machine Interface
IED	Intelligent Electronic Devices
IP	Internet Protocol
LAN	Local Area Network
LRE	Link Redundancy Entity
MAC	Media Access Control
MRP	Media Redundancy Protocol
PRP	Parallel Redundancy Protocol
RCT	Redundancy Check Tag
RedBox	Redundancy Box
RSTP	Rapid Spanning Tree Protocol
SAN	Singly Attached Node
TCP	Transmission Control Protocol
VDAN	Virtual Doubly Attached Node

PROCESS BUS NOTES

CHAPTER 23

Date (month/year):	09/2018			
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.			
Hardware Suffix:	P141/P142/P143 P145 P445 P44x (P442 only for PB) P44y (P443/P446)	L M L M M	P54x (P543/P546 only for PB) P642 P643/P645 P746 P841A (one circuit breaker) P841B (two circuit breakers)	M L M M M M
Software Version:	P14x (P141/P142/P143/P145) P445 P44x (P442 only for PB) P44y (P443/P446)	B4 J9 E3 H9	P54x (P543/P546 only for PB) P64x (P642/P643/P645) P746 P841A (one circuit breaker) P841B (two circuit breakers)	H9 B4 B5/C5 H9 H9
Connection diagrams:	This includes a list of the Connection Diagrams for the Products covered by this document. All Models 10PX002 10PX003			

CONTENTS

TABLES

Page (PB) 23-

FIGURES

Page (PB) 23-

1 INTRODUCTION

The Process Bus board interfaces to IEC 61850-9-2LE and IEC61869-9 compliant Merging Units (MU). The Process Bus board replaces the conventional analogue inputs (analogue module) and is available in these Easergy protection relays:

- P141, P142, P143, P145 (feeder protection)
- P442, P443, P445 and P446 (distance protection)
- P543, P546 (line differential protection)
- P642, P643 and P645 (transformer protection)
- P746 (busbar protection)
- P841(multifunction line terminal IED)

Process bus is mainly used to communicate the primary values of current and voltage to a protection relay via an Ethernet network. Merging Units form the data acquisition layer in the network. They connect to the primary sensor, determining the instantaneous primary measurements and publishing them on the process bus.

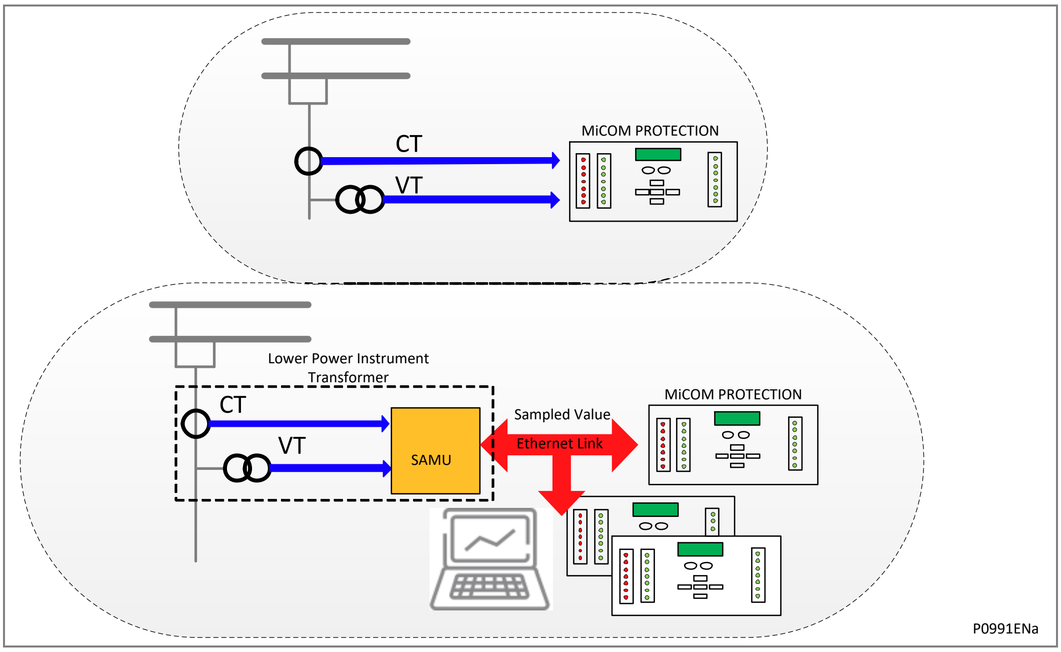


Figure 1 - Process Bus principle

The Process Bus philosophy is to be able to isolate from the secondary system such as protection or control IEDs the primary interfaces such as the breakers, isolators by interposing Breaker IED or Switch IED and/or CTs or VTs by interposing new primary equipment called LPIT (Low Power Instrument Transformers), previously known as NCIT (Non-Conventional Instrument Transformers) or Stand Alone Merging Units (SAMU). The Stand Alone Merging Unit (SAMU) converts 1/5A and 100/110V signals to process bus measurements (called Sampled Values). One feature that is mandatory for the Merging Unit is a very accurate clock source. Time is unique and common in the "analogue world" but is not in the digital world. Sampled values must be synchronized via IEC61850-9-3 (refer to IEC 61588/IEEE1588 Precision Time Protocol) or 1 Pulse Per Second (PPS) signal. The measurement values provided must be suitable for the protection application. This performance is ensured by the selection of primary sensors meeting the CT requirements of the protection application. These requirements must now be met by both the primary CT and the Merging Unit.

An IMU can embed other digital functionality, sending information such as position of breaker and isolators and receiving digital information such as close, open, trip or reclose commands over the process bus.

The process bus links allow multiple measurement streams as well as the digital information to be sent over common ethernet link which saves on the installation of secondary wiring. Also, the same stream can be utilized by multiple relays reducing the number of primary sensors required. This does, however, expose the system to a greater outage due to a link or switch failure. In most cases, redundancy such as IEC62439 PRP will be required to ensure system availability.

2 HARDWARE DESCRIPTION

2.1 Relay Rear Panel

2.1.1 Relay with Process Bus

The Process Bus board provides a IEC61850-9-2LE (80 samples/cycle) or IEC61869 (F4800S2IiUu where i+u<24) Ethernet link and IEC61850-8-1 (GOOSE).

The board fits into a dedicated slot of the Easergy P40 protection. The board can be connected to the network using:

- For the 3 RJ45 connectors board, either the top or both the bottom RJ45 connectors or
- For the 1 RJ45 connector and two optical fibre connectors board, either the top RJ45 connector or both the bottom LC connectors

Optical fiber connectors

- 1300nm multimode 100BaseFx LC® connectors

RJ45 connection

- 100BaseTx RJ45 connector

Case size

- The case size of all Easergy MiCOM P40 Process Bus relays is fixed at 60TE

Board Location

- The Process Bus board is fitted in slot C

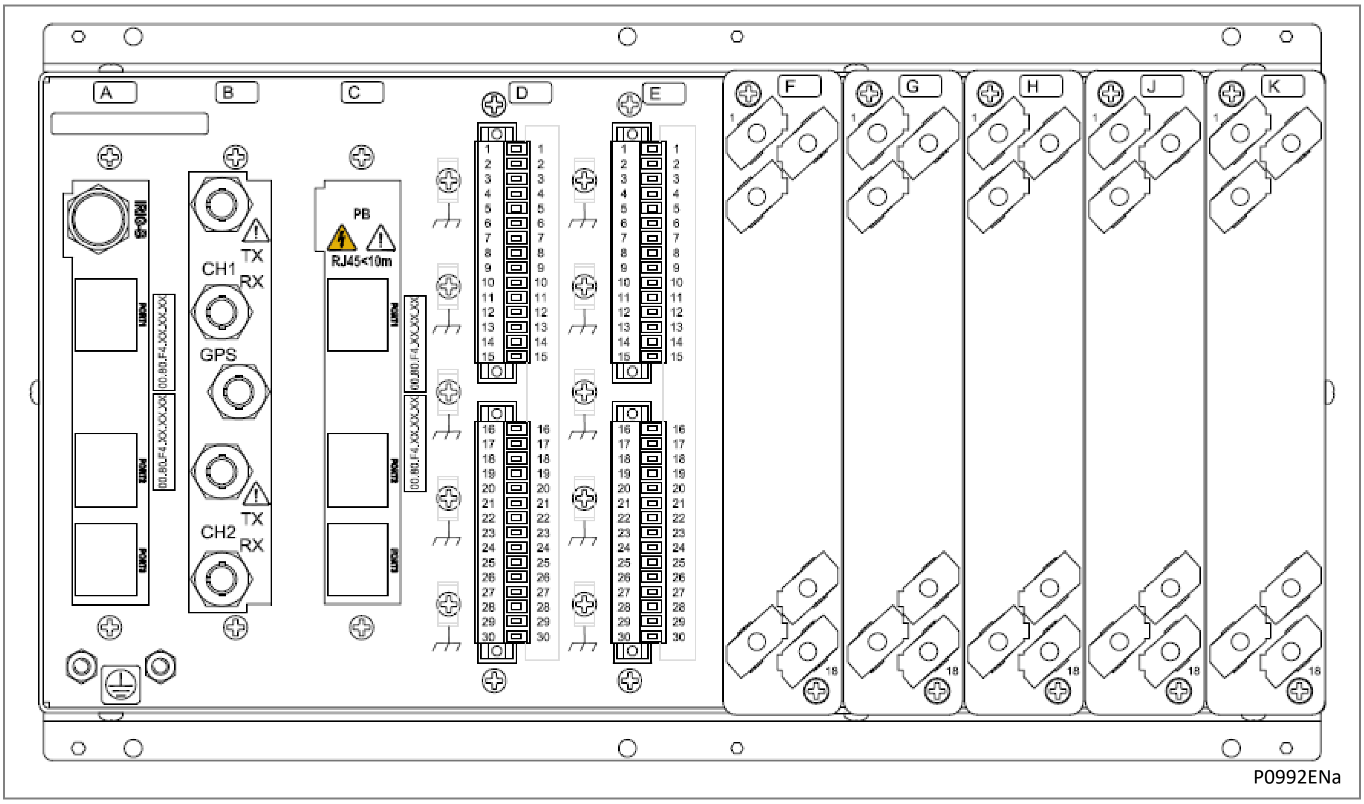


Figure 2 - Rear view of the process bus relay

3 OPERATION

When fitted, the Process Bus board replaces the analogue module board(s) with conventional CTs and VTs. In this case, the Process Bus board resamples the IEC 61850-9-2LE or IEC 61869 samples received from the process bus network and transforms them to the same format sent by the analogue module.

According to the application, Merging Units (MUs) are:

- MUs included in LPITs
- SAMUs, connected to Conventional CTs and/or VTs

Depending on the products, up to 6 or 7 MUs can be simultaneously subscribed by one Easergy P40 protection relay (for P746, the maximum number is 7, for other P40 relays, the maximum number is 6).

The protection algorithms are unchanged, they are the same for the Process Bus board and the analogue module(s).

The number of MUs varies depending upon the product, the SV configuration is flexible to support different kinds of products and application.

Note the derived quality bit introduced in IEC61850-9-2LE (no longer used in IEC61869) is ignored by the relay.

3.1 Single Merging Unit (MU) Configuration

A single MU can be directly connected to the process bus card on a dedicated Ethernet link allowing process bus to be used without any additional network components.

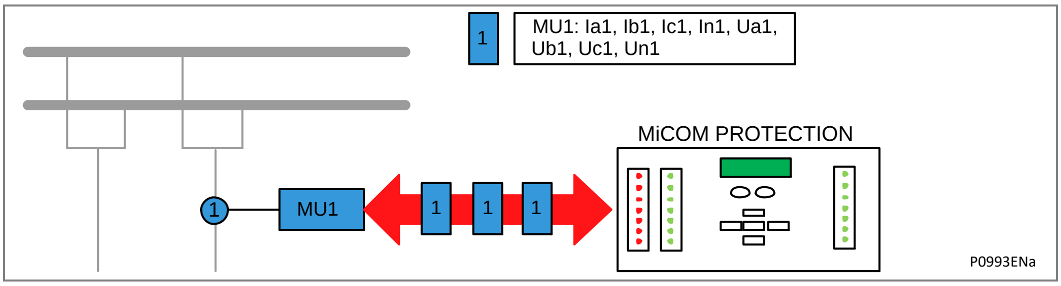
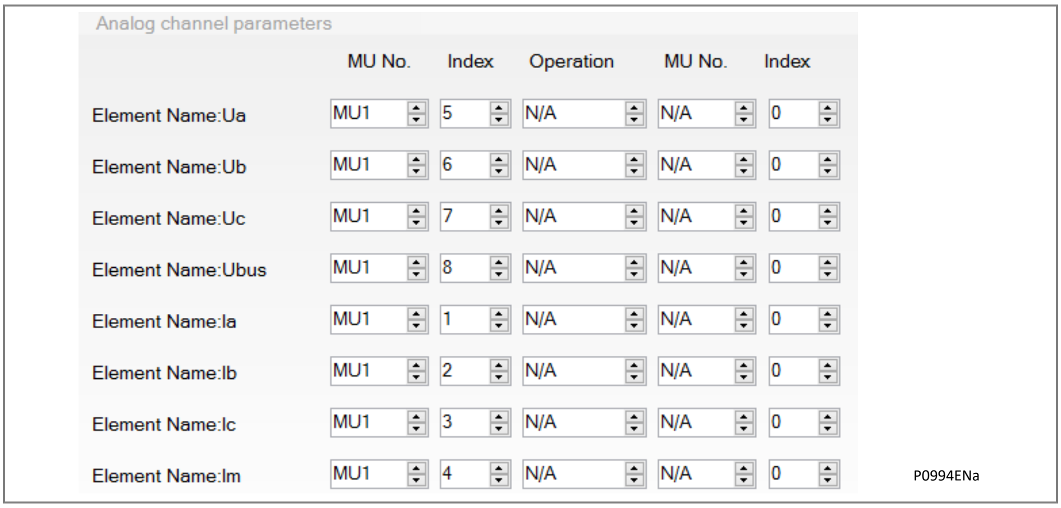


Figure 3 – Single Merging Unit (MU) configuration

3.1.1 SV Configuration Example



Analog channel parameters

	MU No.	Index	Operation	MU No.	Index
Element Name:Ua	MU1	5	N/A	N/A	0
Element Name:Ub	MU1	6	N/A	N/A	0
Element Name:Uc	MU1	7	N/A	N/A	0
Element Name:Ubus	MU1	8	N/A	N/A	0
Element Name:Ia	MU1	1	N/A	N/A	0
Element Name:Ib	MU1	2	N/A	N/A	0
Element Name:Ic	MU1	3	N/A	N/A	0
Element Name:Im	MU1	4	N/A	N/A	0

P0994ENa

Figure 4 – CID configuration for one Merging Unit (MU)

In the above example the wiring normally brought to the relay has been connected to the merging unit. The check synch voltage input and mutual current input would normally require access to additional streams, however, in this case they have been wired to the neutral inputs of the MU. Since the relay inputs are configured by index it is then possible to allocate these channels to the appropriate analogue input.

3.2 Multiple Merging Unit (MU) Configuration

When the relay requires SV streams from multiple MUs an Ethernet network is required to provide the required streams to the relay. An example of a double bus application is shown below. In this case local synchronization is required for the check synch and mutual coupling functions.

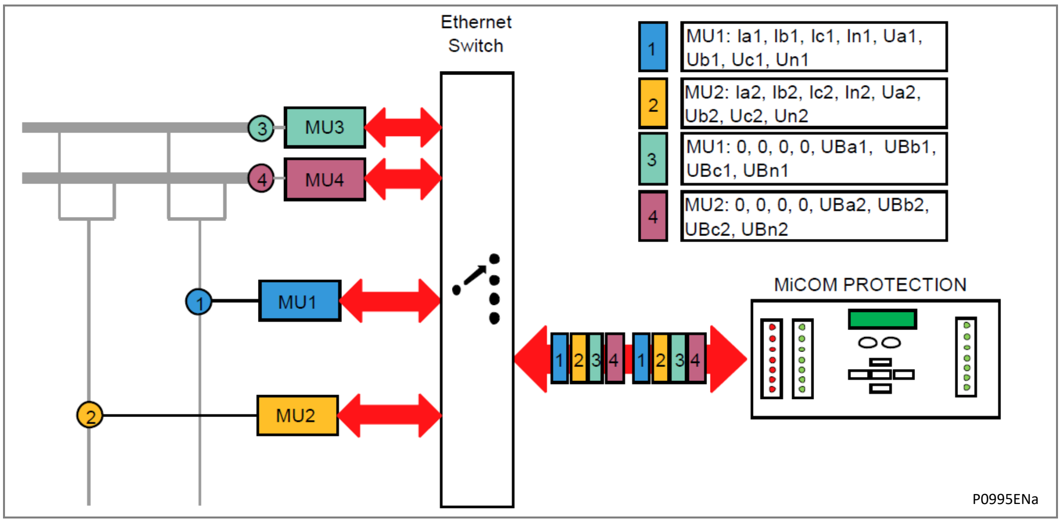
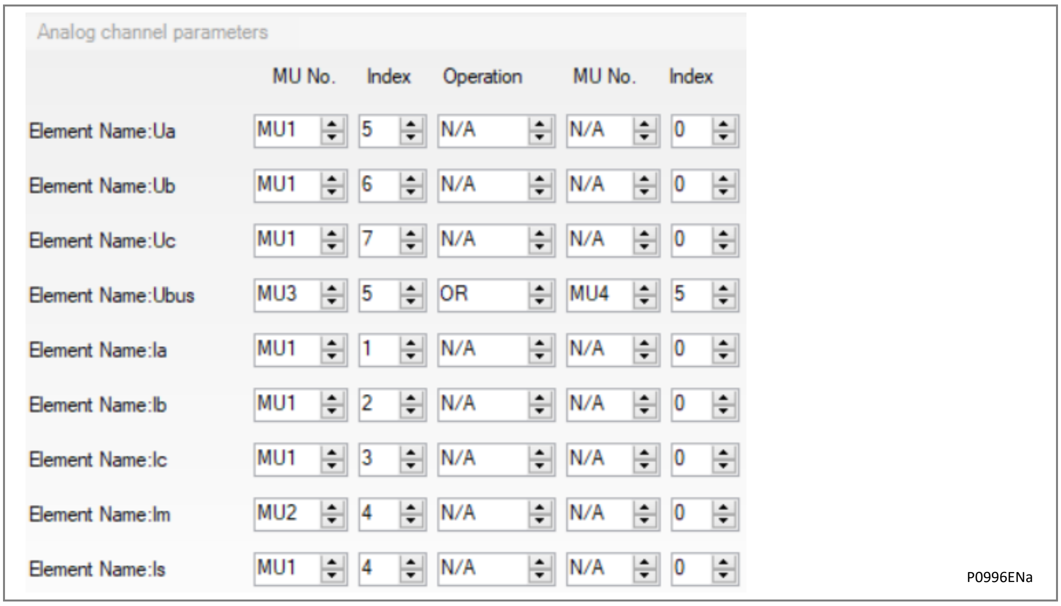


Figure 5 – Multiple Merging Unit (MU) configuration

The analogue channels are:

- MU1 = “Ia1, Ib1, Ic1, In1, Ua1, Ub1, Uc1, Un1”
- MU2 = “Ia2, Ib2, Ic2, In2, Ua2, Ub2, Uc2, Un2”
- MU3 = “0, 0, 0, 0, UBa1, UBb1, UBc1, UBn1”
- MU4 = “0, 0, 0, 0, UBa2, UBb2, UBc2, UBn2”

3.2.1 SV Configuration



Analog channel parameters

	MU No.	Index	Operation	MU No.	Index
Element Name:Ua	MU1	5	N/A	N/A	0
Element Name:Ub	MU1	6	N/A	N/A	0
Element Name:Uc	MU1	7	N/A	N/A	0
Element Name:Ubus	MU3	5	OR	MU4	5
Element Name:Ia	MU1	1	N/A	N/A	0
Element Name:Ib	MU1	2	N/A	N/A	0
Element Name:Ic	MU1	3	N/A	N/A	0
Element Name:Im	MU2	4	N/A	N/A	0
Element Name:Is	MU1	4	N/A	N/A	0

P0996ENa

Figure 6 – CID configuration for four Merging Units (MUs)

In this example the main currents and voltages are provided by MU1. MU2 provides its neutral current to the mutual coupling input. The A phase voltage is used from MU3 or MU4 for the check synch input. The correct stream to use will depend upon which primary isolators are closed. The second bus isolator status is connected to the “Check Synch Alt1” DDB in the relay PSL to select MU4 for check synch when feeder is connected to the second bus. If this signal is low then the Check Synch input will come from MU3.

3.3 Multiple Relays

Since the SV streams are Ethernet signals they can be simultaneously used by multiple relays. In the example above, the feeder currents could also be used by a busbar protection and the busbar voltages would likely be used by other feeder protections. Care must be taken with sharing to avoid overloading the process bus network. VLANs are normally used to control the traffic to ensure that each IED only receives the SVs it uses ensuring no link is overloaded.

3.4 Data Resampling

The Process Bus relay receives 80 Sampled Values per cycle (4000 Sampled Values per second at 50Hz) or 4800 Sampled Values per second from the Merging Unit depending upon whether IEC61850-9-2LE or IEC61869 mode is used. The Process Bus board then resamples these Sampled Values and divides the values received by the input CT/VT ratio to make the data appear the same to the IED as analogue signals would do on its normal inputs from CTs and VTs. When a SAMU is used the ratios should match the primary CT/VT values. If a LPIT is used then the nominal switchgear ratings would normally be used to set the CT/VT ratios.

Caution	***The CT and VT ratios must be set to suitable values to ensure the relay has correct measuring and setting ranges***

The resampling frequency depends on the IED:

- P543, P546, P443, P445, P446, P841 - 48 samples/cycle
- P141, P142, P143, P145, P442, P642, P643, P645, P746 - 24 samples/cycle

Note	*The relay uses frequency tracking to follow the supply frequency, changing the number of samples per second when the frequency changes, where the process bus samples are fixed at 4000 samples/sec (50Hz) or 4800 samples/sec per different standard edition.*

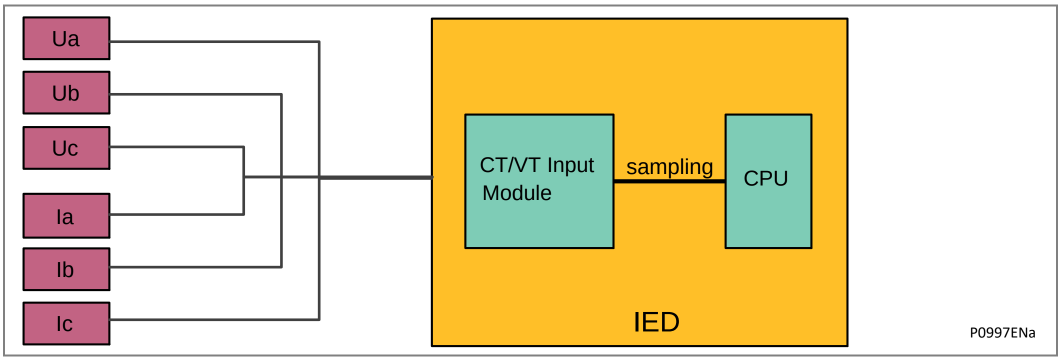


Figure 7 – Data sampling using CTs/VTs and an input board

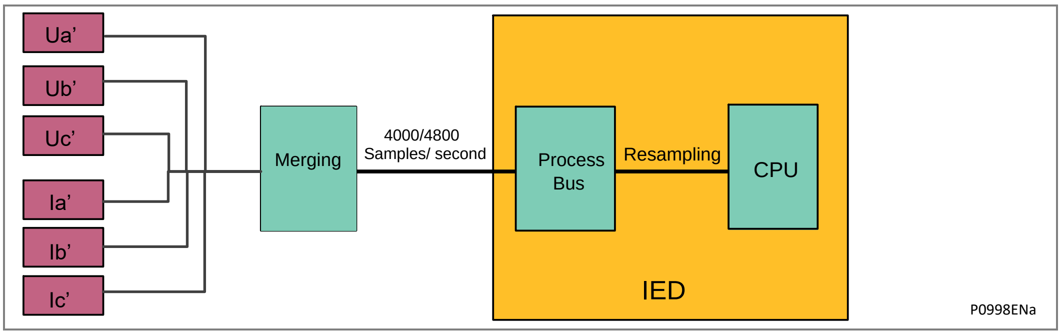


Figure 8 – Data sampling using Process Bus interface

4 CONFIGURATION

4.1 Settings

The Process Bus board must be configured to the system and application by means of appropriate settings. The sequence in which the settings are listed and described in this section will be the ***PB CONFIG*** submenu in the IED submenu.

Col	Row	Menu Text	Default Setting	Available Setting
00	13	Software Ref. 3	<Software Ref. 3>	Not settable
Relay Process Bus card software reference. Visible when Process Bus card fitted.				
00	15	IEC61850 Edition	Ed2	Not settable
This cell displays the supported IEC61850 Edition, only Ed2 is supported in Process Bus relays.				
00	17	PB COMM Mode	Dual IP	Dual IP, PRP
Sets the redundancy protocol of Process Bus board. This setting can only be changed via the UI and will cause the Process Bus board to reboot.				

Table 1 – Column 00 Settings for Process Bus Devices

Col	Row	Menu Text	Default Setting	Available Setting
18	00	PB CONFIG	Column Heading	
This column contains settings and status parameters relative to process bus				
18	01	MU OOS Config	00000000(bin)	
Used to set one or more Merging Units to be run in Out of Service mode.				
18	02	AntiAlias Filter	Disabled	0 = Disabled, 1 = Enabled
This cell activates or deactivates the anti-aliasing filter, which conditions the Sampled Values from the Process Bus network.				
18	03	SMV Version	IEC61850-9-2LE	0=IEC61850-9-2LE, 1 = IEC61869
This cell selects which version of sampled values are used, if it is set to IEC61850-9-2LE, the relay will subscribe the sampled value compliant with IEC61850-9-2LE, otherwise, device will subscribe the sampled value compliant with IEC61869.				
18	04	MUs Delay Offset	0s	From 0s to 3ms step 250us
This cell adjusts the maximum time-delay offset starting at the reception of the Ethernet message from the “first” Merging Unit (MU) to the reception of the Ethernet message from the “last” Merging Unit (MU). This time-delay should be adjusted to ensure all MU samples for the same time instant are received before sending to the relay processor.				
18	05	Mon Delay Offset	No	0 = No, 1 = Yes
When sampled values are received at the IED from different Merging Units, they do not arrive simultaneously due to differences in Merging Unit performance or different network path delays. After this setting is set to Yes, a command to monitor the maximum time-delay will be sent to Process Bus board. After Process Bus board has calculated a delay, it will send the delay time to main board for users to set a proper MUs Delay Offset.				
18	06	Max Delay Offset		Not Settable
This setting specifies the maximum time-delay supervised, supervision starting at the reception of the sampled value frame from the "first" Merging Unit to the reception of the sampled value frame from the last Merging Unit for each sample count. If >3ms, a -1 will be displayed.				
18	30	Synchro Mode	No SYNC CLK	0 = No SYNC CLK, 1 = Local Clock, 2 = Global Clock
This setting specifies the type of Sampled Value synchronization expected by the IED, depending on the application. Global Clock: The Sampled Values are synchronized with a global area clock (GPS like clock). Local Clock: The Sampled Values are synchronized with a local area clock signal at the substation. Sampled Value frames received with Global or Local synchronization are acceptable with this setting. No SYNC CLK: The Sampled Values do not need to be synchronized. With this setting the IED ignores the synchronization flag in the Sampled Value frames.				
18	31	SV Absence Alm		Not Settable

Col	Row	Menu Text	Default Setting	Available Setting
This is a data cell with 8 binary flags. It indicates the presence or absence of Sampled Values from each of the Merging Units the IED is communicating with. The cell data for each Merging Unit is continuously refreshed. Unused MUs will indicate a 0. 0: Sampled Values being received from the Merging Unit. 1: No Sampled Values being received from the Merging Unit.				
18	32	SV SmpSynch Alm		Not Settable
This is a data cell with 8 binary flags. It indicates the healthiness of the Sampled Values being received from each of the Merging Units configured. 0: Sampled Values received are synchronized. 1: Sampled Values received are not synchronized.				
18	33	SV Test Alm		Not Settable
This is a data cell with a binary flag for each of the analogue groups within the relay. It indicates the status of the IEC 61850 Quality attribute ‘Test’ in the Sampled Value frame used for that channel. If a channel is marked Test then functions associated with that channel are blocked unless the relay is in ‘Test Mode’				
18	34	SV Invalid Alm		Not Settable
This is a data cell with a binary flag for each of the analogue groups within the relay. It indicates the status of the IEC 61850 Quality attribute ‘Invalid’ in the Sampled Value frame used for that channel. If a channel is marked Invalid then functions associated with that channel are blocked.				
18	35	SV Quest Alm		Not Settable
This is a data cell with a binary flag for each of the analogue groups within the relay. It indicates the status of the IEC 61850 Quality attribute ‘Questionable’ in the Sampled Value frame used for that channel. If a channel is marked Questionable then functions associated with that channel are blocked.				

