Easergy MiCOM P44x
(P442 & P444)

Numerical Distance Protection

P44x/EN M/Lb7

Software Version E1
Hardware Suffix M
Issue Date 01/2017

Technical Manual

Schneider Electric

CONTENTS

Date:	01/2017
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:	M
Software version:	E1
Connection diagrams:	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)

SAFETY INFORMATION

CHAPTER SI

Date:	07/2016	
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 (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)

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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(s) 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 appropriate 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 mm² (3.3 mm² 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

INTRODUCTION

CHAPTER 1

Date:	01/2017
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. MiCOM P44x (P442 & P444)
Hardware Suffix:	M
Software Version:	E1
Connection diagrams:	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)

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TABLES

FIGURES

Notes:

1 INTRODUCTION TO MiCOM GUIDES

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
	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**	**P44x/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**	**P44x/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**	**P44x/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**	**P44x/EN ST**
	List of all relay settings, including ranges, step sizes and defaults, together with a brief explanation of each setting.	
5	**Application Notes**	**P44x/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.	
6	**Using the PSL Editor**	**Px4x/EN SE**
	This provides a short introduction to using the PSL Editor application.	
7	**Programmable Logic**	**P44x/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.	
8	**Measurements and Recording**	**P44x/EN MR**
	Detailed description of the relays recording and measurements functions including the configuration of the event and disturbance recorder and measurement functions.	
9	**Product Design**	**P44x/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.	
10	**Commissioning**	**P44x/EN CM**
	Instructions on how to commission the relay, comprising checks on the calibration and functionality of the relay.	
11	**Test and Setting Records**	**P44x/EN RC**
	This is a list of the tests made and the settings stored on the MiCOM IED.	
12	**Maintenance**	**Px4x/EN MT**
	A general maintenance policy for the relay is outlined.	

	Description	Chapter Code
13	**Troubleshooting**	**Px4x/EN TS**
	Advice on how to recognize failure modes and the recommended course of action. Includes guidance on whom within Schneider Electric to contact for advice.	
14	**SCADA Communications**	**P44x/EN SC**
	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.	
15	**Installation**	**Px4x/EN IN**
	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.	
16	**Connection Diagrams**	**P44x/EN CD**
	A list of connection diagrams, which show the relevant wiring details for this relay.	
17	**Cyber Security**	**Px4x/EN CS**
	An overview of cyber security protection (to secure communication and equipment within a substation environment). Relevant cyber security standards and implementation are described too.	
18	**Dual Redundant Ethernet Board**	**Px4x/EN REB**
	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.	
19	**Parallel Redundancy Protocol (PRP) Notes**	**Px4x/EN PR**
	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.	
20	**High-availability Seamless Redundancy (HSR)**	**Px4x/EN HS**
	Introduction to the High-availability Seamless Redundancy (HSR); and how it is implemented on MiCOM-based products manufactured by Schneider Electric.	
21	**Version History (of Firmware and Service Manual)**	**P44x/EN VH**
	This is a history of all hardware and software releases for this product.	
	Symbols and Glossary	**Px4x/EN SG**
	List of common technical terms, abbreviations and symbols found in this documentation.	

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

MiCOM P44x (P442 & P444) Numerical Full Scheme Distance Relays provide comprehensive distance protection for different applications like: lines, cables, tapped lines, lines with multiple zero sequence sources, non-homogeneous lines, series compensated lines and parallel lines.

The independently settable resistive reach for each zone allows easy application to short lines and cable protection. Using well-proven, patented techniques to directionalise, and making full use of digital memory, the relays can be applied in situations that can cause classic distance implementations to maloperate (crosscountry faults, close-up faults, etc.).

The MiCOM P442 & P444 have an in-built library of channel aided scheme logic, supplementary and back-up protection. It provides complete protection (4 alternative setting groups) to solidly earthed systems from distribution to transmission voltage levels.

Three phase tripping with faulted phase indication is provided for all protection functions. Single-phase tripping is also allowed for the distance protection and the channel aided DEF protection (67N).

3.1 Functional Overview

The P442 and P444 distance relays equipped with 150MHz CPU and coprocessor board have been enhanced as described in Table 1:

ANSI	IEC 61850	Features	P442	P444
21P	PDIS	Quadrilatéral full scheme phase distance (6 zones)	Yes	Yes
21G	PDIS	Quadrilatéral full scheme ground distance (6 zones)	Yes	Yes
50/51/67	OcpPTOC / RDIR	Directional / non-directional phase overcurrent (2 stages)	Yes	Yes
50N / 51N / 67N	EfdPTOC / RDIR	Directional / non-directional stand by earth fault (2 stages)	Yes	Yes
67N	EfaPSCH	Channel aided directional earth fault protection (DEF)	Yes	Yes
32N		Directional zero sequence power protection	Yes	Yes
67/46	NgcPTOC / RDIR	Directional / non-directional negative sequence overcurrent	Yes	Yes
27	PTUV	Undervoltage (4 stages, 1st stage DT and IDMT)	Yes	Yes
59	PTOV	Overvoltage (4 stages, 1st stage DT and IDMT)	Yes	Yes
37		3-phase undercurrent (2 stages)	Yes	Yes
81U		Underfrequency (4 stages)	Yes	Yes
81O		Overfrequency (2 stages)	Yes	Yes
49	PTTR	Thermal overload protection	Yes	Yes
50 / 27	PSOF	Switch on to fault / trip on reclose (SOTF/TOR)	Yes	Yes
78 / 68	RPSB	Power swing blocking & Out of step tripping (using PSL)	Yes	Yes
85	PSCH	Channel aided schemes (PUP, POP, Blocking)	Yes	Yes
		Weak Infeed (WI) Echo logic	Yes	Yes
		Accelerated trip feature: Loss of Load - Zx extension	Yes	Yes
46BC		Broken conductor (open jumper)	Yes	Yes
50ST	OcpPTOC	Stub bus protection	Yes	Yes
50BF	RBRF	Circuit breaker failure	Yes	Yes
	PTRC	Tripping	1/3p	1/3p
79	RREC	Autoreclose (4 shots)	1/3p	1/3p
25	RSYN	Check synchronism	option	option

ANSI	IEC 61850	Features	P442	P444
VTS		Voltage Transformer Supervision (1, 2 & 3 phase fuse failure detection)	Yes	Yes
CTS		Current Transformer Supervision	Yes	Yes
CVTS		Capacitive Voltage Transformer Supervision	Yes	Yes
51FF	PTOC	Emergency Overcurrent on VT failure	Yes	Yes
	OptGGIO	Digital inputs	16	24
	RlyGGIO	Output relays (fast output optional)	21	32 or 46
		Front communication port (RS232/K-bus)	Yes	Yes
		Rear communication port (RS485/Optic/Ethernet) *	Yes	Yes
		Second rear communication port (RS232/RS485/K-Bus)*	option	option
		Time synchronization port (IRIG-B modulated/un-modulated).*	option	option

*Note ** *It may be possible to get all in one particular model.*

Note *NA:Not applicable*

Table 1 - Overview of protection functions

To complement the wide range of protection functions listed in the table, the P442 and P444 relays are provided with the following **measurement, control, monitoring, post fault analysis** and **self-diagnostic** functions.

- Fault locator
- Display of instantaneous measured and derived values
- Circuit breaker control, status & condition monitoring.
- Trip circuit and coil supervision
- 4 alternative setting groups
- Programmable scheme logic
- Sequence of event recording
- Comprehensive disturbance recording (waveform capture)
- User configurable LEDs
- Local and remote communication ports
- Multiple communication protocol and interface options
- Time synchronisation
- Fully customisable menu texts
- Multi level password protection
- Test facilities
- Power-up diagnostics and continuous self monitoring of the relay
- User friendly setting and analysis software (MiCOM S1 Studio)
- Password protection
- Read only mode

3.1.1 Application Overview

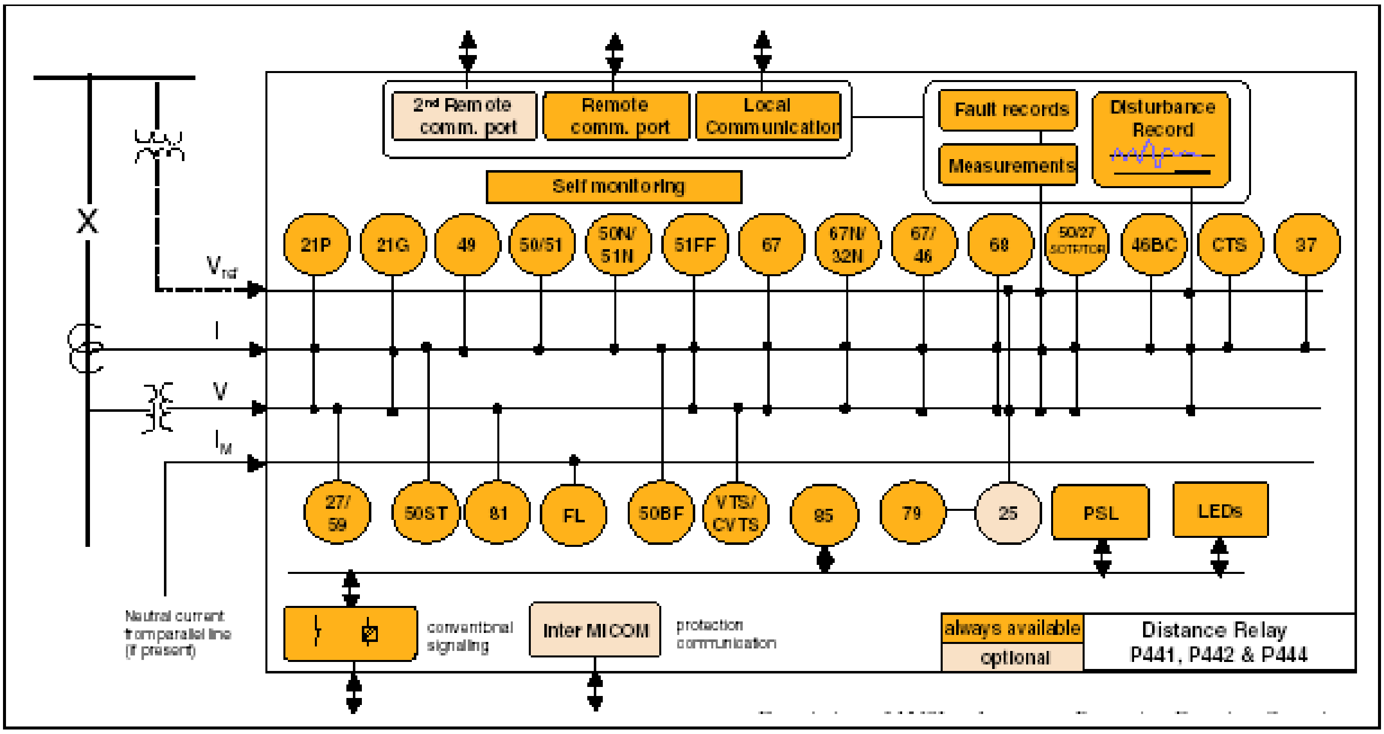

Figure 1 - Functional diagram

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

3.1.2 Rating Options

Features	P442	P444
24 – 32 Vdc only	Yes	Yes
48 – 110 Vdc	Yes	Yes
110 – 250Vdc (100 – 240Vac)	Yes	Yes

Table 2 - Auxiliary Voltage Rating options

Features	P442	P444
Dual rated CT (1&5A: 100-120V)	Yes	Yes
Module Sum (Σ1A / PXDB)	Yes	Yes

Table 3 - In/Vn Rating boards options

3.1.3 Communication Protocol Options

Features	P442	P444
K-Bus / Courier	Yes	Yes
MODBUS	Yes	Yes
VDEW (IEC 60870-5-103) (RS485 or Fibre Optic)	Yes	Yes
DNP3.0	Yes	Yes
IEC 61850 + Courier via rear RS485 port	Yes	Yes
IEC 61850 + IEC60870-5-103 via rear RS485 port	Yes	Yes

Table 4 - Communication protocol options

3.2 Ordering Options

The options vary from one product to another:

- P442 Numerical Distance Protection Relay
- P444 Numerical Distance Protection 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.*

3.2.1 P442 Numerical Distance Protection Relay

Relay Type (Distance protection relay)	P442						M					
Nominal Auxiliary Voltage												
24 – 32V dc		9										
48 – 110V dc		2										
110 – 250V dc (100 – 240V ac)		3										
In/Vn Rating												
Dual rated CT (1 & 5A : 100 - 120V)			1									
Module Sum (∑1A / PXDB)			5									
Hardware options												
Standard version				1								
IRIG-B Only (Modulated)				2								
Fibre optic converter (Courier, Modbus,IEC60870-5-103 or DNP3) (Note: converts RS485 port to fibre optic; NOT extra port)				3								
IRIG-B input and Fibre optic converter (Courier, Modbus,IEC60870-5-103 or DNP3) (Note: converts RS485 port to fibre optic; NOT extra port)				4								
Single Ethernet 100Mbit/s				6								
Second Rear Comms + InterMiCOM				7								
IRIG-B (Modulated) + Second Rear Comms + InterMiCOM				8								
Single Ethernet (100Mbit/s) plus IRIG-B (Modulated)				A								
Single Ethernet (100Mbit/s) plus IRIG-B (De-modulated)				B								
InterMiCOM + Courier Rear Port				E								
InterMiCOM + Courier Rear Port + IRIG-B modulated				F								
Redundant Ethernet Self-Healing Ring, 2 multi-mode fibre ports + Modulated IRIG-B				G								
Redundant Ethernet Self-Healing Ring, 2 multi-mode fibre ports + Un-modulated IRIG-B				H								
Redundant Ethernet RSTP, 2 multi-mode fibre ports + Modulated IRIG-B				J								
Redundant Ethernet RSTP, 2 multi-mode fibre ports + Un-modulated IRIG-B				K								
Redundant Ethernet Dual-Homing Star, 2 multi-mode fibre ports + Modulated IRIG-B				L								
Redundant Ethernet Dual-Homing Star, 2 multi-mode fibre ports + Un-modulated IRIG-B				M								
Redundant Ethernet PRP, 2 multimode fibre ports + Modulated IRIG-B				N								
Redundant Ethernet PRP, 2 multimode fibre ports + De-modulated IRIG-B				P								
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								
Software options												
16 Logic Inputs & 21 Relay Outputs without check synchronising					A							
16 Logic Inputs & 21 Relay Outputs with check synchronising					B							
16 Logic Inputs & 18 Relay Outputs (4 High Break) with check synchronising					C							
Protocol 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 DNP3 over Ethernet and DNP3.0 via rear RS485 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 DNP3 over Ethernet and DNP3.0 via rear RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required	L
Mounting	
Panel / flush Mounting	M
Language	
English, French, German, Spanish	0
English, French, German, Italian	4
Chinese, English or French via HMI, with English or French only via Communications port	C
Software Version	
Unless specified the latest version will be delivered	* *
Settings File	
Standard version	8
Customer engineered version: general	9
Hardware Suffix	
Model and hardware version dependant	*

3.2.2 P444 Numerical Distance Protection Relay

Relay Type (Distance protection relay)	P444
Nominal Auxiliary Voltage	
24 – 32V dc	9
48 – 110V dc	2
110 – 250V dc (100 – 240V ac)	3
In/Vn Rating	
Dual rated CT (1&5A: 100-120V)	1
IEC 61850-9-2-LE Sampled Analogue values Ethernet board	A
Module Sum (Σ1A / PXDB)	5
Hardware options	
Standard version	1
IRIG-B input	2
Fibre optic converter (IEC60870-5-103)	3
IRIG-B input and Fibre optic converter (IEC60870-5-103)	4
Ethernet 10Mbits	5
Rear Comms + InterMiCOM	7
Rear Comms + IRIB-B + InterMiCOM	8
Single Ethernet (100Mbit/s) plus IRIG-B (Modulated)	A
Single Ethernet (100Mbit/s) plus IRIG-B (De-modulated)	B
InterMiCOM + Courier Rear Port	E
InterMiCOM + Courier Rear Port + IRIG-B modulated	F
Redundant Ethernet Self-Healing Ring, 2 multi-mode ST fibre ports + Modulated IRIG-B	G
Redundant Ethernet Self-Healing Ring, 2 multi-mode ST fibre ports + Un-modulated IRIG-B	H
Redundant Ethernet RSTP, 2 multi-mode ST fibre ports + Modulated IRIG-B	J
Redundant Ethernet RSTP, 2 multi-mode ST fibre ports + Un-modulated IRIG-B	K
Redundant Ethernet Dual-Homing Star, 2 multi-mode ST fibre ports + Modulated IRIG-B	L
Redundant Ethernet Dual-Homing Star, 2 multi-mode ST fibre ports + Un-modulated IRIG-B	M
Redundant Ethernet PRP, 2 multimode ST fibre ports + Modulated IRIG-B	N
Redundant Ethernet PRP, 2 multimode ST fibre ports + De-modulated IRIG-B	P
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
Models	

1 & 3 Pole tripping/reclosing with 24 inputs & 32 outputs	A, B, D, E
1 & 3 Pole tripping/reclosing with 24 inputs & 46 outputs	H, J, K, L
1 & 3 Pole tripping/reclosing with 24 logic inputs & 34 relay outputs (12 high break)	C
Software options	
Without check synchronising *	A or H
With check synchronising *	B-E, J-L
* Dependent on amount of I/O	
Protocol 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 DNP3 over Ethernet and DNP3.0 via rear RS485 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 DNP3 over Ethernet and DNP3.0 via rear RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required	L
Mounting	
Panel / flush Mounting	M
19” Rack mounting	N
Language	
English, French, German, Spanish	0
English, French, German, Italian	4
Chinese, English or French via HMI, with English or French only via Communications port	C
Software Version	
Date and application dependant	* *
Settings File	
Standard version	8
Customer engineered version: General	9
Hardware Suffix	
Model and hardware version dependant	*

TECHNICAL DATA

CHAPTER 2

Date:	01/2017
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:	M
Software version:	E1
Connection diagrams:	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)

CONTENTS

Notes:

1 MECHANICAL SPECIFICATION

1.1 Design

Modular MiCOM Px40 platform relay available in three different case sizes:

P442 60TE (12”),

P444 80TE (16”).

Mounting:

front of panel flush mounting,

rack mounted (19” ordering option).

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

60TE: approx.	9.2kg
80TE: approx.	11.0kg

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 (RP1)

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 or DNP3.0 protocol (ordering option).
Isolation to SELV (Safety Extra Low Voltage) level. Ethernet (copper and fibre).

2.7 Optional Second Rear Communication 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.

- PEB = Protective equipotential bonded
- SELV = Safety/Separated extra low voltage

Both PEB and SELV circuits are safe to touch after a single fault condition.

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).

Optical budget: 5.6 dB. Data rate: 2.5 Mbits. Max Length: 1000 m

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

2.10.1 100 Base TX 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

2.10.2 100 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:	ST/LC Connector Optical Interface (depending on model)

Transmitter Optical Characteristics

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.

Receiver Optical Characteristics

Parameter	Sym	Min.	Typ.	Max.	Unit
Input Optical Power Minimum at Window Edge	P_{IN} Min. (W)		–33.5	–31	dBm avg.
Input Optical Power Minimum at Eye Center	P_{IN} Min. (C)		–34.5	–31.8	dBm avg.
Input Optical Power Maximum	P_{IN} Max.	–14	–11.8		dBm avg.