Table 2 – Column 18 Settings for Process Bus Devices

4.2 DDB Signals for Process Bus Relays

The meaning of the DDB signals for Process Bus Relays. The relevant DDB signals are shown in these sections:

- DDB Signals for Process Bus for P14x (P141, P142, P143 & P145)
- DDB Signals for Process Bus for P445 and P44y (P443 & P446)
- DDB Signals for Process Bus for P54x (P543 & P546 for PB)
- DDB Signals for Process Bus for P64x (P642, P643 & P645)
- DDB Signals for Process Bus for P841 (P841A & P841B)

4.2.1 DDB Signals for Process Bus for P14x (P141, P142, P143 & P145)

DDB No.	Source	Description	English Text	P141	P142	P143	P145
314	SW	IEC 61850 accept simulated GOOSE and SV alarm	Sim.Signal Alm	*	*	*	*
778	SW	MU OOS Alarm	MU OOS Alarm	*	*	*	*
792	SW	Invalid IEC 61850 Configuration Alarm for PB	Invalid SV conf.	*	*	*	*
793	SW	SV Absence Alm	SV Absence Alm	*	*	*	*
794	SW	SV SmpSynch alarm	SV SmpSynch Alm	*	*	*	*
795	SW	SV Test alarm	SV Test Alm	*	*	*	*
796	SW	SV Invalid alarm	SV Invalid Alm	*	*	*	*
797	SW	SV Questionable alarm	SV Quest Alm	*	*	*	*
1216	SW	Process Bus Network Interface link 1 fail indication	PB Link 1 Fail	*	*	*	*
1217	SW	Process Bus Network Interface link 2 fail indication	PB Link 2 Fail	*	*	*	*
1218	SW	Process Bus Network Interface link 3 fail indication	PB Link 3 Fail	*	*	*	*
1219	SW	DDB_MU1_ABSENCE	MU1 Absence	*	*	*	*
1220	SW	DDB_MU2_ABSENCE	MU2 Absence	*	*	*	*
1221	SW	DDB_MU3_ABSENCE	MU3 Absence	*	*	*	*
1222	SW	DDB_MU4_ABSENCE	MU4 Absence	*	*	*	*
1223	SW	DDB_MU5_ABSENCE	MU5 Absence	*	*	*	*
1224	SW	DDB_MU6_ABSENCE	MU6 Absence	*	*	*	*
1225	SW	DDB_MU7_ABSENCE	MU7 Absence	*	*	*	*
1226	SW	DDB_MU8_ABSENCE	MU8 Absence	*	*	*	*
1227	SW	Main VT Inhibit	Main VT Inhibit	*	*	*	*
1228	SW	CS VT Inhibit	CS VT Inhibit			*	*
1229	SW	Phs CT Inhibit	Phs CT Inhibit	*	*	*	*
1230	SW	In CT Inhibit	In CT Inhibit	*	*	*	*
1231	SW	SEF CT Inhibit	SEF CT Inhibit	*	*	*	*
1232	SW	Main VT Synch alarm	Main VT Synch alarm	*	*	*	*
1233	SW	CS VT Synch alarm	CS VT Synch alarm			*	*
1234	SW	Phs CT Synch alarm	Phs CT Synch alarm	*	*	*	*
1235	SW	In CT Synch alarm	In CT Synch alarm	*	*	*	*
1236	SW	SEF CT Synch alarm	SEF CT Synch alarm	*	*	*	*
1914	PSL	Alternate other analogue channels	Channel Alt	*	*	*	*
1915	PSL	Signal used to alternate VCS 1	Check Sync Alt1	*	*	*	*

Table 3 – DDB Signals for Process Bus for P14x (P141, P142, P143 & P145)

4.2.2 DDB Signals for Process Bus for P445 and P44y (P443 & P446)

DDB No.	Source	Description	English Text	P443	P445	P446
360	SW	MU OOS alarm	MU OOS Alarm	*	*	*
361	SW	Invalid IEC 61850 Configuration alarm for PB	Invalid SV conf.	*	*	*
362	SW	SV Absence alarm	SV Absence Alm	*	*	*
379	SW	Accept simulated GOOSE and SV alarm	Sim.Signal Alm	*	*	*
380	SW	SV Synchronization alarm	SV SmpSynch Alm	*	*	*
381	SW	SV Test alarm	SV Test Alm	*	*	*
382	SW	SV Invalid alarm	SV Invalid Alm	*	*	*
383	SW	SV Questionable alarm	SV Quest Alm	*	*	*
1914	PSL	Signal used to alternate analogue channels except check synchronization voltages	Channel Alt	*	*	*
1915	PSL	Signal used to alternate VCS 1	Check Sync Alt1	*	*	*
1916	PSL	Signal used to alternate VCS 2	Check Sync Alt2			*
1917	SW	Process Bus Ethernet port 1 link fail indication	PB Link 1 Fail	*	*	*
1918	SW	Process Bus Ethernet port 2 link fail indication	PB Link 2 Fail	*	*	*
1919	SW	Process Bus Ethernet port 3 link fail indication	PB Link 3 Fail	*	*	*
1920	SW	MU1 Absence indication	MU1 Absence	*	*	*
1921	SW	MU2 Absence indication	MU2 Absence	*	*	*
1922	SW	MU3 Absence indication	MU3 Absence	*	*	*
1923	SW	MU4 Absence indication	MU4 Absence	*	*	*
1924	SW	MU5 Absence indication	MU5 Absence	*	*	*
1925	SW	MU6 Absence indication	MU6 Absence	*	*	*
1926	SW	MU7 Absence indication	MU7 Absence	*	*	*
1927	SW	MU8 Absence indication	MU8 Absence	*	*	*
1928	SW	Main VT inhibit indication	Main VT Inhibit	*	*	*
1929	SW	CS VT1 inhibit indication	CS VT1 Inhibit	*	*	*
1930	SW	Phs CT1 inhibit indication	Phs CT1 Inhibit	*	*	*
1931	SW	Mcomp CT inhibit indication	Mcomp CT Inhibit	*		*
1932	SW	SEF CT inhibit indication	SEF CT Inhibit	*	*	*
1933	SW	Phs CT2 inhibit indication	Phs CT2 Inhibit			*
1934	SW	CS VT2 inhibit indication	CS VT2 Inhibit			*
1935	SW	Main VT synchronization alarm	Main VT Sync Alm	*	*	*
1936	SW	CS VT1 synchronization alarm	CS VT1 Sync Alm	*	*	*
1937	SW	Phs CT1 synchronization alarm	Phs CT1 Sync Alm	*	*	*
1938	SW	Mcomp CT synchronization alarm	McompCT Sync Alm	*		*
1939	SW	SEF CT synchronization alarm	SEF CT Sync Alm	*	*	*
1940	SW	Phs CT2 synchronization alarm	Phs CT2 Sync Alm			*
1941	SW	CS VT2 synchronization alarm	CS VT2 Sync Alm			*

Table 4 – DDB Signals for Process Bus for P445 and P44y (P443 & P446)

4.2.3 DDB Signals for Process Bus for P54x (P543 & P546 for PB)

DDB No.	Source	Description	English Text	P543	P546
360	SW	MU OOS alarm	MU OOS Alarm	*	*
361	SW	Invalid IEC 61850 Configuration alarm for PB	Invalid SV conf.	*	*
362	SW	SV Absence alarm	SV Absence Alm	*	*
379	SW	Accept simulated GOOSE and SV alarm	Sim.Signal Alm	*	*
380	SW	SV Synchronization alarm	SV SmpSynch Alm	*	*
381	SW	SV Test alarm	SV Test Alm	*	*
382	SW	SV Invalid alarm	SV Invalid Alm	*	*
383	SW	SV Questionable alarm	SV Quest Alm	*	*
1914	PSL	Signal used to alternate analogue channels except check synchronization voltages	Channel Alt	*	*
1915	PSL	Signal used to alternate VCS 1	Check Sync Alt1	*	*
1916	PSL	Signal used to alternate VCS 2	Check Sync Alt2		*
1917	SW	Process Bus Ethernet port 1 link fail indication	PB Link 1 Fail	*	*
1918	SW	Process Bus Ethernet port 2 link fail indication	PB Link 2 Fail	*	*
1919	SW	Process Bus Ethernet port 3 link fail indication	PB Link 3 Fail	*	*
1920	SW	MU1 Absence indication	MU1 Absence	*	*
1921	SW	MU2 Absence indication	MU2 Absence	*	*
1922	SW	MU3 Absence indication	MU3 Absence	*	*
1923	SW	MU4 Absence indication	MU4 Absence	*	*
1924	SW	MU5 Absence indication	MU5 Absence	*	*
1925	SW	MU6 Absence indication	MU6 Absence	*	*
1926	SW	MU7 Absence indication	MU7 Absence	*	*
1927	SW	MU8 Absence indication	MU8 Absence	*	*
1928	SW	Main VT inhibit indication	Main VT Inhibit	*	*
1929	SW	CS VT1 inhibit indication	CS VT1 Inhibit	*	*
1930	SW	Phs CT1 inhibit indication	Phs CT1 Inhibit	*	*
1931	SW	Mcomp CT inhibit indication	Mcomp CT Inhibit	*	*
1932	SW	SEF CT inhibit indication	SEF CT Inhibit	*	*
1933	SW	Phs CT2 inhibit indication	Phs CT2 Inhibit		*
1934	SW	CS VT2 inhibit indication	CS VT2 Inhibit		*
1935	SW	Main VT synchronization alarm	Main VT Sync Alm	*	*
1936	SW	CS VT1 synchronization alarm	CS VT1 Sync Alm	*	*
1937	SW	Phs CT1 synchronization alarm	Phs CT1 Sync Alm	*	*
1938	SW	Mcomp CT synchronization alarm	McompCT Sync Alm	*	*
1939	SW	SEF CT synchronization alarm	SEF CT Sync Alm	*	*
1940	SW	Phs CT2 synchronization alarm	Phs CT2 Sync Alm		*
1941	SW	CS VT2 synchronization alarm	CS VT2 Sync Alm		*

Table 5 – DDB Signals for Process Bus for P54x (P543 & P546 for PB)

4.2.4 DDB Signals for Process Bus for P64x (P642, P643 & P645)

DDB No.	Source	Description	English Text	P642	P643	P645
520	SW	MU OOS alarm	MU OOS Alarm	*	*	*
521	SW	Invalid IEC 61850 Configuration alarm for PB	Invalid SV conf.	*	*	*
522	SW	SV Absence alarm	SV Absence Alm	*	*	*
539	SW	Accept simulated GOOSE and SV alarm	Sim.Signal Alm	*	*	*
540	SW	SV Synchronization alarm	SV SmpSynch Alm	*	*	*
541	SW	SV Test alarm	SV Test Alm	*	*	*
542	SW	SV Invalid alarm	SV Invalid Alm	*	*	*
543	SW	SV Questionable alarm	SV Quest Alm	*	*	*
1267	PSL	Signal used to alternate analogue channels except check synchronization voltages	Channel Alt	*	*	*
1268	SW	Process Bus Ethernet port 1 link fail indication	PB Link 1 Fail	*	*	*
1269	SW	Process Bus Ethernet port 2 link fail indication	PB Link 2 Fail	*	*	*
1270	SW	Process Bus Ethernet port 3 link fail indication	PB Link 3 Fail	*	*	*
1271	SW	MU1 Absence indication	MU1 Absence	*	*	*
1272	SW	MU2 Absence indication	MU2 Absence	*	*	*
1273	SW	MU3 Absence indication	MU3 Absence	*	*	*
1274	SW	MU4 Absence indication	MU4 Absence	*	*	*
1275	SW	MU5 Absence indication	MU5 Absence	*	*	*
1276	SW	MU6 Absence indication	MU6 Absence	*	*	*
1277	SW	MU7 Absence indication	MU7 Absence	*	*	*
1278	SW	MU8 Absence indication	MU8 Absence	*	*	*
1279	SW	Main VT inhibit indication	Main VT Inhibit		*	*
1280	SW	AUX VT Inhibit indication	Aux VT Inhibit	*	*	*
1281	SW	CT1 Inhibit indication	Phs CT1 Inhibit	*	*	*
1282	SW	CT2 Inhibit indication	Phs CT2 Inhibit	*	*	*
1283	SW	CT3 Inhibit indication	Phs CT3 Inhibit		*	*
1284	SW	CT4 Inhibit indication	Phs CT4 Inhibit			*
1285	SW	CT5 Inhibit indication	Phs CT5 Inhibit			*
1286	SW	TN1 Inhibit indication	IN T1 Inhibit	*	*	*
1287	SW	TN2 Inhibit indication	IN T2 Inhibit	*	*	*
1288	SW	TN3 Inhibit indication	IN T3 Inhibit		*	*
1289	SW	Main VT synchronization alarm	Main VT Sync Alm		*	*
1290	SW	AUX VT synchronization alarm	Aux VT Sync Alm	*	*	*
1291	SW	CT1 synchronization alarm	Phs CT1 Sync Alm	*	*	*
1292	SW	CT2 synchronization alarm	Phs CT2 Sync Alm	*	*	*
1293	SW	CT3 synchronization alarm	Phs CT3 Sync Alm		*	*
1294	SW	CT4 synchronization alarm	Phs CT4 Sync Alm			*
1295	SW	CT5 synchronization alarm	Phs CT5 Sync Alm			*
1296	SW	TN1 synchronization alarm	IN T1 Sync Alm	*	*	*

DDB No.	Source	Description	English Text	P642	P643	P645
1297	SW	TN2 synchronization alarm	IN T2 Sync Alm	*	*	*
1298	SW	TN3 synchronization alarm	IN T3 Sync Alm		*	*

Table 6 – DDB Signals for Process Bus for P64x (P642, P643 & P645)

4.2.5 DDB Signals for Process Bus for P841 (P841A & P841B)

DDB No.	Source	Description	English Text	P841A	P841B
360	SW	MU OOS alarm	MU OOS Alarm	*	*
361	SW	Invalid IEC 61850 Configuration alarm for PB	Invalid SV conf.	*	*
362	SW	SV Absence alarm	SV Absence Alm	*	*
379	SW	Accept simulated GOOSE and SV alarm	Sim.Signal Alm	*	*
380	SW	SV Synchronization alarm	SV SmpSynch Alm	*	*
381	SW	SV Test alarm	SV Test Alm	*	*
382	SW	SV Invalid alarm	SV Invalid Alm	*	*
383	SW	SV Questionable alarm	SV Quest Alm	*	*
1914	PSL	Signal used to alternate analogue channels except check synchronization voltages	Channel Alt	*	*
1915	PSL	Signal used to alternate VCS 1	Check Sync Alt1	*	*
1916	PSL	Signal used to alternate VCS 2	Check Sync Alt2		*
1917	SW	Process Bus Ethernet port 1 link fail indication	PB Link 1 Fail	*	*
1918	SW	Process Bus Ethernet port 2 link fail indication	PB Link 2 Fail	*	*
1919	SW	Process Bus Ethernet port 3 link fail indication	PB Link 3 Fail	*	*
1920	SW	MU1 Absence indication	MU1 Absence	*	*
1921	SW	MU2 Absence indication	MU2 Absence	*	*
1922	SW	MU3 Absence indication	MU3 Absence	*	*
1923	SW	MU4 Absence indication	MU4 Absence	*	*
1924	SW	MU5 Absence indication	MU5 Absence	*	*
1925	SW	MU6 Absence indication	MU6 Absence	*	*
1926	SW	MU7 Absence indication	MU7 Absence	*	*
1927	SW	MU8 Absence indication	MU8 Absence	*	*
1928	SW	Main VT inhibit indication	Main VT Inhibit	*	*
1929	SW	CS VT1 inhibit indication	CS VT1 Inhibit	*	*
1930	SW	Phs CT1 inhibit indication	Phs CT1 Inhibit	*	*
1931	SW	Mcomp CT inhibit indication	Mcomp CT Inhibit	*	*
1932	SW	SEF CT inhibit indication	SEF CT Inhibit	*	*
1933	SW	Phs CT2 inhibit indication	Phs CT2 Inhibit		*
1934	SW	CS VT2 inhibit indication	CS VT2 Inhibit		*
1935	SW	Main VT synchronization alarm	Main VT Sync Alm	*	*
1936	SW	CS VT1 synchronization alarm	CS VT1 Sync Alm	*	*
1937	SW	Phs CT1 synchronization alarm	Phs CT1 Sync Alm	*	*
1938	SW	Mcomp CT synchronization alarm	McompCT Sync Alm	*	*
1939	SW	SEF CT synchronization alarm	SEF CT Sync Alm	*	*
1940	SW	Phs CT2 synchronization alarm	Phs CT2 Sync Alm		*
1941	SW	CS VT2 synchronization alarm	CS VT2 Sync Alm		*

Table 7 – DDB Signals for Process Bus for P841

4.3 Setting Guide

This section details non-protection functions in addition to where and how they may be applied. It provides some worked examples on how the settings are applied to the relay.

4.3.1 Anti-Alias Filter

The Anti-Aliasing filter prevents high frequency noise from being sampled by the process bus board. Except for some special applications, where very high-speed processing is required, always enable this setting. For these special applications, the frequency response of the Merging Unit needs to checked to ensure aliasing does not occur at the relays internal sampling rate.

4.3.2 MUs Delay Offset

When Sampled Value frames come from different Merging Units (MUs) on the Process Bus network, they do not arrive at the same time at the IED. The transmission delay depends on the background Ethernet traffic and how many switches are used in the Process Bus network.

Transmission delays do not usually matter for functions such as three-phase overcurrent protection where current signals are all received in a single frame. However, a function such as distance protection uses voltage and current signals which may be from different MUs with different transmission delays. The Process Bus board synchronizes the voltage and current samples that are sent to the IEDs distance protection function. The IED then uses the **MUs Delay Offset** setting, which is set to the maximum expected delay between the first and last Sampled Value of the same count.

The following examples show how you would need to set the delay.

- If the IED subscribes to SV from one MU only, no delay is needed so it operates correctly with a **MUs Delay Offset** setting of '0ms'.
- If the IED subscribes to SVs from several MUs which arrive within the period of two consecutive SV frames, no delay is needed so it operates correctly with a **Merging Unit Delay** setting of '0ms'.
- If the IED subscribes to SVs from several MUs but the streams do not arrive within the period of two consecutive SV frames, set the **MUs Delay Offset** to an appropriate value for the IED to operate correctly.

To set the MU delay during commissioning, set **Mon Delay Offset** to **Yes**. The IED then monitors the Sampled Value frames received for the next one second and displays the maximum delay between identical time tagged samples (SmpCnt).

The setting will directly impact protection performance, as shown in this diagram:

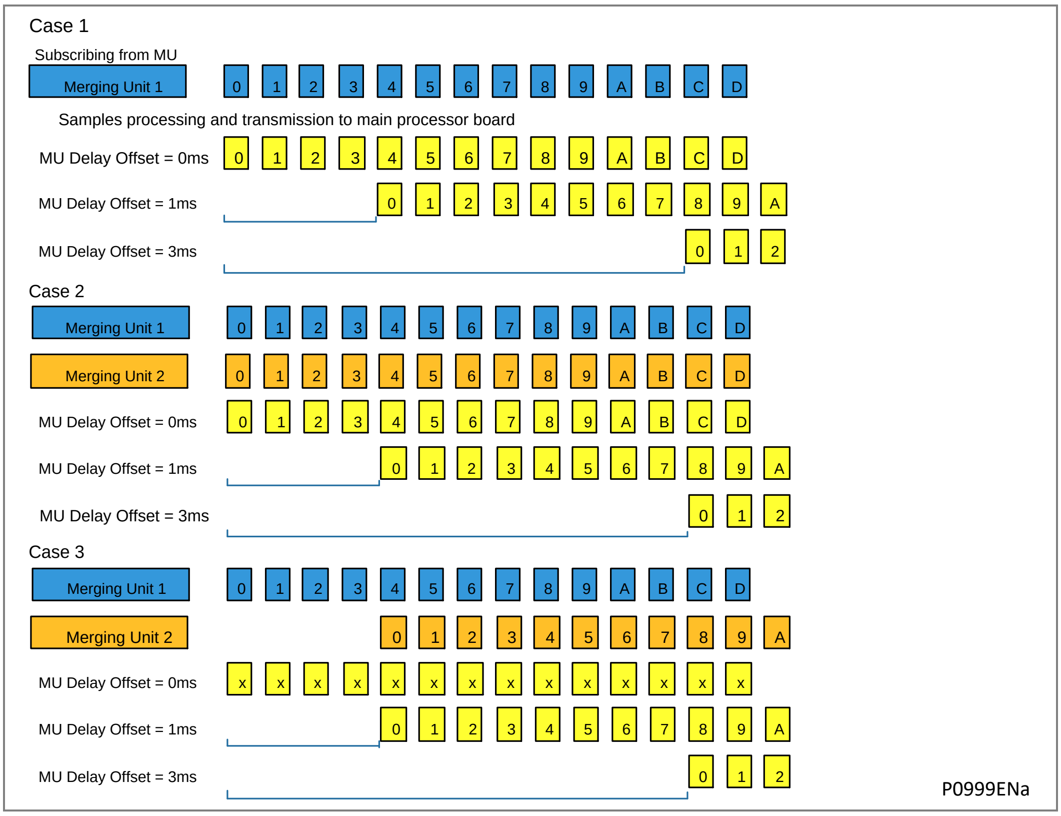


Figure 9 – Different MU Delay Offset for 400Hz Sample Rate

4.3.3 Synchro Mode

To process algorithms that need synchronized samples (for example distance with multiple MUs) coming from several Merging Units, we need to differentiate if the Sample Values (SV) are:

- not synchronized (one Merging Unit),
- synchronized with a local area clock (substation),
- synchronized with a global area clock (GPS…)

Three values are available:

- Global Clock — The relay will generate an alarm if MU synchronization is not "global area synchronization"
- Local Clock — The relay will generate an alarm if the MU synchronization is not global or local synchronization
- No SYNC CLK — The relay will not generate a synchronization alarm

With the exception of current differential, the loss of synchronization does not automatically block functions using these inputs. Whether a function needs to be blocked will depend on whether it uses signals from separate MUs. This will vary by application and affected functions should be blocked by linking the Synch Alarm to the affected function block input in the PSL.

4.3.4 Data Quality

Any degradation in the measurement or transmission of Sampled Values means that the protection function of the IED may not operate correctly. Therefore, to be able to detect invalid or questionable data, the IEC 61850 protocol assigns quality flags to each channel in the Sampled Value frame.

Data frames from a typical MU with, for example, four voltages and four currents [VA, VB, VC, VN, IA, IB, IC, IN] have quality flags for each of the channels. The IED adapts the behaviour of protection functions according to the quality flags. See the examples in the *Analogue Channel Groups* section.

The front panel of the IED shows the quality flags for each of the analogue channel groups configured. The number of analogue channel groups depends on the IED type.

To make protection functions work correctly, the Sampled Values arriving at the IED should have Good quality, as defined by the IEC 61850 or IEC61869 standards. Samples that have an Invalid or Questionable quality could result in unacceptable performance from the protection functions.

A protection function operates normally when all the necessary Sampled Value inputs are available and have a Good quality flag. When the flag for one or more of the Sampled Value inputs changes to Invalid or Questionable, the protection function is temporarily inhibited. The protection function returns to normal state when the quality flags for all the necessary Sampled Value inputs are Good. The quality flags can change with each sample, therefore there is a one-cycle transition delay between the Normal and Inhibit states for each protection function.

4.3.5 Analogue Channel Groups

The following tables shows how Sampled Value errors affect protection functions in the IED in different products.

Note	*The quality for analogue groups is commoned. For example, if one CT channel has poor quality, all channels in the CT group are given poor quality. When the P746 is used in 3 box mode the same quality is given to each group of 3 current channels.*

For example, overcurrent protection can be configured as directional, in which case the voltage inputs have an impact on the function. In another case, the quality of the voltage input is not important if the overcurrent is nondirectional. The meanings as shown here:

- ● = the SMV quality affects inhibit states of the protection function.
- ❍ = the protection function is affected where configured to work with this input.
- ■ = the protection operates if any input has good quality.
- □ = the protection operates if configured to work with this input and it has good quality.

The possible options are in these sections:

- Products with one set of CT, P141, P142
- Products with one set of CT, P143, P145
- Products with one set of CT, P443, P445, P543, P841A
- Products with two sets of CT, P446, P546, P841B
- Products with two sets of CT, P642
- Products with three sets of CT, P643
- Products with five sets of CT, P645

4.3.5.1 Products with one set of CT, P141, P142

Protection for Products with one set of CT, P141, P142	Groups				Comments
	CT	VT	IN CT	SEN CT	
Overcurrent Protection	●	❍			
Negative Sequence	●	❍			
Broken Conductor	●				
Earth Fault 1 Protection		❍	●		
Earth Fault 2 Protection	●	❍			
REF Protection	❍		❍	❍	
SEF Protection		❍		●	
Residual Overvoltage		●			
Voltage Protection		●			
System check		●			
Thermal Overload	●				
Admit Protection		●	❍	❍	
Sensitive Power Protection		●		●	
Power Protection	●	●			
VTS	●	●			
CTS	●	●			
CB Fail	■		■	■	
Frequency Protection	■	■			

Table 8 – How sample quality impacts protection (products with one set of CT, P141, P142)

4.3.5.2 Products with one set of CT, P143, P145

Protection for Products with one set of CT, P143, P145	Groups					Comments
	CT	VT	CS VT	IN CT	SEN CT	
Overcurrent Protection	●	❍				
Negative Sequence	●	❍				
Broken Conductor	●					
Earth Fault 1 Protection		❍		●		
Earth Fault 2 Protection	●	❍				
REF Protection	❍			❍	❍	
SEF Protection		❍			●	
Residual Overvoltage		●				
Voltage Protection		●				
System check		●	❍			
Thermal Overload	●					
Admit Protection		●		❍	❍	
Power Protection	●	●				
Sensitive Power Protection		●			●	
VTS	●	●				
CTS	●	●				
CB Fail	■			■	■	
Frequency Protection	■	■				

Table 9 – How sample quality impacts protection (products with one set of CT, P143, P145)

4.3.5.3 Products with one set of CT, P443, P445, P543, P841A

Protection for Products with one set of CT, P443, P445, P543, P841A	Group					
	CT1	Mutual CT	VT	CS VT1	Sen CT	Comments
Differential Protection	●		❍			
Distance Protection	●	❍	●			
Directional Earth Fault	●		●			
Overcurrent Protection	●		❍			
Negative Sequence	●		❍			
Broken Conductor	●					
Earth Fault Protection	●		❍			
REF Protection					●	
SEF Protection			❍		●	
Residual Overvoltage			●			
Voltage Protection			●			
Check Sync			●	●		
Loss of Load	●					
Thermal Overload	●					
VTS	●				●	
CTS	●				❍	
CB Fail	■				■	
Frequency Protection	■		■			

Table 10 – How sample quality impacts protection (products with one set of CT, P443, P445, P543, P841A)

4.3.5.4 Products with two sets of CT, P446, P546, P841B

Protection for Products with two sets of CT, P446, P546, P841B	Group							
	CT1	CT2	Mutual CT	VT	CS VT1	CS VT2	Sen CT	Comments
Differential Protection	●	●		❍				
Distance Protection	●	●	❍	●				
Directional Earth Fault	●	●		●				
Overcurrent Protection	❍	❍		❍				
Negative Sequence	●	●		❍				
Broken Conductor	●	●						
Earth Fault Protection	●	●		❍				
REF Protection							●	
SEF Protection				❍			●	
Residual Overvoltage				●				
Voltage Protection				●				
Check Sync				●	❍	❍		
Loss of Load	●	●						
Thermal Overload	●	●						
VTS	●	●		❍				
CTS	●	●		❍				
CB1 Fail	■						■	
CB2 Fail		■					■	
Frequency Protection	■	■		■				

Table 11 – How sample quality impacts protection (products with two sets of CT, P446, P546, P841B)

If only one CT is configured the first table would apply to whichever CT is configured. When both CTs are configured within IED configurator the second table would apply.