2.11 Fiber Defect Connector (Watchdog Relay)

Redundant Ethernet board

Connector (3 terminals):	2 NC contacts
Rated voltage:	250 V
Continuous current:	5 A
Short duration current:	30 A for 3 s

2.12 Breaking Capacity

DC: 50 W resistive
DC: 25 W resistive
AC: 1500 VA resistive (cos ϕ = unity)
AC: 1500 VA inductive (cos ϕ = unity)
Subject to maxima of 5 A and 250 V

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:	<0.15VA at In (1A)
Nominal burden per phase:	<0.30VA at In (5A)
Impedance per phase 1 A:	<40mΩ over 0 - 30In
Impedance per phase 5 A:	<8mΩ over 0 - 30In
Thermal withstand:	continuous, 4 In for 10 s: 30 In for 1 s; 100 In

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

Caution ***Separate terminals are provided for the 1A and 5A windings, with the neutral input of each winding sharing one terminal.***

3.3 AC Voltage

Nominal voltage (Vn):	100 to 120 V phase-phase
Nominal burden per phase:	< 0.02 VA at 110/√3 V
Thermal withstand:	continuous 2 Vn for 10s: 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),
(iii) 87 to 300V (dc), 80 to 265V (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: 11W or 24 VA. (Extra 1.25 W when fitted with second rear communications board).

Additions for energized binary inputs/outputs:

For each opto input:

0.09 W (24 to 54 V)

0.12 W (110/125 V)

0.19 W (220/250 V)

For each energized output relay: 0.13W

4.4 Power-up Time

Time to power up < 11 s.

4.5 Power Supply Interruption

Per IEC 60255-11, EN / IEC 60255-26

The relay will withstand a 20 ms interruption in the DC auxiliary supply, without de-energizing.

Per IEC 61000-4-11, EN / IEC 60255-26

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

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
The operating range shall be 40 V to 60 V with an alarm raised at <35 V

4.8 Digital ("Opto") Inputs

Universal opto inputs with programmable voltage thresholds. May be energized from the 48V field voltage, or the external battery supply.

Rated nominal voltage: 24 to 250Vdc
Operating range: 19 to 265Vdc
Withstand: 300Vdc.
Nominal pick-up and reset thresholds:
Pick-up: approx. 70% of battery nominal set,
Reset: approx. 64% of battery nominal set.

Recognition time:
<2 ms with long filter removed.
<10 ms with half cycle ac immunity filter on.

5 OUTPUT CONTACTS

5.1 Standard Contacts

General purpose relay outputs for signalling, tripping and alarming:

Rated voltage:	300 V	
Continuous current:	10 A	
Short-duration current:	30 A for 3 s	
Making capacity:	250A for 30 ms	
Breaking capacity:	DC:	50W resistive
	DC:	62.5W inductive (L/R = 50ms)
	AC:	2500VA resistive (cos ϕ = unity)
	AC:	2500VA inductive (cos ϕ = 0.7)
Response to command:	< 5ms	
Durability:	Loaded contact: 10000 operations minimum,	
	Unloaded contact: 100000 operations minimum.	

5.2 Fast Operation and High Break Contacts

Dedicated purpose relay outputs for tripping: Uses IGBT technology

Make and Carry:	30 Amps for 3 sec, 30A @ 250V resistive
Carry:	250 Amps dc for 30ms
Continuous Carry:	10 Amps dc
Break Capacity:	10 Amps @ 250V resistive (10,000 operations)
	10 Amps @ 250V L/R=40ms
Operating time:	<200us & Reset time: 7.5ms

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 Pollution Degree

Per IEC61010-1:1990/A2:1995:

Normally only non-conductive pollution occurs. Occasionally a temporary conductivity caused by condensation must be expected.

6.4 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

8.4.1 Fast Transient Disturbances on Power Supply (Common Mode Only)

4 kV, 5 ns rise time, 50 ns decay time, 5 kHz repetition frequency, 15 ms burst, repeated every 300 ms for 1 min in each polarity, with a 50 Ω source impedance.

8.4.2 Fast Transient Disturbances on I/O Signal, Data and Control Lines (Common Mode Only)

4 kV, 5 ns rise time, 50 ns decay time, 5 kHz repetition frequency, 15 ms burst, repeated every 300 ms for 1 min in each polarity, with a 50 Ω source impedance.

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 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).

8.8 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.

8.9 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%.

8.10 Radiated Immunity from Digital Radio Telephones

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

8.11 Immunity to Conducted Disturbances Induced by Radio Frequency Fields

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

8.12 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.

8.13 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)

8.14 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.

9 EU DIRECTIVES

9.1 EMC Compliance

2004/108/EC:
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

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

9.3 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.

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 TIMING AND ACCURACY

11.1 Performance Data

For all accuracies specified, the repeatability is ±5%, unless otherwise specified

12 PROTECTION FUNCTIONS

12.1 Distance Protection

All quoted operating times include the closure of the trip output contact.

12.1.1 50Hz Operation

Minimum tripping time:	13ms	(SIR = 5)
	14ms	(SIR = 30)
Maximum tripping time:	18ms	(SIR = 5)
	21ms	(SIR = 30)
Typical tripping time:	17ms	(SIR = 5)
	17.5ms	(SIR = 30)

100% of faults up to 75% of Zone 1 reach setting trip subcycle at SIR=5.

99% of faults up to 75% of Zone 1 reach setting trip subcycle at SIR=30.

12.1.2 60Hz Operation

Minimum tripping time:	13ms	(SIR = 5)
	13ms	(SIR = 30)
Maximum tripping time:	16.5ms	(SIR = 5)
	18ms	(SIR = 30)
Typical tripping time:	14ms	(SIR = 5)
	16ms	(SIR = 30)

100% of faults up to 75% of Zone 1 reach setting trip subcycle at SIR=5.

88% of faults up to 75% of Zone 1 reach setting trip subcycle at SIR=30.

Accuracy

Characteristic shape, up to SIR = 30: ±5% for on-angle fault (the set line angle)
±10% off-angle

(Example: For a 70 degree set line angle, injection testing at 40 degrees would be referred to as “off-angle”).

Zone time delay deviations: ±20 ms or 2%, whichever is greater.

Sensitivity

Settings < 5/In Ω: (0.05In*5/(setting*In)) ±5%
Settings > 5/In Ω: 0.05 In ±5%

Distance Elements

Pick-up:	Setting ±5%
Zone timer deviation:	20ms or ±2%, whichever is greater
Timer accuracy:	±2ms
Minimum trip level for IDMT elements:	1.05 × Setting ± 5%
Inverse time stages:	±40ms or 5%, whichever is greater
Definite time stages:	±40ms or 2%, whichever is greater
Repeatability:	5%
Transient Overreach: Additional tolerance due to increasing X/R ratios:	±5% over the X/R ratio from 1 to 90
Breaker fail timers accuracy:	20ms or ±2%, whichever is greater

12.2 Directional and Non-Directional Overcurrent

(I>1, I>2, I>3 or I>4)

Accuracy

DT Pick-up:	Setting ±5%
IDMT Pick-up	1.05 × Setting ±5%
DT reset:	0.95 × Setting ±2%
IDMT reset:	0.95 × Setting ±5%
Definite time stages:	±20ms or ±2%, whichever is greater
Inverse time stages:	±40ms or ±5%, whichever is greater

12.3 Negative Sequence Overcurrent

(I2>1, I2>2, I2>3 or I2>4)

Accuracy

Zone 1:

Pick-up:	Setting ±5%
Reset:	0.95 × Setting ±5%
Definite time stages:	±40ms or ±5%, whichever is greater

12.4 Broken Conductor Detection

(I2/I1)

Accuracy

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

12.5 Directional and Non-Directional Earth Fault Protection

(IN>1, IN>2, IN>3 or IN>4)

Accuracy

DT Pick-up:	Setting ±5%
IDMT Pick-up	1.05 ×Setting ±5%
Drop-off:	0.95 × setting ±5%
Definite time stages:	±20ms or ±2%, whichever is greater
DT reset:	0.95 × Setting ±2%
Inverse time stages:	40ms or ±5%, whichever is greater
IDMT reset:	0.95 × Setting ±5%

12.6 Aided Directional Earth Fault (DEF) Protection

Accuracy

Zero Sequence Polarisation pick-up:	Setting ±10% with relay characteristic angle = ±90°
Negative Sequence Polarisation pick-up:	Setting ±5%

12.7 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.

12.8 Neutral Displacement/ Residual OverVoltage

(VN>1, VN>2)

Accuracy

DT Pick-up:	Setting ±5%
IDMT Pick-up:	1.05 x setting ±5%
Definite time operation:	±20ms or 2%, whichever is greater
Instantaneous operation:	<50ms
IDMT characteristic shape:	±40ms or 2%, whichever is greater
Reset:	0.95 × Setting ±5%

12.9 Undercurrent Protection

(I<1,I<2)

Accuracy

Pick-up:	±10% or 0.025In, whichever is greater
Drop-off:	±5%
Timer accuracy:	±40ms or 2%, whichever is greater
Reset:	<15ms

12.10 Under Voltage

(V<1, V<2, V<3 or V<4)

Accuracy

DT Pick-up:	Setting ±2%
IDMT Pick-up:	0.95 × Setting ±2%
Definite time operation:	±20ms or 2%, whichever is greater
IDMT characteristic shape:	±40ms or 2%, whichever is greater
Reset:	1.05 × Setting ±5%

12.11 Over Voltage

(V>1, V>2, V>3 or V>4)

Accuracy

DT Pick-up:	Setting ±1%
IDMT Pick-up:	1.05 x Setting ±2%
Definite time operation:	±20ms or 2%, whichever is greater
IDMT characteristic shape:	±40ms or 2%, whichever is greater
Reset:	0.95 × Setting ±5%

12.12 Circuit Breaker Fail and Undercurrent

Accuracy

Pick-up:	±10% or 0.025In, whichever is greater
Operating time:	<12ms
Definite time operation:	±20ms or 2%, whichever is greater

12.13 Voltage Transformer Supervision

Accuracy

Fast block operation:	<1 cycle
Fast block reset:	<1.5 cycles
Definite time operation:	±20ms or 2%, whichever is greater

12.14 Current Transformer Supervision

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

12.15 CB State Monitoring and Condition Monitoring

Accuracy

Timers:	±2% or 20 ms whichever is greater
Broken current accuracy:	±5%

13 PROGRAMMABLE SCHEME LOGIC

Accuracy

Output conditioner timer:	Setting ±2% or 20 ms whichever is greater
Dwell conditioner timer:	Setting ±2% or 20 ms whichever is greater
Pulse conditioner timer:	Setting ±2% or 20 ms whichever is greater

13.1 Autoreclose and Check Synchronism

Accuracy

Timers:	Setting ±20ms or 2%, whichever is greater

14 MEASUREMENTS AND RECORDING FACILITIES

14.1 Measurements

Typically ±1%, but ±0.5% between 0.2 - 2In/Vn

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 IRIG-B AND REAL TIME CLOCK

15.1 Modulated IRIG-B

Modulation ratio:	1/3 or 1/6
Input signal peak-peak amplitude:	200 mV to 20 V
Input impedance at 1000Hz:	6000 Ω
External clock synchronization:	Conforms to IRIG standard 200-98, format B

15.2 Un-modulated IRIG-B

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

15.3 Real Time Clock

Real time clock accuracy: < ±2 seconds/day

16 FAULT AND DISTURBANCE RECORDS

Accuracy

Time and date stamping:	±2ms of applied fault/event
Fault clearance time:	±2%
CB operating time:	±5ms
Protection operating time:	±2%
Waveshape:	Comparable with applied quantities, ±5% of applied quantities
Trigger positions:	±2%
Record length:	8 records each of 1.8s duration (1.5s at 60Hz)

16.1 Fault Locator

Accuracy

Fault location: ±2% of line length (under reference conditions)*
** Reference conditions solid fault applied on line.*

16.2 Reference Conditions

Ambient temperature:	20°C
Frequency Tracking Range	45 to 65Hz

16.3 Breaker Failure

Accuracy

Reset time < 40ms ±2%
Thresholds: settings ±5%

17 SETTINGS, MEASUREMENTS AND RECORDS LIST

17.1 Global Settings (System Data)

Language: English / French / German / Spanish / Russian / Chinese
Frequency: 50/60 Hz

17.2 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		

Distance Protection:	Disabled/Enabled
Power Swing:	Disabled/Enabled
Back-Up I>:	Disabled/Enabled
Negative Sequence overcurrent:	Disabled/Enabled
Broken Conductor:	Disabled/Enabled
Earth Fault overcurrent protection:	Disabled/ Zero sequence power/ Earth fault overcurrent
Aided Directional Earth Fault (DEF):	Disabled/Enabled
Voltage Protection:	Disabled/Enabled
Circuit Breaker Fail & I<:	Disabled/Enabled
Supervision (Voltage, Current or Capacitive Voltage Transformer):	Disabled/Enabled
System Checks:	Disabled/Enabled
Thermal Overload:	Disabled/Enabled
I< Protection:	Disabled/Enabled
Residual Overvoltage protection:	Disabled/Enabled
Frequency Protection:	Disabled/Enabled
Internal Autoreclose:	Disabled/Enabled
Input Labels:	Invisible/Visible
Output Labels:	Invisible/Visible
CT & VT Ratios:	Invisible/Visible
Record Control:	Invisible/Visible
Disturbance Recorder:	Invisible/Visible
Measurement Setup:	Invisible/Visible
Communication Settings:	Invisible/Visible
Commission Tests:	Invisible/Visible
Setting Values:	Primary/Secondary
Control Input:	Invisible/Visible
Control Input Config:	Invisible/Visible
Control Input Labels:	Invisible/Visible
Direct Access:	Disabled/Enabled
InterMiCOM:	Disabled/Enabled
Ethernet NCIT:	Invisible/Visible
Function key:	Invisible/Visible
Virtual Input Labels:	Invisible/Visible
Virtual Output Labels:	Invisible/Visible
User Alarm Labels:	Invisible/Visible
RearPortt1ReadOnly	Disabled/Enabled
RearPort2ReadOnly	Disabled/Enabled
RearNICReadOnly	Disabled/Enabled
LCD Contrast:	(Factory pre-set)

17.3 Distance Protection

17.4 Line Setting

Line Length (Ln):	0.3 to 1000km (step 0.010) or 0.2 to 625 miles (step 0.005)
Line Impedance:	0.001V / In to 500V / In or 0.001 / In W
Positive sequence angle (Line Angle, ϑ_1):	–90.0° to +90° (step 0.1°)

17.5 Zone Setting

Zone Status:	Z1X Enabled/Disabled Z2 Enabled/Disabled ZP Enabled/Disabled ZQ Enabled/Disabled Z3 Enabled/Disabled Z4 Enabled/Disabled
Z1 (Impedance reach:)	0.001/In to 500/In Ω (step 0.001/In Ω)
Z1X	0.001/In to 500/In Ω (step 0.001/In Ω)
kZ1 residual compensation factor:	0 to 7 (step 0.001)
KZ1 residual compensation angle:	0 to +360° (step 0.1°)
R1G (Resistive reach for phase-earth fault):	0 Ω to 400/In Ω (step 0.01/In Ω)
R1Ph (Resistive reach for phase-phasefault):	0 Ω to 400/In Ω (step 0.01/In Ω)
tZ1 (time-delay for Zone 1):	0 to 10s (step 0.002s)
Z2:	0.001/In to 500/In Ω (step 0.001/In/Ω)
kZ2 res comp:	0 to 7 (step 0.001)
kZ2 Angle:	0 to 360° (step 0.1°)
R2G:	0 Ω to 400/In Ω (step 0.01/In Ω)
R2Ph:	0 Ω to 400/In Ω (step 0.01/In Ω)
tZ2:	0 to 10s (step 0.002s)
Z3:	0.001/In to 500/In Ω (step 0.001/In/Ω)
kZ3/4 res comp:	0 to 7 (step 0.001)
kZ3/4 Angle:	0 to 360° (step 0.1°)
R3G-R4G:	0 Ω to 400/In Ω (step 0.01/In Ω)
R3Ph-R4Ph:	0 Ω to 400/In Ω (step 0.01/In Ω)
tZ3:	0 to 10s (step 0.002s)
Z4:	0.001/In to 500/In Ω (step 0.01/In Ω)
tZ4:	0 to 10s (step 0.01s)
Zone P – Directionality	Forward/Reverse
Zp:	0.001/In to 500/In Ω (step 0.001/In/Ω)
kZp res comp:	0 to 7 (step 0.001)
kZp Angle:	0 to 360° (step 0.1°)
RpG:	0 Ω to 400/In Ω (step 0.01/In Ω)
RpPh:	0 Ω to 400/In Ω (step 0.01/In Ω)
tZp:	0 to 10s (step 0.002s)
Zone Q – Directionality	Forward/Reverse
Zq:	0.001/In to 500/In Ω (step 0.001/In/Ω)
kZq res comp:	0 to 7 (step 0.001)
kZq Angle:	0 to 360° (step 0.1°)
RqG:	0 Ω to 400/In Ω (step 0.01/In Ω)
RqPh:	0 Ω to 400/In Ω (step 0.01/In Ω)
tZq:	0 to 10s (step 0.002s)

17.6 Zone Setting Other Parameters

Series Compensated Line:	Enabled/Disabled
Overlap Z mode:	Enabled/Disabled
Z1m Tilt Angle:	-45° to +45° (step 1°)
Z1p Tilt Angle:	-45° to +45° (step 1°)
Z2/Zp/Zq Tilt Angle	-45° to +45° (step 1°)
Fwd Z Chgt Delay:	0 to 100ms (step 1ms)
Volt. Memory Validity:	0 to 10s (step 10ms)
Earth Current detection:	0 to 0.1×I1 (step 0.01×I1)

Fault locator:

KZm mutual Comp:	0 to 7 (step1)
KZm Angle:	0 to 360° (step 1°)

Smart Zone * 0 to 100 % (step 1%)

17.7 Busbar Isolation Mode*

Busbar status Enabled/Disabled

*: D6.x

17.8 Distance Scheme Setting

Program mode Standard or open scheme

Standard Modes:
Basic + Z1X,
POP Z1,
POP Z2,
PUP Z2,
PUP Forward,
BOP Z1,
BOP Z2.

Note *POP = Permissive Overreach Protection*
PUP = Permissive Underreach Protection
BOP = Blocking Overreach Protection

Fault type:

Phase to Ground,
Phase to Phase,
Both enabled.

Trip Mode:

Force 3 Pole,
1 Pole Z1 and Carrier Received (CR),
POP Z1 Z2 and CR.

Signal sent from a zone to the relays setting (open scheme):

CsZ1 (Carrier sent by Z1),
CsZ2,
CsZ4.

Aided scheme on Carrier receipt "Dist CR" (open scheme):

None,
PermZ1: Permissive Z1 (Z1 can trip without waiting the end of tZ1 timout),
PermZ2,
PermFwd (forward),
Blocking Z1 (BlkZ1) (Z1 can only trip if a Carrier is not received),
BlkZ2.

Additional time-delay for PUP Z2, PUP FWD, POP Z1 and POP Z2 schemes:
0 to 1s (stem 2ms)

tReversal Guard: 0 to 0.15s (step 2ms)

Unblocking schemes (with permissive schemes):

None,
Loss of Guard mode,
Loss of Carrier mode.