4.3.5.5 Products with two sets of CT, P642

Protection for Products with two sets of CT, P642	Groups					Comments
	CT1	CT2	TN1	TN2	Aux VT	
Overcurrent protection	❍	❍			❍	
Negative phase sequence overcurrent	❍	❍			❍	
Earth Fault protection (Derived)	❍	❍				
Earth Fault protection (Measured)			❍	❍		
REF protection (REF HV)	❍		●			
REF protection (REF LV)		❍		●		
Thermal overload (HV)	●					
Thermal overload (LV)		●				
Thermal overload (Bias)	●	●				
Overvoltage protection					●	
Undervoltage protection					●	
Negative sequence overvoltage					●	
Differential protection	●	●				
Overfluxing protection					●	
Through fault (HV)	●					
Through fault (LV)		●				
CTS	●	●				
T1 CB Fail	■		□	□		
T2 CB Fail		■	□	□		
Frequency protection	■	■			■	

Table 12 – How sample quality impacts protection (products with two sets of CT, P642)

4.3.5.6 Products with three sets of CT, P643

Protection for Products with three sets of CT, P643	Groups								Comments
	CT1	CT2	CT3	TN1	TN2	TN3	Main VT	Aux VT	
Overcurrent protection	❍	❍	❍				❍		
Negative phase sequence overcurrent	❍	❍	❍				❍		
Earth Fault protection (Derived)	❍	❍	❍				❍		
Earth Fault protection (Measured)				❍	❍	❍	❍		
REF protection (REF HV)	❍	❍		●					
REF protection (REF LV)		❍	❍		●				
REF protection (REF TV)		❍				●			
Residual overvoltage							●		
Thermal overload (HV)	●	❍							
Thermal overload (LV)		❍	●						
Thermal overload (TV)		●							
Thermal overload (Bias)	●	❍	●						
Overvoltage protection							●		
Undervoltage protection							●		
Negative sequence overvoltage							●		
Differential protection	●	❍	●						
Overfluxing protection		❍					❍	❍	
Through fault (HV)	●	❍							
Through fault (LV)		❍	●						
Through fault (TV)		●							
VTS	❍	❍	❍				●		
CTS	●	❍	●						
T1 CB Fail	■			□	□	□			
T2 CB Fail		■		□	□	□			
T3 CB Fail			■	□	□	□			
Frequency protection	■	■	■				■	■	

Table 13 – How sample quality impacts protection (products with three sets of CT, P643)

4.3.5.7 Products with five sets of CT, P645

Protection for Products with five sets of CT, P645	Groups										Comments
	CT1	CT2	CT3	CT4	CT5	TN1	TN2	TN3	Main VT	Aux VT	
Overcurrent protection	❍	❍	❍	❍	❍				❍		
Negative phase sequence overcurrent	❍	❍	❍	❍	❍				❍		
Earth Fault protection (Derived)	❍	❍	❍	❍	❍				❍		
Earth Fault protection (Measured)						❍	❍	❍	❍		
REF protection (REF HV)	❍	❍	❍	❍		●					
REF protection (REF LV)		❍	❍	❍	❍		●				
REF protection (REF TV)		❍	❍	❍				●			
Residual overvoltage									●		
Thermal overload (HV)	●	❍	❍	❍							
Thermal overload (LV)		❍	❍	❍	●						
Thermal overload (TV)		❍	●	❍							
Thermal overload (Bias)	●	❍	❍	❍	●						
Overvoltage protection									●		
Undervoltage protection									●		
Negative sequence overvoltage									●		
Differential protection	●	❍	❍	❍	●						
Overfluxing protection									❍	❍	
Through fault (HV)	●	❍	❍	❍							
Through fault (LV)		❍	❍	❍	●						
Through fault (TV)		❍	●	❍							
VTS	❍	❍	❍	❍					●		
CTS	●	❍	❍	❍	●						
T1 CB Fail	■					□	□	□			
T2 CB Fail		■				□	□	□			
T3 CB Fail			■			□	□	□			
T4 CB Fail				■		□	□	□			
T5 CB Fail					■	□	□	□			
Frequency protection	■	■	■	■	■				■	■	

Table 14 – How sample quality impacts protection (products with five sets of CT, P645)

4.4 Simulation SV

Process Bus relays can be configured to subscribe to normal or simulation SVs. This is achieved by modifying the setting cell ***Sub.Sim.Signal*** in ***IED Configurator*** menu. The setting can be set to Yes or No.

In the data package of the SV frame, one bit is used to indicate the SV is 'Simulated' SV or normal SV. When ***Sub.Sim.Signal*** is set to No, only normal SV will be subscribed. When ***Sub.Sim.Signal*** is set to Yes, an alarm "Sim.Signal Alm" will be raised, the behaviour of the relay is the same as handling simulation GOOSE. The relay will subscribe normal SV until it finds a corresponding simulation SV. It will then subscribe to the simulation SV.

Warning	**The *Sub.Sim. Signal* must be disabled after testing.**

4.5 Merging Unit (MU) Out-Of-Service (OOS) Configuration

Primary plant and its associated Merging Unit (MU) may be placed out of service but require the protection to remain in service. For example, a tie breaker on a breaker-and-a-half scheme may be taken Out Of Service (OOS) for maintenance. During this time the feeder is still in service being fed from the other breaker, therefore the protection needs to be active. If the MU stream is missing, has bad quality or is in test mode the protection would normally be disabled. To enable the relay to operate under these conditions a setting ***MU OOS Config*** is implemented to set one or more MUs to be run in OOS mode. When a MU is set to OOS, no matter what the actual Sampled Value is, the process bus board will set the analogue value and the quality of the MU to 0 with good synchronization. When one or more MU are set to OOS mode, an alarm "MU OOS Alarm" will be raised.

4.6 Analogue Channel Switching

The analogue channels may need to be switched from one CT/VT to another CT/VT during operation. The analogue channels switching function is setup in the CID configuration. The PSL is then used to energize one or more dedicated DDB signals to switch the streams.

The relay allows the user to switch all main CT and VT analogue channels input between two independent Sampled Value frames while the IED is in service. This may correspond to two separate CT or VT in the primary system. The single-phase check synchronizing voltages is also allowed to be selected from two independent Sampled Value frames.

Every check synchronizing voltage channel is controlled by a DDB, but different products may have different number of check synchronizing voltage channels. For example, P543 only has one such channel (Vcs1), while P546 has two channels (Vcs1 and Vcs2). Vcs1 switching is always controlled by DDB_VCS1_ALT, Vcs2 switching is always controlled by DDB_VCS2_ALT. All other analogue channels are controlled by another DDB, which is DDB_CHAN_ALT. If a product does not have check synchronizing, it will only have one dedicated DDB to be used to control channel switching.

It can take up to 100ms for the relay to switch channels. This is normally performed when the affected function is off-line (e.g. check synch input is not switched at the same time as synch check is being performed). A switching transient may be produced, particularly if there is a phase difference between the signals. This transient could appear as a frequency change or current/voltage delta. If on line switching is to be used this may require elements to be blocked to ensure the transients do not affect connected functions.

4.6.1 Switch Check Synchronizing Voltage Channel

Assume we are using a P543 relay which only has Vline and Vcs1 which are compared for the check synch function. If the line is connected to B-I the relay needs to compare Vline vs VT B-I but if the line is connected to B-II the relay needs to compare VLine vs VT B-II. In process bus application VT B-I and VT B-II can be provided by 1 or 2 different Merging Units. The measured value of VT B-I and VT B-II will be published and the relay needs to be able to subscribe the appropriate stream based on the position of busbar isolators.

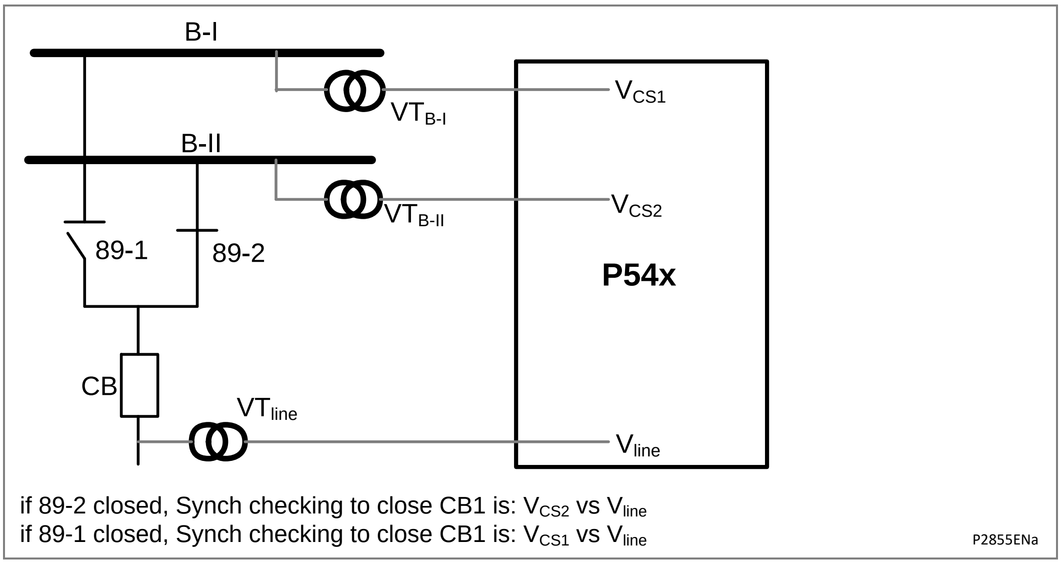


Figure 10 – A typical P543 application

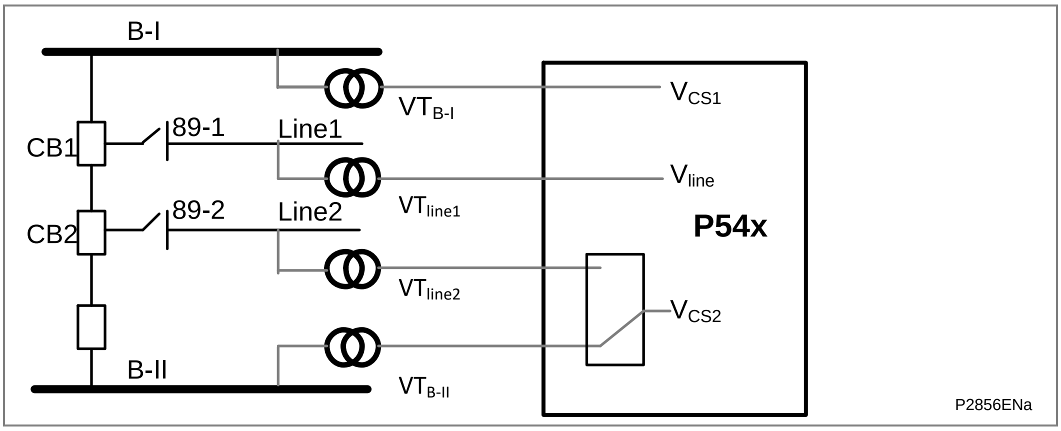


Figure 11 – One CB and a half application

As it can be seen in one-and-a-half breaker configuration, up to 4 VT measurements may be required. Therefore, the PB application requires access to the same measurements. In a traditional scheme the Vcs2 is fed from an external voltage selection scheme based on isolator positions. To replicate this functionality in PB we need to replace the voltage selection by stream switching based on the same logic used to operate the traditional voltage selection scheme.

To switch a check synchronizing channel, configure an OR operator using IED configurator as shown below:

Figure 12 – IED configurator

The switching is controlled by the status of the DDB_VCS1_ALT. The PSL configuration and the logic is shown in the following table. When Opto Input 1 is energized, DDB_VCS_ALT becomes TRUE, and then Ubus is switched from the 8th channel of MU1 to the 8th channel of MU2.

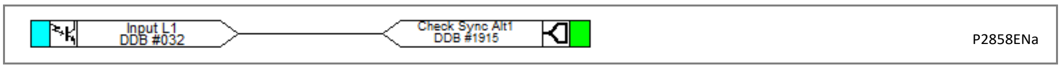


Figure 13 – PSL configuration and logic

DDB_VCS1_ALT Status	Check Sync Voltage Source
0	Check synchronizing voltage frames of MU1
1	Check synchronizing voltage frames of MU2

Table 15 - PSL configuration and logic

4.6.2 Switch Other Analogue Channels

To switch the three-phase voltage configure the CID as shown below:

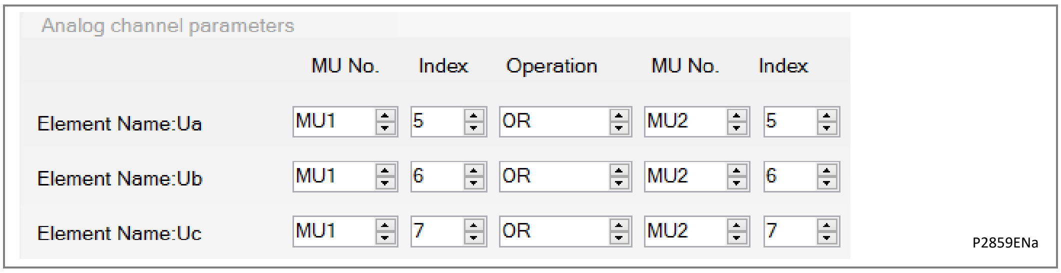


Figure 14 - OR operation

The switching is controlled by the status of the DDB_CHAN_ALT. The logic is shown in the following table.

DDB_CHAN_ALT Status	Three Phase-Voltage Source
0	Voltage frames of MU1
1	Voltage frames of MU2

Table 16 – Switching logic

4.7 Measurement Operation

Besides analogue channel switching, the relay also provides two Sampled Value operations for all channels, the two operations are plus and minus.

4.7.1 Measurement Addition Operation

An analogue channel can be configured to give the Sampled Value addition from two separate SVs.

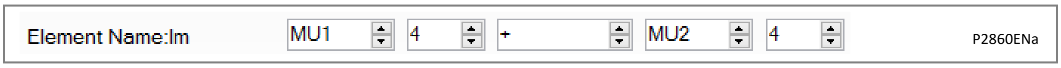


Figure 15 – Configure analogue channel for addition

If Sampled Value addition operation is configured for Im, the actual value of of Im will be the Sampled Value summation of the 4th data channel of MU1 and the 4th data channel of MU2.

4.7.2 Measurement Subtraction Operation

An analogue channel can be configured to give the Sampled Value difference result from two separate SVs.

Figure 16 – Configure analogue channel for subtraction

If Sampled Value plus operation is configured for Ia, the actual value of Ia will be the Sampled Value difference of the 1st data channel of MU1 and the 1st data channel of MU2.

4.8 IEC61850 Enhanced Features

4.8.1 Two Dedicated GOOSE Control Blocks

In addition to the existing 16 GOOSE control blocks, the Process Bus relays provide two dedicated GOOSE Control Blocks, GCB17 and GCB18. Only these two GCBs can be published via the Process Bus board. The existing 16 GCBs can only be published via the Station Bus board.

Note that only digital information can be published via Process Bus GOOSE control blocks.

4.8.2 GOOSE VIP

All GOOSE VIP signals will be detected by both Station Bus and Process Bus boards, which means different VIP signals should be used in different networks, Station Bus network or Process Bus network.

If a GOOSE is published to both Station Bus network and Process Bus network, both Station Bus board and Process Bus board will subscribe to the GOOSE.

Caution	***The Station Bus and Process Bus boards should not be connected to the same network to avoid bandwidth and quality of service issues.***

4.9 Current Differential Function

The feeder differential function uses a P543 or P546 at each end of the protected circuit which can be a two ended or three-ended scheme depending on the application. The IEDs send local current information to the remote ends. The decisions whether to trip are made locally after calculating the bias and differential currents based on the received currents.

For the current differential function to work correctly, Sampled Values from each end of the feeder must be synchronized to correspond to the same time instant. This also applies to any other quantities derived from samples such as Fourier values. This is essential to properly evaluate bias and differential currents and if not synchronized could result in false differential currents and unwanted operation of the differential scheme.

In a differential scheme with conventional P543 or P546 IEDs, either:

- time stamps plus current information is exchanged between the IEDs
- all the IEDs in the scheme are synchronized to 1 PPS GPS inputs.

When the IEDs in the scheme have a Process Bus interface, the synchronization must account for delays in receiving Sampled Values over the Process Bus network. This is not important for conventional IEDs where the primary CTs are directly wired to the IED's analogue inputs. The following diagram shows P546 IEDs at both line ends with Process Bus. The Merging Units and the Sampled Value distribution networks at End A and End B are independent of each other. Therefore, the Sampled Values may arrive at the P546 IEDs with different delays.

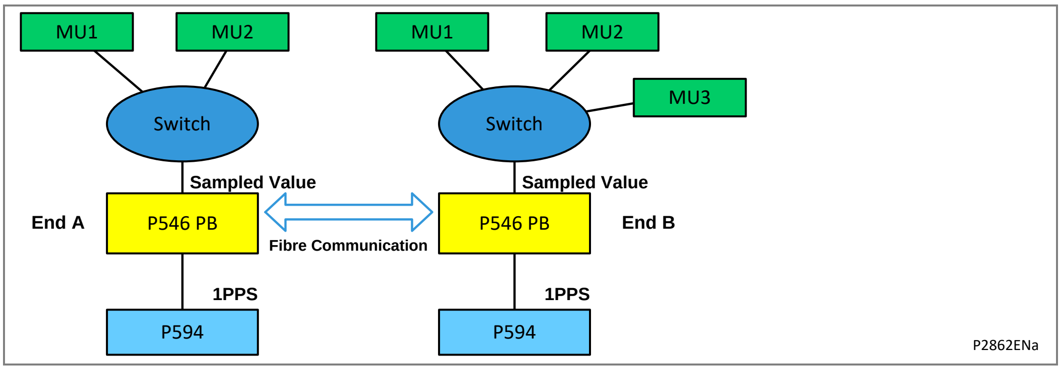


Figure 17 – Two-ended P54x scheme with Process Bus IEDs at both ends

To synchronize the Sampled Values across multiple P546 IEDs with Process Bus interfaces, all must be synchronized using a 1 PPS GPS signal from a P594. This applies for all IEDs in the scheme when one or more of the feeder ends uses Sampled Value inputs.

These conditions are also needed for the feeder differential function to work correctly:

- All P54x IEDs in the scheme must work in GPS Synchronized mode and must have 1PPS GPS inputs from the P594.
- At all line ends, the Merging Units in the feeder differential scheme must use a reference time clock for synchronization. For example, IEEE 1588 or GPS synchronized 1PPS.
- The GPS sources for the P54x IEDs and the Merging Units must be synchronized as they may not be common.
- The first Sampled Value frame from the Merging Units for each second has a sequence count of 0. This corresponds to a zero-time offset from the start of the second.

The P54x uses the sample count in the Sampled Value frames, plus its own 1PPS GPS synchronization input, to calculate delays between 1PPS trigger and the time when coprocessor board has detected the current sample is calculated based on the sample with SmpCnt 0. The P54x then phase shifts the current vectors to time-align them before performing bias and differential currents calculations. The delay is recalculated every second to adapt to any changes in the Process Bus, enhancing the security of the protection scheme.

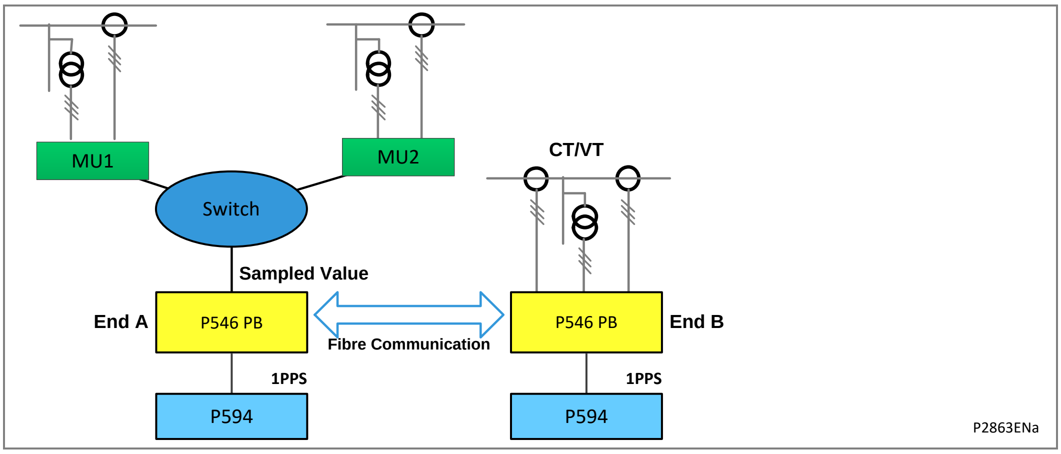


Figure 18 - P54x PB IED scheme and conventional P54x IED combined in a current differential scheme

The current differential scheme is inhibited at all feeder ends if any of the following conditions occur:

- The Sampled Value frames received at the P54x are not synchronized.
- The 1PPS input to the P54x is not GPS synchronized.
- The setting **PB CONFIG->Synchro Mode** is set to ***No_SYNC_CLK***.
- There is a delay of 10 ms or more between the receipt of a Sampled Value frame with SmpCnt 0, and the 1 PPS input pulse to the P54x indicating the start of the second.

When the GPS synchronization recovers in any of these cases, the current differential scheme inhibit is removed on the next occurrence of the ‘SmpCnt 0’ in the Sampled Value frames.

4.10 Configuration Examples

In this section, some configuration and connection examples will be displayed as references.

In the following diagrams, the Merging Units (MU) are illustrated as follows:

- The first line contains the measured currents and voltages
- The second line contains the Merging Unit reference
- The third line illustrates the dataset elements used by the Process Bus board

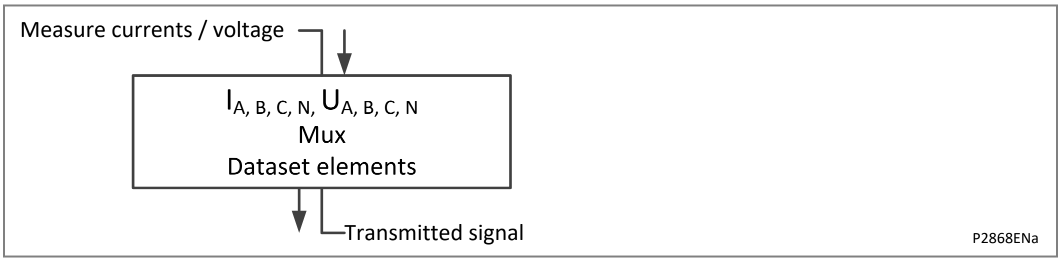


Figure 19 – Measured currents/voltages and transmitted signal

Note the standard inputs and outputs defined by PhsMeas1 have been used in these examples. In IEC61850-9LE this structure is fixed, however, the MU will send whatever signal is applied to the physical input on the corresponding channel. For example, a check synch voltage could be applied to the U_N input and the MU would send this value as U_N in the SV stream. Since the P40 relays allow flexible channel allocation the U_N element can be assigned to the check synch voltage input. This also applies to IEC61869, however, it also supports other PhsMeasx datasets allowing custom datasets to also be used. The flexible channel allocation can then be used to assign any relay input to the appropriate channel.

The examples given here include:

- Example 1 - Line Protection
- Example 2 - Line Protection with Mutual Coupling
- Example 3 - Line protection with Check Synch
- Example 4 - Double Bus Line Protection with Check Synch
- Example 5 - Breaker and a Half with Mutual Coupling and Check Synch

4.10.1 Example 1 - Line Protection

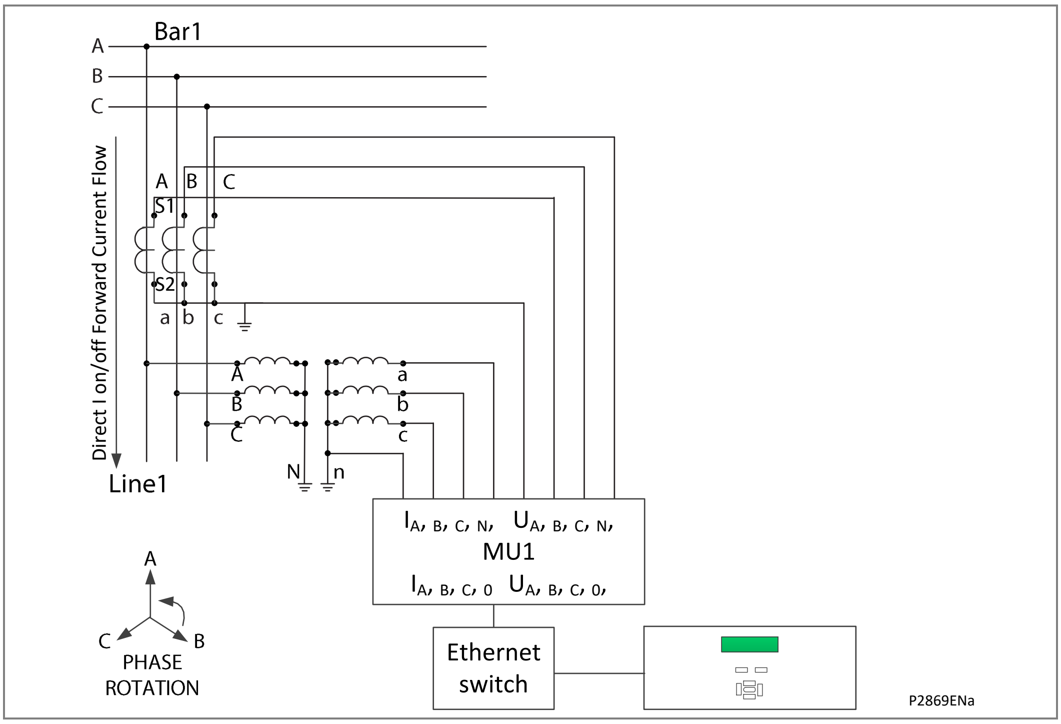


Figure 20 - Connection

Analog channel parameters

	MU No.	Index	Operation	MU No.	Index
Element Name:Ua	MU1	5	N/A	0	0
Element Name:Ub	MU1	6	N/A	0	0
Element Name:Uc	MU1	7	N/A	0	0
Element Name:Ubus	0	0	N/A	0	0
Element Name:Ia	MU1	1	N/A	0	0
Element Name:Ib	MU1	2	N/A	0	0
Element Name:Ic	MU1	3	N/A	0	0

P2870ENa

Figure 21 – CID configuration

4.10.2 Example 2 - Line Protection with Mutual Coupling

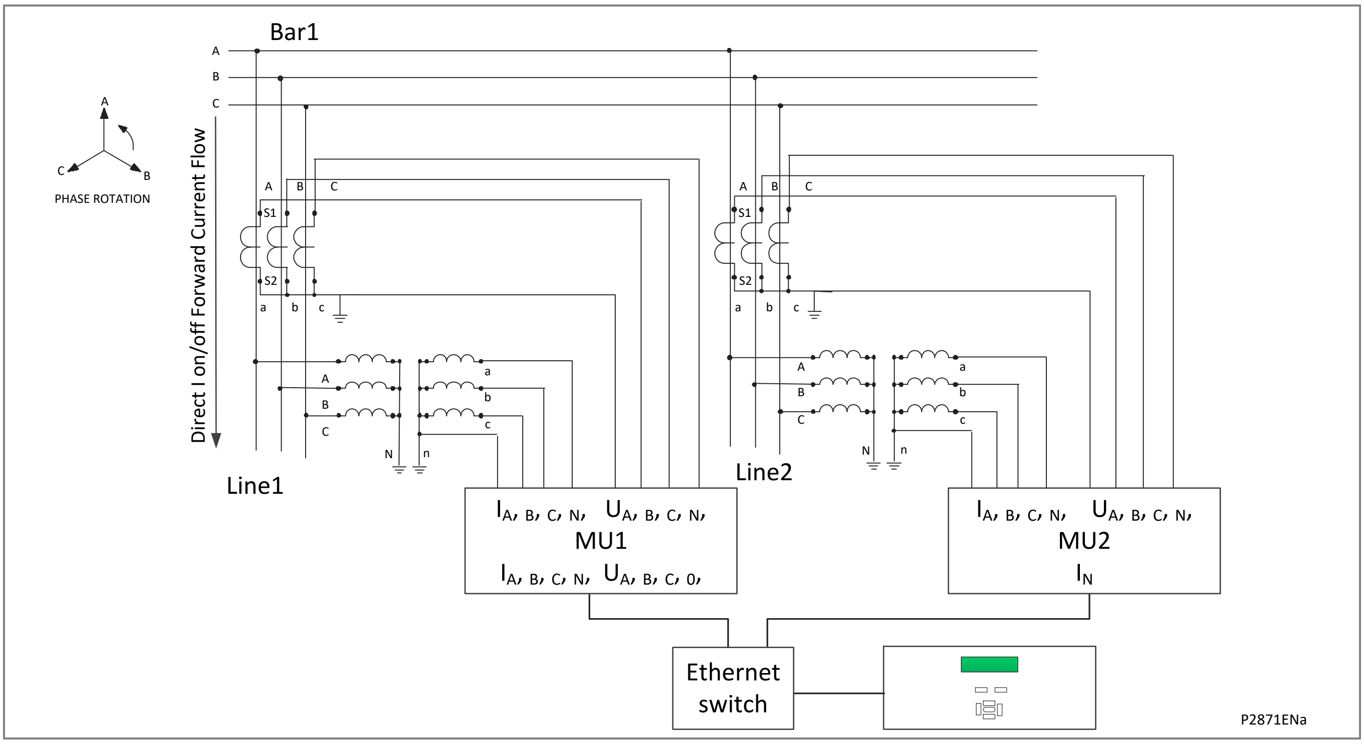


Figure 22 - Connection

Analog channel parameters

	MU No.	Index	Operation	MU No.	Index
Element Name:Ua	MU1	5	N/A	0	0
Element Name:Ub	MU1	6	N/A	0	0
Element Name:Uc	MU1	7	N/A	0	0
Element Name:Ubus	0	0	N/A	0	0
Element Name:Ia	MU1	1	N/A	0	0
Element Name:Ib	MU1	2	N/A	0	0
Element Name:Ic	MU1	3	N/A	0	0
Element Name:Im	MU2	4	N/A	0	0
Element Name:Is	MU1	4	N/A	0	0