TOR (Trip On Reclose)–SOTF (Switch On To Fault) modes enabled or disabled for:

TOR logic in case of fault in Z1, Z2, Z3 or All Zones,
SOTF logic in case of fault in Z1, Z2, Z3 or All Zones,
TOR or SOTF in Distance scheme,
SOTF logic in case of fault Z1+Rev, Z2+Rev or I>3 Enabled,
SOTF initiated by level detectors,

SOTF Delay: 10 to 3600s (step 1s)

Z1X extension on channel fail: Enabled/Disabled

17.9 Weak Infeed

Mode Status:	Disabled/Echo/WI Trip & Echo/PAP
Single Pole:	Disabled/Enabled
V< Threshold:	10 to 70V (step 5V)
Trip time delay:	0 to 1s (step 2ms)

17.10 Loss of Load (LoL)

Mode Status:	Enabled/Disabled
LoL on Channel failed:	Enabled/Disabled
I<:	0.05×In to 1×In (step 0.05×In)
LoL Window:	0.01s to 0.1s (step 0.01s)

17.11 Power Swing Detection and Blocking

Power Swing detection boundaries:	
Delta R:	0 to 400/ In Ω (step 0.01/In Ω)
Delta X:	0 to 400/ In Ω (step 0.01/In Ω)
IN Status:	Enabled/Disabled
IN> (%max)	10% to 100% (step 1%)
I2> Status:	Enabled/Disabled
I2> (%max)	10% to 100% (step 1%)
Imax line Status:	Enabled/Disabled
Imax line> (%max):	1×In to 20×In (step 0.01×In)
Delta I Status:	Enabled/Disabled
Unblocking time-delay:	0 to 30s (step 0.1s)
Blocking zones:	
Z1/Z1X Block:	Yes/No
Z2 Block:	Yes/No
Zp Block:	Yes/No
Zq Block:	Yes/No
Z3 Block:	Yes/No
Z4 Block	Yes/No
Out of Step (OOS):	1 to 255 (step 1)
Stable swing:	1 to 255 (step 1)

17.12 Directional and Non Directional Overcurrent Protection (baBck-uP I>)

Directional and non directional I> protections:	I>1, I>2 (range 0.08–10×In)
Non directional I> protections:	I>3, I>4 (range 0.08–32×In)
I>1 Function / I>2 Function:	Disabled, Definite Time (DT), IEC Standard inverse IEC Very inverse IEC Extremely inverse UK Long Time Inverse, IEEE Moderately Inverse, IEEE Very Inverse IEEE Extremely Inverse US Inverse US Short Time Inverse
IN> (%max)	10% to 100% (step 1%)
I>1 / I>2 Directional:	Non-directional, Directional forward Directional reverse
I>1 / I>2 VTS Block:	Block/Non-directional
I>1 / I>2 current set:	0.08×In to 10.00×In (step 0.01×In)
I>1 / I>2 Time-delay:	0 to 100s (step 0.01s)
I>1 / I>2 Time-delay VTS:	0 to 100s (step 0.01s)
I>1 / I>2 Time Multiplier Setting (TMS):	0.025 to 1.2 (step 0.005)
I>1 / I>2 Time Dial:	0.5 to 15 (step 0.1)
I>1 / I>2 Reset characteristics:	DT or Inverse
I>1 / I>2 tReset	0 to 100s (step 0.01s)
I>3 Status / I>4 Status:	Enabled/Disabled
I>3 / I>4 current set:	0.08×In to 32.00×In (step 0.01×In)
I>3 / I>4 Time-delay:	0 to 100s (step 0.01s)

17.13 Negative Sequence Overcurrent Protection

Directional and non directional I2> protections:	I2>1, I2>2 (range 0.08–4×In)
Non directional I2> protections:	I2>3, I2>4 (range 0.08–4×In)
I2>1 Function / I2>2 Function:	Disabled, Definite Time (DT), IEC Standard inverse IEC Very inverse IEC Extremely inverse UK Long Time Inverse, IEEE Moderately Inverse, IEEE Very Inverse IEEE Extremely Inverse US Inverse US Short Time Inverse
IN> (%max)	10% to 100% (step 1%)
I2>1 / I2>2 Directional:	Non-directional, Directional forward Directional reverse
I2>1 / I2>2 VTS Block:	Block/Non-directional
I2>1 / I2>2 current set:	0.08×In to 4.00×In (step 0.01×In)
I2>1 / I2>2 Time-delay:	0 to 100s (step 0.01s)
I2>1 / I2>2 Time VTS:	0 to 100s (step 0.01s)
I2>1 / I2>2 TMS:	0.025 to 1.2 (step 0.005)

I2>1 / I2>2 Time Dial:	0.01 to 100 (step 0.01)
I2>1 / I2>2 Reset characteristics:	DT or Inverse
I2>1 / I2>2 tReset	0 to 100s (step 0.01s)
I2>3 Status / I2>4 Status:	Enabled/Disabled
I2>3 / I2>4 Directional:	Non-directional, or Directional forward or Directional reverse
I2>3 / I2>4 VTS Block:	Block/Non-directional
I2>3 / I2>4 current set:	0.08×In to 32.00×In (step 0.01×In)
I2>3 / I2>4 Time-delay:	0 to 100s (step 0.01s)
I2>3 / I2>4 Time VTS:	0 to 100s (step 0.01s)
I>2 Char angle	–95° to +95° (step 1°)

17.14 Maximum of Residual Power – Zero Sequence Power

Zero Sequence Power Status:	Activated/Disabled
K Time delay factor:	0 to 2 (step 0.2)
Basis Time Delay:	0 to 10s (step 0.01s)
Residual current:	0.05×In to 1×In (step 0.01×In)
P0 threshold:	0.3 to 6.0VA (step 30mVA)

17.15 Broken Conductor Detection

Broken conductor:	Enabled/Disabled
I2/I1 setting:	0.2 to 1 (step 0.01)
I2/I1Time Delay:	0 to 100s (step 1s)
I2/I1 Trip:	Enabled/Disabled

17.16 Directional and Non-Directional Earth Fault Overcurrent (O/C) Protection

Directional and non directional IN> protections:	IN>1, IN>2 (range 0.08–10×In)
Non directional IN> protections:	IN>3, IN>4 (range 0.08–32×In)
IN>1 Function / IN>2 Function:	Disabled, Definite Time (DT), IEC Standard inverse IEC Very inverse IEC Extremely inverse UK Long Time Inverse, IEEE Moderately Inverse, IEEE Very Inverse IEEE Extremely Inverse US Inverse US Short Time Inverse
IN> (%max)	10% to 100% (step 1%)
IN>1 / IN>2 Directional:	Non-directional, or Directional forward or Directional reverse
IN>1 / IN>2 VTS Block:	Block/Non-directional
IN>1 / IN>2 current set:	0.08×In to 10.00×In (step 0.01×In)
IN>1 / IN>2 Time-delay:	0 to 200s (step 0.01s)
IN>1 / IN>2 Time VTS:	0 to 200s (step 0.01s)
IN>1 / IN>2 TMS:	0.025 to 1.2 (step 0.005)
IN>1 / IN>2 Time Dial:	0.5 to 15 (step 0.01)
IN>1 / IN>2 Reset characteristics:	DT or Inverse

IN>1 / IN>2 tReset	0 to 100s (step 0.01s)
IN>3 Status / IN>4 Status:	Enabled/Disabled
IN>3 / IN>4 Directional:	Non-directional, Directional forward Directional reverse
IN>3 / IN>4 VTS Block:	Block/Non-directional
IN>3 / IN>4 current set:	0.08×In to 32.00×In (step 0.01×In)
IN>3 / IN>4 Time-delay:	0 to 200s (step 0.01s)
IN>3 / IN>4 Time VTS:	0 to 200s (step 0.01s)
IN> Directional	
IN2 Char angle	–95° to +95° (step 1°)
Polarisation:	Zero Sequence, Negative Sequence.
IN> Blocking	
IN> Block Pole Dead (C7.x and D6.x)	Enabled/Disabled

17.17 Aided Directional Earth Fault (DEF) Overvoltage Protection

Aided DEF Status:	Enabled/Disabled
Polarisation:	Zero Sequence or Negative Sequence.
V> Voltage set:	0.5V to 20V (step 0.01V)
IN Forward:	0.05×In to 4×In (step0.01×In)
Time delay:	0s to 10s (step 0.1s)
Scheme logic:	Shared/Blocking/Permissive
Tripping:	Three Phase/Single Phase
Tp:	0 to 1000ms (step 2ms)
IN Rev Factor:	0 to 1 (step 0.1)

17.18 Thermal Overload

Thermal characteristics:	Disabled/Single/Dual
Thermal trip:	0.08×In to 3.2×In (step 0.01×In)
Thermal alarm:	50% to 100% (step 1%)
Time constant 1:	1 mn to 200mn (step 1mn)
Time constant 2:	1 mn to 200mn (step 1mn)

17.19 Residual Overvoltage

VN Type:	Residual/Homopolar[*]
VN>1 function:	Disabled/DT/IDMT
VN>1 voltage set:	1V to 180V (step 1V)
homopolar:	0.5V to 60V (step 0.5V)[*]
VN>1 Time delay:	0s to 100s (step 0.01s)
VN>1 TMS:	0.5 to 100 (step 0.5)
VN>1 tReset:	0 to 100s (step 0.5s)
VN>2 Status:	Enaled/Disabled
VN>2 voltage set:	1V to 180V (step 1V)
homopolar:	0.5V to 60V (step 0.5V)[*]
VN>2 Time delay:	0s to 100s (step 0.01s)

[*] (software version C7.x only)

17.20 Undercurrent Protection

I< mode (threshold activation):

I<1 status:	activated/deactivated

I<2 status: activated/deactivated

I<1 status: Enabled/Disabled
I<1 current set 0.08×I1 to 4×I1 (step 0.01×I1)
I<1 Time Delay: 0 to 100s (step 0.01s)
I<2 status: Enabled/Disabled
I<2 current set 0.08×I1 to 4×I1 (step 0.01×I1)
I<2 Time Delay: 0 to 100s (step 0.01s)

17.21 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

18 VOLTAGE PROTECTION

18.1 Voltage Protection

V< & V> modes (threshold activation):

V<1 function:	activated/deactivated
V<2 status:	activated/deactivated
V<3 status:	activated/deactivated
V<4 status:	activated/deactivated
V>1 function:	activated/deactivated
V>2 status:	activated/deactivated
V>3 status:	activated/deactivated
V>4 status:	activated/deactivated

18.2 Undervoltage

V< Measurement mode:	Phase–Neutral, Phase–Phase
V<1 function:	Disabled/DT/IDMT
V<1 voltage set	10 to 120V (step 1V)
V<1 Time Delay:	0 to 100s (step 0.01s)
V<1 TMS:	0.5 to 100 (step 0.5)
V<2, V<3 or V<4 status:	Enabled/Disabled
V<2, V<3, V<4 voltage set:	10 to 120V (step 1V)
V<2, V<3 or V<4 Time Delay:	0s to 100s (step 0.01s)

18.3 Overvoltage

V> Measurement mode:	Phase–Neutral, Phase–Phase
V>1 function:	Disabled/DT/IDMT
V>1 voltage set	40* or 60 to 185V (step 1V)
V>1 Time Delay:	0 to 100s (step 0.01s)
V>1 TMS:	0.5 to 100 (step 0.5)
V>2, V>3 or V>4 status:	Enabled/Disabled
V>2, V>3, V>4 voltage set:	40* or 60 to 185V (step 1V)
V>2, V>3 or V>4 Time Delay:	0s to 100s (step 0.01s)

*: C7.x and D6.x

19 FREQUENCY PROTECTION

19.1 Underfrequency

F<1 Status:	Disabled/Enabled
F<1 Setting:	45Hz to 65Hz (step 0.01Hz
F<1 Time Delay:	0 to 100s (step 0.01s)
F<2, F<3 or F<4 Status:	Disabled/Enabled
F<2, F<3 or F<4 Setting:	45Hz to 65Hz (step 0.01Hz
F<2, F<3 or F<4 Time Delay:	0 to 100s (step 0.01s)

19.2 Overfrequency

F>1 Status:	Disabled/Enabled
F>1 Setting:	45Hz to 65Hz (step 0.01Hz
F>1 Time Delay:	0 to 100s (step 0.01s)
F>2 Status:	Disabled/Enabled
F>2 Setting:	45Hz to 65Hz (step 0.01Hz
F>2 Time Delay:	0 to 100s (step 0.01s)

19.3 Circuit Breaker Fail and I< protection (CB Fail & I<)

Circuit Breaker Fail

CB Fail 1 Status:	Disabled/Enabled
CB Fail 1 timer:	0 to 10s (step 0.01s)
CB Fail 2 Status:	Disabled/Enabled
CB Fail 2 timer:	0 to 10s (step 0.01s)
CB Fail Non I reset:	I< only, CB Open & I<, Prot reset & I<, Prot reset or I<, Disable
CBF Ext reset:	I< only, CB Open & I<, Prot reset & I<, Prot reset or I<, Disable

Undercurrent I<:

I< current set: 0.05×In to 3.2×In (step 0.01×In)

20 NON-PROTECTION FUNCTIONS SETTINGS

20.1 CB Condition

CB Operations (number):	0 to 10000 (step 1)
CBA Operations:	0 to 10000 (step 1)
CBB Operations:	0 to 10000 (step 1)
CBC Operations:	0 to 10000 (step 1)
Total IA Broken:	0 to 25000In^ (step 1In^)
Total IB Broken:	0 to 25000In^ (step 1In^)
Total IC Broken:	0 to 25000In^ (step 1In^)
CB Operate time:	0 to 0.5s (step 0.001)
Reset CB Data:	Yes/No
Total 1P Reclosures:	0 to 0.85s (0.001)
Total 3P Reclosures:	0 to 0.85s (0.001)
Reset Total A/R:	Yes/No

20.2 CB Monitor Setup

Broken I^: 0 to 2 (step 0.1)

I^Maintenance:

- Alarm Enabled/Alarm Disabled
- 1In^ to 25000In^ (step 1In^)

I^ Lockout:

- Alarm Enabled/Alarm Disabled
- 1In^ to 25000In^ (step 1In^)

Number CB Operations Maintenance:

- Alarm Enabled/Alarm Disabled
- 1 to 10000 (step 1)

CB Operating time Maintenance:

- Alarm Enabled/Alarm Disabled
- 0.005s to 0.5s (step 0.001s)

CB Operating time Lockout Maintenance:

- Alarm Enabled/Alarm Disabled
- 0.005s to 0.5s (step 0.001s)

CB Fault frequency:

- Lock: Alarm Enabled/Alarm Disabled
- Count: 0 to 9999 (step 1)

Fault frequency time: 0 to 9999s (step 1s)

Lockout reset: Yes/No

Reset Lockout by: CB Close/User interface

Man Close reset delay: 0.01 to 600 (step 1)

20.3 CB Control

CB Control by: Disabled, or Local, or Remote, or Local + Remote, or Opto-input, or Opto input + Local, or Opto input + Remote, or Opto input + Local + Remote.

Close Pulse Time:	0.1s to 10s (step 0.01s)
Trip Pulse Time:	0.1s to 5s (step 0.01s)
Man Close Delay:	0.01s to 600s (step 0.01s)
Healthy Window:	0.01s to 9999s (step 0.01s)
Check Synchronizing (C/S) Window:	0.01s to 9999s (step 0.01s)
A/R Single Pole:	Enabled/Disabled
A/R Three Pole:	Enabled/Disabled

20.4 CT and VT Ratios

Main VT ratios:	100V to 1MV (step 1V)
Main VT's Secondary:	80V to 140V (step 1V)
Check Synchronizing (C/S) VT:	
Primary:	100V to 1MV (step 1V)
Secondary	80V to 140V (step 1V)
Phase CT:	
Primary:	1A to 30kA (step 1A)
Secondary	1A/5A
Mutual Compensation CT:	
Primary:	1A to 30kA (step 1A)
Secondary	1A/5A
Check Synchronizing (C/S) input:	A (phase A)–N (Neutral)/ B–B/C–N/A–B/B–C/C–A
Main VT Location:	Line/Bus
CT polarity:	Standard/Inverted

20.5 Sequence of Event Recorder (Record Control)

Clear Events:	Yes/No
Clear Faults:	Yes/No
Clear Maint:	Yes/No
Alarm Event:	Enabled/Disabled
Relay O/P Event:	Enabled/Disabled
Opto Input Event:	Enabled/Disabled
General Event:	Enabled/Disabled
Fault Rec Event:	Enabled/Disabled
Maint Rec Event:	Enabled/Disabled
Protection Event:	Enabled/Disabled
Clear Dist Recs:	Yes/No
Security Event:	Enabled/Disabled
DDB 31 – 0:	*(up to):*
DDB 2047 – 2016:	

Binary function link strings, selecting which DDB signals will be stored as events, and which will be filtered out

20.6 Measured Operating Data (Measure't Setup)

Default Display:	Description Plant reference, U – I – Freq, P – Q, Date and Time.
Local Values:	Primary/Secondary
Remote Values:	Primary/Secondary
Measurement Ref:	VA/VB/VC/IA/IB/IC
Measurement Mode:	0/1/2/3
Demand Interval:	1…99mn (step 1mn)
Distance Unit:	Miles/Kilometres
Fault Location:	Distance Ohms % of Line

20.7 Communications

20.7.1 Courier Protocol

Courier protocol:	Protocol and RP1 Card Status indicated
RP1 Address:	0 to 255 (step 1)
RP1 Inactiv timer:	1min to 30 mins (step 1min)
RP1 Physical link:	Copper/Fibre optic
RP1 Port configuration:	K-Bus/EIA485 (RS485)
RP1 comms mode:	IEC60870 FT1.2/10-Bit No Parity
RP1 Baud Rate:	9600/19200/38400 bits/s

20.7.2 IEC60870-5-103 Protocol

IEC60870-5-103 protocol:	Protocol indicated
RP1 Address:	1 to 254 (step 1)
RP1 Inactiv timer:	1min to 30 mins (step 1min)
RP1 Baud Rate:	9600/19200 bits/s
RP1 Measurement period:	1s to 60s (step 1s)
RP1 Physical link:	Copper/Fibre optic
CS103 blocking:	Disabled/Monitor blocking/Command blocking

20.7.3 MODBUS Protocol

Modbus protocol:	Protocol indicated
RP1 Address:	1 to 247 (step 1)
RP1 Inactiv timer:	1min to 30 mins (step 1min)
RP1 Baud Rate:	9600/19200/38400 bits/s
RP1 Parity:	Odd/Even/None
RP1 Physical link:	Copper/Fibre optic
Modbus IEC Time:	Standard/Reverse

20.7.4 DNP3.0 Protocol

DNP3.0 protocol:	Protocol indicated
RP1 Address:	1 to 65519 (step 1)
RP1 Baud Rate:	1200/2400/4800/9600/19200/38400 bits/s
RP1 Parity:	Odd/Even/None
RP1 Physical link:	RS485/Fibre optic
DNP Time Sync:	Disabled/Enabled
Meas scaling:	Primary/Secondary/Normalised
Message gap:	0ms to 50ms (step 1ms)
DNP Need Time:	1min to 30mins (step 1min)
DNP Application fragment size:	100 to 2048 (step 1)
DNP Application fragment timeout:	1s to 120s (step 1s)
DNP SBO timeout:	1s to 10s (step 1s)
DNP link timeout:	0s to 120s (step 1s)

20.7.5 Ethernet Port, IEC61850 Protocol

Ethernet port, IEC61850 Protocol:	Protocol, NIC MAC address(es), Redundancy IP address, Subnet mask and Gateway address indicated
ETH tunnel timeout:	1min to 30min (step 1min)

20.7.6 Ethernet Port, DNP3.0 Protocol

Ethernet port, DNP3.0 protocol:	Protocol, NIC MAC address(es), Redundancy IP address, Subnet mask and Gateway address indicated
DNP Time Sync:	Disabled/Enabled
Meas scaling:	Primary/Secondary/Normalised
DNP need time:	1min to 30mins (step 1min)
DNP Application Fragment size:	100 to 2048 (step 1)
DNP Application fragment timeout:	1s to 120s (step 1s)
DNP SBO timeout:	1s to 10s (step 1s)
DNP Link timeout:	0s to 120s (step 1s)
ETH tunnel timeout:	1min to 30mins (step 1min)

20.7.7 Second Rear Port Connection Setting

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*

20.8 Commissioning Tests

Monitor bit 1 to Monitor bit 8:
Selects DDB signals have their status visible in the Test Port Status.