P2872ENa

Figure 23 - CID configuration

4.10.3 Example 3 - Line protection with Check Synch

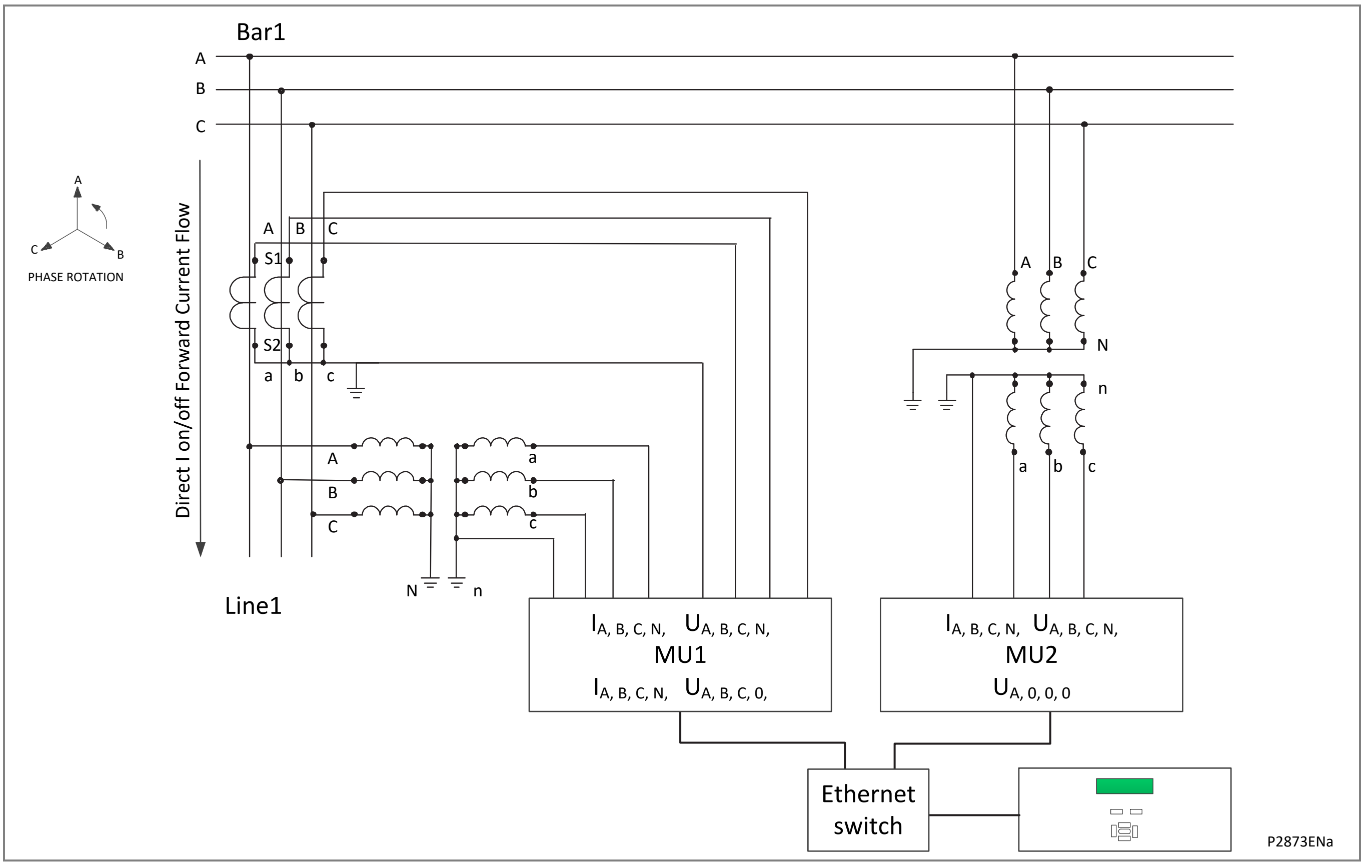
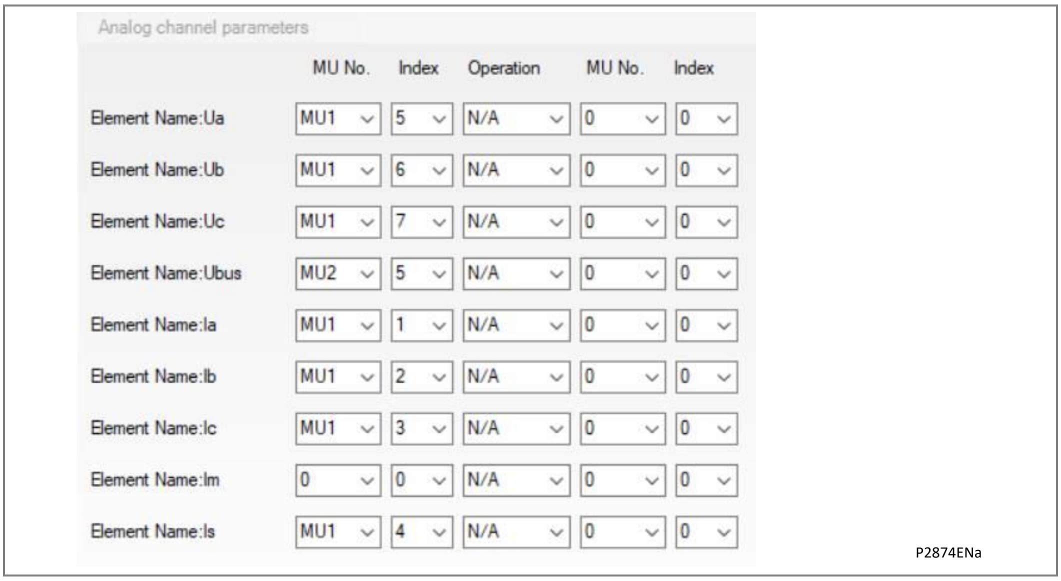


Figure 24 - Connection



Analog channel parameters

	MU No.	Index	Operation	MU No.	Index
Element Name:Ua	MU1	5	N/A	0	0
Element Name:Ub	MU1	6	N/A	0	0
Element Name:Uc	MU1	7	N/A	0	0
Element Name:Ubus	MU2	5	N/A	0	0
Element Name:Ia	MU1	1	N/A	0	0
Element Name:Ib	MU1	2	N/A	0	0
Element Name:Ic	MU1	3	N/A	0	0
Element Name:Im	0	0	N/A	0	0
Element Name:Is	MU1	4	N/A	0	0

P2874ENa

Figure 25 - CID configuration

4.10.4 Example 4 - Double Bus Line Protection with Check Synch

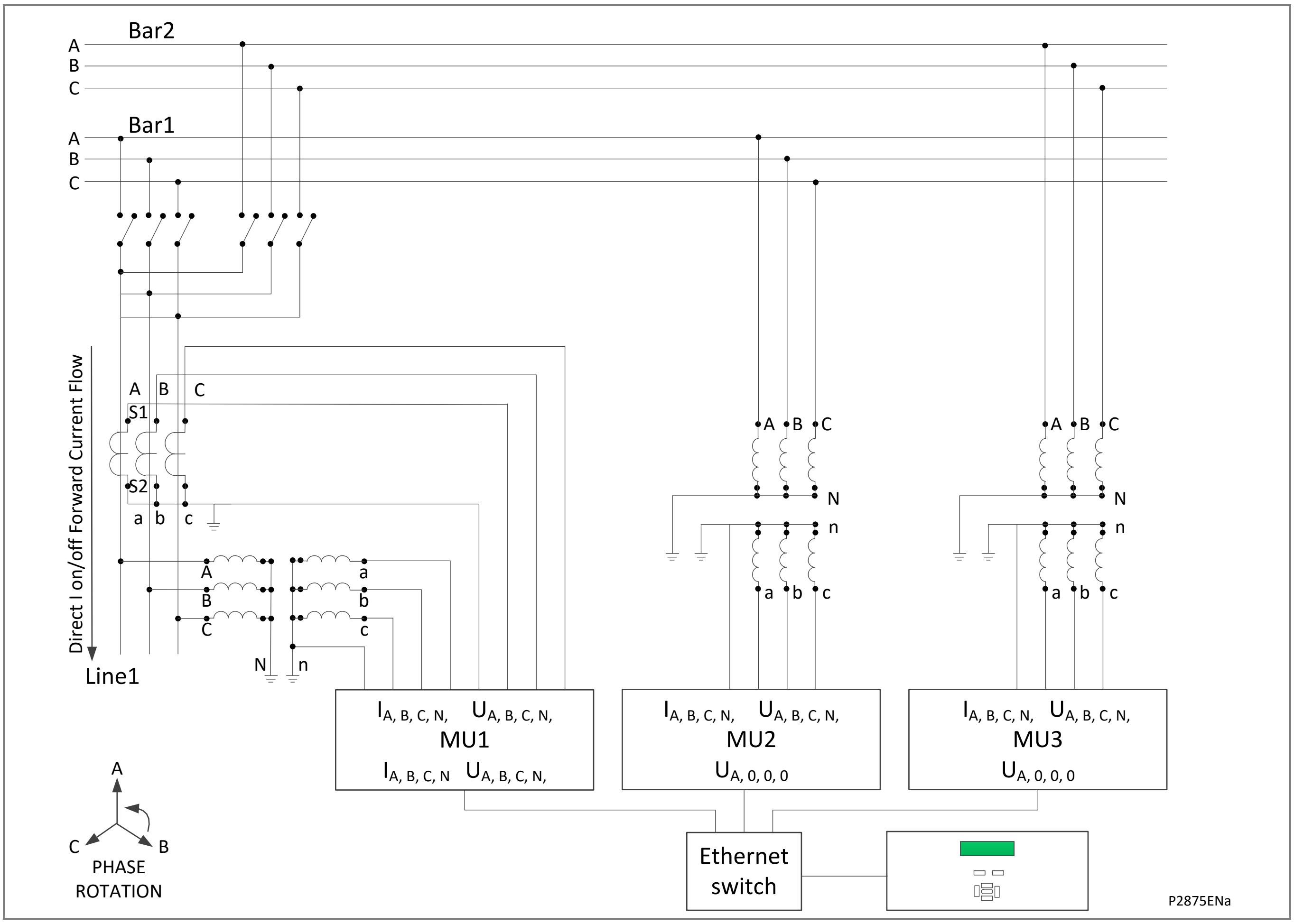
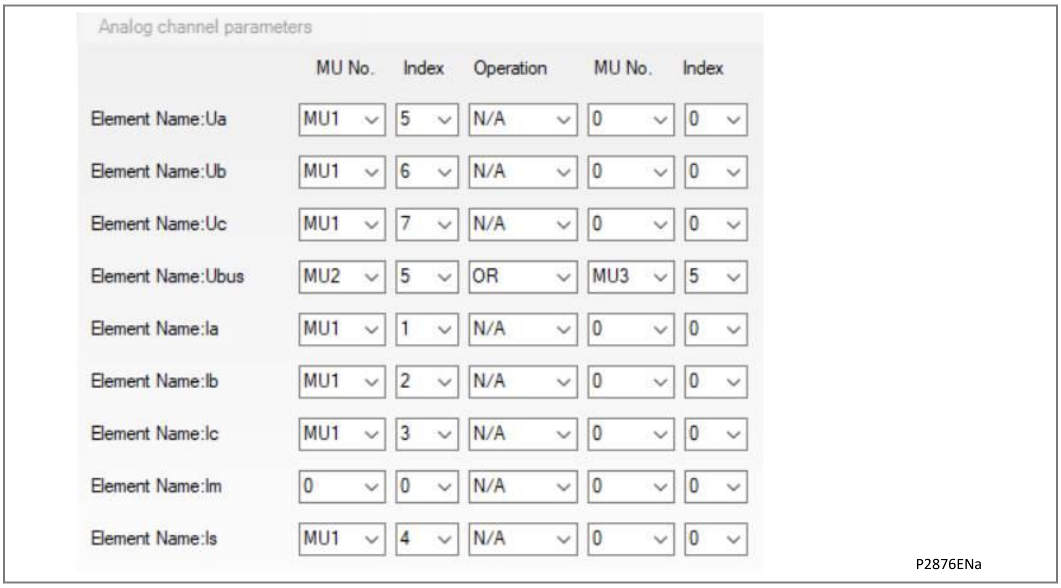


Figure 26 - Connection



Analog channel parameters

	MU No.	Index	Operation	MU No.	Index
Element Name:Ua	MU1	5	N/A	0	0
Element Name:Ub	MU1	6	N/A	0	0
Element Name:Uc	MU1	7	N/A	0	0
Element Name:Ubus	MU2	5	OR	MU3	5
Element Name:Ia	MU1	1	N/A	0	0
Element Name:Ib	MU1	2	N/A	0	0
Element Name:Ic	MU1	3	N/A	0	0
Element Name:Im	0	0	N/A	0	0
Element Name:Is	MU1	4	N/A	0	0

P2876ENa

Figure 27 - CID configuration

4.10.5 Example 5 - Breaker and a Half with Mutual Coupling and Check Synch

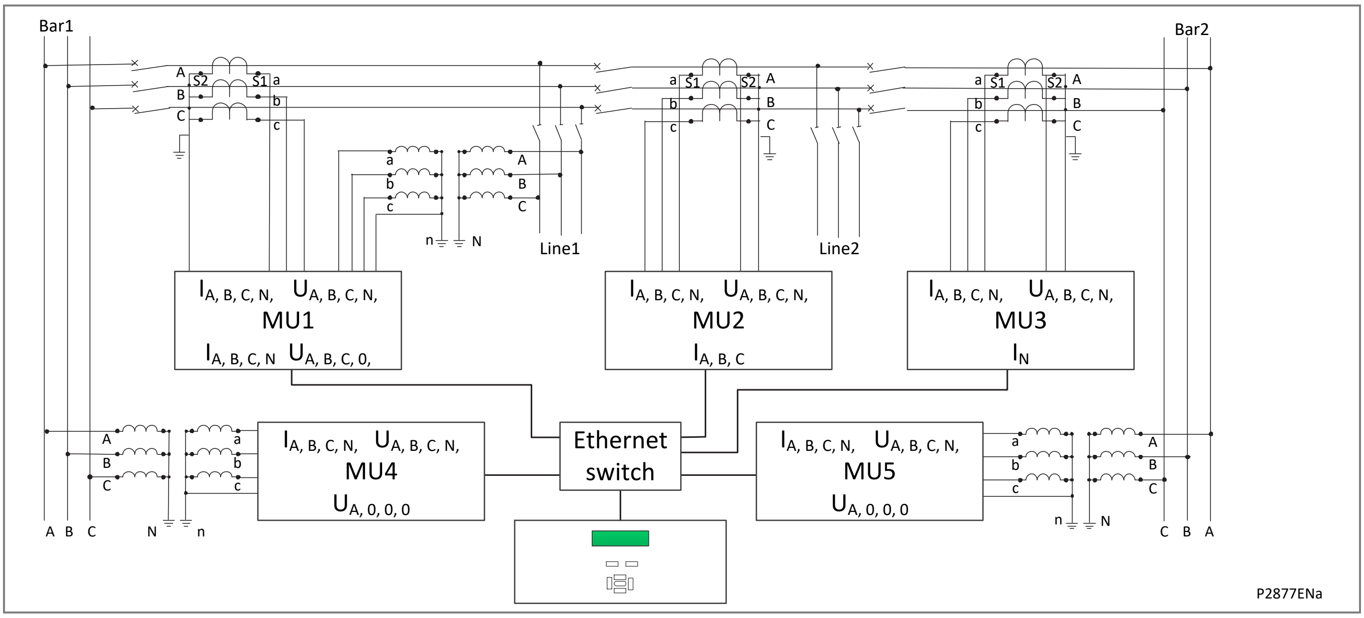
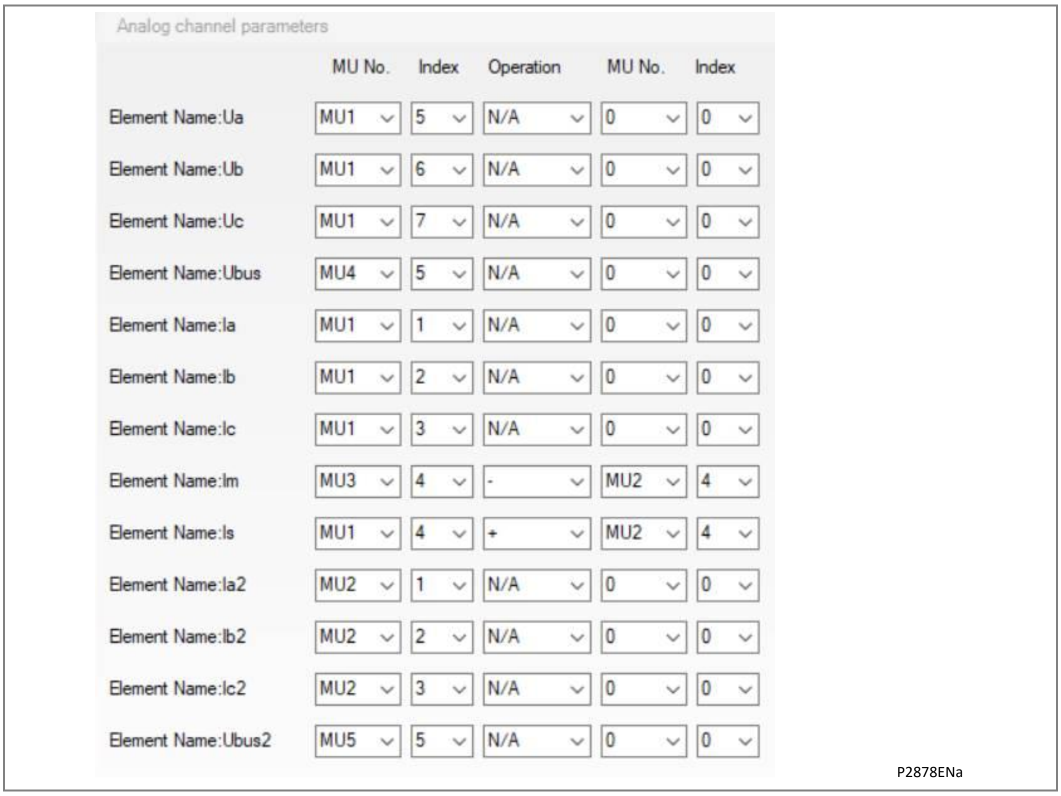


Figure 28 - Connection



Analog channel parameters

	MU No.	Index	Operation	MU No.	Index
Element Name:Ua	MU1	5	N/A	0	0
Element Name:Ub	MU1	6	N/A	0	0
Element Name:Uc	MU1	7	N/A	0	0
Element Name:Ubus	MU4	5	N/A	0	0
Element Name:Ia	MU1	1	N/A	0	0
Element Name:Ib	MU1	2	N/A	0	0
Element Name:Ic	MU1	3	N/A	0	0
Element Name:Im	MU3	4	-	MU2	4
Element Name:Is	MU1	4	+	MU2	4
Element Name:Ia2	MU2	1	N/A	0	0
Element Name:Ib2	MU2	2	N/A	0	0
Element Name:Ic2	MU2	3	N/A	0	0
Element Name:Ubus2	MU5	5	N/A	0	0

P2878ENa

Figure 29 - CID configuration

5 COMMISSIONING

Commissioning methods differ slightly, depending on whether the relay uses the Process Bus Interface or not. The relevant details are shown in the ***Commissioning*** chapter, but are copied here for easy reference.

5.1 Product Checks for IEDs which use the Process Bus Interface

5.1.1 IED Configured with One Merging Unit (MU)

The settings for the Process Bus interface are in the IED menu ***IED Config***. See the Settings chapter.

1. If necessary, isolate or block any outgoing trips from the IED. If physical contacts from the IED are wired in the scheme, in ***COMMISSION TESTS*** menu, set ***Test Mode*** to *Contacts Blocked* if operation of the contacts is not desired. If GOOSE outputs are used, from the main IED menu COMMISIONING TEST column select ***Test Mode***.
2. Connect the IEDs Ethernet port on the Process Bus board to the Sampled Value source. If necessary this can be routed through an Ethernet switch.
3. Make a valid SV configuration (a CID file via **IED Configurator**) and download it to relay and activate the configuration bank.
4. Check that the MU configuration in the CID file matches the actual Sampled Value source (test kit or Merging Unit). Make any changes in the source Sampled Value configuration. This prevents mismatches in Sampled Value when the IED is put into service when testing existing schemes.
5. Set the IED ***Synchro Mode*** to *No SYNC CLK* so the IED accepts Sampled Value frames with or without synchronization.
6. Generate Sampled Value frames with the rated current and voltage as required in the IED's Sampled Value configuration.
7. In the ***MEASUREMENTS*** menu, check the magnitudes and phase angles are displayed correctly. The display may be in primary or secondary values. Also, the IED's CT ratio or VT ratio settings affect the display. A typical accuracy of 1% can be expected for magnitudes.
8. Change the SV configuration configured in the test kit or Merging Unit to mismatch the Sampled Value configuration of the relay. Check the data cell ***SV Absence Alm*** displays '*******1' (where * is a don't care state for this test, normally its value is 0) for the Merging Unit configured in the CID. Check that all ***MEASUREMENTS*** displays for voltage or current are zero.
9. Depending on the scheme, if Merging Unit is configured to publish SV in IEC61869 format, set ***SMV Version*** to *IEC61869*, if Merging Unit is configured to publish SV in IEC61850-9-2LE compatible format, set ***SMV Version*** to *IEC61850-9-2LE*.

5.1.2 IED Configured with Two or More Merging Units (MUs)

The settings for the IEC61850-9-2LE or IEC61869 interface are in the IED menu ***PB CONFIG***.

1. If necessary, isolate or block any outgoing trips from the IED. If physical contacts from the IED are wired in the scheme, in ***COMMISSION TESTS*** menu, set ***Test Mode*** to *Contacts Blocked* if operation of the contacts is not desired. If GOOSE outputs are used, from the main IED menu COMMISIONING TEST column select ***Test Mode***.
2. Connect the IEDs Ethernet port on Process Bus board to an Ethernet switch, which is connected to the Sampled Value sources. If necessary this can be routed through an Ethernet switch.
3. Make a valid SV configuration (a CID file via **IED Configurator**) and download it to relay and activate the configuration bank.
4. Check that the MU configuration in the CID file matches the actual Sampled Value source (test kit or Merging Unit). Make any changes in the source Sampled Value configuration. This prevents mismatches in Sampled Value when the IED is put into service when testing existing schemes.
5. Set the IED Synchro Alarm to 'Local Clock' so the IED accepts Sampled Value frames with local or global synchronization.
6. Check that the Sampled Value source (test kit or Merging Unit) is GPS synchronized.
7. Check the receipt of Sampled Value frames one by one for each Logical Node configured in the IED.

Repeat the following steps for each Merging Unit, configuring them one by one in the Sampled Value source(s).

1. Generate Sampled Value frames with the rated current and voltage as required in the IED’s Logical Node configuration. You can check the receipt of Sampled Value frames for the configured Logical Node.
2. In the ***MEASUREMENTS*** menu, check the magnitudes and phase angles are displayed correctly. The display may be in primary or secondary values. Also, the IED’s CT ratio or VT ratio settings affect the display. A typical accuracy of 1% can be expected for magnitudes.
3. Change the SV configuration configured in the test kit or Merging Unit to mismatch the Sampled Value configuration of the relay. Check the data cell ***SV Absence Alm*** displays '00000001' (where * is a don’t care state for this test, normally its value is 0) for the first Merging Unit configured in the CID, or '******1*' (where * is a don’t care state for this test, normally its value is 0) for the second Merging Unit configured in the CID. Check that all ***MEASUREMENTS*** displays for voltage or current are zero.

5.2 GPS Synchronization for IEDs which use the Process Bus Interface

The P54x has a feature whereby the timing information used to align the local and remote current vectors used in the phase differential algorithm can be very accurately synchronized via the Global Positioning Satellite (GPS) system. If specified, a P594 GPS synchronizing unit is employed to decipher GPS signals and provide the P54x relay with a suitable synchronizing signal.

If the P54x is using GPS synchronization to enhance the phase current differential protection, then the associated P594 unit will need to be commissioned in accordance with the relevant commissioning instructions. The P594 commissioning instructions can be found in the Commissioning chapter of the P594 Technical Manual.

If P594 synchronizing units are not employed, go to the *Setting Checks* section.

5.2.1 Commission the P594

The commissioning instructions and record sheets for the P594 GPS synchronization are available in the P594 Technical Manual. The P594 should be commissioned as per the instructions for a P594 being used to synchronize a P54x relay.

For more information refer to:

- 5.3 - Commissioning Mode for P54x Relay with Process Bus and then
- 5.4 - Commissioning Mode

5.3 Commissioning Mode for P54x Relay with Process Bus

The P54x needs a 1PPS GPS input to function correctly. See the IED manual for GPS synchronization tests. Use a P594 with version D firmware to comply with IEC 61850-9-2LE or IEC 61869 requirements for Local Clock and Global Clock.

5.3.1 Strength of P594 Optical Signal at IED for P54x Relay with Process Bus

1. Put the P594 in **Test Cycle Mode**. See the P594 manual.
2. Check the optical fibre cable to the P594 transmitter is connected correctly.
3. Disconnect the other end of the cable from the IED and measure the received signal strength.
4. Record the value. It should be -16.8 dBm to -25.4 dBm.
5. Reconnect the optical fibre to the IED.

5.3.2 Checking GPS Synchronization Signal at IED for P54x Relay with Process Bus

1. In the P594 menu, set Test Cycle Mode to 'Disable'.
2. Connect the transmit fibre from the P594 to the IED's GPS port.
3. At the IED, set ***PROT COMMS/IM64 > GPS Sync*** to *GPS Standard*. This enables GPS synchronization.
4. Select ***MEASUREMENTS 4 > Channel Status***. If the IED receives the GPS synchronization signal, the display reads **********11** (where * is a don’t care state for this test). This means both the Local GPS and Remote GPS are received.
5. To check the GPS failure condition, disconnect the fibre from the P594 and check the display reverts to **********00**.
6. Reconnect the fibre and check the display reads **********11**.

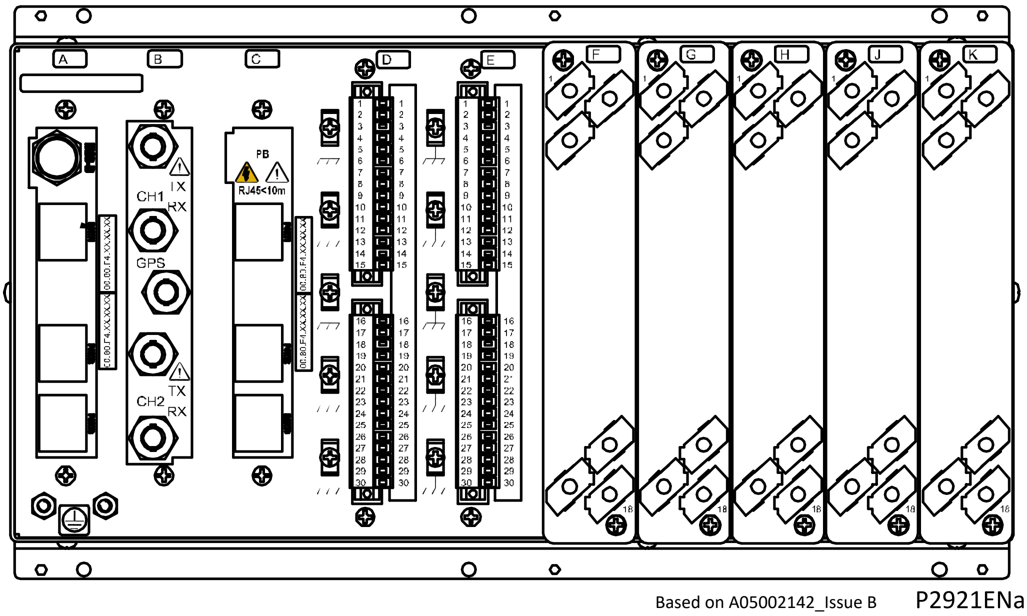
5.4 Commissioning Mode

Global synchronization is needed for a current differential scheme to function correctly. The protection function is inhibited if global synchronization is not present. As IED test kits may not be able to generate Sampled Value frames with global synchronization, the IED has a commissioning mode which allows the differential function to be tested with local synchronization alone.

1. In the ***PB CONFIG*** menu, set ***Synchro Mode*** to *Local Clock*. The current differential protection function then executed for Sampled Value frames received with either Local Clock or Global Clock synchronization. But if Merging Unit is not synchronized with global 1 PPS signal, the differential current will be compared to actual differential current, the value only can be used as a reference due to the phase rotation basis is not established.
2. Test the current differential protection function using a test kit synchronized to GPS, publishing Sampled Value frames with Local Clock synchronization.
3. When the commissioning tests are complete, set the ***Synchro Mode*** to *Global Clock* before the IED is returned to service. The current differential protection operates only with Global 1 PPS synchronization.
4. Check the Merging Unit's maximum delay and if necessary adjust the ***MUs Delay Offset*** setting. If the monitored maximum delay offset is -1, it means the time difference of different SV arrived at device is longer than 3ms, which cannot meet the protection running condition, the whole network needs to be reconfigured to find why there is such a huge transmission delay for some Merging Units.

6 CONNECTION DIAGRAMS

Some of the Connection Diagrams differ slightly, depending on whether the relay uses the Process Bus Interface or not. The relevant details are shown in the ***Connection Diagrams*** chapter, but are copied here for easy reference.



Code	Board		Code	Board
A	Ethernet Board		F	Opto input board *
B	Coprocessor board*		G	Opto input board
C	Process Bus Board		H	Output Relay Board *
D	RTD Board *		J	Output relay board
E	CILO Board*		K	Power Supply board
Where * means that this board is optional. Whether it is present or not depends on the model.				