Test Mode:	Disabled/Test Mode/Contacts Blocked
Test Pattern:	Configuration of which output contacts are to be energized when the contact test is applied.
Contact Test:	No Operation, Apply Test, Remove Test
Test LEDs:	No Operation, Apply Test
Autoreclose test:	No operation/3 Pole test/Pole A test/Pole B test/Pole C test

20.9 Opto Configuration

Opto input voltage range: 24-27V / 30-34V / 48-54V / 110-125V / 220-250V / Custom
Opto Input 1 (up to # = max. opto no. fitted)
Custom options allow independent thresholds to be set per opto, from the same range as above

21 HOTKEYS AND CONTROL INPUTS

21.1 Control Inputs Operation (Control Inputs & CTRL I/P Config menus)

Control Input Operation (Control Inputs Menu): Status of control inputs indication
Control Inputs Operation: SET/RESET/No Operation
Control Inputs Configuration (CTRL I/P config. Menu):
The control inputs can be individually assigned to the hotkeys by setting,
Control input configuration: Latched/Pulsed

Following text displayed in the hotkey menu can be set: Set/Reset / In/Out / Enabled/Disabled / On/Off

21.2 Opto Input Labels (Opto I/P Labels menu)

User defined text string to describe the function of the particular opto input.

22 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.

Channels statistics:	Visible/Invisible Nbr of tripping messages received Nbr blocking messages received, Number of messages received: tripping, blocking, total and incorrect, Lost messages, Elapsed time, Reset statistics: Yes/No
Channel diagnostics:	Visible/Invisible “Data carrier detect” status, Frame synchronization status, Message status, Channel status, InterMiCOM hardware status.

User defined test pattern,
Loopback status

23 INTERMICOM CONFIGURATION

IM Msg Alarm Level: 0 to 100.0% (step 1%)
InterMiCOM Command Types:
IM1, IM2, IM3 and IM4 Command types: Disabled/Direct/Blocking
IM5, IM6, IM7 and IM8 Command types: Disabled/Permissive/Direct
Fallback Mode: Default/Latched
Default Value: 0/1
Frame Synchronization Time: 10ms to 1.50s (step 10ms)

24 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.

25 SUPERVISION FUNCTIONS

25.1 VT Supervision

Time-delay:	1 to 20s (step: 1s)
I2&I0 inhibition:	0 to 1A (step: 1mA)
I> inhibition(D6.x):	0.08In to 32 In (step: 0.01 In)
3P voltage detection:	Enabled/Disabled
Threshold 3P	10 to 70V (step 1V)

25.2 CT Supervision

Status:	Enabled/Disabled
VN< Inhibition:	0.5 to 22V (step 0.5V) or 2V to 88V (step 2V)
IN> setting	0.08×In to 4×In (step 0.01×In)
Time-delay:	0 to 10s (step 1s)

25.3 CVT Supervision

Status:	Enabled/Disabled
VN>:	0.5 to 22V (step 0.5V)
Time-delay:	0 to 300s (step 0.01s)

25.4 Check Synchronization ("System Check" Menu)

Check Synchronism for autoreclosure or Manual CB closure:

Live bus/dead line:	Yes/No
Dead bus /Live line:	Yes/No
Live bus / Live line:	Yes/No
V< Dead line:	5 to 30V (step 1V)
V> Live line:	30 to 120V (step 1V)
V< Dead bus:	5 to 30V (step 1V)
V> live bus:	30 to 120V (step 1V)
Differential voltage:	0.5V to 40V (step 0.1V)
Diff. frequency:	0.02Hz to 1Hz (step 0.01Hz)
Diff phase	5° to 90° (step 2.5°)
Bus-Line time-delay:	0.1s to 2s (step 0.1s)

25.5 Autorecloser

25.5.1 Autoreclose Mode:

Number of shots:	1P trip mode:	1, 1/3, 1/3/3 or 1/3/3/3
	3P trip mode:	3, 3/3, 3/3/3 or 3/3/3/3
1P – Dead time 1	0.1s to 5s (step 0.01s)	
1P – Dead time 1	0.1s to 60s (step 0.01s)	
Dead time 2	1s to 3600s (step 1s)	
Dead time 3	1s to 3600s (step 1s)	
Dead time 4	1s to 3600s (step 1s)	
Reclaim time:	1 to 600s (step 1s)	
Reclose time-delay:	0.1s to 10s (step 0.1s)	
Discrimination time:	0.1s to 5s (step 0.01s)	
A/R Inhibit window:	1s to 3600s (step 1s)	
C/S on 3P reclosure during Dead time 1:		Enabled/Disabled

25.5.2 Autoreclose Lockout

Autoreclose is blocked when user defined fault occurs:

at T2, t2, Tzp or Tzq
for Loss of Load Trip
for I>1 or I>2 Trip
for V<1, V<2, V<3 or V<4 Trip
for V>1, V>2, V>3 or V>4 Trip
for IN>1, IN>2, IN>3 or IN>4 Trip
for Aided D.E.F Trip
for Zero Sequence Power Trip
for PAP Trip (specific customer engineered function)
for Thermal Trip
for I2>1, I2>2, I2>3 or I2>4 Trip
for VN>1 or VN>2 Trip
for I<1 or I<2 Trip
for F<1, F<2, F<3 or F<4 Trip
for F>1 or F>2 Trip

25.6 Security Config

When Option installed

The security configuration features allows password attempts setting and port access enabling:

Attemps to enter a valid password setting:	0 to 3*
Attemps time-delay:	1 to 3mn (step 1mn)*
Blocking time-delay (incorrect password):	1 to 30mn (step 1mn)*
Front port access:	Enabled/Disabled
Rear Port 1 access:	Enabled/Disabled
Rear Port 2 access:	Enabled/Disabled
Ethernet port access:	Enabled/Disabled
Courier tunneling logical port access:	Enabled/Disabled
IEC61850 logical port access:	Enabled/Disabled
DNP3 logical port access:	Enabled/Disabled

*: displayed on HMI

25.7 PSL Timers

Software version C7.x
PSL timers setting from HMI

Timer 1 to 32: 1ms to 14400s (step 1ms)

26 FUNCTION KEYS AND LABELS

26.1 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.

26.2 Opto Input Labels

Opto Input 1 to 24: Input L1 to Input L24
User-defined text string to describe the function of the particular opto input.

26.3 Output Labels

Relay 1 to Relay 46:
User-defined text string to describe the function of the particular relay output contact.

26.4 Control Input Labels

Control Input 1 to Control Input 32:
User defined text string to describe the function of the particular control input.
Command text can be individually assigned to each Control input by selecting one of the following pairs:

SET/RESET
IN/OUT
ENABLED/DISABLED
ON/OFF

26.5 Virtual Input Labels

Virtual Input 1 to Virtual Input 64:
User defined text string to describe the function of the particular virtual input.

26.6 Virtual Output Labels

Virtual Output 1 to Virtual Output 32:
User defined text string to describe the function of the particular virtual output.

26.7 SR/MR User Alarm Labels

SR User Alarm 1 to SR User Alarm 16:
User-defined text string to describe the function of the particular self-reset user alarm.
MR User Alarm 17 to MR User Alarm 32:
User-defined text string to describe the function of the particular manual reset user alarm.

Notes:

GETTING STARTED

CHAPTER 3

Date:	01/2017
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:	M
Software version:	E1
Connection diagrams:	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)

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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 Safety Information chapter/Safety Guide SFTY/5L M/L11 or later issue, the Technical Data chapter and the ratings on the equipment rating label.

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.

Front views of the MiCOM P442 and P444 relays are shown below.

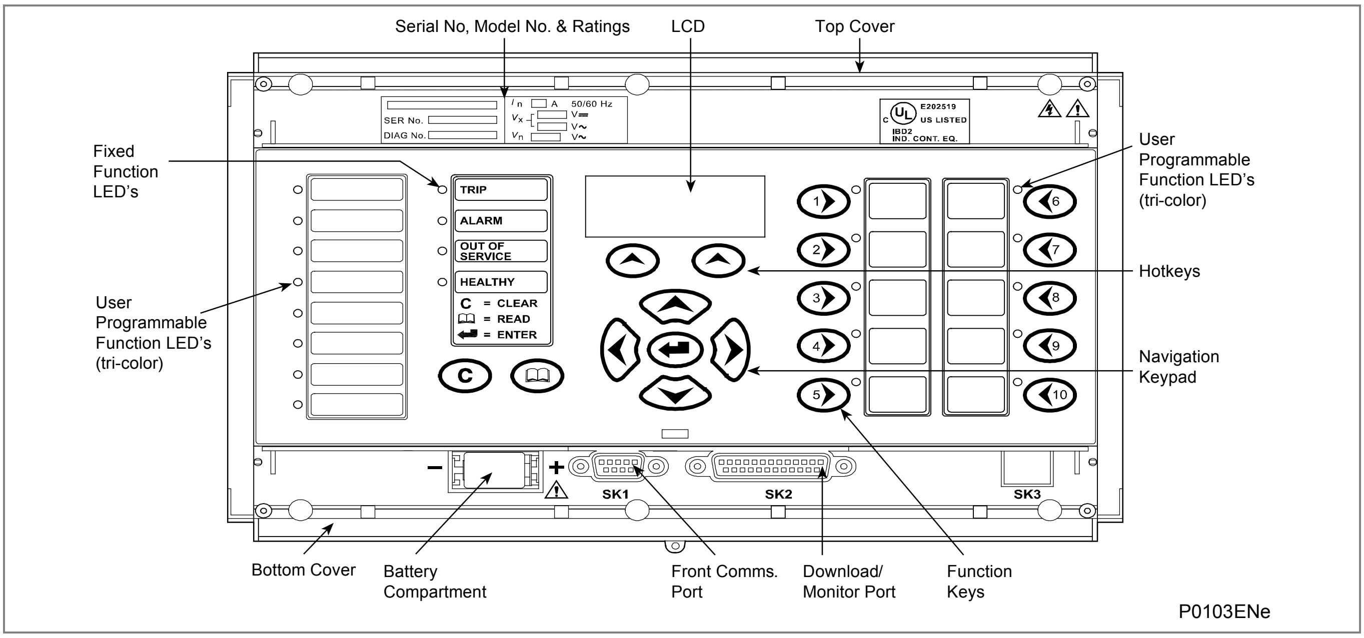


Figure 1 - P442 Relay front view (60TE case)

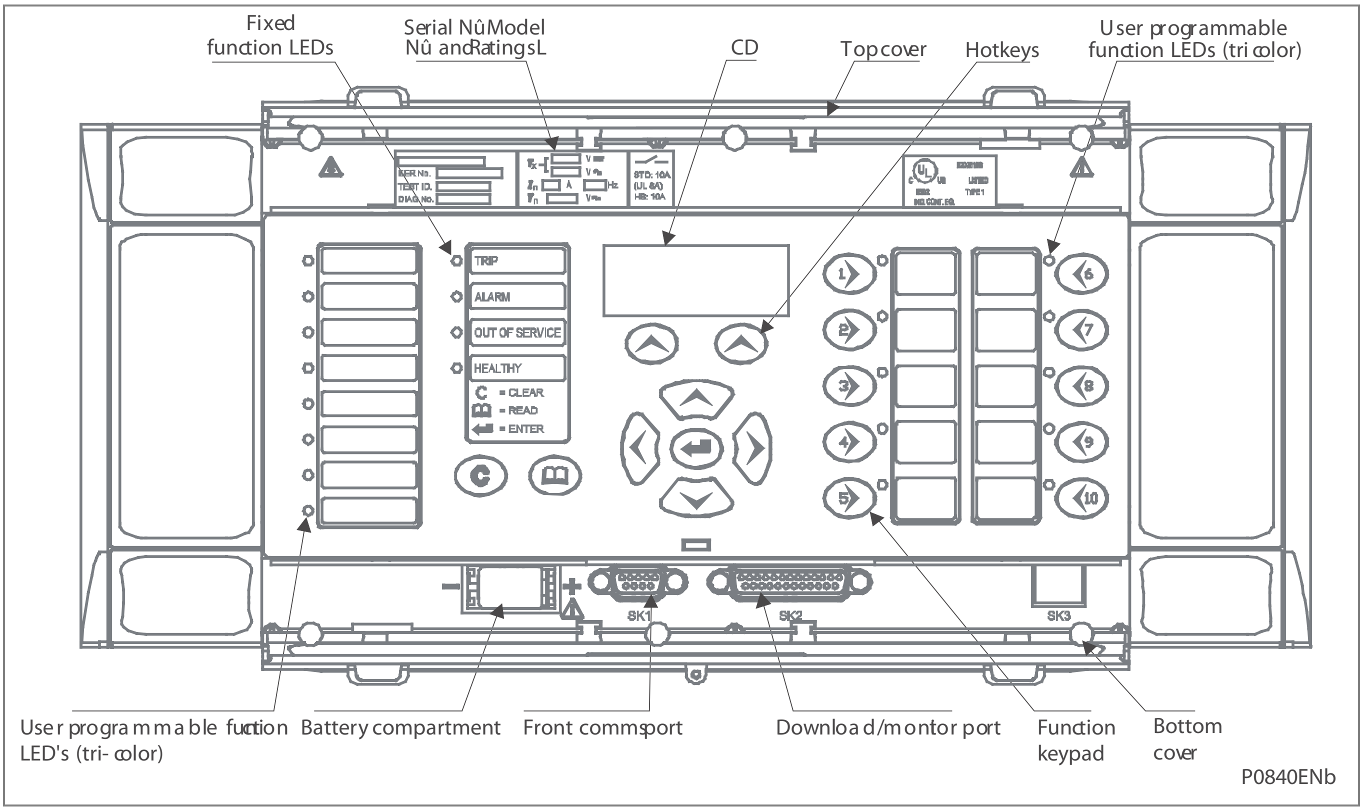


Figure 2 - P444 Relay front view (80TE case)

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

- A 16-character by 3-line alphanumeric Liquid Crystal Display (LCD).
- A 9-key keypad with 4 arrow keys (◁, ▷, △ and ▽), an enter key (↵), a clear key (ⓒ), a read key (📖), 2 hot keys (△).
- 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.

Function Key Functionality:

- 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.

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:

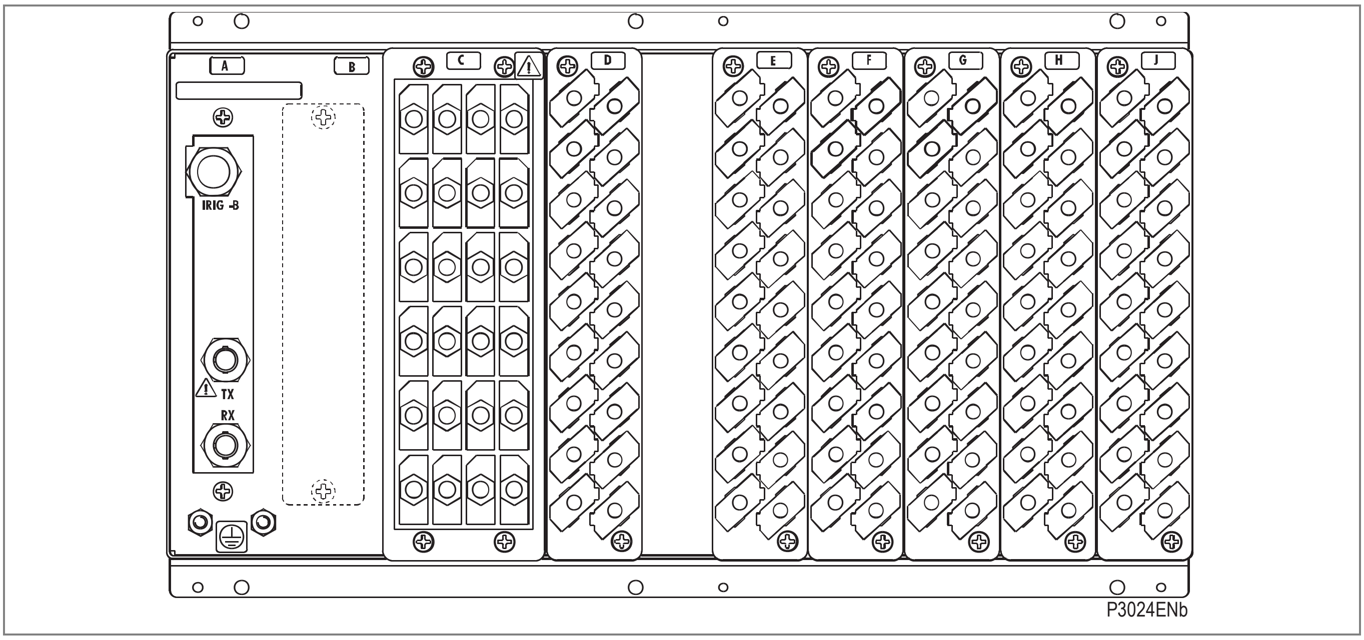
- **Trip** (Red) switches ON when the relay issues a trip signal. It is reset when the associated fault record is cleared from the front display. Also the trip LED can be configured as self-resetting.
- **Alarm** (Yellow) flashes when the relay registers an alarm. This may be triggered by a fault, event 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

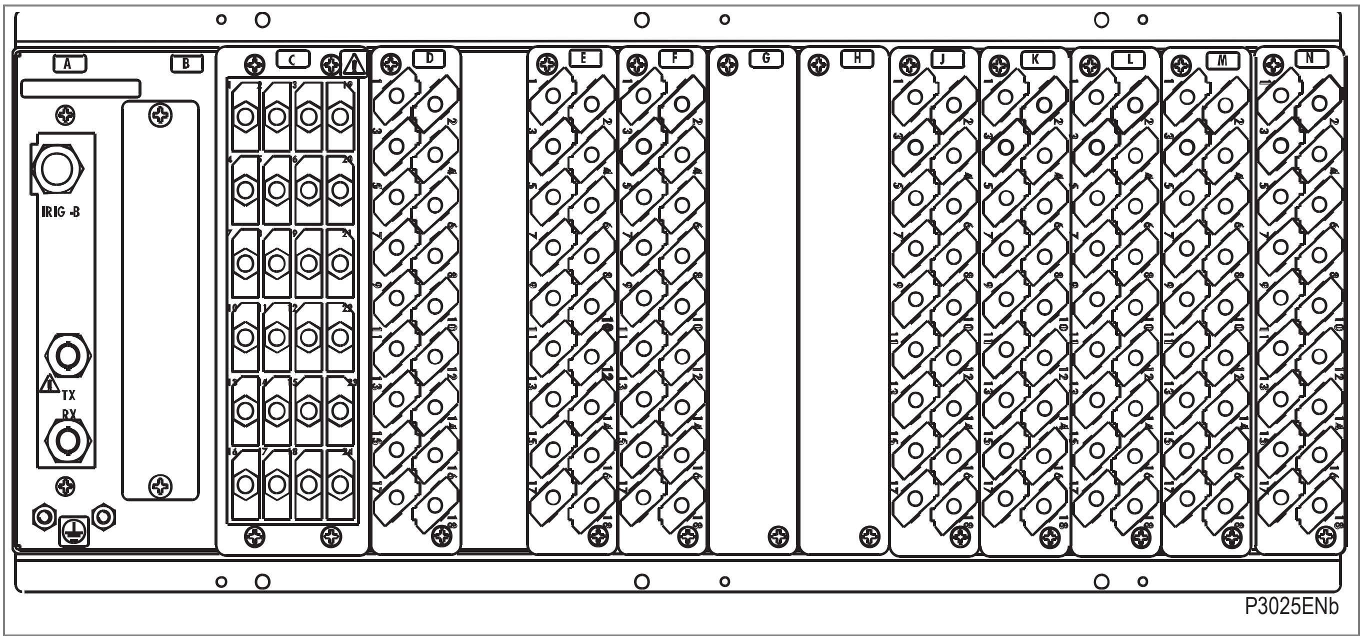
Examples of the rear panel of the relay are shown in the following figure. All current and voltage signals, digital logic input signals and output contacts are connected at the rear of the relay. Also connected at the rear is the twisted pair wiring for the rear EIA(RS)485 communication port; the IRIG-B 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.