Figure 30 – MiCOM Px40 process bus – rear view

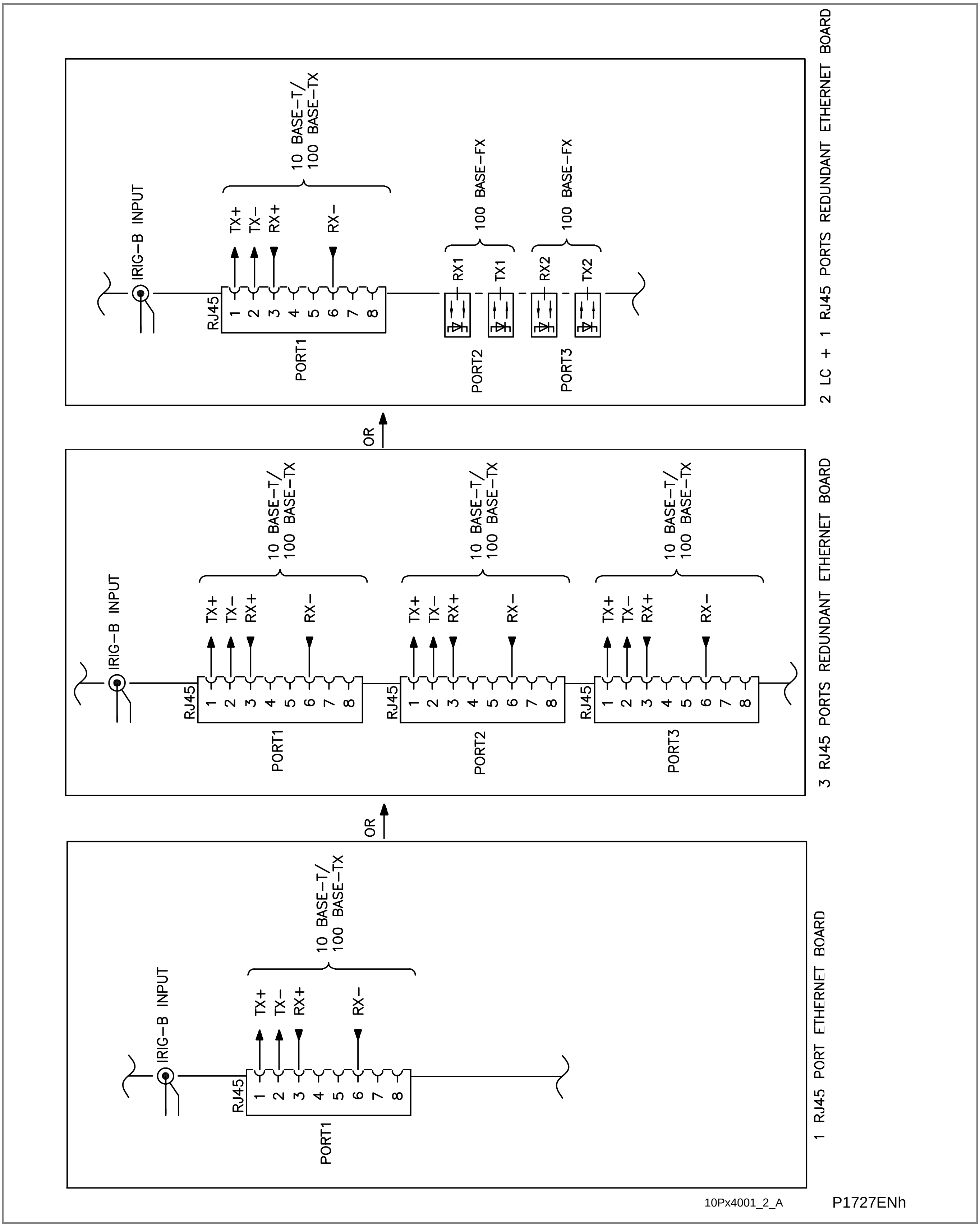


Figure 31 – Front Comm. and process bus comm. options MiCOM Px40 process bus platform

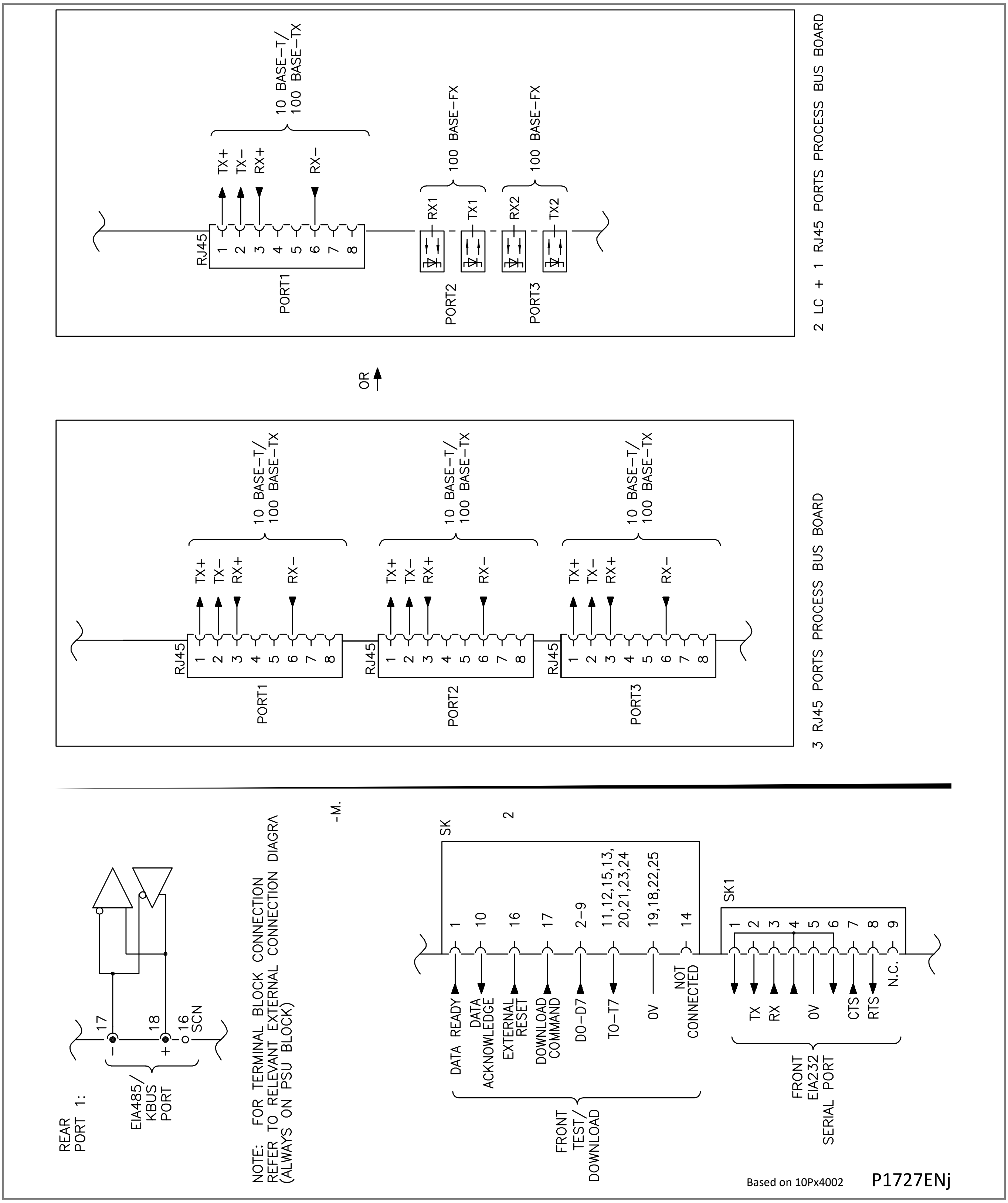


Figure 32 – Ethernet Communications option MiCOM Px40 process bus platform

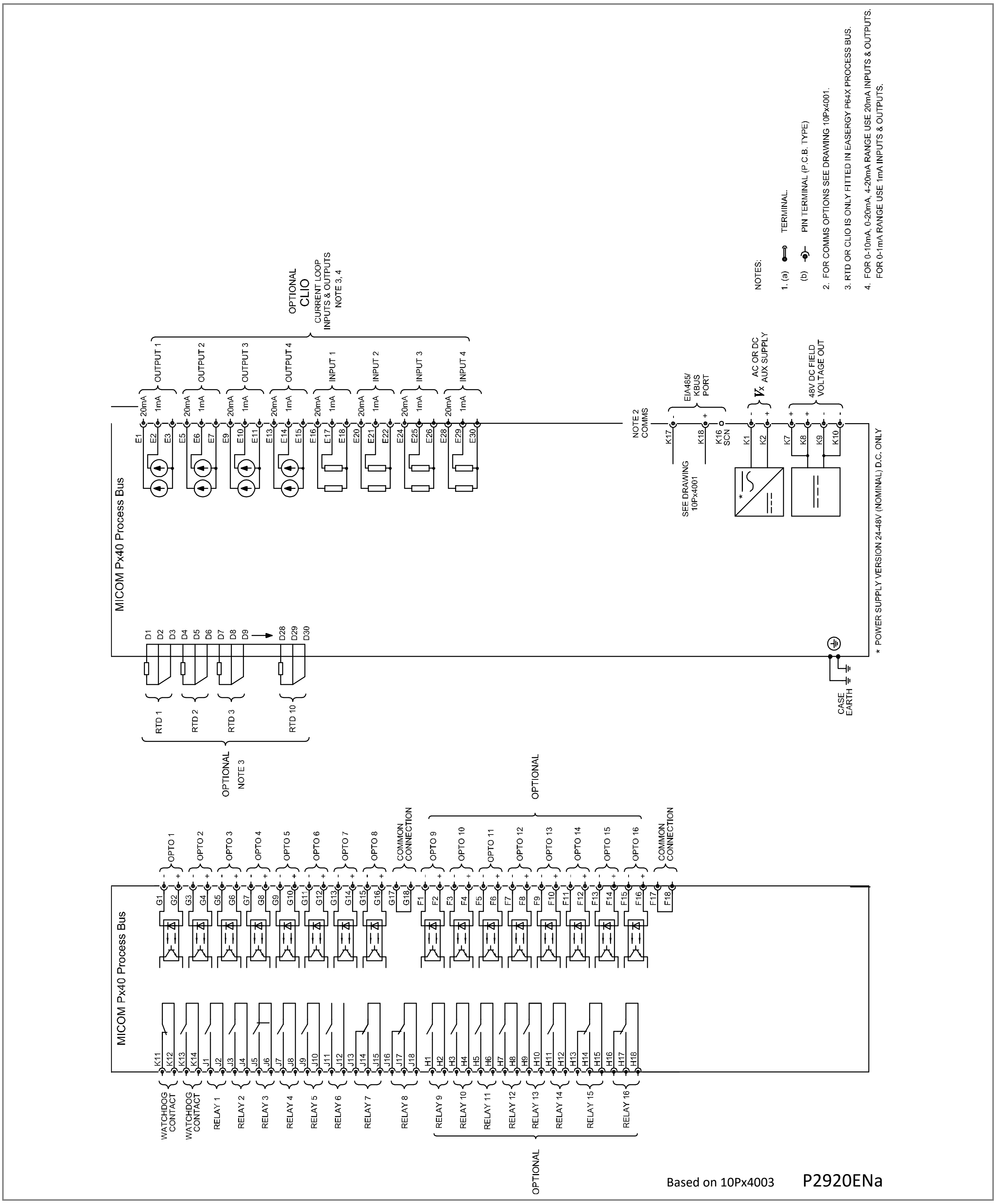


Figure 33 – MiCOM Px40 process bus 8 I/P 8 O/P or 16 O/P (+ CILO & RDT)

7 SAFETY INFORMATION

The Safety Information differs slightly, depending on whether the relay uses the Process Bus Interface or not. The relevant details are shown in the ***Safety Information*** chapter, but are copied here for easy reference.

7.1 Risk of Electric Shock using RJ45 cables

This diagram shows how a P40 IED could be connected to a Stand Alone Merging Unit (SAMU), using either an optical or an RJ45 cable. When connecting devices using RJ45 wired network cables, there is a potential risk of electrical shock.

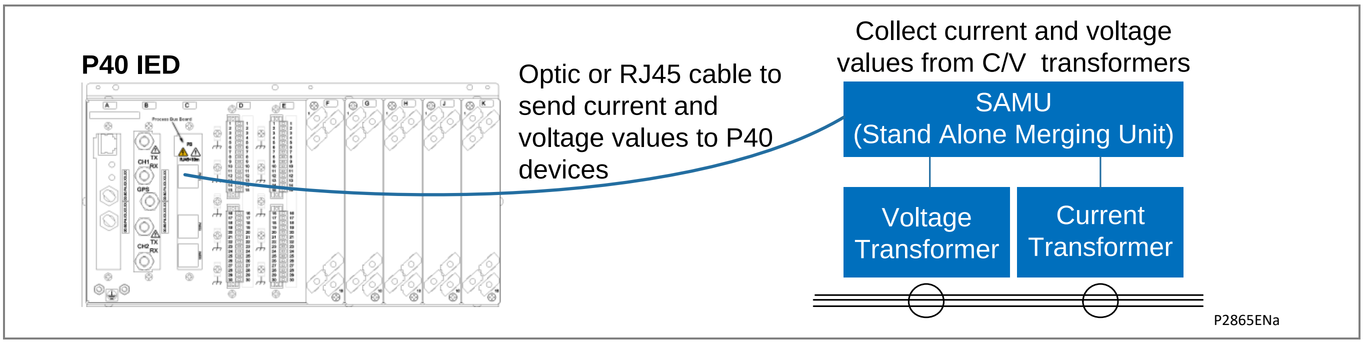


Figure 34 – Connecting a Px40 device to a SAMU

The risk arises due to the widely separated equipment having a different earth potential; and/or faults being propagated on the RJ45 cable. This diagram shows the possible risk:

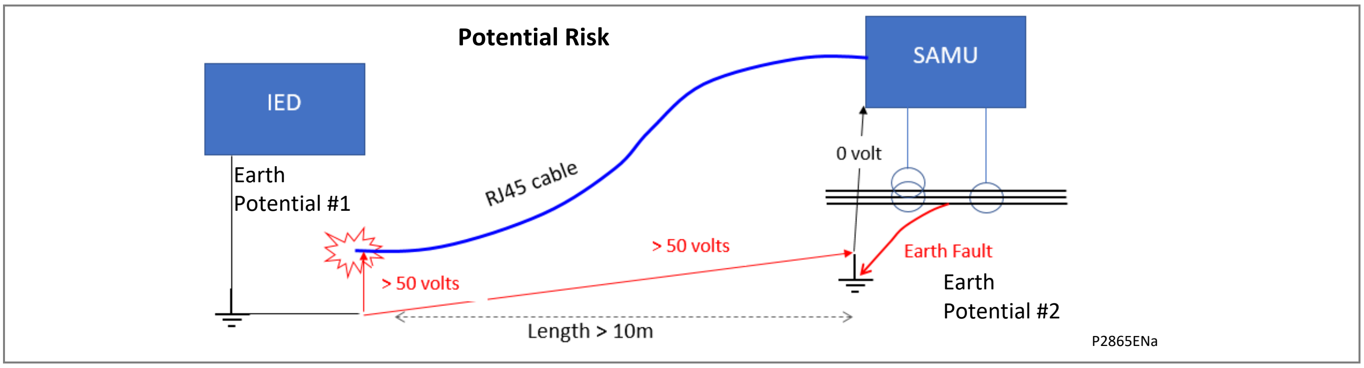


Figure 35 – RJ45 connection electric shock risk

Electric shock could occur if:

- An RJ45 cable is used instead of an optical cable
- The distance from the P40 IED (or a switch) to the SAMU is greater than 10m
- There is an earth potential difference between the two locations
- A fault occurs on SAMU/Voltage Transformer/Current Transformer side
- The earth potential difference and/or the fault is propagated along the RJ45 cable
- Someone comes into electrical contact with the other end of the RJ45 cable (when it is disconnected from P40 device) and they could receive an electric shock

The latest advice for connecting a Low Power Instrument Transformer (LPIT) or a Stand Alone Merging Unit (SAMU) to an IED/switch is, if the distance from the IED/switch is:

- greater than 10m: you must only use a fiber optic cable
- less than 10m: you can use fiber optic or RJ45 cable

When a connection to a LPIT or SAMU is made with the RJ45 cable, this RJ45 cable must not be longer than 10 meters.

The reason is that, during a ground fault, the ground potential of the LPIT or the SAMU rises and is transmitted by the RJ45 cable. If someone was touching the conductive sleeve at the other end of the cable, they could be electrocuted or seriously injured.

DANGER	**If you connect items of equipment with different earth potentials with an RJ45 cable, there is a risk of electric shock, explosion or arc flash.**

DANGER	**Do not use RJ45 cable longer than 10 meters. Failure to do this may result in death or serious injury.**

VERSION HISTORY

CHAPTER 24

Date:	09/2018
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware Suffix:	L (P141, P142 & P143) & M (P145)
Software Version:	B4 - P14x (P141, P142, P143 & P145)
Connection Diagrams:	10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11)

CONTENTS

TABLES

Notes:

1 VERSION HISTORY

This table shows the Software Version together with the Hardware Suffix the particular software runs on. The changes introduced by each Software Version are shown with each change on one row.

The Easergy Studio software is updated periodically. These updates provide support for new features (such as allowing you to manage new MiCOM products, as well as using new software releases and hardware suffixes). The updates may also include fixes. **Accordingly, we strongly advise customers to use the latest Schneider Electric version of Easergy Studio.** This table shows the earliest version of the software which lets you use that feature. Unless otherwise stated in the Studio software, the latest version lets you to use all the features of previous versions.
If you need more information regarding bug fixes, please contact your **Schneider Electric** local support.

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
00	A	A	Oct 1998	Original Issue	V2.08	TG8612C
00	B	A	Nov 1998	Correction to make output relay test pattern settable through Courier Modification to make output relay test pattern function correctly Corrected frequency measurement cell visibility Rectified AR mode selection problems Corrected system frequency measurement in fault records	V2.08	TG8612C
00	C	A	Nov 1998	Corrected extraction of binary flags in event log Modification to AR deadtime logic Additional 100ms dwell timer added CB fail output in default PSL Modification to default undervoltage settings Correction to logic input label text	V2.08	TG8612C
00	D	A	Feb 1999	Correction to IEC870 events	V2.08	TG8612C
00	E	A	March 1999	Modification to residual overvoltage protection Modification to negative sequence overcurrent and overvoltage protection Minor bug fixes	V2.08	TG8612C
00	F	A	March 1999	Thresholds applied to measurements to prevent jitter Modification to low impedance REF settings Modification to battery failure alarms Minor bug fixes	V2.08	TG8612C
00	G	A	June 1999	Modification to minimum current setting for SEF protection Check sync signal made visible in PSL Minor bug fixes	V2.08	TG8612C
00	H	A	July 1999	Disturbance recorder modified to include correct substation name MODBUS frequency measurement corrected Fault locator miles setting now indicates miles not metres Frequency measurement indicates "Not available" instead being invisible when no current or voltage is applied. PSL downloads are now logged as events	V2.08	TG8612C
00	I	A	July 1999	IREF>Is1 setting correctly scaled by CT ratio	V2.08	TG8612C
00	J	A	Aug 1999	Modification to fault recorder prevents undervoltage starts being logged as undervoltage trips Corrected spelling mistake in French language text Modification to make "ISEF Direction" setting invisible when "Lo Z REF" is selected	V2.08	TG8612C
01	A	A	Sept 1999	Corrected spelling mistakes in French language text Modification to disturbance recorder to ensure that logic state changes are displayed at the correct times Correction to VTS logic to enable scaling of the current threshold with CT ratio Correction to VCO logic to enable scaling of the V< threshold with VT ratio Modification to prevent VT ratios returning to default when the auxiliary supply is interrupted	V2.08	TG8612C
01	B	A	Oct 1999	Modification to prevent an error code being generated when the opto inputs are switched on and off between 200 and 10,000 times per second	V2.08	TG8612C

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
02	A	A	Nov 1999	Frequency protection added Minor changes to Courier implementation	V2.08	TG8612C
02	B	A	Nov 1999	Modification to transient overreach algorithm to improve sensitivity for faults just above threshold	V2.08	TG8612C
02	C	A	Dec 1999	Correction to prevent error code being generated when reading thermal state via a MODBUS master station	V2.08	TG8612C
02	D	A	Feb 1999	Modification to correct system frequency, fault duration and relay trip time measurements when extracting fault records via MODBUS master station	V2.08	TG8612C
02	E	A	May 2002	Resolved possible reboot caused by invalid MODBUS requests Modification to improve compatibility between Px20 and Px40 relays on MODBUS communications networks	V2.08	TG8612C
03	A	A	April 2000	Admittance protection added External initiation of auto-reclose added Cos phi and Sin phi features added to SEF protection Maximum Vn polarizing voltage setting increased from 22V to 80V (increased to 320V for 440V relays) Maximum NVD setting increased from 50V to 80V (increased to 320V for 440V relays) Minimum "Fault Frequency Counter" setting increased from 0 to 1	V2.08	TG8612C
03	B	A	May 2002	Resolved possible reboot caused by invalid MODBUS requests Modification to improve compatibility between Px20 and Px40 relays on MODBUS communications networks	V2.08	TG8612C
04	A	A	July 2000	Not released to production DNP3.0 protocol added Courier and MODBUS enhancement to improve compatibility with other protection Correction to scaling of REF setting with CT ratio Corrected spelling mistakes in French, German and Spanish language text Cos phi and Sin phi features added to SEF protection	V2.08	TG8612C
04	B	A	Aug 2000	Not released to production Correction to ensure that all analogue events are generated correctly Modification to ensure the relay uses the correct deadband settings for analogue events	V2.08	TG8612C
04	C	A	Aug 2000	Not released to production Modification to IN1> and IN2> directional elements to prevent stages 2, 3 and 4 being blocked when stage 1 is set none directional	V2.08	TG8612C
04	D	A	Sept 2000	Modification to improve compatibility between Px20 and Px40 relays on MODBUS communications networks	V2.08	TG8612C
04	E	A	Oct 2000	Not released to production Modification to CB fail and CB condition monitoring logic Correction to ensure that address changes can be made using DNP3.0 remote address change feature New data type (D15) added to DNP3.0 protocol	V2.08	TG8612C
05	A	A	Nov 2000	Event filtering added	V2.08	TG8612C
05	B	A	Dec 2000	Improvements made to event filtering and energy measurements	V2.08	TG8612C
05	C	A	July 2001	Not released to production Support for MODBUS code 7 added	V2.08	TG8612C
05	D	A	Dec 2001	Modification to allow CB fail initiation by the under and over frequency elements Fault locator enhanced to allow "MILES" setting to modified via MiCOM S1	V2.08	TG8612C
05	E	A	Jan 2002	Resolved possible reboot caused by Disturbance Recorder	V2.08	TG8612C
05	F	A	Jan 2002	Resolved possible reboot caused by invalid MODBUS requests	V2.08	TG8612C

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
05	G	A	July 2002	Not released to production Corrected MODBUS trip and close with "0" command	V2.08	TG8612C
05	H	A	Nov 2002	Modification to allow extracted IEC60870-5-103 to be correctly sequenced Enhanced DNP3.0 Object 10 support for CB Close pulse Modification to reduce switching time between setting groups Fault locator line length setting corrected in groups 2, 3 & 4 DNP3.0 Object 10 included in Class 0 poll DNP3.0 support for season in time information	V2.08	TG8612C
05	I	A	Nov 2002	Modification to improve compatibility between Px30 and Px40 relays IEC60870 communications networks	V2.08	TG8612C
05	J	A	July 2003	Disturbance recorder triggering no longer causes loss of disturbance recorder data, temporary freezing of the user interface or loss of rear port comms	V2.08	TG8612C
05	K	A	Jan 2004	Correction to prevent loss of communications via the front courier port, noticed particularly with rear port MODBUS relays DNP3.0 Analogue scan rate reduced from 5s to 1s DNP3.0 Digital scan rate reduced from 5s to 0.5s Improvements to DNP3.0 deadband settings for data types D1 to D7 Modification to event filtering to resolve problem with undercurrent elements causing a buffer overflow Reboot of relay if clear key is pressed following a remote reset of indications	V2.08	TG8612C
05	L	A	May 2004	Auto-reclose trip test now produces a fault record on the user interface Overvoltage fault record page on the user interface is now correct for VCN faults Overvoltage fault record page on the user interface is now correct for VCN faults Even/odd parity setting is now correctly recognized for DNP3.0 and MODBUS at power up The analogue check channels are monitored all of the time MODBUS has improved frame reception and does not lock up when spurious messages are injected on to the RS485 network The relay will lock out if it detects an SRAM failure at power up	V2.08	TG8612C
05	M	A	July 2004	MODBUS device driver can incorrectly interpret frame length and return invalid data for valid message Remote commands can occasionally result in a reboot	V2.08	TG8612C
05	N	A	June 2005	MODBUS device driver updated to improve performance on 60 Hz Power measurements display at non-zero current inputs corrected Phase under/over voltage protection hysteresis changed to 2% CB maintenance alarm now set for each new trip AR behavior in User Set Mode improved	V2.08	TG8612C
05	P	A	Jan 2010	Update platform to B3.11 DTS PCS3198: Incorrect resetting of change of direction drop-off count strategy for evolving fault	V2.08	TG8612C
09	Special Release for Taiwan - based on Version 10 with duplicate CB Trip/Close cells in new menu column					
09	A	B	April 2002	CB trip and close functionality available via the default display	V2.08	Based upon P14x/EN T/A22
09	B	B	Dec 2002	Control inputs modified to produce protection events Control inputs enhanced to be none volatile IDG curve stage 2 improvements Modified AR mode to be none volatile Fault locator line length setting corrected in groups 2, 3 & 4 DNP3.0 Object 10 included in Class 0 poll DNP3.0 support for season in time information "Reset Relays/LED" DDB signal corrected to reset LEDs Slip frequency measurement corrected via MODBUS Modification to reduce switching time between setting groups ISEF> IDG time setting modified to include units (seconds)	V2.08	Based upon P14x/EN T/A22

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
09	C	B	Nov 2003	Modification to improve compatibility between Px30 and Px40 relays on IEC60870 communications networks Check synch time settings - step size reduced from 100ms to 10ms Disturbance recorder triggering no longer causes loss of disturbance recorder data, temporary freezing of the user interface or loss of rear port comms Modification to improve compatibility between Px30 and Px40 relays IEC60870 communications networks	V2.09 + Patch	Based upon P14x/EN T/A22
09	D	B	June 2005	MODBUS device driver updated to improve performance on 60 Hz Power measurements display at non-zero current inputs corrected Phase under/over voltage protection hysteresis changed to 2% CB maintenance alarm now set for each new trip AR behavior in User Set Mode improved IEC60870-5-103. Status of summer bit corrected Commissioning test pattern for output relays improved to take account of fitted relays Commissioning test DDB status cell 1022-992 now shows 31 bits (instead of 32)	V2.11	Based upon P14x/EN T/A22
10	A	B	Oct 2001	Not released to production Support for 8 input, 8 output and 4+4 cards Universal opto input added + "Opto input config" column Output contacts uprated from 5A to 10A Modification to allow CB fail initiation by the under and over frequency elements PSL reference I/D cell added Increased ddb signals from 512 to 1023	V2.08	P14x/EN T/A22
10	B	B	Nov 2001	Increased user alarms from 9 to 36 US/IEEE curves modified to TD/7 with TD IDG, Rectifier and RI characteristics added Auto-reclose and checksync enhancements Phase angles added to sequence quantities Thermal overload modified to RMS based Range of SEF high sets increased from 0.8In to 2In SEF Inhibit & AR trip test can be operated via opto input	V2.08	P14x/EN T/A22
10	C	B	Nov 2001	Not released to production Correction to P142 and P143 default PSL to re-map input L7 and V>2 trip signals	V2.08	P14x/EN T/A22
10	D	B	Feb 2002	Resolved possible reboot caused by Disturbance Recorder Resolved possible reboot caused by invalid MODBUS requests	V2.08	P14x/EN T/A22
10	E	B	Dec 2002	Control inputs modified to produce protection events Control inputs enhanced to be none volatile IDG curve stage 2 improvements Modified AR mode to be none volatile Fault locator line length setting corrected in groups 2, 3 & 4 DNP3.0 Object 10 included in Class 0 poll DNP3.0 support for season in time information Reset Relays/LED" DDB signal corrected to reset LEDs Slip frequency measurement corrected via MODBUS Modification to reduce switching time between setting groups ISEF> IDG Time setting modified to include units (seconds) Enhanced DNP3.0 Object 10 support for CB Close pulse	V2.08	P14x/EN T/A22
10	F	B	Sept 2003	Disturbance recorder triggering no longer causes loss of disturbance recorder data, temporary freezing of the user interface or loss of rear port comms Modification to improve compatibility between Px30 and Px40 relays IEC60870 communications networks	V2.08	P14x/EN T/A22
13	Special release for LADWP (Los Angeles)					

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
13	A	B	April 2002	Beta release SEF power measurement added 4 DDB signals added indicating directional starts	V2.08	
13	B	B	May 2002	Pre-validation release		
13	C	C	May 2002	Power supply modified to limit peak inrush to less than 10A Support for second rear communication port	V2.08	
13	D	C	June 2002	SEF start count strategy changed		
13	E	C	Jan 2003	ISEF> IDG Time setting modified to include units (seconds) Fault locator line length setting corrected in groups 2, 3 & 4 DNP3.0 Object 10 included in Class 0 poll DNP3.0 support for season in time information Slip frequency measurement corrected via MODBUS Modification to reduce switching time between setting groups Modified AR mode to be none volatile Control inputs modified to produce protection events Improved AR performance for short duration faults "Reset Relays/LED" DDB signal corrected to reset LEDs Corrected MODBUS trip and close with "0" command Support for trip and close pulse in DNP3.0 Object 10 IDG curve stage 2 improvements	V2.08	
15	A	C	Sept 2002	Not released to production Support for second rear communication port Power supply modified to limit peak inrush to less than 10A Support for VDEW with private codes Support for VDEW uncompressed disturbance recorder Modification so that internal clock failure is correctly reported	V2.08	P14x/EN T/A33
15	B	C	Sept 2002	Default PSL identifier corrected for P144 REF options removed for P144		P14x/EN T/A33
15	C	C	Feb 2003	IEC 103 DR no longer generates a false disturbance record when two triggers occur in close succession Some menu text changed in French and Spanish languages Modification so that manual reset user alarms are logged correctly in event records Control inputs enhanced to be none volatile Fault locator line length setting corrected in groups 2, 3 & 4 DNP3.0 Object 10 included in Class 0 poll DNP3.0 support for season in time information ISEF> IDG Time setting modified to include units (seconds) Slip frequency measurement corrected via MODBUS	V2.08	P14x/EN T/A33
15	D	C	Jan 2004	Disturbance recorder triggering no longer causes loss of disturbance recorder data, temporary freezing of the user interface or loss of rear port comms DNP3.0 Analogue scan rate reduced from 5s to 1s DNP3.0 Digital scan rate reduced from 5s to 0.5s Improvements to DNP3.0 deadband settings for data types D1 to D7 Modification to event filtering to resolve problem with undercurrent elements causing a buffer overflow	V2.08	P14x/EN T/A33

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
15	E	C	May 2004	MODBUS IEC time stamp format may be expressed in forward or reverse format by means of a setting Reset LED/latches DDB signal has same functionality as reset indications menu cell in user interface SEF power measurements include a minimum threshold Overvoltage fault record page on the user interface is now correct for VCN faults Check Synch. Reset of under/over voltage blocking is independent for bus and line Even/odd parity setting is now correctly recognized for DNP3.0 and MODBUS at power up IEC60870. The FAN now correctly increments for new fault conditions The analogue check channels are monitored all of the time	V2.08	P14x/EN T/A33
15	E	C	May 2004	MODBUS has improved frame reception and does not lock up when spurious messages are injected on to the RS485 network The relay will lock out if it detects an SRAM failure at power up	V2.08	P14x/EN T/A33
15	F	C	Aug 2004	MODBUS device driver can incorrectly interpret frame length and return invalid data for valid message Time synch resolution accuracy improved for all comms protocols DNP3.0 Enhancements: Object 20: Broken currents IAx, Ibx, ICx added to points list Object 30: Fault location in % line length added to points list.	V2.08	P14x/EN T/A33
15	G	C	April 2005	MODBUS device driver updated to improve performance on 60 Hz Correction to IDG IDMT characteristic configuration Phase under/over voltage protection hysteresis changed to 2% CB maintenance alarm now set for each new trip AR behavior in User Set Mode improved IEC60870-5-103. Status of summer bit corrected Commissioning test pattern for output relays improved to take account of fitted relays Commissioning test DDB status cell 1022-992 now shows 31 bits (instead of 32) Correction to Thermal state measurement display for remote Courier access Power measurements display at non-zero current inputs corrected	V2.08	P14x/EN T/B43
15	H	C	April 2006	MODBUS device transmit driver updated to use DMA during transmission - to reduce CPU overhead DDB ‘Frequency Not Found’ on power up correction DNP3.0 setting changes correction CS103 repeated request message correction CS103 AR Lockout Alarm between GI and spontaneous event correction	V2.08	P14x/EN T/B43
15	J	C	Nov 2007	AR Protection Lockout for SOTF for inst. protection Auto-reclose. The Hold Reclaim Logic signal does not comply with the diagram IEEE/US IDMT reset characteristics fixed DNP3 comms improvement for event avalanche Limit Power Factor measurements to +/-1	V2.08	P14x/EN T/B43
15	K	C	July 2008	CS103: Incorrect management of ACD flag for indicating class 1 data is available during a General Interrogation	V2.08	P14x/EN T/B43
15	U	C	Feb 2011	Rebranded to Schneider Electric	V2.08	P14x/EN T/B43
16	Special release for Australian market (based upon 15B software)					

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	**Minor**					
16	A	C	Feb 2003	Option for pulsed/latched control inputs added IEC 103 DR no longer generates a false disturbance record when two triggers occur in close succession Some menu text changed in French and Spanish languages Modification so that manual reset user alarms are logged correctly in event records Control inputs enhanced to be none volatile Fault locator line length setting corrected in groups 2, 3 & 4 DNP3.0 Object 10 included in Class 0 poll DNP3.0 support for season in time information ISEF> IDG Time setting modified to include units (seconds) Slip frequency measurement corrected via MODBUS	V2.10	P14x/EN T/A33 (with addendum)
17	Special release for LADWP (based upon 16 software)					
17	A	C	Nov 2003	Not released to production Option for pulsed/latched control inputs added DNP3.0 Analogue scan rate reduced from 5s to 1s DNP3.0 Digital scan rate reduced from 5s to 0.5s Modification to event filtering to resolve problem with undercurrent elements causing a buffer overflow Missing CT Option "None" setting (P144 only) for 3 CT applications Improvements to DNP3.0 deadband settings for data types D1 to D7 Support for primary measurements over DNP3.0 using scaling factors, which may be viewed/changed both locally and remotely Disturbance recorder triggering no longer causes loss of disturbance recorder data, temporary freezing of the user interface or loss of rear port comms	V2.10	
17	B	C	Dec 2003	DNP3.0 manual reset user alarm points are now non-volatile DNP3.0 time synch command no longer causes a reboot when IRIG-B is enabled	V2.10	P14x/EN T/A33 (with addendum)
17	C	C	March 2010	DTS PCS3199 The analogue check channels are monitored all of the time.	V2.10	P14x/EN T/A33 (with addendum)
20	A	G	June 2003	Not released to production New CPU card and front display. Display is a 16 x 3 character dot matrix type with direct access keys (hotkeys) Enhanced check synch functionality including predictive close feature Support for UCA2 protocol and associated features (GOOSE etc.) Configurable opto input filtering added Time synchronization via opto inputs added Missing CT Option "None" setting (P144 only) for 3 CT applications Time synchronization via opto inputs added Enhancement to rear courier port to give K-bus and EIA(RS)485 compatibility Support for 512 events Automatic disturbance recorder extraction support for Courier, VDEW and UCA2	V2.09	P14x/EN T/A44
20	B	G	Nov 2003	Not released to production Support for Russian Language text added Automatic disturbance recorder extraction support for MODBUS	V2.09	P14x/EN T/A44
20	C	G	Dec 2003	Not released to production Improvement to ensure the restoration of Ethernet communications following a long term loss of Ethernet hub Correction to prevent relay reboot if any Ethernet settings are Modified without Ethernet card being present	V2.09	P14x/EN T/A44
20	D	G	Feb 2004	Not released to production Resolution of EMC problems with rear K-Bus port	V2.09	P14x/EN T/A44

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
20	E	G	Feb 2004	Improvement to increase the maximum pending UCA2 requests Number of simultaneous UCA2 clients increased from 4 to 10 Modification to prevent blank page from being displayed in the fault records when a record is generated without a genuine fault (i.e. via opto input). The blank page only occurs if fault record in generated whilst an alarm is already present	V2.09	P14x/EN T/A44
20	F	G	June 2004	Modification to prevent reboot when disturbance records are extracted over UCA2 MODBUS. IEC time stamp format may be expressed in forward or reverse format by means of a setting Overvoltage fault record page on the user interface is now correct for VCN faults Check Synch. Reset of under/over voltage blocking is independent for bus and line. Hysteresis reduced to 2% IEC60870. The FAN now correctly increments for new fault conditions	V2.09	P14x/EN T/B54
20	G	G	May 2005	MODBUS device driver updated to improve performance on 60 Hz Power measurements display at non-zero current inputs corrected Phase under/over voltage protection hysteresis changed to 2% CB maintenance alarm now set for each new trip AR behavior in User Set Mode improved IEC60870-5-103. Status of summer bit corrected Commissioning test pattern for output relays improved to take account of fitted relays Commissioning test DDB status cell 1022-992 now shows 31 bits (instead of 32) Second rear Courier communications port improved Px40 UCA2 communications improvement	V2.09	P14x/EN T/B54
20	H	G	June 2006	Resolution of IEC61850 VxWorks problem - association lost after 49 days IRIG-B Status reported incorrectly DNP3 interframe gap reinstated in Phase 2 CPU. Spurious indication of Voltage Controlled Overcurrent if feature is enabled and Phase Overcurrent is disabled. Spurious protection lockout events when autoreclose not enabled. US IDMT reset characteristic behaviour incorrect Autoreclose. The Hold Reclaim Logic signal does not comply with the diagram.	V2.09	P14x/EN T/B54
21	A	G	May 2004	4 stage time delayed rate of change of frequency protection. Initiation of CB Fail from external single pole or earth fault protection. Check synch indication of blocking on Stage 1. LCD contrast change confirmation. UCA2 - Ethernet card MAC address display. UCA2 - Local GOOSE IED name. MODBUS - IEC time stamp format may be expressed in forward or reverse format by means of a setting. Overvoltage fault record page on the user interface is now correct for VCN faults Check Synch - Reset of under/over voltage blocking is independent for bus and line IEC60870 - The FAN now correctly increments for new fault conditions	V2.10	P14x/EN T/B54
21	B	G	Dec 2004	Second rear Courier communications port failure Phase under/over voltage protection - 2% hysteresis CB maintenance alarm set for each new trip AR State Machine can lock in User Set Mode	V2.10	P14x/EN T/B54
21	C	G	Dec 2008	Reduced minimum setting of df/dt Averaging cycles to 2Hz/s	V2.10	P14x/EN T/B54

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
30	A	J	Dec 2004	4 stage definite time directional negative sequence overcurrent. Dual opto input operate/reset characteristics. Fiber optic support for Courier/MODBUS/DNP3.0 protocols. Check synch stage 2 blocking indications. Triggering of disturbance recorder from Control Inputs, GOOSE Inputs and GOOSE Outputs. Fault record information over IEC60870-5-103 protocol. Fault location and broken current information over DNP3.0 protocol. Menu text change from ALSTOM to AREVA. Grey case. Default text for relay and opto labels rationalized. Phase under/over voltage protection - 2% hysteresis. CB maintenance alarm set for each new trip. AR behavior in User Set Mode improved.	V2.11	P14x/EN T/B54
30	B	J	Feb 2006	DNP3.0 interframe gap reinstated in Phase 2 CPU IRIG-B status reporting and spurious events correction Correction to IDG IDMT characteristic configuration	V2.11	P14x/EN T/B54
30	D	J	Dec 2008	Reduced minimum setting of df/dt Averaging cycles to 2Hz/s	V2.11/2.12	P14x/EN T/B54
31	P145 only: Original Issue					
31	A	J	Feb 2005	P145 Evolution with extended User Interface (10 Function Keys and 18 tricolour LEDs) Control Input status stored in FLASH memory 10 Maintenance Records instead of 5 Programmable opto initiation of setting group change by DDB signals (rather than fixed L1 and L2) Blocking of remote CB Trip/Close by DDB signals Inhibit of Earth Fault 1&2 by DDB signals Skip first shot of AR sequence by DDB signal	V2.12	P145/EN M/A11
32	P141/P142/P143/P144 Release Only For North African EDF Market					
32	A	J	Oct 2005	P141/P142/P143/P144 only New DDB signals for PSL initiation of setting group selection New DDB signal for Blocking of remote CB Trip/Close commands New DDB signal to inhibit Earth Fault 1&2 Skip first shot of AR sequence by ddb signal Zero reference ddb signal Maintenance Records increased Phase Rotation in all 4 setting groups EPATR_B characteristic in SEF stages 1 and 2 Auto-reclose modifications to include: 4 Reclaim timers - one per AR shot AR Skip Shot 1 setting DDB Signals for Inhibit Reclaim, Reclaim In Progress and Reclaim Time Complete Df/dt configuration cell moved	V2.12	P14x/EN T/B64
32	B	J	May 2006	DNP3.0 interframe gap reinstated in Phase 2 CPU IRIG-B status reporting and spurious events correction	V2.12	P14x/EN AD/B64
34	P141/P142/P143 release only for Chinese market					
34	A	J	June 2006	P141/P142/P143 only - based on 32A functionality HMI has Chinese, English and French language options using a two line display (rather than 3 line) Front and rear ports support English and French only	V2.13	P145/EN T/B54+ B64 Translated into Chinese by PCW
35	P141/P142/P143/P144/P145 release for World market					

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
35	A	J	Oct 2006	IEC61850 Communications protocol DNP3.0 Serial evolution High break contacts - P142/3/4/5 Negative Sequence Overcurrent with IDMT characteristics Chinese HMI (taken from 34A) Definite Time Adder for POC/EF/SEF/NPSOC IDMT characteristics	V2.13	P14x/EN M/C74
35	B	J	Nov 2006	Resolution of IEC61850 reboot problem when ethernet is not connected and ddb signals change at a fast rate	V2.13	P14x/EN M/C74
35	C	J	Feb 2007	Resolution of IEC61850 VxWorks problem - association lost after 49 days. IEC60870-5-103 - Additional Measurements via Generic Services (as Courier [02xx], [03xx], [04xx])	V2.13	P14x/EN M/C74
35	D	J	March 2007	Improvements to IEC61850 data model following KEMA tests. Fix to P145 Function Keys over packed DDB.	V2.13	P14x/EN M/C74
35	U	J	March 2011	Rebranded to Schneider Electric	V2.13	P14x/EN M/C74
36	P141/P142/P143/P144/P145 release for World market					
36	A	J	April 2007	Based on 35D functionality. 16 non volatile latches with SRQ available as ddb signals. Support for local time zone.	V2.14	P14x/EN AD/C84
36	B	J	Oct 2007	AR Protection Lockout for SOTF for inst. Protection. Initialisation of non volatile latches. Year not set if IRIG-B has signal healthy.	V2.14	P14x/EN AD/C84
36	C	J	Dec 2010	Based on 41A platform release K3.10. Fixed and enhanced various small issues.	V2.14	P14x/EN AD/C84
39	P141/P142 Modbus only Release For SMEPC China only					
39	B	J	July 2009	Based on 43B functionality. Due to Modbus register misalignment, introduced in version 40 (extended DDB), Modbus registers set to version 30. Four stages of Advanced Frequency df/dt copied to df/dt coumn..	Studio/2.14	P14x/EN M/Cc4
40	P141/P142/P143/P144/P145 Release For World Market					
40	A	J	March 2008	Based on 36B functionality. Broken Conductor Start. Any Trip independent of Relay 3. PSL positional data - number of ddbs increased to 1280. 64 SR Latches added - configured by PSL Editor. IEC61850 over ethernet + CS103 over RS485. DNP3 over ethernet + Courier over Kbus/RS485. InterMiCOM.	Studio/2.14	P14x/EN M/C74 (with addendum) P14x/EN AD/C94
41	P141/P142/P143/P144/P145 Release For World Market					
41	A	J	June 2008	Based on 40A functionality. DNP3 Aliased Control Inputs for SSE. 2nd harmonic blocking of I>,IN1>,IN2>,ISEF>,I2>	Studio/2.14	P14x/EN M/Ca4
41	B	J	Nov 2009	Platform updated last version J2.14. Bug Fixes.	Studio/2.14	P14x/EN M/Ca4
42	P141/P142/P143/P144/P145 Release For World Market					
42	B	J	Nov 2008	IEC61850 phase II enhancements. Read Only Mode. Improvement to time tagging of opto-inputs.	Studio/2.14	P14x/EN M/Ca4
42	C	J	March 2009	New platform software release required for Kema conformance issues. The CB Manual Close delay is removed from any remote CB operations.	Studio/2.14	P14x/EN M/Ca4
42	D	J	Sep 2009	New platform software release required to resolve some IEC61850 issues and DNP protocol issues.	Studio/2.14	P14x/EN M/Ca4

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
43	P141/P142/P143/P144/P145 Release for World Market					
43	A	J	May 2009	IEC61850 phase III enhancements P940 porting Power Protection P143 32 I/O Check Synchronization Enhancements	Studio/2.14	P14x/EN M/Ca4
43	B	J	May 2009	PCS3148 The "Stg f+t Freq" Advanced Frequency Protection setting in Hz for all 9 stages, is incorrectly dependant on the Main VT ratios settings.	Studio/2.14	P14x/EN M/Ca4
43	C	J	Oct 2010	Virtual inputs increased to 128. Retrieval of fault records in DNP 3.0. dv / dt protection. Increase number of Overcurrent Stages. Increase CB close pulse to 50 seconds. 199V Phase – Phase VT Requirement. Increase of SR gates from 64 to 128. Increase P141 hardware configuration to 8 I/O. IEC61850 Metering Quantities.pulsQty set to 1000. Fixed and enhanced various small issues.	Studio/2.14	P14x/EN M/Ca4
44	P141/P142/P143/P144/P145 Release for World Market					
44	A	J	Feb 2010	Platform release L2.5 Bug Fixes.	Studio/2.14	P14x/EN M/De6+ P14x/EN AD/Ee7
44	B	J	May 2010	Bug Fixes.	Studio/2.14	P14x/EN M/De6 + P14x/EN AD/Ee7 P14x/EN AD/Gf7
44	C	J	July 2010	Platform Release L4.3: Bug Fixes.	Studio/2.14	P14x/EN M/De6 + P14x/EN AD/Ee7 P14x/EN AD/Gf7
44	D	J	Sep 2010	Platform Release L4.3: Bug Fixes.	Studio/2.14	P14x/EN M/De6 + P14x/EN AD/Ee7 P14x/EN AD/Gf7
44	E	J	Oct 2010	MMSLITE_V5.1001C:	Studio/2.14	P14x/EN M/De6 + P14x/EN AD/Ee7 P14x/EN AD/Gf7
44	F	J	Dec 2010	Platform Release L4.5: Platform Release L4.6: Px40 Platform library release MMSLITE_V5.1001D Bug Fixes.	Studio/2.14	P14x/EN M/De6 + P14x/EN AD/Ee7 P14x/EN AD/Gf7
44	U	J	Feb 2011	Rebranded to Schneider Electric	Studio/2.14	P14x/EN M/De6 + P14x/EN AD/Ee7 P14x/EN AD/Gf7
44	V	J	Feb 2012	The P140v44V Schneider maintenance software release has been made available based on the P140v44U Schneider software release with an update to fix and enhance various small issues.	Studio/2.14 and later versions	P14x/EN M/De6 + P14x/EN AD/Ee7 P14x/EN AD/Gf7
44	W	J	N/A	Non-Commercial Release	N/A	N/A
44	X	J	N/A	Non-Commercial Release	N/A	N/A
44	Y	J	N/A	Hold / Stopped Release	N/A	N/A
44	Z	J	July 2014	Bug Fixes.	Studio/2.14 and later versions	P14x/EN M/De6 + P14x/EN AD/Ee7 P14x/EN AD/Gf7

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
46	A	J	May 2011	Load encroachment (Blinder) Voltage restrained over current protection Programmable curves Monitor bits in PSL Setting changes through IEC103 protocol Improvements in CB fail algorithm		P14x/EN M/De6 + P14x/EN AD/Ee7 P14x/EN AD/Gf7
46	U	J	May 2011	Load encroachment (Blinder) Voltage restrained over current protection Programmable curves Monitor bits in PSL Setting changes through IEC103 protocol Improvements in CB fail algorithm		P14x/EN M/De6 + P14x/EN AD/Ee7 P14x/EN AD/Gf7
46	V	J	Jan 2013	The P140v46V Schneider maintenance software release has been made available based on the P140v46U Schneider software release with an update to a **PRP Parallel Redundancy Protocol. with that two more hardware options will be added to reflect the modulated and de-modulated status. P14X??N??????? for modulated BOM: 2072082 A09, Issue: A & P14X??P??????? for de-modulated BOM: 2072082 A10, Issue: A **Stable solution of Goose Improvement. **Goose optimization. **Adding extra cell of VDIFF CheckSync Bus_Line Voltage **Autoreclose enhancement.	Studio/2.14 and later versions	P14x/EN M/De6 + P14x/EN AD/Ee7 P14x/EN AD/Gf7
46	W	J	N/A	Non-Commercial Release	N/A	N/A
46	X	J	Dec 2013	The P140v46X software release is required in order to incorporate enhancement to P140V46W and also to add PRP enhancement, goose optimization, goose enhancement, voltage magnitude differential measurement and autoreclose enhancement of P14x46V to the existing CBF enhancement and MEA project. Added to that 46X provides new platform. Bug Fixes.	Studio/2.14 and later versions	P14x/EN M/De6 + P14x/EN AD/Ee7 P14x/EN AD/Gf7
46	Y	J	July 2014	Bug Fixes.	Studio/2.14 and later versions	P14x/EN M/De6 + P14x/EN AD/Ee7 P14x/EN AD/Gf7
46	Z	J		46Z provides new platform development with plus new release of MMS Stack to resolve few features.	Studio/2.14 and later versions	P14x/EN M/De6 + P14x/EN AD/Ee7 P14x/EN AD/Gf7
A0	A	L (P141, P142 & P143) M (P145)	Oct 2014	User Alarms Labels Column Virtual Input Labels Column Virtual Output Labels Column New protocol IEC61850-DNP3 (NO. 9) Increase DR digital channel to 128 External Reset DDB for CB Fail IRIG-B status DDB Special customizable inputs functionality and entries.	Studio/2.14 and later versions	P14x/EN M/Hg8
A0	B	L (P141, P142 & P143) M (P145)	Nov 2015	Maintenance release.	Studio/2.14 and later versions	P14x/EN M/Ih8

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
A0	C	L (P141, P142 & P143) M (P145)	May 2016	Meet customer requirement about Primary/Secondary setting change behavior.	Studio/2.14 and later versions	P14x/EN M/Ih8
A1	A	L (P141, P142 & P143) M (P145)	May 2016	Maintenance release.	Studio/2.14 and later versions	P14x/EN M/Ih8
B0	A	L (P141, P142 & P143) M (P145)	Dec 2014	**Hardware:** Update hardware design suffix to L/M. The 24-48 Vdc power supply range has been changed to cover 24-32 Vdc only. Three new Ethernet boards released. **Software:** IEC 61850 Ed.2 and Ed.1 by configuration. GOOSE number and GOOSE performance enhancement. Disturbance Record LN RDRE Enhancement. Time Synchronization via LTIM/LTMS. Monitor DDB for port physical link status. High-availability Seamless Redundancy (HSR). Dual Ethernet communications (Dual IP). Cyber Security. **Notes:** DNP Over Ethernet is not included in this release	V5.0.1 or later versions	P14x/EN M/Ih8
B0	B	L (P141, P142 & P143) M (P145)	April 2015	Remove Cyber Security RBAC and replaced by Cyber Security Phase 1 (password based). Extend the protocol release scope except DNPOE.	V5.0.1 or later versions	P14x/EN M/Ih8
B0	C	L (P141, P142 & P143) M (P145)	Jan 2016	Transmit the last fault record information via IEC61850 report.	V5.0.1 or later versions	P14x/EN M/Ji8
B1	A	L (P141, P142 & P143) M (P145)	Nov 2015	Integrate Cyber Security RBAC and separate the implementation for CSL1 and CSL0 CLS0 - Simple password management - No Security Administration Tool (SAT) required. CLS1 - Advanced user account right management, security logs/events and secure administration capability - Security Administration Tool (SAT) required Role capabilities corrected Restore record clear functions Secure function key Add three new protocol options G, H, J This release integrated the Cyber Security RBAC and provided the option for the user if they want/don't want to use the Cyber Security. This depends on the protocol options.	V5.0.1 or later versions	P14x/EN M/Ji8

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
B2	A	L (P141, P142 & P143) M (P145)	June 2016	New protocol IEC61850 Edition 1 / 2 and DNPoE and DNP3 Serial. Fault Record via DNP3.0 and IEC61850. New DDB IRIG-B status is available. Cyber Security. This release integrated the Cyber Security RBAC and provided the option for the user if they want/don't want to use the Cyber Security which depends on the protocol options. CLS0 - Simple password management - No Security Administration Tool (SAT) required. CLS1 - Advanced user account right management, security logs/events and secure administration capability - Security Administration Tool (SAT) required.	V7.0.0 or later versions	P14x/EN M/Kj8
B3	A	L (P141, P142 & P143) M (P145)	October 2017	DNP3OE unsolicited messages feature. The setting value consistency (Primary /Secondary) in all ports can be configurable now.	V8.0.0 or later versions	P14x/EN M/Lk8
B4	A	L (P141, P142 & P143) M (P145)	September 2018	PTP and RSTP has been added. SNMP has been removed. Pre-configured dataset High Performance GOOSE is removed.	V8.1.0 or later	P14x/EN M/Ml8
B4	B	L (P141, P142 & P143) M (P145)	November 2018	Process Bus is supported.	V8.1.0 or later	P14x/EN M/Ml8

Table 1 - Version history

This table shows the Software Version together with the Hardware Suffix the particular software runs on. The changes introduced by each Software Version are shown with each change on one row.

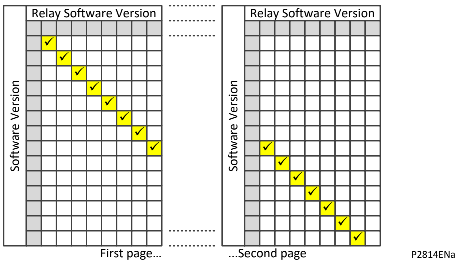
The Easergy Studio software is updated periodically. These updates provide support for new features (such as allowing you to manage new MiCOM products, as well as using new software releases and hardware suffixes). The updates may also include fixes. **Accordingly, we strongly advise customers to use the latest Schneider Electric version of Easergy Studio.** This table shows the earliest version of the software which lets you use that feature. Unless otherwise stated in the Studio software, the latest version lets you to use all the features of previous versions.
If you need more information regarding bug fixes, please contact your **Schneider Electric** local support.

2 SETTING FILE AND RELAY SOFTWARE

To enhance readability, this table has been split over two pages. The columns are shown on adjacent pages:

		Relay Software Version																	
		00	01	02	03	04	05	09	10	13	15	16	17	20	21	30	31	32	34
Setting File Software Version	00	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	01	×	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	02	×	×	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	03	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	04	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	05	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×
	09	×	×	×	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×
	10	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×	×
	13	×	×	×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
	15	×	×	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×
	16	×	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×
	17	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×
	20	×	×	×	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×
	21	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×
	30	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×
	31	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×
	32	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×
	34	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	35	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	36	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	40	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	41	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	42	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	43	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	44	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	45	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	46	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	A0	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B0	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B1	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B2	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B3	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B4	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×

Important: The second set of columns are shown on the following page.



Important:	***The first set of columns are shown on the previous page.***

		Relay Software Version																	
		35	**36**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**A0**	**B0**	**B1**	**B2**	**B3**	**B4**			
	00	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	01	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	02	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	03	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	04	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	05	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	09	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	10	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	13	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	15	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	16	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	17	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	20	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	21	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	30	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
Setting File Software Version	**31**	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	32	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	34	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	35	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	36	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×			
	40	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×			
	41	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×			
	42	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×			
	43	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×			
	44	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×			
	45	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×			
	46	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×			
	A0	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×			
	B0	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×			
	B1	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×			
	B2	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×			
	B3	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×			
	B4	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓			

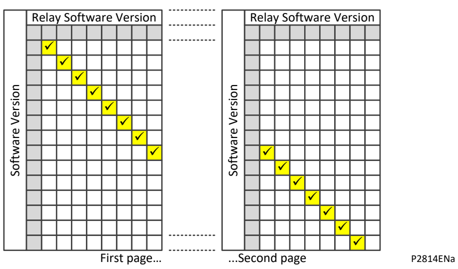
Table 2 - Setting file and relay software

3 PSL FILE AND RELAY SOFTWARE

To enhance readability, this table has been split over two pages. The columns are shown on adjacent pages:

		Relay Software Version																	
		00	01	02	03	04	05	09	10	13	15	16	17	20	21	30	31	32	34
PSL File Software Version	00	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	01	×	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	02	×	×	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	03	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	04	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	05	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×
	09	×	×	×	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×
	10	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×	×
	13	×	×	×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
	15	×	×	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×
	16	×	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×
	17	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×
	20	×	×	×	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×
	21	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×
	30	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×
	31	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×
	32	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×
	34	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	35	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	36	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	40	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	41	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	42	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	43	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	44	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	45	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	46	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	A0	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B0	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B1	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B2	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B3	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B4	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×

Important: The second set of columns are shown on the following page.