A - Optional board *	D - Opto-input board	G - Output relay board
B - Optional board *	E - Opto-input board	J - Power supply board
C - Current and voltage input board	F - Output relay/High Break board *	* = option depending on the model

Figure 2 - P442 Relay rear view (60 TE case)



A - Optional board *
B - Optional board *
C - Current and voltage input board
D - Opto-input board
E - Opto-input board
F - Opto Input board
G - Relay board *
H - Relay board
J - Output relay/High Break board *
K - Output relay/High Break board *
L - Output relay/High Break board *
M - Relay board
N - Power supply board
* = option depending on the model

Figure 3 - P444 Relay rear view (80 TE case)

1.4 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 ranges for dc and ac

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:

- front panel user interface via the LCD and keypad
- front port which supports Courier communication
- rear port which supports one protocol of either:
    - Courier
    - Modbus
    - IEC 60870-5-103
    - DNP3.0
- optional Ethernet or dual Ethernet
- optional second rear port which supports Courier protocol

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

The measurement information and relay settings which can be accessed from the different interfaces are summarised 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
Clear event, fault & disturbance records	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.

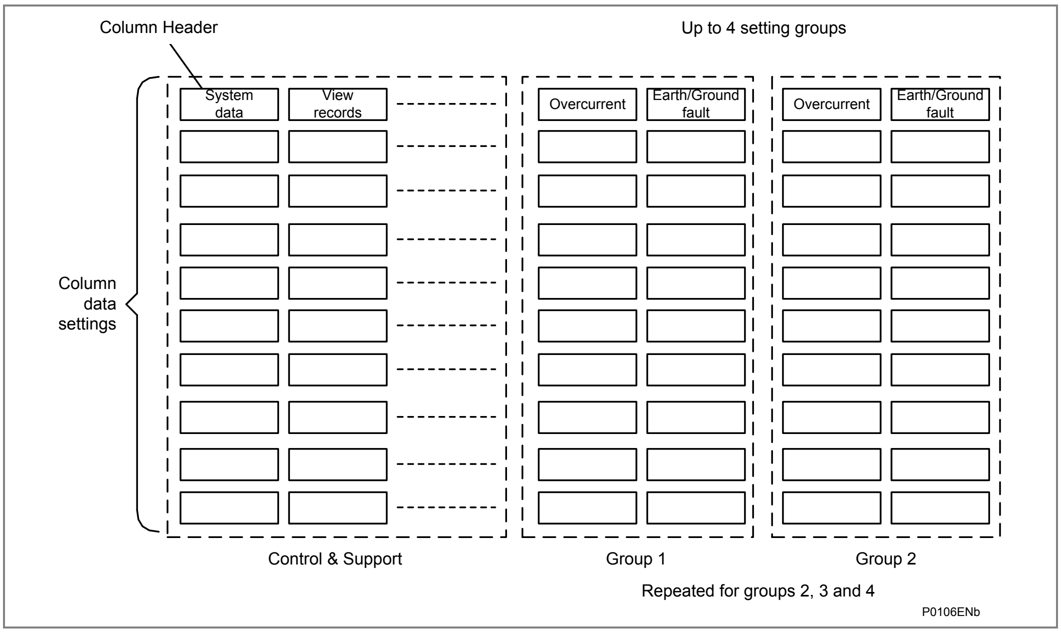


Figure 4 - Menu structure

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:

- Relay configuration settings
- Open/close circuit breaker (may vary according to relay type or model)
- CT & VT ratio settings
- Reset LEDs
- Active protection setting group
- Password & language settings
- Communications settings
- Measurement settings
- Event & fault record settings
- User interface settings
- Commissioning settings
- Circuit breaker control & monitoring settings (may vary according to relay type or model)

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.

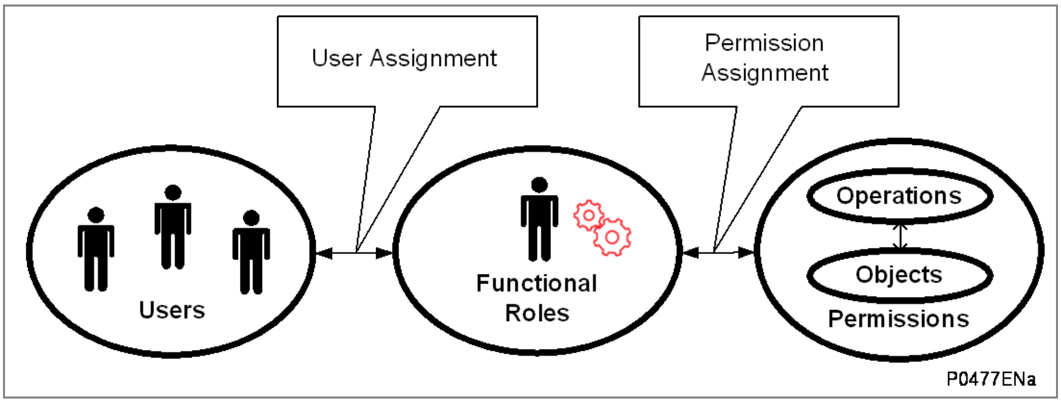


Figure 5 - RBAC Role structure

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.

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

To do this firstly set the 'Copy from' cell to the protection setting group to be copied, then set the 'Copy to' cell to the protection 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 relay following confirmation.

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 relay's settings, not just the protection groups' settings. The default settings will initially be placed in the scratchpad and will only be used by the relay after they have been confirmed. Note that 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.

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.

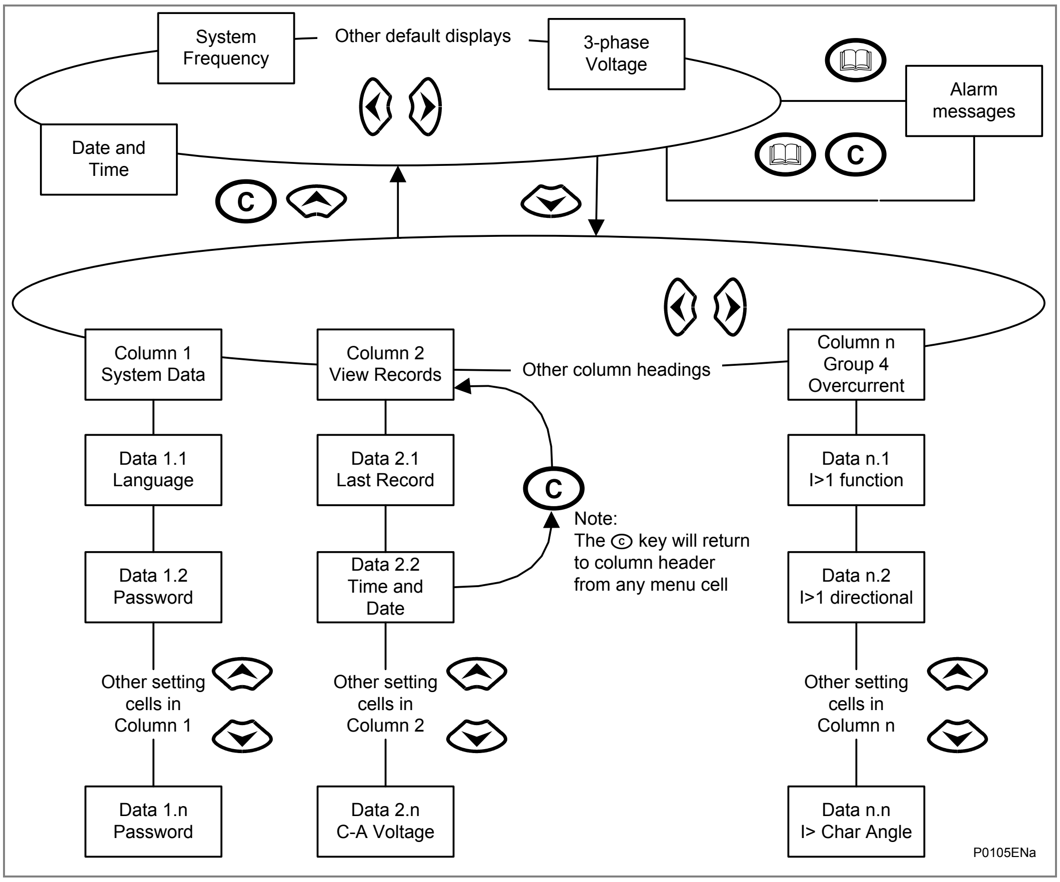


Figure 6 - Front panel user interface

6.1 Default Display and Menu Time-Out

The front panel menu has a default display. To change the default display selection requires password level 3 and the following items can be selected by using the ◁ and ▷ keys:

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

If the user has got level 3 (or enters a level 3 password when prompted as above), then the IED will then inform the user that to move to another default display will make the IED non-NERC compliant, as follows:

```
DISPLAY NOT-NERC
COMPLIANT. OK?
```

‘Enter’ will move the default display to the next one, ‘Cancel’ will leave the display at the user banner display. The confirmation for non-NERC compliance will only be asked when moving off the user banner display. The request for level 3 password will always be asked for any change to the default display selection if the current level is not already 3.

Whenever the relay has an uncleared alarm (such as fault record, protection alarm, or control alarm) the default display is replaced by the following display.

```
Alarms/Faults
Present
```

Enter the menu structure of the relay from the default display, even if the display shows 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 (C) 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 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.

6.3.2 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.

6.3.3 CB Control

The CB control functionality varies from one Px40 relay to another. For a detailed description of the CB control via the hotkey menu refer to the “Circuit Breaker Control” section of the Setting chapter.

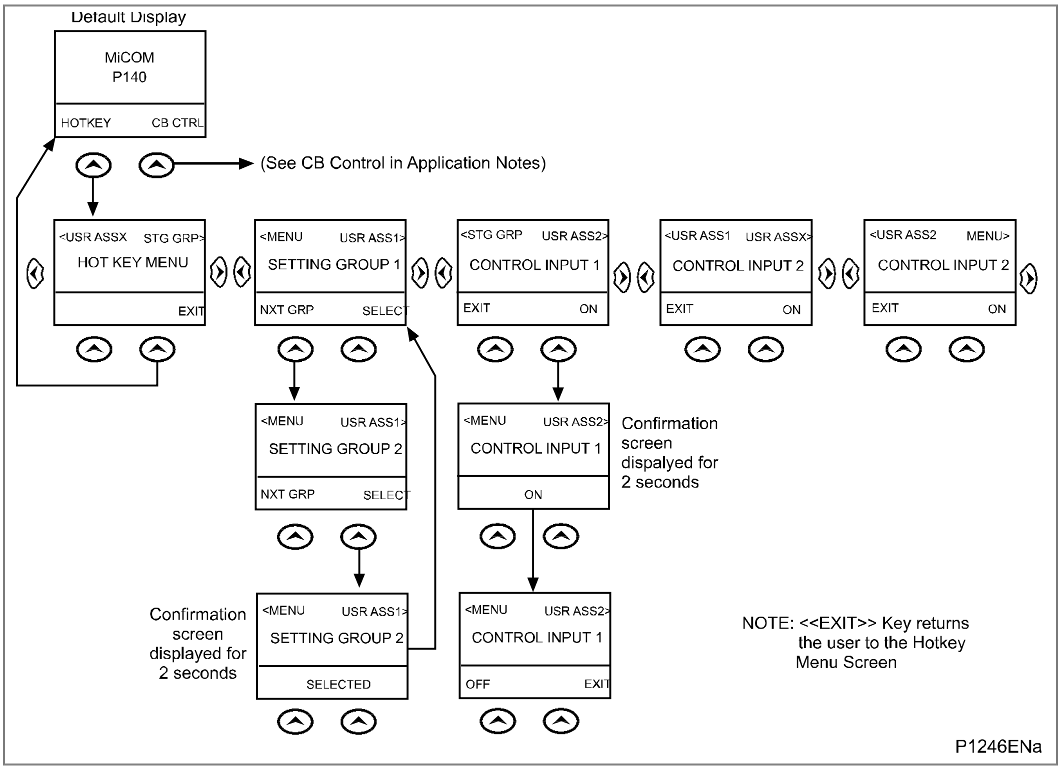


Figure 7 - Hotkey menu navigation

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:

<table>
<tr><th>CS Version</th><th>Interface</th><th>RBAC/PW Cases</th><th>Login Process</th></tr>
<tr><td rowspan="3">CSL1</td><td rowspan="2">Front panel</td><td>Factory RBAC</td><td>Auto login with EngineerLevel</td></tr>
<tr><td>Customized RBAC</td><td>Local Default Access Enabled: Login with Local Default Access
Local Default Access Disabled: Login with Prompt User List</td></tr>
<tr><td>Courier Interface</td><td>All cases</td><td>Login with Prompt User List</td></tr>
<tr><td rowspan="4">CSL0</td><td rowspan="2">Front panel</td><td>Factory RBAC</td><td>Auto login with EngineerLevel</td></tr>
<tr><td>Password changed</td><td>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</td></tr>
<tr><td rowspan="2">Courier Interface</td><td>Factory RBAC</td><td>Auto login with EngineerLevel</td></tr>
<tr><td>Password changed</td><td>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</td></tr>
</table>

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 Column Heading level and you press the Up button, you may be prompted to log out with the following 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 (MiCOM S1 Studio).

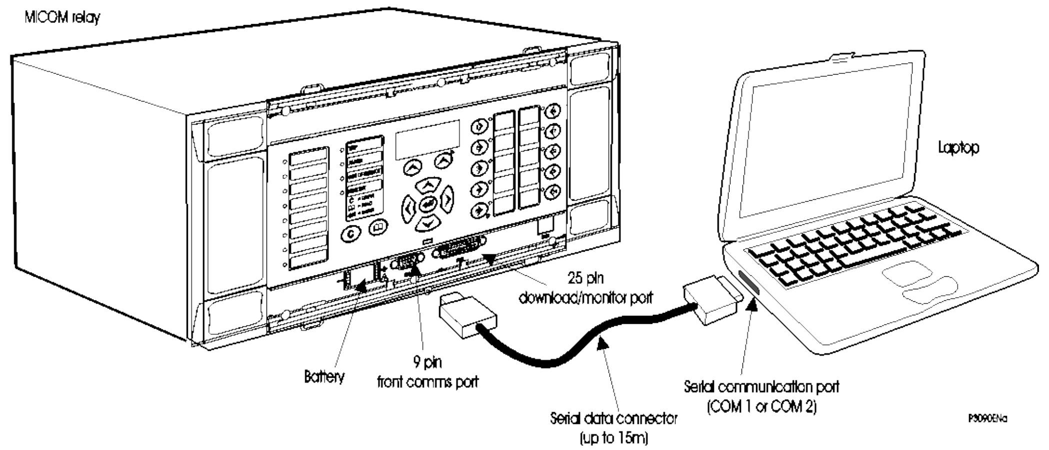


Figure 8 - Front port connection

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 - IED serial 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 - IED serial port 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.*

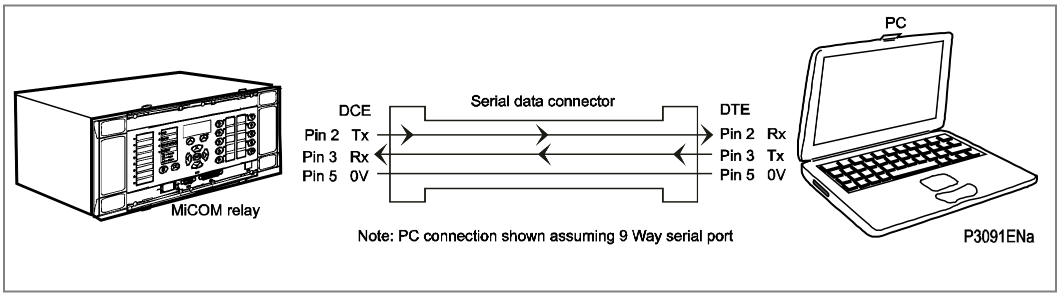


Figure 9 - PC – relay signal connection

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 (MICOM S1 STUDIO) RELAY COMMUNICATIONS BASICS

The EIA(RS)232 front communication port is particularly designed for use with the relay settings program Easergy Studio (MiCOM S1 Studio). Easergy Studio (MiCOM S1 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 (MiCOM S1 Studio) provides full access to MiCOM Px10, Px20, Px30, Px40 and Mx20 measurements units.

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).**

8.1 PC Requirements

The minimum and recommended hardware requirements for Easergy Studio (MiCOM S1 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 (MiCOM S1 Studio) must be started with Administrator privileges.

Easergy Studio (MiCOM S1 Studio) Additional components

The following components are required to run Easergy Studio (MiCOM S1 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 (MiCOM S1 Studio)

This section is a quick start guide to using Easergy Studio (MiCOM S1 Studio) and assumes this is installed on your PC. See the Easergy Studio (MiCOM S1 Studio) program 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 MiCOM S1 Studio, select **Programs** > **Schneider Electric** > **MiCOM S1 Studio** > **MiCOM S1 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 (MiCOM S1 Studio)

Easergy Studio (MiCOM S1 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 (MiCOM S1 Studio) program online help for more information.

Notes:

SETTINGS

CHAPTER 4

Date:	01/2017
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:	M
Software version:	E1
Connection diagrams:	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)

CONTENTS

FIGURES

TABLES

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 RELAY 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.