Important:	***The first set of columns are shown on the previous page.***

		Relay Software Version																	
		35	36	40	41	42	43	44	45	46	A0	B0	B1	B2	B3	B4			
	00	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	01	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	02	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	03	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	04	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	05	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	09	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	10	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	13	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	15	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	16	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	17	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	20	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	21	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	30	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
PSL File Software Version	31	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	32	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	34	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	35	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	36	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×			
	40	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×			
	41	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×			
	42	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×			
	43	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×			
	44	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×			
	45	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×			
	46	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×			
	A0	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×			
	B0	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×			
	B1	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×			
	B2	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×			
	B3	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×			
	B4	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓			

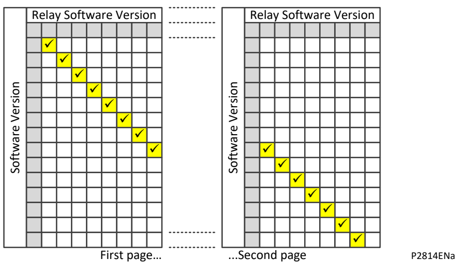
Table 3 - PSL file and relay software

4 MENU TEXT FILE AND RELAY SOFTWARE

To enhance readability, this table has been split over two pages. The columns are shown on adjacent pages:

		Relay Software Version																	
		00	01	02	03	04	05	09	10	13	15	16	17	20	21	30	31	32	34
Menu Text File Software Version	00	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	01	×	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	02	×	×	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	03	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	04	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×
	05	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×
	09	×	×	×	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×
	10	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×	×	×	×	×
	13	×	×	×	×	×	×	×	×	✓	✓	✓	✓	×	×	×	×	×	×
	15	×	×	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×	×	×
	16	×	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×
	17	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×
	20	×	×	×	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×
	21	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×
	30	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×
	31	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×
	32	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×
	34	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	35	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	36	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	40	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	41	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	42	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	43	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	44	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	45	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	46	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	A0	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B0	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B1	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B2	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B3	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	B4	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×

Important: ***The second set of columns are shown on the following page.***



Important: The first set of columns are shown on the previous page.

		Relay Software Version																	
		35	36	40	41	42	43	44	45	46	A0	B0	B1	B2	B3	B4			
	00	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	01	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	02	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	03	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	04	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	05	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	09	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	10	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	13	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	15	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	16	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	17	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	20	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	21	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	30	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	31	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
Menu Text File Software Version	32	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	34	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	35	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×			
	36	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×			
	40	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×			
	41	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×			
	42	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×			
	43	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×			
	44	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×			
	45	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×			
	46	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×			
	A0	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×			
	B0	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×			
	B1	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×			
	B2	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×			
	B3	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×			
	B4	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓			

Table 4 - Menu text file and relay software

SYMBOLS AND GLOSSARY

CHAPTER SG

Date	02/2018	
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.	
Hardware Suffix	All MiCOM Px4x products	
Software Version	All MiCOM Px4x products	
Connection Diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P445: 10P445xx (xx = 01 to 04) P44x (P442 & P444): 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)	P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 01 to 10) 10P643xx (xx = 01 to 06) 10P645xx (xx = 01 to 09) P74x (P741, P742 & P743): 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)

CONTENTS

TABLES

FIGURES

Notes:

1 ACRONYMS AND ABBREVIATIONS

Term	Description
<	Less than: Used to indicate an “under” threshold, such as undercurrent (current dropout).
>	Greater than: Used to indicate an “over” threshold, such as overcurrent (current overload)
A	Ampere
AA	Application Association
AC / ac	Alternating Current
ACSI	Abstract Communication Service Interface
ACSR	Aluminum Conductor Steel Reinforced
ALF	Accuracy Limit Factor
AM	Amplitude Modulation
ANSI	American National Standards Institute
AR	Auto-Reclose
ARIP	Auto-Reclose In Progress
ASCII	American Standard Code for Information Interchange
ATEX	ATEX is the Potentially Explosive Atmospheres directive 94/9/EC
AUX / Aux	Auxiliary
AV	Anti virus
AWG	American Wire Gauge
BAR	Block Auto-Reclose signal
BCD	Binary Coded Decimal
BCR	Binary Counter Reading
BDEW	Bundesverband der Energie- und Wasserwirtschaft | Startseite (i.e. German Association of Energy and Water Industries)
BMP	BitMaP – a file format for a computer graphic
BN>	Neutral over susceptance in the context of the protection element: Reactive component of admittance calculation from neutral current and residual voltage.
BOP	Blocking Overreach Protection - a blocking aided-channel scheme.
BPDU	Bridge Protocol Data Unit
BRCB	Buffered Report Control Block
BRP	Beacon Redundancy Protocol
BU	Backup: Typically a back-up in the context of the protection element
Business Service Layer	This layer coordinates the application, processes commands, make logical decision and calculation according to the business rules
CA	Certification Authority
CAT	Computer Administration Tool , for replacing CMT
C/O	A ChangeOver contact having normally-closed and normally-open connections: Often called a “form C” contact.
CB	Circuit Breaker
CB Aux.	Circuit Breaker auxiliary contacts: Indication of the breaker open/closed status.
CBF	Circuit Breaker Failure in the context of protection element. Could be labelled 50BF in ANSI terminology.
CDC	Common Data Class
CET	Sepam Configuration tool
CF	Control Function
Ch	Channel: usually a communications or signaling channel
Check Synch	Check Synchronizing function

Term	Description
CID	Configured IED Description
CIFS	Common Internet File System. Microsoft protocol use to share resources on a network.
CIP	Critical Infrastructure Protection
CIP Standards	Critical Infrastructure Protection standards. NERC CIP standards have been given the force of law by the Federal Energy Regulatory Commission (FERC)
CLIO	Current Loop Input Output: 0-1 mA/0-10 mA/0-20 mA/4-20 mA transducer inputs and outputs CLI = current loop input - 0-1 mA/0-10 mA/0-20 mA/4-20 mA transducer input CLO = current loop output - 0-1 mA/0-10 mA/0-20 mA/4-20 mA transducer output
CLK / Clk	Clock
Cls	Close - generally used in the context of close functions in circuit breaker control.
CMC	Certificates Management over CMS. An IETF RFC for distribution and registration of public keys and certificates
CMP	Certificates Management Protocol. An IETF RFC for distribution and registration of public keys and certificates (RFC 4210)
CMV	Complex Measured Value
CNV	Current No Volts
COMFEDE	Common Format for Event Data Exchange
CPNI	Centre for the Protection of National Infrastructure
CRC	Cyclic Redundancy Check
CRL	Certificates Revocation List. A list of revoked certificates. Theoretically still valid, but forbidden by the Security Administrator or the Security Server
CRP	Cross-network Redundancy Protocol
CRV	Curve (file format for curve information)
CRx	Channel Receive: Typically used to indicate a teleprotection signal received.
Crypto Device	A small device embedding cryptographic capabilities and storage memory. It could be a smartcard, USB stick, serial dongle, etc.
CS	Cyber Security or Check Synchronism.
CSMS	Cyber Security Management System
CSV	Comma Separated Values (a file format for database information)
CT	Current Transformer
CTRL	Control - as used for the Control Inputs function
CTS	Current Transformer Supervision: To detect CT input failure.
CTx	Channel Transmit: Typically used to indicate a teleprotection signal send.
CUL	Canadian Underwriters Laboratory
CVT	Capacitor-coupled Voltage Transformer - equivalent to terminology CCVT.
CZ	Abbreviation of “Check Zone”: Zone taking into account only the feeders.
DA	Data Attribute
DAN	Double or Doubly Attached Node
DANH	Double or Doubly Attached Node with HSR protocol
DANP	Double or Doubly Attached Node implementing PRP
Data Layer	Consists of the domain-related objects and their relationships that are manipulated by the user during the interaction with the software
DAU	Data Acquisition Unit
DC	Data Concentrator
DC / dc	Direct Current

Term	Description
DCC	An Omicron compatible format
DCE	Data Communication Equipment
DCS	Distributed Control System
DDB	Digital Data Bus within the programmable scheme logic: A logic point that has a zero or 1 status. DDB signals are mapped in logic to customize the relay's operation.
DDR	Dynamic Disturbance Recorder
DEF	Directional Earth Fault (protection): A directionalized ground fault aided protection scheme. Could be labeled 67N in ANSI terminology.
df/dt	Rate of Change of Frequency (equivalent to ROCOF). Could be labeled 81R in ANSI terminology.
df/dt>1	First stage of df/dt in the context of protection element
DFT	Discrete Fourier Transform
DG	Distributed Generation
DHCP	Dynamic Host Configuration Protocol
DHM	Dual Homing Manager
DHP	Dual Homing Protocol
DHS	Dual Homing Star. Ethernet protocol allowing bumpless redundancy. Used with Redundant Ethernet board with dual homing protocol
Diff	Differential in the context of protection elements . Could be labeled 87 in ANSI terminology.
DIN	Deutsches Institut für Normung (German standards body)
Dist	Distance in the context of protection elements . Could be labeled 21 in ANSI terminology.
DITA	Darwinian Information Typing Architecture
DLDB	Dead-Line Dead-Bus: In system synchronism check, indication that both the line and bus are de-energized.
DLLB	Dead-Line Live-Bus: In system synchronism check, indication that the line is de-energised whilst the bus is energized.
DLR	Dynamic Line Rating
DLY / Dly	Time Delay
DMT	Definite Minimum Time
DNP	Distributed Network Protocol
DO	Data Object
DPWS	Device Profile for Web Services
DR	Disturbance Record
DREB	Dual Redundant Ethernet Board
DSP	Digital Signal Processor
DST	Daylight Saving Time
DT	Definite Time: in the context of protection elements: An element which always responds with the same constant time delay on operation. Or Abbreviation of "Dead Time" in the context of auto-reclose:
DTD	Document Type Definition
DTOC	Definite Time Overcurrent in the context of protection element
DTS	Date and Time Stamp
DVC	Direct Variable Cost
DZ	Dead Zone. Area between a CT and an open breaker or an open isolator.
EF or E/F	Earth Fault (directly equivalent to Ground Fault)
EIA	Electronic Industries Alliance
ELR	Environmental Lapse Rate

Term	Description
EMC	ElectroMagnetic Compatibility
ENA	Energy Networks Association
ER	Engineering Recommendation
ESD	ElectroStatic Discharge
ESP	Electronic Security Perimeter
ESS	Embedded Security Server
ETS	Element To Secure. An ETS is an entity that represents a tool, utility or application function block that can be protected within the tool suite. It gathers a list of corresponding permissions with their set of values. This list is pre-defined and cannot be edited by any business user. A same ETS can be associated to many roles with different set of authorizations.
FAA	Ageing Acceleration Factor: Used by Loss of Life (LOL) element
FCS	Frame Check Sequence
FFail	A field failure (loss of excitation) element: Could be labeled 40 in ANSI terminology.
FFT	Fast Fourier Transform
FIR	Finite Impulse Response
FLC	Full load current: The nominal rated current for the circuit.
FLT / Flt	Fault - typically used to indicate faulted phase selection.
Fn or FN	Function
FPGA	Field Programmable Gate Array
FPS	Frames Per Second
FTP	File Transfer Protocol or Foil Twisted Pair
FTPS	FTP over TLS protocol. The classic file transfer protocol (FTP) secured using TLS tunneling.
FWD, Fwd or Fwd.	Indicates an element responding to a flow in the “Forward” direction
Gen Diff	A generator differential element: Could be labeled 87G in ANSI terminology.
Gen-Xformer Diff	A generator-transformer differential element: Could be labeled 87GT in ANSI terminology.
GI	General Interrogation
GIF	Graphic Interchange Format – a file format for a computer graphic
GN>	Neutral over conductance in the context of protection element: Real component of admittance calculation from neutral current and residual voltage.
GND / Gnd	Ground: used in distance settings to identify settings that relate to ground (earth) faults.
GoCB	GOOSE Control Block
GOOSE	Generic Object Oriented Substation Event
GPS	Global Positioning System
GRP / Grp	Group. Typically an alternative setting group.
GSE	General Substation Event
GSSE	Generic Substation Status Event
GUESS	Generator Unintentional Energization at StandStill.
GUI	Graphical User Interface
HIPS	Host Intrusion Prevention System based on “white list” of accepted executables.
HMI	Human Machine Interface
HSR	High Availability Seamless Redundancy
HTML	Hypertext Markup Language
I	Current

Term	Description
I/O	Input/Output
I/P	Input
IANA	Internet Assigned Numbers Authority
ICAO	International Civil Aviation Organization
ICD	IED Capability Description
ID	Identifier or Identification. Often a label used to track a software version installed.
IDMT	Inverse Definite Minimum Time. A characteristic whose trip time depends on the measured input (e.g. current) according to an inverse-time curve.
IEC	International Electro-technical Commission
IED	Intelligent Electronic Device - a term used to describe microprocessor-based controllers of power system equipment. Common types of IEDs include protective relaying devices, load tap changer controllers, circuit breaker controllers, capacitor bank switches, recloser controllers, voltage regulators, etc.
IEEE	Institute of Electrical and Electronics Engineers
IET	IED Engineering ToolSuite. Similar to SET but dedicated to IED. Or IED Engineering Tool.
IETF	Internet Engineering Task Force
IID	Instantiated/Individual IED Description
IIR	Infinite Impulse Response
Inh	An Inhibit signal
Inst	An element with Instantaneous operation: i.e. having no deliberate time delay.
IP	Internet Protocol
IRIG	InterRange Instrumentation Group
ISA	International Standard Atmosphere or Instrumentation Systems and Automation Society
ISO	International Standards Organization
JPEG	Joint Photographic Experts Group – a file format for a computer graphic
L	Live
LAN	Local Area Network
LCB	Log Control Block
LCD	Liquid Crystal Display: The relay front-panel text display.
LD	Level Detector: An element responding to a current or voltage below its set threshold. Or Logical Device
LDAP	Lightweight Directory Access Protocol
LDOV	Level Detector for OverVoltage
LDUV	Level Detector for UnderVoltage
LED	Light Emitting Diode
LLDB	Live-Line Dead-Bus : In system synchronism check, indication that the line is energized whilst the bus is de-energized.
Ln	Natural logarithm
LN	Logical Node
LOGS	All the operations related to the security (connection, configuration…) are automatically caught in events that are logged in order to provide a good visibility of the previous actions to the security administrators.
LoL	A Loss of Load scheme, providing a fast distance trip without needing a signaling channel.
LPDU	Link Protocol Data Unit
LPHD	Logical Physical Device
LRE	Link Redundancy Entity

Term	Description
MAC	Media Access Control or Mandatory Access Control
MC	MultiCast
MCB	Miniature Circuit Breaker
MIB	Management Information Base
MICS	Model Implementation Conformance Statement
MMF	Magneto-Motive Force
MMS	Manufacturing Message Specification (IEC 61850)
MRP	Media Redundancy Protocol
MU	Merging Unit (function)
MV	Measured Value
N	Neutral
N/A	Not Applicable
N/C	A Normally Closed or “break” contact: Often called a “form B” contact.
N/O	A Normally Open or “make” contact: Often called a “form A” contact.
NERC	North American Reliability Corporation
NERO	NERC Electric Reliability Organization (ERO) certified by the Federal Energy Regulatory Commission to establish and enforce reliability standards for the bulk-power system.
NIC	Network Interface Card: i.e. the Ethernet card of the IED
NIST	National Institute of Standards and Technology
NPS	Negative Phase Sequence
NTP	The Network Time Protocol (NTP) is a protocol for synchronizing the clocks of computer systems.
NVD	Neutral Voltage Displacement: Equivalent to residual overvoltage protection.
NXT	Abbreviation of “Next”: In connection with hotkey menu navigation.
o	A small circle on the input or output of a logic gate: Indicates a NOT (invert) function.
OC	Ordinary clock: A clock that has a single Precision Time Protocol (PTP) port in a domain and maintains the timescale used in the domain. It may serve as a source of time, i.e., be a master clock, or may synchronize to another clock, i.e., be a slave clock.
O/C	Overcurrent
O/P	Output
OCB	Oil Circuit Breaker
OCSP	Online Certificate Status Protocol. An IETF RFC for online verification of certificates by servers (RFC 2560).
OID	Object IDentifier
OOS	Out-Of-Step
Opto	An Optically coupled logic input. Alternative terminology: binary input.
OSI	Open Systems Interconnection
PAP	Policy Administration Point. Software entity that manage the security Policy
PCB	Printed Circuit Board
PCT	Protective Conductor Terminal (Ground)
PDC	Phasor Data Concentrator
PDP	Policy Decision Point. Software entity that evaluates the applicable policy and takes an authorization decision
PEP	Policy Enforcement Point. Software entity that performs access control and enforces authorization decision.
Ph	Phase - used in distance settings to identify settings that relate to phase-phase faults.

Term	Description
PICS	Protocol Implementation Conformance Statement
PIP	Policy Information Point. Software entity acting as an information source for the PDP.
PKI	Public Key infrastructure
PMU	Phasor Measurement Unit
PNG	Portable Network Graphics – a file format for a computer graphic
Pol	Polarize - typically the polarizing voltage used in making directional decisions.
POR	A Permissive OverReaching transfer trip scheme (alternative terminology: POTT).
POTT	A Permissive Overreaching Transfer Trip scheme (alternative terminology: POR).
PRP	Parallel Redundancy Protocol
PSB	Power Swing Blocking, to detect power swing/out of step functions, could be labeled 78 in ANSI terminology.
PSL	Programmable Scheme Logic: The part of the relay's logic configuration that can be modified by the user, using the graphical editor within MiCOM S1 Studio software.
PSlip	A Pole slip (out-of-step - OOS) element: could be labeled 78 in ANSI terminology.
PSP	Physical Security Perimeter
PSTN	Public Switched Telephone Network (RTC in French)
PT	Power Transformer
PTP	Precision Time Protocol
PUR	A Permissive UnderReaching transfer trip scheme (alternative terminology: PUTT).
PURR	A Permissive Underreaching Transfer Trip scheme (alternative terminology: PUR).
Q	Quantity defined as per unit value
Qx	Isolator number x
R	Resistance
RA	Registration Authority
R&TTE	Radio and Telecommunications Terminal Equipment
RBAC	Role Based Access Control. Authentication and authorization mechanism based on roles granted to a user. Roles are made of rights, themselves being actions that can be applied on objects. Each user's action is authorized or not based on his roles
RBN	Lead burden for the neutral path.
RBPh	Lead burden for the phasepath.
RCA	Relay Characteristic Angle - The center of the directional characteristic.
RCB	Report Control Block
RCT	Redundancy Control Trailer or Redundancy Check Tag
REB	Redundant Ethernet Board
RedBox	Redundancy Box
REF	Restricted Earth Fault
Rev.	Indicates an element responding to a flow in the "reverse" direction
RMS / rms	Root mean square. The equivalent a.c. current: Taking into account the fundamental, plus the equivalent heating effect of any harmonics.
RoCoF	Rate of Change of Frequency
RP	Rear Port: The communication ports on the rear of the IED
RS232	A common serial communications standard defined by the EIA
RS485	A common serial communications standard defined by the EIA (multi-drop)
RST or Rst	Reset generally used in the context of reset functions in circuit breaker control.
RSTP	Rapid Spanning Tree Protocol.

Term	Description
RTCS	Real Time Certificate Status. Facility. An IETF draft for online certificates validation.
RTD	Resistance Temperature Device
RTU	Remote Terminal Unit
RX	Receive: Typically used to indicate a communication transmit line/pin.
SAM	Security Administration Module. Device in charge of security management on an IP-over-Ethernet network.
SAMU	Stand Alone Merging Unit (device)
SAN	Singly or Single Attached Node
SAS	Substation Automation Solutions / System
SAT	Security Administration Tool TSF based application used to define and create security configuration
SAU	Security Administration Utility
SBS	Straight Binary Second
SC	Synch-Check or system Synchronism Check.
SCADA	Supervisory Control and Data Acquisition
SCD	Substation Configuration Description
SCEP	Simple Certificate Enrollment Protocol. An IETF draft for distribution and registration of public keys and certificates
SCL	Substation Configuration Language. In IEC 61850, the definition of the configuration files.
SCSM	Specific Communication Service Mappings: In IEC 61850, the SCSMs define the actual information exchange mechanisms currently used (e.g. MMS).
SCU	Substation Control Unit
SCVP	Server-based Certificate Validation Protocol. An IETF RFC for online certificates validation.
SDEF	Sensitive Differential Earth Fault in the context of protection element. Could be labeled 87N in ANSI terminology.
SEF	Sensitive Earth Fault in the context of protection element
Sen	Sensitive
SET	System Engineering Tools. New Tools in place of SCE and SMT, to deal with complete life cycle for Systems (design, realization, testing, commissioning, maintenance).
SFTP	A Secured File Transfer Protocol based on SSH.
SGCB	Setting Group Control Block
SHM	Self-Healing Manager
SHP	Self Healing Protocol
SHR	Self Healing Ring: Ethernet protocol allowing bumpless redundancy. Used with Redundant Ethernet board with self-healing protocol.
SIR	Source Impedance Ratio
SLA	Service Level Agreement
SMB	Server Message Block. Microsoft protocol for network resources sharing. Called CIFS on NT
SMT	Substation Management Tool (previously used on PACIS project)
SMTP	Simple Mail Transfer Protocol (SMTP) is an Internet standard for electronic mail (e-mail) transmission across Internet Protocol (IP) networks.
SMV	Sampled Measured Values
SNMP	Simple Network Management Protocol (SNMP) is an "Internet-standard protocol for managing devices on IP networks
SNTP	Simple Network Time Protocol
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SOC	Second of Century

Term	Description
SOTF	Switch on to Fault
SP	Single pole.
SPAR	Single pole auto-reclose.
SPC	Single Point Controllable
SPDT	Single Pole Dead Time. The dead time used in single pole auto-reclose cycles.
SPS	Single Point Status
SQRT	Square Root
SSD	Solid State Device
SSH	Secured Shell. A secured encrypted network protocol for remote administration of computers
SSL	Secured Socket Layer or Source Impedance Ratio or See TLS (TLS is based on SSLv3).
SSO	Single Sign On
STP	Shielded Twisted Pair or Spanning Tree Protocol
SUI	Substation User Interface
SV	Sampled Values
SVC	Static Var Compensator
SVM	Sampled Value Model
TAF	Turbine Abnormal Frequency
TAT	Transfer Administration Tool
TBD	To Be Defined
TC	Transparent Clock: A device that measures the time taken for a Precision Time Protocol (PTP) event message to transit the device and provides this information to clocks receiving this PTP event message. See also: end-to-end transparent clock; peer-to-peer transparent clock.
TCP	Transmission Control Protocol
TCS	Trip Circuit Supervision
TD	Time Dial. The time dial multiplier setting: Applied to inverse-time curves (ANSI/IEEE).
TE	Unit for case measurements: One inch = 5TE units
THD	Total Harmonic Distortion
TICS	Technical Issues Conformance Statement
TIFF	Tagged Image File Format – a file format for a computer graphic
TLS	Transport Layer Security network protocol successor to SSL. Or Transport Layer Security. Creates encrypted tunnel for TCP connections. Can guarantee authentication when used in a PKI.
TMS	Time Multiplier Setting: Applied to inverse-time curves (IEC)
TOC	Trip On Close (“line check”) (protection). Offers SOTF and TOR functionality.
TOR	Trip On Reclose (protection). Modified protection on autoreclosure of the circuit breaker.
TP	Two-Part
TSF	Tool Suite Foundation. Common framework for SET and IET. Mainly 3 parts Core, Workbench (for standardized HMI), Utilities (applicative components like trace viewer, installer)
TUC	Timed UnderCurrent
TVE	Total Vector Error
Tx	Transmit
UA	User Account. A user account is a logical representation of a person with some configurable parameters. It includes information about the user identity and gives him a login to be recognized within the tool suite. A user account is principally interesting when it is associated to some roles that will grant him authorizations.

Term	Description
UDP	User Datagram Protocol
UL	Underwriters Laboratory
UPCT	User Programmable Curve Tool
UTC	Universal Time Coordinated
V	Voltage
VA	Phase A voltage: Sometimes L1, or red phase
VB	Phase B voltage: Sometimes L2, or yellow phase
VC	Phase C voltage: Sometimes L3, or blue phase
VCO	Voltage Controlled Overcurrent element
VDAN	Virtual Double or Doubly Attached Node
VDEP OC>	A voltage dependent overcurrent element: could be a voltage controlled or voltage restrained overcurrent element and could be labeled 51V in ANSI terminology.
VDR	Voltage Dependent Resistor
VDS	Virtual Device Solution
V/Hz	An overfluxing element, flux is proportional to voltage/frequency: could be labeled 24 in ANSI terminology.
Vk	IEC knee point voltage of a current transformer.
VPN	Virtual Private Network (a secure private connection established on a public network or other unsecured environment).
VT	Voltage Transformer
VTS	Voltage Transformer Supervision: To detect VT failure.
WAN	Wide Area Network
XACML	eXtensible Access Control Markup Language. An OASIS standard defining an XML access control policy implementation.
Xformer	Transformer
XKMS	XML Keys Management Specifications. A 3C standard, XML based, for distribution and registration of public keys and certificates
XML	Extensible Markup Language
XSD	XML Schema Definition

Table 1 - Acronyms and abbreviations

2 COMPANY PROPRIETARY TERMS

Term	Description
Courier	Schneider Electric’s proprietary SCADA communications protocol
Easergy	Schneider Electric’s brand of protection relays and related software products
Metrosil	Brand of non-linear resistor produced by M&I Materials Ltd.
MiCOM	Schneider Electric’s brand of protection relays

Table 2 - Company-proprietary terms

3 ANSI TERMS

ANSI no.	Description
3PAR	Three pole auto-reclose.
3PDT	Three pole dead time. The dead time used in three pole auto-reclose cycles.
52a	A circuit breaker closed auxiliary contact: The contact is in the same state as the breaker primary contacts
52b	A circuit breaker open auxiliary contact: The contact is in the opposite state to the breaker primary contacts
64R	Rotor earth fault protection
64S	100% stator earth (ground) fault protection using a low frequency injection method.
89a	An Isolator closed auxiliary contact: The contact is in the same state as the breaker primary contacts.
89b	An Isolator open auxiliary contact: The contact is in the opposite state to the breaker primary contacts.

Table 3 - ANSI abbreviations

ANSI no.	Function	Description
Current Protection Functions		
50/51	Phase overcurrent	Three-phase protection against overloads and phase-to-phase short-circuits.
50N/51N	Earth fault	Earth fault protection based on measured or calculated residual current values: • 50N/51N: residual current calculated or measured by 3 phase current sensors
50G/51G	Sensitive earth fault	Sensitive earth fault protection based on measured residual current values: • 50G/51G: residual current measured directly by a specific sensor such as a core balance CT
50BF	Breaker failure	If a breaker fails to be triggered by a tripping order, as detected by the non-extinction of the fault current, this backup protection sends a tripping order to the upstream or adjacent breakers.
46	Negative sequence / unbalance	Protection against phase unbalance, detected by the measurement of negative sequence current: • sensitive protection to detect 2-phase faults at the ends of long lines • protection of equipment against temperature build-up, caused by an unbalanced power supply, phase inversion or loss of phase, and against phase current unbalance
46BC	Broken conductor protection	Protection against phase imbalance, detected by measurement of I2/I1.
49RMS	Thermal overload	Protection against thermal damage caused by overloads on machines (transformers, motors or generators). The thermal capacity used is calculated according to a mathematical model which takes into account: • current RMS values • ambient temperature • negative sequence current, a cause of motor rotor temperature rise
Re-Closer		
79	Recloser	Automation device used to limit down time after tripping due to transient or semipermanent faults on overhead lines. The recloser orders automatic reclosing of the breaking device after the time delay required to restore the insulation has elapsed. Recloser operation is easy to adapt for different operating modes by parameter setting.
Directional Current Protection		
67N/67NC type 1 and 67	Directional phase overcurrent	Phase-to-phase short-circuit protection, with selective tripping according to fault current direction. It comprises a phase overcurrent function associated with direction detection, and picks up if the phase overcurrent function in the chosen direction (line or busbar) is activated for at least one of the three phases.

ANSI no.	Function	Description
67N/67NC	Directional earth fault	Earth fault protection, with selective tripping according to fault current direction. Three types of operation: • Type 1: the protection function uses the projection of the I0 vector • Type 2: the protection function uses the I0 vector magnitude with half-plane tripping zone • Type 3: the protection function uses the I0 vector magnitude with angular sector tripping zone
67N/67NC type 1	Directional current protection	Directional earth fault protection for impedant, isolated or compensated neutral systems, based on the projection of measured residual current.
67N/67NC type 2	Directional current protection	Directional overcurrent protection for impedance and solidly earthed systems, based on measured or calculated residual current. It comprises an earth fault function associated with direction detection, and picks up if the earth fault function in the chosen direction (line or busbar) is activated.
67N/67NC type 3	Directional current protection	Directional overcurrent protection for distribution networks in which the neutral earthing system varies according to the operating mode, based on measured residual current. It comprises an earth fault function associated with direction detection (angular sector tripping zone defined by 2 adjustable angles), and picks up if the earth fault function in the chosen direction (line or busbar) is activated.
Directional Power Protection Functions		

32P	Directional active overpower	Two-way protection based on calculated active power, for the following applications:
		• active overpower protection to detect overloads and allow load shedding
		• reverse active power protection:
		  • against generators running like motors when the generators consume active power
		  • against motors running like generators when the motors supply active power

32Q/40	Directional reactive overpower	Two-way protection based on calculated reactive power to detect field loss on synchronous machines: • reactive overpower protection for motors which consume more reactive power with field loss • reverse reactive overpower protection for generators which consume reactive power with field loss.
Machine Protection Functions		
37	Phase undercurrent	Protection of pumps against the consequences of a loss of priming by the detection of motor no-load operation. It is sensitive to a minimum of current in phase 1, remains stable during breaker tripping and may be inhibited by a logic input.

48/51LR/14	Locked rotor / excessive starting time	Protection of motors against overheating caused by:
		• excessive motor starting time due to overloads (e.g. conveyor) or insufficient supply voltage.
		The reacceleration of a motor that is not shut down, indicated by a logic input, may be considered as starting.
		• locked rotor due to motor load (e.g. crusher):
		  • in normal operation, after a normal start
		  • directly upon starting, before the detection of excessive starting time, with detection of locked rotor by a zero speed detector connected to a logic input, or by the underspeed function.

66	Starts per hour	Protection against motor overheating caused by:
		• too frequent starts: motor energizing is inhibited when the maximum allowable number of starts is reached, after counting of:
		  • starts per hour (or adjustable period)
		  • consecutive motor hot or cold starts (reacceleration of a motor that is not shut down, indicated by a logic input, may be counted as a start)
		• starts too close together in time: motor re-energizing after a shutdown is only allowed after an adjustable waiting time.

ANSI no.	Function	Description
50V/51V	Voltage-restrained overcurrent	Phase-to-phase short-circuit protection, for generators. The current tripping set point is voltage-adjusted in order to be sensitive to faults close to the generator which cause voltage drops and lowers the short-circuit current.
26/63	Thermostat/Buchholz	Protection of transformers against temperature rise and internal faults via logic inputs linked to devices integrated in the transformer.
38/49T	Temperature monitoring	Protection that detects abnormal temperature build-up by measuring the temperature inside equipment fitted with sensors: • transformer: protection of primary and secondary windings • motor and generator: protection of stator windings and bearings.
Voltage Protection Functions		
27D	Positive sequence undervoltage	Protection of motors against faulty operation due to insufficient or unbalanced network voltage, and detection of reverse rotation direction.
27R	Remanent undervoltage	Protection used to check that remanent voltage sustained by rotating machines has been cleared before allowing the busbar supplying the machines to be re-energized, to avoid electrical and mechanical transients.
27	Undervoltage	Protection of motors against voltage sags or detection of abnormally low network voltage to trigger automatic load shedding or source transfer. Works with phase-to-phase voltage.
59	Overvoltage	Detection of abnormally high network voltage or checking for sufficient voltage to enable source transfer. Works with phase-to-phase or phase-to-neutral voltage, each voltage being monitored separately.
59N	Neutral voltage displacement	Detection of insulation faults by measuring residual voltage in isolated neutral systems.
47	Negative sequence overvoltage	Protection against phase unbalance resulting from phase inversion, unbalanced supply or distant fault, detected by the measurement of negative sequence voltage.
Frequency Protection Functions		
81O	Overfrequency	Detection of abnormally high frequency compared to the rated frequency, to monitor power supply quality. Other organizations may use 81H instead of 81O.
81U	Underfrequency	Detection of abnormally low frequency compared to the rated frequency, to monitor power supply quality. The protection may be used for overall tripping or load shedding. Protection stability is ensured in the event of the loss of the main source and presence of remanent voltage by a restraint in the event of a continuous decrease of the frequency, which is activated by parameter setting. Other organizations may use 81L instead of 81U.
81R	Rate of change of frequency	Protection function used for fast disconnection of a generator or load shedding control. Based on the calculation of the frequency variation, it is insensitive to transient voltage disturbances and therefore more stable than a phase-shift protection function. **Disconnection** In installations with autonomous production means connected to a utility, the “rate of change of frequency” protection function is used to detect loss of the main system in view of opening the incoming circuit breaker to: • protect the generators from a reconnection without checking synchronization • avoid supplying loads outside the installation. **Load shedding** The “rate of change of frequency” protection function is used for load shedding in combination with the underfrequency protection to: • either accelerate shedding in the event of a large overload • or inhibit shedding following a sudden drop in frequency due to a problem that should not be solved by shedding.
Dynamic Line Rating (DLR) Protection Functions		

ANSI no.	Function	Description
49DLR	Dynamic line rating (DLR)	Protection of overhead lines based on calculation of rating or ampacity to dynamically take into account the effect of prevailing weather conditions as monitored by external sensors for: • Ambient Temperature • Wind Velocity • Wind Direction • Solar Radiation

Table 4 - ANSI descriptions

4 CONCATENATED TERMS

Term
Undercurrent
Overcurrent
Overfrequency
Underfrequency
Undervoltage
Overvoltage

Table 5 - Concatenated terms

5 UNITS FOR DIGITAL COMMUNICATIONS

Unit	Description
b	bit
B	Byte
kb	Kilobit(s)
kbps	Kilobits per second
kB	Kilobyte(s)
Mb	Megabit(s)
Mbps	Megabits per second
MB	Megabyte(s)
Gb	Gigabit(s)
Gbps	Gigabits per second
GB	Gigabyte(s)
Tb	Terabit(s)
Tbps	Terabits per second
TB	Terabyte(s)

Table 6 - Units for digital communications

6 AMERICAN VS BRITISH ENGLISH TERMINOLOGY

British English	American English
…ae…	…e…
…ence	…ense
…ise	…ize
…oe…	…e…
…ogue	…og
…our	…or
…ourite	…orite
…que	…ck
…re	…er
…yse	…yze
Aluminium	Aluminum
Centre	Center
Earth	Ground
Fibre	Fiber
Ground	Earth
Speciality	Specialty

Table 7 - American vs British English terminology

7 LOGIC SYMBOLS AND TERMS

Symbol	Description	Units
&	Logical “AND”: Used in logic diagrams to show an AND-gate function.	
Σ	“Sigma”: Used to indicate a summation, such as cumulative current interrupted.	
τ	“Tau”: Used to indicate a time constant, often associated with thermal characteristics.	
ω	System angular frequency	rad
<	Less than: Used to indicate an “under” threshold, such as undercurrent (current dropout).	
>	Greater than: Used to indicate an “over” threshold, such as overcurrent (current overload)	
o	A small circle on the input or output of a logic gate: Indicates a NOT (invert) function.	
1	Logical “OR”: Used in logic diagrams to show an OR-gate function.	
ABC	Clockwise phase rotation.	
ACB	Anti-Clockwise phase rotation.	
C	Capacitance	A
df/dt	Rate of Change of Frequency protection	Hz/s
df/dt>1	First stage of df/dt protection	Hz/s
F<	Underfrequency protection: Could be labeled 81-U in ANSI terminology.	Hz
F>	Overfrequency protection: Could be labeled 81-O in ANSI terminology.	Hz
F<1	First stage of under frequency protection: Could be labeled 81-U in ANSI terminology.	Hz
F>1	First stage of over frequency protection: Could be labeled 81-O in ANSI terminology.	Hz
f_{max}	Maximum required operating frequency	Hz
f_{min}	Minimum required operating frequency	Hz
f_n	Nominal operating frequency	Hz
I	Current	A
I^	Current raised to a power: Such as when breaker statistics monitor the square of ruptured current squared (∧ power = 2).	An
I’f	Maximum internal secondary fault current (may also be expressed as a multiple of In)	A
I<	An undercurrent element: Responds to current dropout.	A
I>>	Current setting of short circuit element	In
I>	A phase overcurrent protection: Could be labeled 50/51 in ANSI terminology.	A
I>1	First stage of phase overcurrent protection: Could be labeled 51-1 in ANSI terminology.	A
I>2	Second stage of phase overcurrent protection: Could be labeled 51-2 in ANSI terminology.	A
I>3	Third stage of phase overcurrent protection: Could be labeled 51-3 in ANSI terminology.	A
I>4	Fourth stage of phase overcurrent protection: Could be labeled 51-4 in ANSI terminology.	A
I>BB	Minimum pick-up phase threshold for the local trip order confirmation.	A
I>DZ	Minimum pick-up phase threshold for the Dead Zone protection.	A
I_0	Earth fault current setting Zero sequence current: Equals one third of the measured neutral/residual current.	A
I_1	Positive sequence current.	A
I_2	Negative sequence current.	A
I2>	Negative sequence overcurrent protection (NPS element).	A
I2pol	Negative sequence polarizing current.	A
I2therm>	A negative sequence thermal element: Could be labeled 46T in ANSI terminology.	
IA	Phase A current: Might be phase L1, red phase.. or other, in customer terminology.	A
IB	Phase B current: Might be phase L2, yellow phase.. or other, in customer terminology.	A
IbiasPh> Cur.	SDEF blocking bias current threshold.	

Symbol	Description	Units
IC	Phase C current: Might be phase L3, blue phase.. or other, in customer terminology.	A
ID>1	Minimum pick-up phase circuitry fault threshold.	
ID>2	Minimum pick-up differential phase element for all the zones.	
IDCZ>2	Minimum pick-up differential phase element for the Check Zone.	
Idiff	Current setting of biased differential element	A
IDN>1	Minimum pick-up neutral circuitry fault threshold.	
IDN>2	Minimum pick-up differential neutral element for all the zones.	
IDNCZ>2	Minimum pick-up differential neutral element for the Check Zone.	
IDZ	Minimum pick-up differential neutral element for the Check Zone.	
If	Maximum secondary through-fault current	A
If max	Maximum secondary fault current (same for all feeders)	A
If max int	Maximum secondary contribution from a feeder to an internal fault	A
If Z1	Maximum secondary phase fault current at Zone 1 reach point	A
Ife	Maximum secondary through fault earth current	A
IfeZ1	Maximum secondary earth fault current at Zone 1 reach point	A
Ifn	Maximum prospective secondary earth fault current or 31 x I> setting (whichever is lowest)	A
Ifp	Maximum prospective secondary phase fault current or 31 x I> setting (whichever is lowest)	A
I_m	Mutual current	A
IM64	InterMiCOM64.	
IMx	InterMiCOM64 bit (x=1 to 16)	
I_n	Current transformer nominal secondary current. The rated nominal current of the relay: Software selectable as 1 amp or 5 amp to match the line CT input.	A
IN	Neutral current, or residual current: This results from an internal summation of the three measured phase currents.	A
IN>	A neutral (residual) overcurrent element: Detects earth/ground faults.	A
IN>1	First stage of ground overcurrent protection: Could be labeled 51N-1 in ANSI terminology.	A
IN>2	Second stage of ground overcurrent protection: Could be labeled 51N-2 in ANSI terminology.	A
IN>BB	Minimum pick-up neutral threshold for the local trip order confirmation.	
IN>DZ	Minimum pick-up neutral threshold for the Dead Zone protection.	
Inst	An element with “instantaneous” operation: i.e. having no deliberate time delay.	
I/O	Inputs and Outputs - used in connection with the number of optocoupled inputs and output contacts within the relay.	
I/P	Input	
Iref	Reference current of P63x calculated from the reference power and nominal voltage	A
IREF>	A Restricted Earth Fault overcurrent element: Detects earth (ground) faults. Could be labeled 64 in ANSI terminology.	A
IRm2	Second knee-point bias current threshold setting of P63x biased differential element	A
Is	Value of stabilizing current	A
IS1	Differential current pick-up setting of biased differential element	A
IS2	Bias current threshold setting of biased differential element	A
I_{SEF}>	Sensitive Earth Fault overcurrent element.	A
Isn	Rated secondary current (I secondary nominal)	A
Isp	Stage 2 and 3 setting	A
Ist	Motor start up current referred to CT secondary side	A
K	Dimensioning factor	

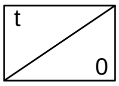
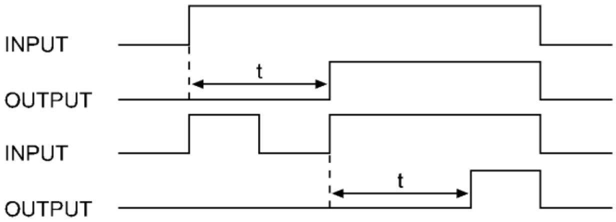
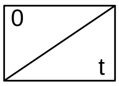
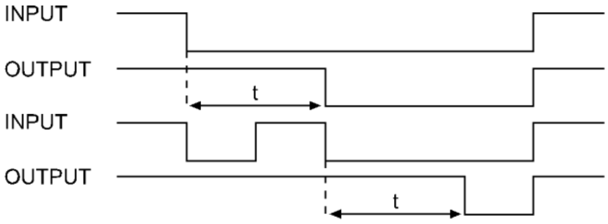
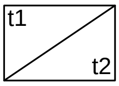
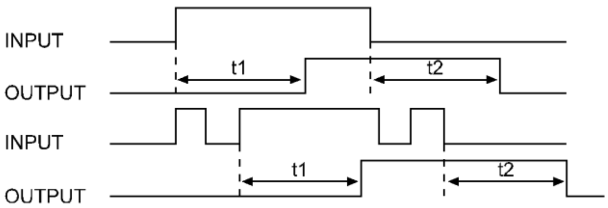
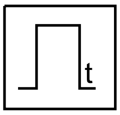
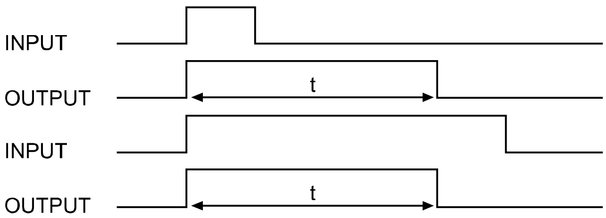
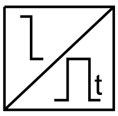
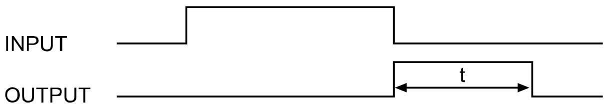
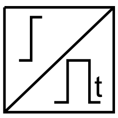
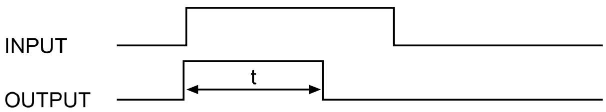
Symbol	Description	Units
K_1	Lower bias slope setting of biased differential element	%
K_2	Higher bias slope setting of biased differential element	%
KCZ	Slope of the differential phase element for the Check Zone.	
K_e	Dimensioning factor for earth fault	
km	Distance in kilometers	
K_{max}	Maximum dimensioning factor	
KNCZ	Slope of the differential neutral element for the Check Zone.	
K_{rpa}	Dimensioning factor for reach point accuracy	
K_s	Dimensioning factor dependent upon through fault current	
K_{ssc}	Short circuit current coefficient or ALF	
K_t	Dimensioning factor dependent upon operating time	
kZm	The mutual compensation factor (mutual compensation of distance elements and fault locator for parallel line coupling effects).	
kZN	The residual compensation factor: Ensuring correct reach for ground distance elements.	
L	Inductance	A
m1	Lower bias slope setting of P63x biased differential element	None
m2	Higher bias slope setting of P63x biased differential element	None
mi	Distance in miles.	
N	Indication of “Neutral” involvement in a fault: i.e. a ground (earth) fault.	
-P>	A reverse power (W) element: could be labeled 32R in ANSI terminology.	
P>	An overpower (W) element: could be labeled 32O in ANSI terminology.	
P<	A low forward power (W) element: could be labeled 32L in ANSI terminology.	
P1	Used in IEC terminology to identify the primary CT terminal polarity: Replace by a dot when using ANSI standards.	
P2	Used in IEC terminology to identify the primary CT terminal polarity: The non-dot terminal.	
P_n	Rotating plant rated single phase power	W
PN>	Wattmetric earth fault protection: Calculated using residual voltage and current quantities.	
Q<	A reactive under power (VAr) element	
R	Resistance (Ω)	Ω
R< or 64S R<	A 100% stator earth (ground) fault via low frequency injection under resistance element: could be labeled 64S in ANSI terminology.	
R Gnd.	A distance zone resistive reach setting: Used for ground (earth) faults.	
R Ph	A distance zone resistive reach setting used for Phase-Phase faults.	
Rct	Secondary winding resistance	Ω
RCT	Current transformer secondary resistance	Ω
Rl	Resistance of single lead from relay to current transformer	Ω
Rr	Resistance of any other protective relays sharing the current transformer	Ω
Rrn	Resistance of relay neutral current input	Ω
Rrp	Resistance of relay phase current input	Ω
Rs	Value of stabilizing resistor	Ω
Rx	Receive: typically used to indicate a communication receive line/pin.	
S<	An apparent under power (VA) element	
S1	Used in IEC terminology to identify the secondary CT terminal polarity: Replace by a dot when using ANSI standards.	

Symbol	Description	Units
S2	Used in IEC terminology to identify the secondary CT terminal polarity: The non-dot terminal. Also used to signify negative sequence apparent power, S2 = V2 x I2.	
S2>	A negative sequence apparent power element, S2 = V2 x I2.	
t	A time delay.	
t’	Duration of first current flow during auto-reclose cycle	s
T1	Primary system time constant	s
TF	Through Fault monitoring	
tfr	Auto-reclose dead time	s
Thermal I>	A stator thermal overload element: could be labeled 49 in ANSI terminology.	
Thru/TF	Through Fault monitoring	
tIdiff	Current differential operating time	s
Ts	Secondary system time constant	s
Tx	Transmit: typically used to indicate a communication transmit line/pin.	
V	Voltage.	V
V<	An undervoltage element: could be labeled 27 in ANSI terminology	V
V<1	First stage of undervoltage protection: Could be labeled 27-1 in ANSI terminology.	V
V<2	Second stage of undervoltage protection: Could be labeled 27-2 in ANSI terminology.	V
V>	An overvoltage element: could be labeled 59 in ANSI terminology	V
V>1	First stage of overvoltage protection: Could be labeled 59-1 in ANSI terminology.	V
V>2	Second stage of overvoltage protection: Could be labeled 59-2 in ANSI terminology.	V
V0	Zero sequence voltage: Equals one third of the measured neutral/residual voltage.	V
V1	Positive sequence voltage.	V
V2	Negative sequence voltage.	V
V2>	A Negative Phase Sequence (NPS) overvoltage element: could be labeled 47 in ANSI terminology.	
$V2_{pol}$	Negative sequence polarizing voltage.	V
V_A	Phase A voltage: Might be phase L1, red phase.. or other, in customer terminology.	V
V_B	Phase B voltage: Might be phase L2, yellow phase.. or other, in customer terminology.	V
V_C	Phase C voltage: Might be phase L3, blue phase.. or other, in customer terminology.	V
Vf	Theoretical maximum voltage produced if CT saturation did not occur	V
Vin	Input voltage e.g. to an opto-input	V
V_k	Required CT knee-point voltage. IEC knee point voltage of a current transformer.	V
VN	Neutral voltage displacement, or residual voltage.	V
VN>	A residual (neutral) overvoltage element: could be labeled 59N in ANSI terminology.	V
V_n	Nominal voltage	V
Vn	The rated nominal voltage of the relay: To match the line VT input.	V
VN>1	First stage of residual (neutral) overvoltage protection.	V
VN>2	Second stage of residual (neutral) overvoltage protection.	V
VN3H>	A 100% stator earth (ground) fault 3rd harmonic residual (neutral) overvoltage element: could be labeled 59TN in ANSI terminology.	
VN3H<	A 100% stator earth (ground) fault 3rd harmonic residual (neutral) undervoltage element: could be labeled 27TN in ANSI terminology.	
Vres.	Neutral voltage displacement, or residual voltage.	V
Vs	Value of stabilizing voltage	V
V_x	An auxiliary supply voltage: Typically the substation battery voltage used to power the relay.	V

Symbol	Description	Units
WI	Weak Infeed logic used in teleprotection schemes.	
X	Reactance	None
X/R	Primary system reactance/resistance ratio	None
Xe/Re	Primary system reactance/resistance ratio for earth loop	None
Xt	Transformer reactance (per unit)	p.u.
Y	Admittance	p.u.
YN>	Neutral overadmittance protection element: Non-directional neutral admittance protection calculated from neutral current and residual voltage.	
Z	Impedance	p.u.
Z<	An under impedance element: could be labeled 21 in ANSI terminology.	
Z0	Zero sequence impedance.	
Z1	Positive sequence impedance.	
Z1	Zone 1 distance protection.	
Z1X	Reach-stepped Zone 1X, for zone extension schemes used with auto-reclosure.	
Z2	Negative sequence impedance.	
Z2	Zone 2 distance protection.	
ZP	Programmable distance zone that can be set forward or reverse looking.	
Zs	Used to signify the source impedance behind the relay location.	
Φal	Accuracy limit flux	Wb
Ψr	Remanent flux	Wb
Ψs	Saturation flux	Wb

Table 8 - Logic Symbols and Terms

8 LOGIC TIMERS

Logic symbols	Explanation	Time chart
	Delay on pick-up timer, t	
	Delay on drop-off timer, t	
	Delay on pick-up/drop-off timer	
	Pulse timer	
	Pulse pick-up falling edge	
	Pulse pick-up raising edge	

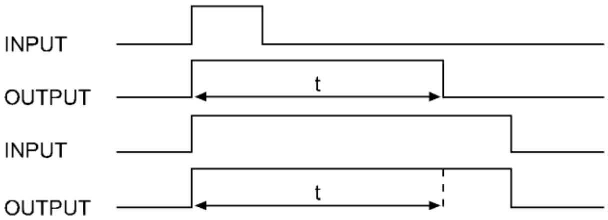
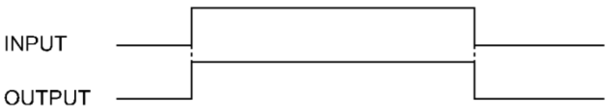
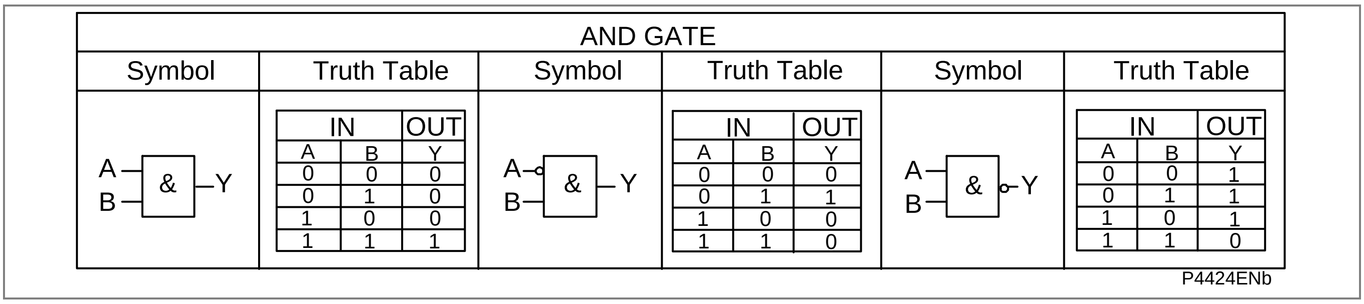
Logic symbols	Explanation	Time chart
Latching	Latch	
Dwell Timer	Dwell timer	
Straight	Straight (non latching): Hold value until input reset signal	

Table 9 - Logic Timers

9 LOGIC GATES

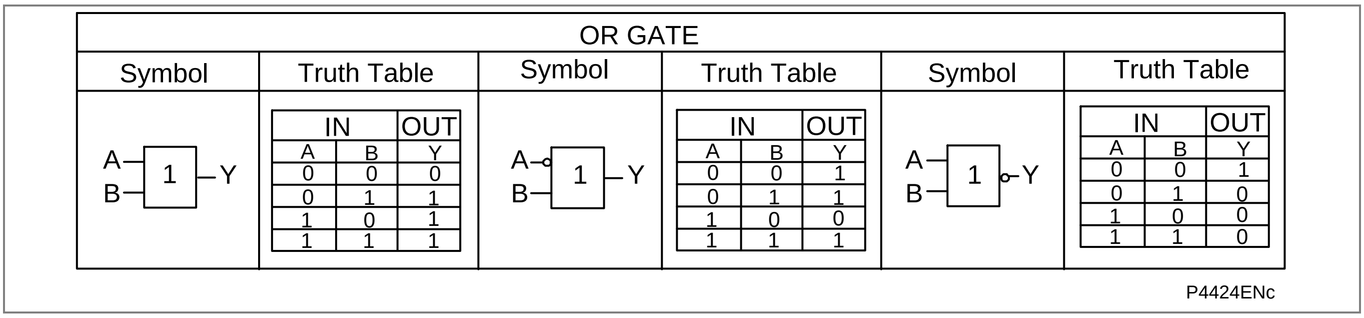


IN		OUT
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	0
1	1	0

IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

Figure 1 - Logic Gates - AND Gate

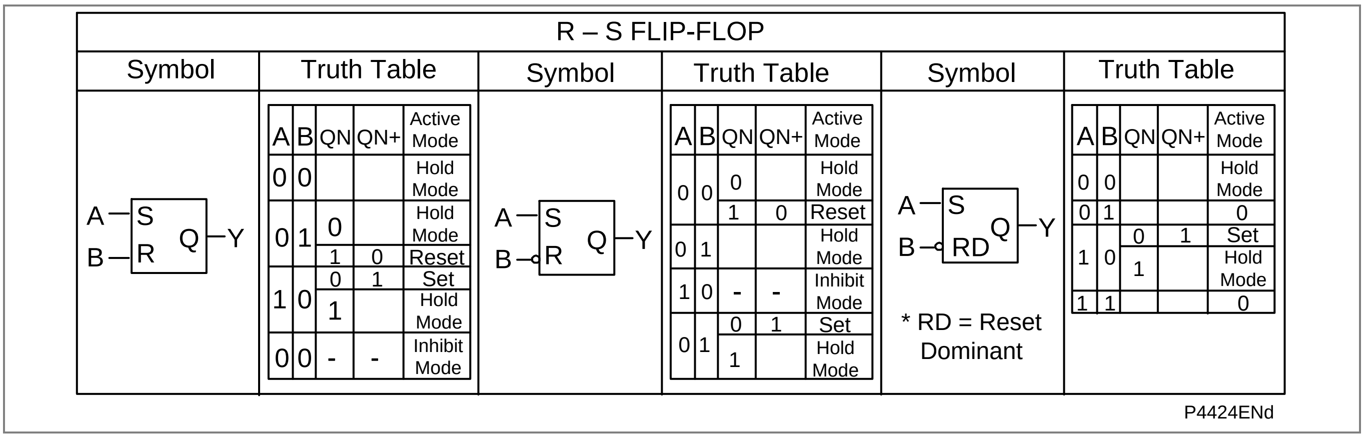


IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	0
1	1	1

IN		OUT
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

Figure 2 - Logic Gates - OR Gate

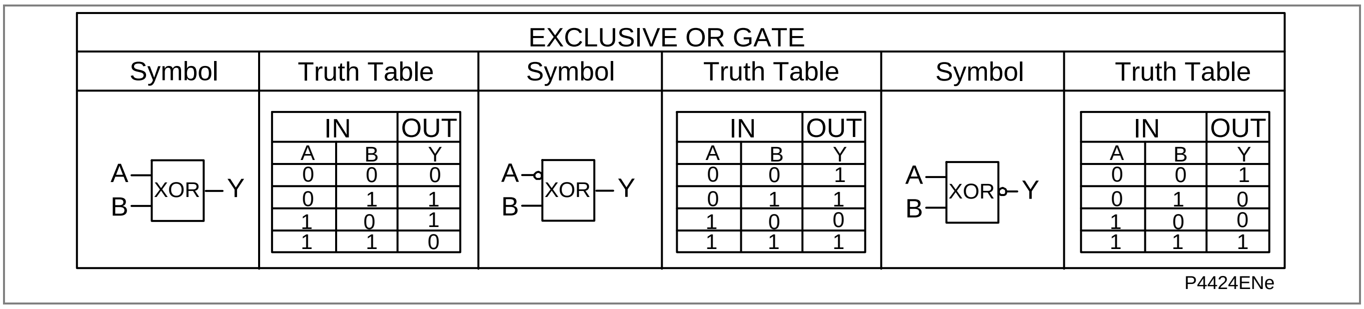


A	B	QN	QN+	Active Mode
0	0			Hold Mode
0	1	0		Hold Mode
		1	0	Reset
1	0	0	1	Set
		1		Hold Mode
0	0	-	-	Inhibit Mode

A	B	QN	QN+	Active Mode
0	0	0		Hold Mode
		1	0	Reset
0	1			Hold Mode
1	0	-	-	Inhibit Mode
0	1	0	1	Set
		1		Hold Mode

A	B	QN	QN+	Active Mode
0	0			Hold Mode
0	1			0
1	0	0	1	Set
		1		Hold Mode
1	1			0

Figure 3 - Logic Gates - R-S Flip-Flop Gate



IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

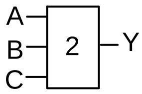
IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	0
1	1	1

IN		OUT
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

Figure 4 - Logic Gates - Exclusive OR Gate

PROGRAMMABLE GATE

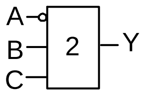
Symbol



Truth Table

IN			OUT
A	B	C	Y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

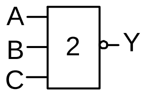
Symbol



Truth Table

IN			OUT
A	B	C	Y
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

Symbol



Truth Table

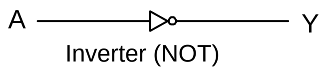
IN			OUT
A	B	C	Y
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

P4424ENf

Figure 5 - Logic Gates - Programmable Gate

NOT GATE

Symbol



Truth Table

IN	OUT
A	Y
0	1
1	0

P4424ENg

Figure 6 - Logic Gates - NOT Gate

Notes:

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