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.*

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

Col	Row	Courier Text	Default Setting	Available Setting
Description				
09	00	CONFIGURATION		
This column contains all the general configuration options				
09	01	Restore Defaults	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.				
09	02	Setting Group	Select via Menu	0 = Select via Menu or 1 = Select via Opto
Allows setting group changes to be initiated via Opto Input or via Menu				
09	03	Active Settings	Group 1	0 = Group 1, 1 = Group 2, 2 = Group 3, 3 = Group 4
Selects the active setting group.				
09	04	Save Changes	No Operation	0 = No Operation, 1 = Save, 2 = Abort
Saves all IED settings.				
09	05	Copy From	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				
09	06	Copy to	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				
09	07	Setting Group 1	Enabled	0 = Disabled or 1 = Enabled
Enables or disables Group 1 settings. If the setting is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this setting.				
09	08	Setting Group 2	Enabled	0 = Disabled or 1 = Enabled
Enables or disables Group 2 settings. If the setting is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this setting.				
09	09	Setting Group 3	Enabled	0 = Disabled or 1 = Enabled
Enables or disables Group 3 settings. If the setting is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this setting.				
09	0A	Setting Group 4	Enabled	0 = Disabled or 1 = Enabled
Enables or disables Group 4 settings. If the setting is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this setting.				
09	0D	Dist. Protection	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Distance Protection function.				
09	10	Power-Swing	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Power-Swing function.				
09	11	Back-up I>	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Backup I> Protection function.				
09	12	Neg Sequence O/C	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Negative Sequence Overcurrent Protection function. I2> stages: ANSI 46/67				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
09	13	Broken Conductor	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Broken Conductor function. I2/I1> stage: ANSI 46				
09	14	Earth Fault PROT	Disabled	0 = Disabled or 1 = Earth Fault O/C or 2 = Zero Seq. Power
To enable (activate) or disable (turn off) the back up Earth Fault Protection function. IN >stages: ANSI 50N/51N/67N				
09	15	Aided D.E.F	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Aided D.E.F Protection function.				
09	16	Volt Protection	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				
09	17	CB Fail & I<	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Circuit Breaker Fail Protection function: ANSI 50BF.				
09	18	Supervision	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Supervision (VTS & CTS) functions: ANSI 47/27/46.				
09	19	System Checks	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the System Checks (Check Sync. and Voltage Monitor) function: ANSI 25.				
09	1A	Thermal Overload	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Thermal Overload Protection function. ANSI 49.				
09	1C	I< Protection	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the I< Protection function.				
09	1D	Residual O/V NVD	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Residual Over Voltage Protection function.				
09	1E	Freq Protection	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Frequency Protection function.				
09	24	Internal A/R	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Internal Autoreclose function.				
09	25	Input Labels	Visible	0 = Invisible, 1 = Visible
Sets the Input Labels menu visible further on in the IED setting menu.				
09	26	Output Labels	Visible	0 = Invisible, 1 = Visible
Sets the Output Labels menu visible further on in the IED setting menu.				
09	28	CT & VT Ratios	Visible	0 = Invisible, 1 = Visible
Sets the Current & Voltage Transformer Ratios menu visible further on in the IED settings menu.				
09	29	Record Control	Visible	0 = Invisible, 1 = Visible
Sets the Record Control menu visible further on in the IED settings menu.				
09	2A	Disturb Recorder	Visible	0 = Invisible, 1 = Visible
Sets the Disturbance Recorder menu visible further on in the IED settings menu.				
09	2B	Measure't Setup	Visible	0 = Invisible, 1 = Visible
Sets the Measurement Setup menu visible further on in the IED settings menu.				
09	2C	Comms Settings	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				
09	2D	Commission Tests	Invisible	0 = Invisible, 1 = Visible
Sets the Commissioning Tests menu visible further on in the IED settings menu.				
09	2E	Setting Values	Secondary	0 = Primary, 1 = Secondary

Col	Row	Courier Text	Default Setting	Available Setting
Description				
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.				
09	2F	Control Inputs	Visible	0 = Invisible, 1 = Visible
Activates the Control Input status and operation menu further on in the IED setting menu.				
09	35	Ctrl I/P Config	Visible	0 = Invisible, 1 = Visible
Sets the Control Input Configuration menu visible further on in the IED setting menu.				
09	36	Ctrl I/P Labels	Visible	0 = Invisible, 1 = Visible
Sets the Control Input Labels menu visible further on in the IED setting menu.				
09	39	Direct Access	Enabled	0 = Disabled or 1 = Enabled
Defines whether direct access is allowed or not. 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. Not available on Chinese version relays.				
09	40	InterMicom	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) InterMiCOM.				
09	48	Ethernet NCIT	Visible	0 = Invisible, 1 = Visible
Sets the Ethernet NCIT menu visible further on in the IED setting menu.				
09	50	Function Key	Visible	0 = Invisible, 1 = Visible
Sets the Function Key menu visible further on in the IED setting menu.				
09	70	VIR I/P Labels	Invisible	0 = Invisible, 1 = Visible
This makes the virtual inputs label settings visible or invisible.				
09	80	VIR O/P Labels	Invisible	0 = Invisible, 1 = Visible
This makes the virtual outputs label settings visible or invisible.				
09	90	Usr Alarm Labels	Invisible	0 = Invisible, 1 = Visible
This makes the user alarm labels settings visible or invisible.				
09	FB	RP1 Read Only	Disabled	0 = Disabled or 1 = Enabled
Enable Remote Read Only Mode on RP1 courier or IEC60870-5-103 communication protocol. Visible when comms options are: 1 – Courier, 3 – CS103, 6&G – IEC61850 with 1st Rear Courier, 7&H – IEC61850 with 1st Rear CS103.				
09	FC	RP2 Read Only	Disabled	0 = Disabled or 1 = Enabled
Enable Remote Read Only Mode on RP2 courier communication protocol. Visible when hardware options are: 7, 8, E or F.				
09	FD	NIC Read Only	Disabled	0 = Disabled or 1 = Enabled
Enable Remote Read Only Mode on the Network Interface card (IEC 61850 tunneled courier). Visible when comms options are: 6&G – IEC61850 with 1st Rear Courier, 7&H – IEC61850 with 1st Rear CS103, B&L– IEC61850 with DNPoE with DNP .				
09	FF	LCD Contrast	11	0 to 31 (step 1)
Sets the LCD contrast.				

Table 1 - Relay Settings Configuration

4 GROUPED PROTECTION SETTINGS

4.1 Alternative Setting Groups

The MiCOM P44x relays can store up to four independent groups of settings. The active group is selected either locally via the menu or remotely via the serial communications. The ability to quickly reconfigure the relay to a new setting group may be desirable if changes to the system configuration demand new protection settings. Typical examples where this feature can be used include:

- Single-bus installations with a transfer bus;
- Double-bus installations, with or without a separate transfer bus, where the transfer circuit breaker or bus coupler might be used to take up the duties of any feeder circuit breaker when both the feeder circuit breaker and the current transformers are by-passed.

In the case of a double-bus installation, it is usual for bus 1 to be referred to as the main bus and bus 2 as the reserve bus, and for any bypass circuit isolator to be connected to bus 2 as shown in Figure 1. This arrangement avoids the need for a current polarity reversing switch that would be required if both buses were to be used for by-pass purposes. The standby relay, associated with the transfer circuit breaker or the bus coupler, can be programmed with the individual setting required for each of the outgoing feeders. For bypass operation, the appropriate setting group can be selected as required. This facility is extremely useful in the case of unattended substations where all of the switching can be controlled remotely.

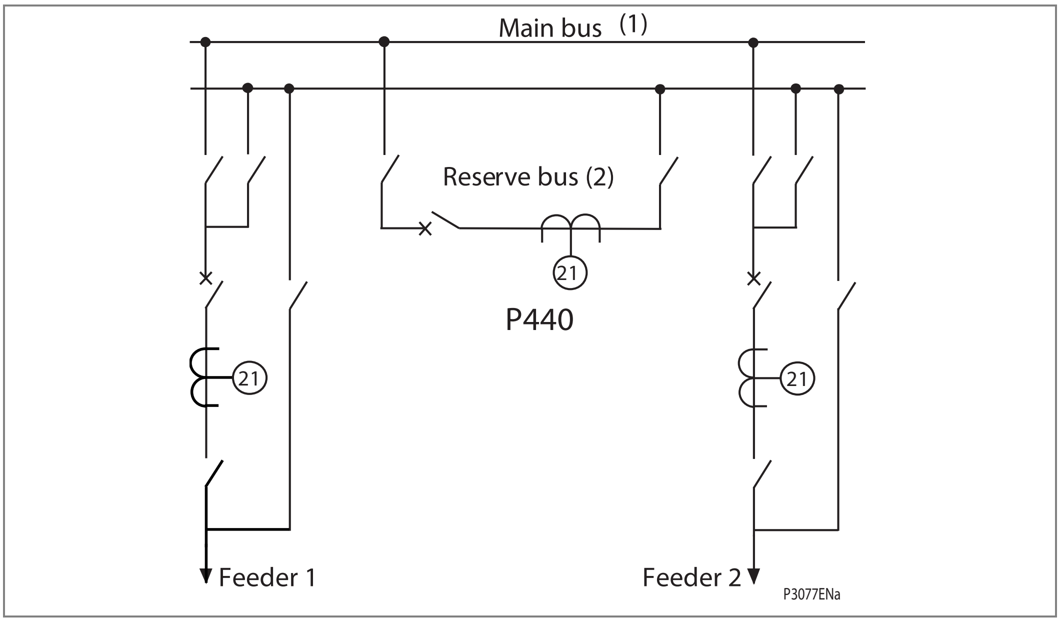


Figure 1 - Typical double bus installation with bypass facilities

A further use for this feature is the ability to provide alternative settings for teed feeders or double circuit lines with mutual coupling. Similar alternative settings could be required to cover different operating criteria in the event of the channel failing, or an alternative system configuration (ie. lines being switched in or out).

4.2 Selection of Setting Groups

Setting groups can be changed by one of two methods:

- Automatic group selection by state changes of two opto-isolated inputs, assigned to Setting Group Change bit 0 (opto 1), and Setting Group Change bit 1 (opto 2), as shown in Table 2. The new setting group binary code must be maintained for 2 seconds before a group change is implemented, thus rejecting spurious induced interference.(See also hysteresis value for logic level 0 & logic level 1 in section 4.1 of this document).

  When this selection is made, the two opto-isolated inputs assigned to this function will be opto inputs 1 and 2 and they must not be connected to any output signal in the PSL. Special care should be taken to avoid using them for another purpose (i.e please note that in the default PSL they have been used for another functions: DIST/DEF Chan. Recv. for opto 1 and DIST/DEF carrier out of service for opto 2).

  Default PSL: To enable the setting group via logic inputs, the opto inputs 1 and 2 must be dedicated only to the group selection (remove Opto-Label 01 and Opto-Label 02 from the PSL).

  (If assigned in the PSL, instead of Dist DEF Carrier Receive Logic Start, a setting group change will occur)

Note	*Eeach setting group has its own dedicated PSL, which should be configured and sent to the relay independently.*

- Or using the relay operator interface / remote communications. Should the user issue a menu command to change group, the relay will transfer to that settings group, and then ignore future changes in state of the bit 0 and bit 1 opto inputs. Thus, the user is given greater priority than automatic setting group selection.

Binary State of SG Change bit 1 Opto 2	Binary State of SG Change bit 0 Opto 1	Setting Group Activated
0	0	1
0	1	2
1	0	3
1	1	4

Table 2 - Setting group selection

Reminder	*If selected in the menu (change by Optos), Opto 1 & 2 must be removed from the PSL (they are dedicated to Group selection).*

4.3 Distance Zone Settings

The “Distance elements” menu setting is used to set the line protection (line and zone setting). The Zone setting menu allows 6 zones setting.

Refer to the Application Notes chapter for a complete explanation of the this menu.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
30	00	GROUP 1: DISTANCE ELEMENT		
GROUP1: Distance Elements				
30	01	Line Setting		

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Set the parameters for Protected Line in the following settings				
30	02	Line Length	100km	From 0.3km to 1000km step 10m
Setting of the protected line/cable length in km or in miles. This setting is available if MEASURE'T SETUP column is selected as 'Visible' in the CONFIGURATION column. The unit (km or miles) depends on the 'Distance unit' setting in the MEASURE'T SETUP column.				
30	03	Line Length	62mi	From 0.2mi to 625mi step 0.005mi
Setting of the protected line/cable length in km or in miles. This setting is available if MEASURE'T SETUP column is selected as 'Visible' in the CONFIGURATION column. The unit (km or miles) depends on the 'Distance unit' setting in the MEASURE'T SETUP column.				
30	04	Line Impedance	12Ω	From 0.001/In Ω to 500/In Ω step 0.001/In Ω
Setting for protected line/cable positive sequence impedance in either primary or secondary terms, depending on the "Setting Values" reference chosen in the CONFIGURATION column. The set value is used for Fault locator, and for all distance zone reaches calculation if 'Simple' setting mode under "GROUP x LINE PARAMETERS" is selected. This line parameter can be set in polar or rectangular form (see section P44x/EN AP for a complete description)				
30	05	Line Angle	70°	From -90° to 90° step 0.1°
Setting of the line angle (line positive sequence impedance angle). This setting can be set in polar or rectangular form (see section P44x/EN AP).				
30	06	Zone Setting		
Set the parameters for Protected Zone in the following settings				
30	07	Zone Status	110110(bin)	Bit 00 (last digit)=Z1X enabled Bit 01=Z2 enabled Bit 02=Zp enabled Bit 03=Zq enabled Bit 04=Z3 enabled Bit 05 (first digit)=Z4 enabled
Zone Status: Distance protection zones can be enabled or disabled individually. Setting the relevant bit to 1 will enable the zone. Zone 1 should be always enabled. The other zones should be enabled when required (for use in channel aided schemes). If Z3 is disabled, the forward limit element becomes the smaller zone (Zp if selected forward) If Z3 & Zp Fwd are disabled, the forward limit element becomes Z2 If Z3 & Zp Fwd & Z2 are disabled, the forward limit element becomes Z1 If Z4 is disabled, the directional limit for the fordward zone is 30°. Z4 is always reverse. The following settings are displayed when the relevant zone is enabled. See P44x/EN AP for complete description and calculation for these elements.				
30	08	kZ1 Res Comp	1	0 to 7 step 0.001
Zone 1 compensation (KZ1 residual compensation and kZ1 angle, refer to section P44x/EN AP for zone setting				
30	09	kZ1 Angle	0°	From -180° to 180° step 0.1°
Zone 1 compensation (KZ1 residual compensation and kZ1 angle, refer to section P44x/EN AP for zone setting				
30	0A	Z1	10Ω	From 0.001/In Ω to 500/In Ω step 0.001/In Ω
Zone 1 impedance setting.				
30	0B	Z1X	15Ω	From 0.001/In Ω to 500/In Ω step 0.001/In Ω
Z1X impedance setting for Z1 extension schemes.				
30	0C	R1G	10Ω	From 0/In Ω to 400/In Ω step 0.01/In Ω
R1G: Resistive reach (Earth fault element, refer to P44x/EN AP for resistive reach calculation (earth and phase) setting)				
30	0D	R1Ph	10Ω	From 0/In Ω to 400/In Ω step 0.01/In Ω
R1Ph: Resistive reach (phase fault element, refer to P44x/EN AP for resistive reach calculation (earth and phase) settings).				
30	0E	tZ1	0s	From 0 to 10 step 2ms
Zone 1 time delay (TZ1): Zone 1 time delay setting (refer to P44x/EN AP for setting).				
30	0F	kZ2 Res Comp	1	0 to 7 step 0.001
Zone 2 compensation (KZ2 residual compensation and kZ2 angle, refer to section P44x/EN AP for zone setting				
30	10	kZ2 Angle	0°	From -180° to 180° step 0.1°

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Zone 2 compensation (KZ2 residual compensation and kZ2 angle) setting.				
30	11	Z2	20Ω	From 0.001/In Ω to 500/In Ω step 0.001/In Ω
Zone 2 impedance setting.				
30	12	R2G	20Ω	From 0/In Ω to 400/In Ω step 0.01/In Ω
R2G: resistive reach – Earth fault element setting for zone 2.				
30	13	R2Ph	20Ω	From 0/In Ω to 400/In Ω step 0.01/In Ω
R2Ph: Resistive reach – phase fault elements setting for zone 2.				
30	14	tZ2	200ms	From 0s to 10s step 10ms
Zone 2 time delay (TZ2) setting.				
30	15	kZ3/4 Res Comp	1	0 to 7 step 0.001
Zone 3/4 compensation (KZ3/4 residual compensation and kZ3/4 angle, refer to section P44x/EN AP for zone setting				
30	16	kZ3/4 Angle	0°	From -180° to 180° step 0.1°
Zone 3 and 4 compensations (KZ3/4 residual compensation and kZ3/4 angle) setting.				
30	17	Z3	30Ω	From 0.001/In Ω to 500/In Ω step 0.001/In Ω
Zone 3 impedance setting.				
30	18	R3G - R4G	30Ω	From 0/In Ω to 400/In Ω step 0.01/In Ω
R3G – R4G: Resistive reach – Earth fault elements setting for zones 3 and 4.				
30	19	R3Ph - R4Ph	30Ω	From 0/In Ω to 400/In Ω step 0.01/In Ω
R3Ph – R4Ph: resistive reach – Phase fault elements setting for zones 3 and 4.				
30	1A	tZ3	600ms	From 0s to 10s step 10ms
Zone 3 time delay (TZ3) setting.				
30	1B	Z4	40Ω	From 0.001/In Ω to 500/In Ω step 0.001/In Ω
Zone 4 impedance setting.				
30	1C	tZ4	1s	From 0s to 10s step 10ms
Zone 4 time delay (TZ4) setting.				
30	1D	ZoneP - Direct	Directional FWD	Directional FWD, Directional REV
Zone P direction setting.				
30	1E	kZp Res Comp	1	0 to 7 step 0.001
Zone p compensation (KZp residual compensation and kZp angle, refer to section P44x/EN AP for zone setting				
30	1F	kZp Angle	0°	From -180° to 180° step 0.1°
Zone P compensation (KZp residual compensation and kZp angle).				
30	20	Zp	25Ω	From 0.001/In Ω to 500/In Ω step 0.001/In Ω
Zone p impedance setting.				
30	21	RpG	25Ω	From 0/In Ω to 400/In Ω step 0.01/In Ω
RpG: Resistive reach – Earth fault element for zone P.				
30	22	RpPh	25Ω	From 0/In Ω to 400/In Ω step 0.01/In Ω
RpPh: Resistive reach – phase fault element for zone p.				
30	23	tZp	400ms	From 0s to 10s step 10ms
Zone P time delay (TZp)				
30	24	ZoneQ - Direct	Directional FWD	Directional FWD, Directional REV
Zone q is a further distance zone. It can be faster or slower than any other zone (except zone 1), and it can be in either direction. The only constraint is that it must be inside the overall Z3/Z4 start-up zone.				
30	25	kZq Res Comp	1	0 to 7 step 0.001
Zone q compensation (KZq residual compensation and kZq angle, refer to section P44x/EN AP for zone setting				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
30	26	kZq Angle	0°	From -180° to 180° step 0.1°
Zone Q compensation (KZq residual compensation and kZq angle)				
30	27	Zq	27Ω	From 0.001/In Ω to 500/In Ω step 0.001/In Ω
Zone q impedance setting.				
30	28	RqG	27	From 0/In Ω to 400/In Ω step 0.01/In Ω
RqG: Resistive reach – Earth fault element for zone Q.				
30	29	RqPh	27	From 0/In Ω to 400/In Ω step 0.01/In Ω
RqPh: Resistive reach – phase fault element for zone Q.				
30	2A	tZq	500ms	From 0s to 10s step 10ms
Zone Q time delay (TZq)				
30	2B	Other Parameters		
The other parameters are configured in the following configuration.				
30	2C	Series Cmp. Line	Disabled	Enabled or Disabled
Series Compensated Line: If enabled, the Directional Line used in the Delta Algorithms is set at 90° (Fwd = Quad1&4 / Rev = Quad 2&3). If disabled, the Directional Line of the Delta algorithms is set at -30° like conventional algorithms				
30	2D	Overlap Z Mode	Disabled	Enabled or Disabled
Overlap Z Mode: If enabled, the zones overlap so a fault in Z1 will also be a Z2/Zp/Z3 start (or trip if not cleared) in LCD/Events/Drec – The internal logic is not modified				
30	2E	Z1m Tilt Angle	0°	From -45° to 45° step 1°
The settings dealing with the tilt (‘Z1m Tilt Angle’, ‘Z1p Tilt Angle’, ‘Z2p/Zp/Zq Tilt Angle’) and the evolving forward zone detection to zone1 (to avoid a Z1 detection in case of impedance locus getting out from the quad, due to remote CB operating) but crossing the Z1 before being out from the quad (with enough points that a Z1 decision) can be confirmed if that timer has been set to 0ms. Z1m and Z1p Tilt Angle: The tilt angles can be independently set (±45°) for phase-to-ground and phase-to-phase setting.				
30	2F	Z1p Tilt Angle	0°	From -45° to 45° step 1°
The settings dealing with the tilt (‘Z1m Tilt Angle’, ‘Z1p Tilt Angle’, ‘Z2p/Zp/Zq Tilt Angle’) and the evolving forward zone detection to zone1 (to avoid a Z1 detection in case of impedance locus getting out from the quad, due to remote CB operating) but crossing the Z1 before being out from the quad (with enough points that a Z1 decision) can be confirmed if that timer has been set to 0ms. Z1m and Z1p Tilt Angle: The tilt angles can be independently set (±45°) for phase-to-ground and phase-to-phase setting.				
30	30	Z2/p/q Tilt Angl	0°	From -45° to 45° step 1°
Tilt characteristic for zone 2, zone P and zone Q (common setting for phase-to-ground and phase-to-phase).				
30	31	Fwd Z Chg. Delay	30ms	From 0s to 100ms step 10ms
This time delay is set to prevent maloperation due to zone evolution from zone n to zone n-1 by CB operation.				
30	32	V Mem Validity	10s	From 0s to 10s step 10ms
The duration of the voltage memory availability after fault detection can be set. When the voltage memory is declared unavailable (e.g. the V Mem Validity set duration has expired, SOTF Mode, no healthy network to record memory voltage), other polarizing quantities can be considered. These include zero, negative and positive sequence (if voltage is sufficient). Otherwise directional decision is forced to forward.				
30	33	Earth I Detect.	0.05*I1	0*I1 to 0.1*I1 step 0.01*I1
The residual current threshold (Earth I Detect.) is used by the conventional algorithm to detect earth faults.				
30	34	Smart Zone	0.15	From 0% to 100% step 1%
Sets the ratio “smart zone impedance / load impedance limit Z3/Z4”. If Z3/Z4 impedance exceeds this limit (for more than 20 ms) an alarm is raised.				
30	40	Fault Locator		
Fault localtor setting				
30	41	kZm Mutual Comp	0	0 to 7 step 0.01
Zone m compensation (KZm residual compensation)				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
30	42	kZm Angle	0°	From -180° to 180° step 0.1°
Zone m compensation (kZm angle)				
30	43	Busbar isolation mode		
30	44	Busbar isol.Mode	Disabled	Enabled or Disabled
Enables or disables Busbar Isolation. 'Enabled' setting forces busbar isolation (e.g. for maintenance mode). In this case, all zones are symmetric, tripping mode is only a 3-pole trip and no scheme logic is used				

Table 3 - Distance Elements settings

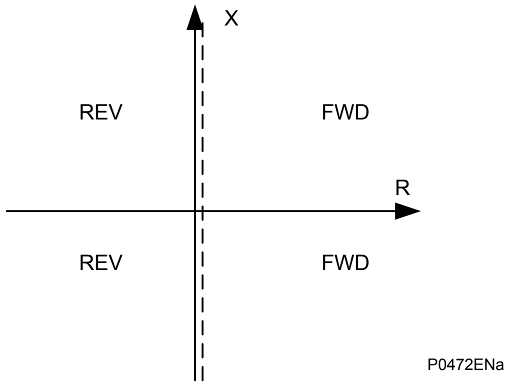


Figure 2 - Series Compensation Disabled - Directional Line used in the Delta Algorithms is set to -90°

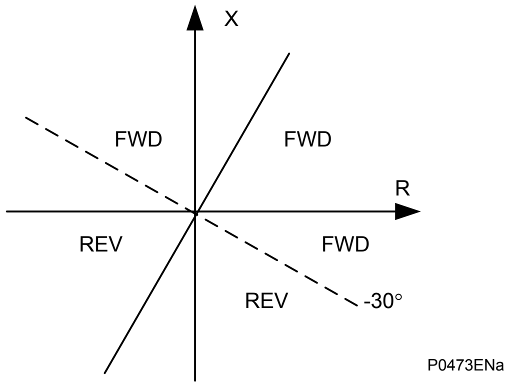


Figure 3 - Series Compensation Enabled - Directional Line used in the Delta algorithms is set to 30° like conventional algorithms

Remark	*The settings dealing with the tilt ('Z1m Tilt Angle', 'Z1p Tilt Angle', 'Z2p/Zp/Zq Tilt Angle') and the evolving forward zone detection to zone1 (to avoid a Z1 detection in case of impedance locus getting out from the quad (due to remote CB operating) but crossing the Z1 before being out from the quad (with enough points that a Z1 decision can be confirmed if that timer has been set to 0ms).*

4.4 Distance Protection Schemes

The option of using separate channels for Directional Earth Fault (DEF) aided tripping, and distance protection schemes, is offered in the relays. Alternatively, the aided DEF protection can share the distance protection signalling channel, and the same scheme logic. In this case, a permissive overreach or blocking distance scheme must be used. The aided tripping schemes can perform single pole tripping. The relays include basic five-zone distance scheme logic for stand-alone operation (where no signalling channel is available) and logic for a number of optional additional schemes. The features of the basic scheme will be available whether or not an additional scheme has been selected.

The function is based on a specification with a dedicated application equivalent to a customised weak infeed.

<table>
<tr><th>Col</th><th>Row</th><th>Courier Text</th><th>Default Setting</th><th>Available Setting</th></tr>
<tr><th colspan="5">Description</th></tr>
<tr><td>31</td><td>00</td><td>GROUP 1: DISTANCE SCHEMES</td><td></td><td></td></tr>
<tr><td colspan="5">GROUP1: Distance Schemes</td></tr>
<tr><td>31</td><td>01</td><td>Program Mode</td><td>Standard Scheme</td><td>Standard Scheme
Open Scheme</td></tr>
<tr><td colspan="5">The ‘Program Mode’ cell is used to select the standard program mode or open program mode. When Standard program mode is set, a standard basis scheme is selectable.
When a scheme is not covered in the Standard modes, the open programming mode can be selected. The user then has the facility to decide which distance relay zone is to be used to program the signalling channel, and what type of aided scheme runs when the channel is received. The signal send zone options, and the aided scheme options on channel receipt are settable.</td></tr>
<tr><td>31</td><td>02</td><td>Standard Mode</td><td>Basic + Z1X</td><td>Basic + Z1X, P.O.P Z1, P.O.P Z2, P.U.P Z2, P.U.P FWD, B.O.P Z1, B.O.P Z2</td></tr>
<tr><td colspan="5">The following schemes are available when the Standard program mode is selected:
– Basic + Zone 1 extended (see section P44x/EN AP),
– Permissive Underreach Transfer Trip Schemes PUP Z2 and PUP Fwd,
– Permissive Overreach Transfer Trip Schemes POP Z2 and POP Z1;
– Blocking Schemes BOP Z2 and BOP Z1.
The PUP, POP and BOP schemes are detailed in section P44x/EN AP</td></tr>
<tr><td>31</td><td>03</td><td>Fault Type</td><td>Both enabled</td><td>Phase to Ground, Phase to Phase, Both enabled.</td></tr>
<tr><td colspan="5">Fault type setting</td></tr>
<tr><td>31</td><td>04</td><td>Trip Mode</td><td>Force 3 poles</td><td>Force 3 poles, 1P Z1 & CR, 1P Z1 Z2 & CR</td></tr>
<tr><td colspan="5">Sets the tripping mode: 1-pole trip or 3-pole trip.</td></tr>
<tr><td>31</td><td>05</td><td>Sig Send Zone</td><td>None</td><td>None, CsZ1, CsZ2, CsZ4.</td></tr>
<tr><td colspan="5">The ‘Signal Send Zone’ option is available when an open scheme program mode is set. The user can decide which distance relay zone is used to send the signalling channel:
– CsZ1 or CsZ2 (‘Carrier send’ from Z1 or Z2): when a fault is detected in zone 1, or zone 2, the ‘Carrier Send’ is emitted from this zone to the relay. These settings are used to configure a permissive scheme.
– CsZ4 (‘Carrier send’ from Z4) when a fault is detected in zone 4 (reverse). This setting can be used to configure a blocking scheme. See section decision logic in the section P44x/EN AP.</td></tr>
<tr><td>31</td><td>06</td><td>DistCR</td><td>None</td><td>None, PermZ1, PermZ2, PermFWD, BlkZ1, BlkZ2.</td></tr>
</table>

Col	Row	Courier Text	Default Setting	Available Setting
Description				
The ‘Distance Carrier received’ option is available when an open scheme program mode is set. Aided scheme options on CR receipt: – Select ‘None’ to configure a basic scheme, – Select ‘PermZ1’ or ‘PermZ2’ to configure a permissive scheme where Zone 1 or Zone 2 can only trip (without waiting tZ1 or tZ2 timeout) if a signal is received, – Select ‘BlkZ1’ or ‘BlkZ2’ to configure a blocking scheme where Zone 1 or Zone 2 can only trip if a Distance Carrier is NOT received, – Select ‘PermFwd’ to configure a permissive scheme where any forward distance zone start will cause an aided trip if a Distance Carrier is received.				
31	07	Tp	20ms	From 0s to 1s step 2ms
Time setting				
31	08	tReversal Guard	20ms	From 0s to 150ms step 2ms
Where appropriate, the tReversal Guard and ‘Aid Dist Delay’ (transmission time in blocking scheme) time-delays (in the case of a blocking scheme covering the transmission time) settings will appear in the relay menu. Further customising of distance schemes can be achieved using the Programmable Scheme Logic to condition send and receive logic.				
31	09	Unblocking Logic	None	None, Loss of Guard, Loss of Carrier.
Three modes of unblocking logic are available for use with permissive schemes (blocking schemes are excluded): – None (basic mode), – Loss of Guard mode, – Loss of carrier mode. See section P44x/EN AP for details.				
31	0A	SOTF/TOR Mode	100000000110000(bin)	Bit 00=TOR Z1 enabled Bit 01=TOR Z2 enabled Bit 02=TOR Z3 enabled Bit 03=TOR All Zones Bit 04=TOR Dist. Scheme Bit 05=SOTF All Zones Bit 06=SOTF Lev. Detect. Bit 07=SOTF Z1 enabled Bit 08=SOTF Z2 enabled Bit 09=SOTF Z3 enabled Bit 0A=SOTF Z1 + Rev en. Bit 0B=SOTF Z2 + Rev en. Bit 0C=SOTF Dist. Scheme Bit 0D=SOTF Disable Bit 0E=SOTF I>3 enabled
Sets individual protection zones to enable or disable the TOR / SOTF protection. Setting the relevant bit to 1 will enable TOR / SOTF for the selected zone, setting bits to 0 will disable TOR / SOTF for the selected zone: – TOR (or SOTF) Zi enabled: TOR or SOTF logic enabled in case of fault in zone i, – TOR (or SOTF) All Zones: TOR or SOTF logic enabled for all zones, – TOR (or SOTF) Dist. Scheme: TOR or SOTF logic enabled for aided trip zones, – SOTF I>3 enabled: TOR and SOTF initiated after detection by I>3 overcurrent, – SOTF Lev. Detect.: SOTF initiated by level detectors. See SOTF / TOR section P44x/EN AP for TOR-SOFT logic and SOFT-TOR trip logic.				
31	0B	SOTF Delay	110s	10s to 3600s step 1s
The Switch On To Fault (SOTF) protection (high speed clearance of any detected fault immediately following manual closure of the circuit breaker) and Trip On Reclose (TOR) protection (high speed clearance of any fault detected immediately following autoreclosure of the circuit breaker). It is possible to set the time-delay to trip when, for example, the relay has detected a fault that is still present on a feeder after energising.				
31	0C	Z1Ext Fail	Disabled	Disabled or Enabled
Enable or disable the “Z1X extension on channel fail”: For the duration of any alarm condition (loss of guard, loss of carrier), the “zone 1 extension” trip logic will be invoked if this option has been enabled.				
31	0D	Weak Infeed		
Weak Infeed schemes are used when there is a weak source at one end of the line				
31	0E	WI:Mode Status	Disabled	Disabled, PAP, Echo, Trip & Echo
Weak infeed logic can be enabled with weak infeed echo option or weak infeed trip option (PAP is a specific customer application). Refer to Weak Infeed section (P44x/EN AP) for mode status and settings.				
31	12	PAP:Tele Trip En	Disabled	Disabled or Enabled

Col	Row	Courier Text	Default Setting	Available Setting
Description				
PAP (Passive Antenna Protection) is a specific customer application.				
31	13	PAP:Del. Trip En	Disabled	Disabled or Enabled
PAP (Passive Antenna Protection) is a specific customer application.				
31	14	PAP:P1	Disabled	Disabled or Enabled
PAP (Passive Antenna Protection) is a specific customer application.				
31	15	PAP:1P Time Del	500ms	From 100ms to 1.5s step 100ms
PAP (Passive Antenna Protection) is a specific customer application.				
31	16	PAP:P2	Disabled	Disabled or Enabled
PAP (Passive Antenna Protection) is a specific customer application.				
31	17	PAP:P3	Disabled	Disabled or Enabled
PAP (Passive Antenna Protection) is a specific customer application.				
31	18	PAP:3P Time Del	2s	From 100ms to 12s step 100ms
PAP (Passive Antenna Protection) is a specific customer application.				
31	19	PAP:IN Thres	0.5*I1	0.1*I1 to 1*I1 step 0.01*I1
PAP (Passive Antenna Protection) is a specific customer application.				
31	1A	PAP: K (%Vn)	0.5	0.5 to 1 step 0.05
PAP (Passive Antenna Protection) is a specific customer application.				
31	1B	Loss Of Load		
The loss of load (LoL) provides fast fault clearance for faults (see P44x/EN AP, LOL section)				
31	1C	LoL:Mode Status	Disabled	Disabled or Enabled
Setting that enables (turns on) or disables (turns off) the Loss of Load scheme. When enabled, the loss of load logic provides fast fault clearance for faults over the whole of a double end fed protected circuit for all types of fault, except three phases.				
31	1D	LoL:Chan Fail	Disabled	Disabled or Enabled
The Loss of Load logic can be chosen to be enabled when the channel associated with an aided scheme has failed.				
31	1E	LoL:I<	0.5*I1	0.05*I1 to 1*I1 step 0.05*I1
LOL undercurrent detector that indicates a loss of load condition on the unfaulted phases, indicating that the remote end has just opened.				
31	1F	LoL:Window	40ms	From 10ms to 100ms step 10ms
Length of LOL window - the time window in which Zone 2 accelerated tripping can occur following LOL undercurrent detector operation.				

Table 4 - Distance Schemes settings

4.5 Power Swing Detection and Blocking (PSB)

Power swings are oscillations in the power flow after a power system disturbance, caused by sudden removal of faults, loss of synchronism or power flow direction changing (as a result of switching). Such disturbances can cause generators acceleration or deceleration adapted to power flow, which in turn leads to power swinging.

A power swing may cause the impedance presented to a distance relay to move away from the normal load area and into one or more of its tripping characteristics. Depending on the setting or power swing stability, the relay should trip or not.

See the Application Notes chapter for a complete description of power swings.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
32	00	GROUP 1: POWER-SWING		
GROUP1: Power-Swing				
32	01	Delta R	0.5Ω	0 to 400/I1 Ω step 0.01/I1 Ω
Power swing detection Resistive band which surrounds phase fault trip characteristic (see section P44x/EN AP, section 4.1). Typically, the ΔR and ΔX band settings are both set between 10 - 30% of R3Ph. This gives a secondary impedance between 0.6 and 1.8Ω. For convenience, 1.0Ω could be set. The width of the power swing band is calculated as follows: $\Delta R = 1.3 \times \tan(\pi \times \Delta f \times \Delta t) \times RLOAD$ Assuming that the load corresponds to 60° angles between sources and if the resistive reach is set so that Rlim = RLOAD/2, the following is obtained: $\Delta R = 0.032 \times \Delta f \times RLOAD$ To ensure that a power swing frequency of 5Hz is detected, the following is obtained: $\Delta R = 0.16 \times RLOAD$ Where: ΔR: width of the power swing detection band Δf: power swing frequency (fA – fB) Rlim resistive reach of the starting characteristic (=R3ph-R4ph) Z: network impedance corresponding to the sum of the reverse (Z4) and forward (Z3) impedances				
32	02	Delta X	0.5Ω	0 to 400/I1 Ω step 0.01/I1 Ω
Power swing detection Reactive band which surrounds phase fault trip characteristic (see section P44x/EN AP).				
32	03	IN> status	Enabled	Disabled or Enabled
Residual current power swing unblocking criteria activation: Enables or disables the earth fault protection during Power Swing Bloc.king. When enabled, the relay will trip when IN > 'IN > (% Imax)' or when IN < 0.1 × In.				
32	04	IN> (%Imax)	0.4	10% to 100% step 1%
Residual current threshold for power swing unblocking. It is a percentage of the highest measured current on any phase. – Typical setting: 40% – Minimum setting (to avoid maloperation for asymmetric in power swing currents): > 30% – Maximum setting (to ensure unblocking for line faults): < 100%				
32	05	I2> status	Enabled	Disabled or Enabled
Negative Sequence current power swing unblocking criteria activation: Enables or disables the phase-phase fault protection during Power Swing Blocking. When enabled, the relay will trip when I2 > 'I2 > (% Imax)' or when I2 < 0.1 × In.				
32	06	I2> (%Imax)	0.3	10% to 100% step 1%
Negative Sequence current threshold for power swing unblocking. It is a percentage of the highest measured current on any phase. – Typical setting: 30% – Minimum setting (to avoid maloperation for asymmetric in power swing currents): > 10% – Maximum setting (to ensure unblocking for line faults): < 50%				
32	07	ImaxLine> Status	Enabled	Disabled or Enabled
Phase current power swing unblocking criteria activation: Enables or disables the three-phase fault protection during Power Swing Blocking. When enabled, the relay will trip when phase current threeshold exceeds Imax line >.				
32	08	ImaxLine >	3*I1	1*I1 to 20*I1 step 0.01*I1
Phase current threshold for power swing unblocking (unit:A) – Minimum setting: 1.2 × [maximum power swing current] – Maximum setting: 0.8 × [minimum phase fault current level]				
32	09	Delta I Status	Enabled	Disabled or Enabled
Delta I criterion status activation: Enables or disables the unblocking logic three-phase fault protection during Power Swing Blocking. Time delay is settable.				
32	0A	Unblocking delay	30s	From 0s to 30s step 100ms

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Time-delay after which blocking criteria is automatically removed. Typical setting: – 30s if a near permanent block is required, – 2s if unblocking is required to split the system.				
32	0B	Blocking Zones	000000(bin)	Bit 00=Z1&Z1X blocking Bit 01=Z2 blocking Bit 02=Zp blocking, Bit 03=Zq blocking Bit 04=Z3 blocking Bit 05=Z4 blocking
Allow zone blocking in case of a power swing. The Blocked Zones function bits are set to 1 to block zone tripping or are set to 0 to allow tripping as normal. When the criteria for power swing detection are met (3 single phase loop inside the quad & crossing the ΔR band in less than 5 ms in a 50 Hz network), and when out of step tripping is selected, then the distance protection with all of its stages is blocked – in order to prevent tripping by the distance protection (the relay can operate normally for any fault occurring during a power swing as there are different criteria which can be used by monitoring current & delta current).				
32	0C	Out of Step	1	1 to 255 step 1
Threshold of number of out of steps. Triggers DDB #352 when reached. Setting of the number of steps to confirm Out Of Step (OOS) condition.				
32	0D	Stable Swing	1	1 to 255 step 1
Threshold of number of Stable Swings. Triggers DDB #353 when reached. Setting of the number of steps to confirm Stable Swing condition				

Table 5 - Power Swing settings

4.6 Directional and Non-Directional 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.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
35	00	GROUP 1: BACK-UP I>		
GROUP1: Back-Up I>				
35	01	I>1 Function	DT	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
Sets the first phase overcurrent threshold (I>1) characteristic.				
35	02	I>1 Directional	Directional FWD	Non Directional, Directional FWD, Directional REV
Sets the directional control for the first stage overcurrent element.				
35	03	I>1 VTS Block	Block	Block, Non Directional
When the directional control for the ‘I>1’ is set, sets the Voltage Transformer Supervision (VTS) directionality (see section P44x/EN AP). The operation of the VTS will block the stage or will revert to Non-directional upon operation of the VTS.				
35	04	I>1 Current Set	1.5*I1	0.08*I1 to 10.0*I1 step 0.01*I1
Sets the value for the overcurrent threshold.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
35	05	I>1 Time delay	1s	From 0s to 100s step 10ms
Sets the time delay associated with I>1. The setting is available only when DT function is selected.				
35	06	I>1 Time VTS	200ms	From 0s to 100s step 10ms
If VTS Block is set to Non-Directional the element will operate with this time delay under VTS conditions				
35	07	I>1 TMS	1	0.025 to 1.2 step 0.005
Sets the Time Multiplier Setting (TMS), to adjust the operating time of the IEC/UK IDMT characteristics.				
35	08	I>1 Time Dial	7	0.5 to 15 step 0.1
Sets the time dial settings, to adjust the operating time of the IEEE/ US IDMT curves. The Time Dial is a multiplier of the standard curve equation, in order to achieve the required tripping time. The reference curve is based on Time Dial = 1. Care: Certain manufacturer's use a mid-range value of time dial = 5 or 7. So; it may be necessary to divide by 5 or 7 to achieve parity.				
35	09	I>1 Reset Char	DT	DT or Inverse
Setting to determine the type of reset / release characteristics of IEEE / US curves.				
35	0A	I>1 tReset	0s	From 0s to 100s step 10ms
Setting that determines the reset/release time for definite time reset characteristic.				
35	0B	I>2 Function	DT	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
Sets the second phase overcurrent threshold (I>1) characteristic.				
35	0C	I>2 Directional	Non Directional	Non Directional, Directional FWD, Directional REV
Sets the directional control for the second stage overcurrent element.				
35	0D	I>2 VTS Block	Block	Block, Non Directional
When the directional control for the 'I>2' is set, sets the Voltage Transformer Supervision (VTS) directionality (see section P44x/EN AP). The operation of the VTS will block the stage or will revert to Non-directional upon operation of the VTS.				
35	0E	I>2 Current Set	2*I1	0.08*I1 to 10.0*I1 step 0.01*I1
Sets the value for the overcurrent threshold.				
35	0F	I>2 Time delay	2s	From 0s to 100s step 10ms
Sets the time delay associated with I>2. The setting is available only when DT function is selected.				
35	10	I>2 Time VTS	2s	From 0s to 100s step 10ms
If VTS Block is set to Non-Directional the element will operate with this time delay under VTS conditions				
35	11	I>2 TMS	1	0.025 to 1.2 step 0.005
Sets the Time Multiplier Setting (TMS), to adjust the operating time of the IEC/UK IDMT characteristics.				
35	12	I>2 Time Dial	7	0.5 to 15 step 0.1
Sets the time dial settings, to adjust the operating time of the IEEE/ US IDMT curves. The Time Dial is a multiplier of the standard curve equation, in order to achieve the required tripping time. The reference curve is based on Time Dial = 1. Care: Certain manufacturer's use a mid-range value of time dial = 5 or 7. So; it may be necessary to divide by 5 or 7 to achieve parity.				
35	13	I>2 Reset Char	DT	DT or Inverse
Setting to determine the type of reset / release characteristics of IEEE / US curves.				
35	14	I>2 tReset	0s	From 0s to 100s step 10ms
Setting that determines the reset/release time for definite time reset characteristic.				
35	15	I>3 Status	Enabled	Disabled or Enabled
The third element is fixed as non-directional, for instantaneous or definite time delayed tripping.				
35	16	I>3 Current Set	3*I1	0.08*I1 to 32*I1 step 0.01*I1
Sets the value for the overcurrent threshold.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
35	17	I>3 Time delay	3s	From 0s to 100s step 10ms
Sets the time delay associated with I>3.				
35	18	I>4 Status	Disabled	Disabled or Enabled
The fourth element is non directional and can be used for stub bus protection. If the “stub bus enable” input is equal to 0, the I>4 function operates as a normal overcurrent stage with I>4 time delay, if the “stub bus enable” input is equal to 1, only the I>4 function is active (not I>1, I>2 and I>3) and it operates instantaneously.				
35	19	I>4 Current Set	4*I1	0.08*I1 to 32*I1 step 0.01*I1
Sets the value for the overcurrent threshold.				
35	1A	I>4 Time delay	4s	From 0s to 100s step 10ms
Sets the time delay associated with I>4 if no stub bus condition is activated through the binary input "stub bus enable"				

Table 6 - Backup I> settings

4.7 Negative Sequence 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 overcurrent element can operate for both phase-to-phase and phase to earth faults.

The following section describes how negative phase sequence overcurrent protection may be applied in conjunction with standard overcurrent and earth fault protection in order to alleviate some less common application difficulties.

- Negative phase sequence 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, an negative phase sequence 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 negative phase sequence current and hence an upstream negative phase sequence 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 negative phase sequence currents on the system. Operators may then investigate the cause of the unbalance.

The negative phase sequence overcurrent element has a current pick up setting 'I2> Current Set', and is time delayed in operation by the adjustable timer 'I2> Time Delay'. The user may choose to directionalise operation of the element, for either forward or reverse fault protection for which a suitable relay characteristic angle may be set. Alternatively, the element may be set as non-directional.

The relay menu for the negative sequence overcurrent element is shown below:

Col	Row	Courier Text	Default Setting	Available Setting
Description				
36	00	GROUP 1: NEG SEQUENCE O/C		
GROUP1: Negative Sequence O/C				
36	01	I2>1 Function	DT	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
Sets the first negtive sequence overcurrent threshold (I2>1) characteristic.				
36	02	I2>1 Directional	Non Directional	Non Directional, Directional FWD, Directional REV
Sets the directional control for the first stage negative sequence element				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
36	03	I2>1 VTS Block	Block	Block, Non Directional
When the directional control for the ‘I2>1’ is set, sets the Voltage Transformer Supervision (VTS) directionality. The operation of the VTS will block the stage or will revert to Non- directional upon operation of the VTS.				
36	04	I2>1 Current Set	0.2*I1	0.08*I1 to 4*I1 step 0.01*I1
Sets the value for the negative sequence current threshold.				
36	05	I2>1 Time delay	10s	From 0s to 100s step 10ms
Sets the time delay associated with I2>1. The setting is available only when DT function is selected.				
36	06	I2>1 Time VTS	200ms	From 0s to 100s step 10ms
If VTS Block is set to Non-Directional the element will operate with this time delay in seconds under VTS conditions				
36	07	I2>1 TMS	1	0.025 to 1.2 step 0.005
Sets the Time Multiplier Setting (TMS), to adjust the operating time of the IEC/UK IDMT characteristics.				
36	08	I2>1 Time Dial	1	0.01 to 100 step 0.01
Sets the time dial settings, to adjust the operating time of the IEEE/ US IDMT curves. The Time Dial is a multiplier of the standard curve equation, in order to achieve the required tripping time. The reference curve is based on Time Dial = 1. Care: Certain manufacturer’s use a mid-range value of time dial = 5 or 7. So; it may be necessary to divide by 5 or 7 to achieve parity.				
36	09	I2>1 Reset Char	DT	DT, Inverse
Setting to determine the type of reset / release characteristics of IEEE / US curves.				
36	0A	I2>1 tReset	0s	From 0s to 100s step 10ms
Setting that determines the reset/release time for definite time reset characteristic.				
36	0B	I2>2 Function	DT	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
Sets the second negtive sequence overcurrent threshold (I2>2) characteristic.				
36	0C	I2>2 Directional	Non Directional	Non Directional, Directional FWD, Directional REV
Sets the directional control for the first stage negative sequence element				
36	0D	I2>2 VTS Block	Block	Block, Non Directional
When the directional control for the ‘I2>2’ is set, sets the Voltage Transformer Supervision (VTS) directionality. The operation of the VTS will block the stage or will revert to Non- directional upon operation of the VTS.				
36	0E	I2>2 Current Set	0.2*I1	0.08*I1 to 4*I1 step 0.01*I1
Sets the value for the negative sequence current threshold.				
36	0F	I2>2 Time delay	10s	From 0s to 100s step 10ms
Sets the time delay associated with I2>2. The setting is available only when DT function is selected.				
36	10	I2>2 Time VTS	200ms	From 0s to 100s step 10ms
If VTS Block is set to Non-Directional the element will operate with this time delay in seconds under VTS conditions				
36	11	I2>2 TMS	1	0.025 to 1.2 step 0.005
Sets the Time Multiplier Setting (TMS), to adjust the operating time of the IEC/UK IDMT characteristics.				
36	12	I2>2 Time Dial	1	0.01 to 100 step 0.01
Sets the time dial settings, to adjust the operating time of the IEEE/US IDMT curves. The Time Dial is a multiplier of the standard curve equation, in order to achieve the required tripping time. The reference curve is based on Time Dial = 1. Care: Certain manufacturer’s use a mid-range value of time dial = 5 or 7. So; it may be necessary to divide by 5 or 7 to achieve parity.				
36	13	I2>2 Reset Char	DT	DT, Inverse
Setting to determine the type of reset / release characteristics of IEEE / US curves.				
36	14	I2>2 tReset	0s	From 0s to 100s step 10ms

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Setting that determines the reset/release time for definite time reset characteristic.				
36	15	I2>3 Status	Disabled	Disabled, Enabled
The third element can be used for instantaneous or definite time delayed tripping.				
36	16	I2>3 Directional	Non Directional	Non Directional, Directional FWD, Directional REV
Sets the directional control for the first stage negative sequence element				
36	17	I2>3 VTS Block	Block	Block, Non Directional
When the directional control for the 'I2>3' is set, sets the Voltage Transformer Supervision (VTS) directionality. The operation of the VTS will block the stage or will revert to Non- directional upon operation of the VTS.				
36	18	I2>3 Current Set	0.2*I1	0.08*I1 to 32*I1 step 0.01*I1
Sets the value for the negative sequence current threshold.				
36	19	I2>3 Time delay	10s	From 0s to 100s step 10ms
Sets the time delay associated with I2>3.				
36	1A	I2>3 Time VTS	200ms	From 0s to 100s step 10ms
If VTS Block is set to Non-Directional the element will operate with this time delay in seconds under VTS conditions				
36	1B	I2>4 Status	Disabled	Disabled, Enabled
The fourth element can be used for instantaneous or definite time delayed tripping.				
36	1C	I2>4 Directional	Non Directional	Non Directional, Directional FWD, Directional REV
Sets the directional control for the first stage negative sequence element				
36	1D	I2>4 VTS Block	Block	Block, Non Directional
When the directional control for the 'I2>4' is set, sets the Voltage Transformer Supervision (VTS) directionality. The operation of the VTS will block the stage or will revert to Non- directional upon operation of the VTS.				
36	1E	I2>4 Current Set	0.2*I1	0.08*I1 to 32*I1 step 0.01*I1
Sets the value for the negative sequence current threshold.				
36	1F	I2>4 Time delay	10s	From 0s to 100s step 10ms
Sets the time delay associated with I2>4.				
36	20	I2>4 Time VTS	200ms	From 0s to 100s step 10ms
If VTS Block is set to Non-Directional the element will operate with this time delay in seconds under VTS conditions				
36	21	I2> Char Angle	-45º	-95º to 95º step 1º
Where negative phase sequence current may flow in either direction through a relay location, such as parallel lines or ring main systems, directional control of the element should be employed (see section P44x/EN AP). Negative phase sequence relay characteristic angle. Comparison of the angle between the negative phase sequence voltage and the negative phase sequence current to achieve directionality (see section P44x/EN AP). It should be set equal to the phase angle of the negative phase sequence current, with respect to the inverted Negative phase sequence voltage (–V2)				

Table 7 - Negative Sequence Overcurrent settings

4.8 Maximum of Residual Power Protection - Zero Sequence Power Protection

The 'Zero Seq Power' menu is displayed when 'CONFIGURATION/Earth Fault Prot' cell is set to "Zero Seq Power".

The following chart shows the adjustment menu for the zero-sequence residual overcurrent protection, the adjustment ranges and the default in-factory adjustments.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
3C	00	GROUP 1: ZERO SEQ. POWER		
GROUP1: Zero Sequence Power				
3C	01	P0 Status	Enabled	Disabled, Enabled
Setting that enables or disables the zero sequence power protection.				
3C	02	Time Delay Fact.	0s	From 0s to 2s step 200ms
Setting for the K time delay factor. The K time delay factor adjusts the IDMT T(s) time-delay. T(s) = K × (Sref/Sr) where: – Sref = Reference residual power – Sr = Residual power generated by the fault				
3C	03	Fix Time Delay	1s	From 0s to 10s step 10ms
Setting for the fixed time delay				
3C	04	IN Current Set	0.1*I1	0.05*I1 to 1*I1 step 0.01*I1
Setting for the residual current				
3C	05	P0 Threshold	0.5*V1*I1	From 0.3*I1*V1 to 6*I1*V1 step 0.01*I1*V1
Setting to adjust the residual power threshold				

Table 8 - Zero Seq Power settings

4.9 Broken Conductor Detection

The following table shows the relay menu for the Broken Conductor protection, including the available setting ranges and factory defaults:

Col	Row	Courier Text	Default Setting	Available Setting
Description				
37	00	GROUP 1: BROKEN CONDUCTOR		
GROUP1: Broken Conductor				
37	01	Broken Conductor	Enabled	Disabled, Enabled
Setting that enables or disables the broken conductor protection				
37	02	I2/I1 Setting	0.2	0.2 to 1 step 0.01
Setting to determine the pick-up level of the negative sequence to positive sequence current ratio.				
37	03	I2/I1 Time delay	60s	From 0s to 100s step 100ms
Setting for the function operating time-delay.				
37	04	I2/I1 Trip	Disabled	Disabled, Enabled
Enables or disables the negative to positive current ratio protection. If disabled, only a Broken Conductor Alarm is possible.				

Table 9 - Broken Conductor settings

4.10 Directional and Non-Directional Earth Fault

The ‘Earth Fault O/C’ menu is displayed when ‘CONFIGURATION/Earth Fault Prot’ cell is set to “Earth Fault O/C”.

The following elements of Earth Fault protection are available, as follows:

IN> element	Channel aided Directional Earth Fault (DEF) protection;
IN>1 element	Directional or non-directional protection, Definite Time (DT) or IDMT time-delayed.
IN>2 element	Directional or non-directional, DT and IDMT delayed.
IN>3 element	Directional or non-directional, DT delayed.
IN>4 element	Directional or non-directional, DT delayed.

The Earth Fault protection elements include four thresholds. The first and the second thresholds can be set as DT or IDMT trip delay time. The curves are the same as for the Directional and Non-Directional Overcurrent Protection.

The IN> element may only be used as part of a channel-aided scheme, and is fully described in the Aided DEF section of the Application Notes chapter.

The IN>1, IN>2, IN>3 and IN>4 backup elements always trip three pole, and have an optional timer hold facility on reset, as per the phase fault elements. (The IN> element can be selected to trip single and/or three pole).

All Earth Fault overcurrent elements operate from a residual current quantity which is derived internally from the summation of the three phase currents.

These current thresholds are activated as an exclusive choice with Zero sequence Power Protection:

The following table shows the relay menu for the Earth Fault protection, including the available setting ranges and factory defaults.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
38	00	GROUP 1: EARTH FAULT O/C		
GROUP1: Earth Fault O/C				
38	01	IN>1 Function	DT	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
Sets the first earth fault overcurrent threshold (IN>1) characteristic.				
38	02	IN>1 Directional	Directional FWD	Non Directional, Directional FWD, Directional REV
Sets the directional control for the first stage earth fault element				
38	03	IN>1 VTS Block	Block	Block, Non Directional
When the directional control for the ‘IN>1’ is set, sets the Voltage Transformer Supervision (VTS) directionality. The operation of the VTS will block the stage or will revert to Non- directional upon operation of the VTS.				
38	04	IN>1 Current Set	0.2*I1	0.08*I1 to 10.0*I1 step 0.01*I1
Sets the value for the negative sequence current threshold.				
38	05	IN>1 Time delay	1s	From 0s to 200s step 10ms
Sets the time delay associated with IN>1. The setting is available only when DT function is selected.				
38	06	IN>1 Time VTS	200ms	From 0s to 200s step 10ms

Col	Row	Courier Text	Default Setting	Available Setting
Description				
If VTS Block is set to Non-Directional the element will operate with this time delay under VTS conditions				
38	07	IN>1 TMS	1	0.025 to 1.2 step 0.005
Sets the Time Multiplier Setting (TMS), to adjust the operating time of the IEC/UK IDMT characteristics.				
38	08	IN>1 Time Dial	7	0.5 to 15 step 0.1
Sets the time dial settings, to adjust the operating time of the IEEE/ US IDMT curves. The Time Dial is a multiplier of the standard curve equation, in order to achieve the required tripping time. The reference curve is based on Time Dial = 1. Care: Certain manufacturer's use a mid-range value of time dial = 5 or 7. So; it may be necessary to divide by 5 or 7 to achieve parity.				
38	09	IN>1 Reset Char	DT	DT, Inverse
Setting that determines the reset / release time reset characteristics.				
38	0A	IN>1 tReset	0s	From 0s to 100s step 10ms
Setting that determines the reset/release time for definite time reset characteristic.				
38	0B	IN>2 Function	DT	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
Sets the second earth fault overcurrent threshold (IN>2) characteristic.				
38	0C	IN>2 Directional	Non-Directional	Non Directional, Directional FWD, Directional REV
Sets the directional control for the second stage earth fault element				
38	0D	IN>2 VTS Block	Block	Block, Non Directional
When the directional control for the 'IN>2' is set, sets the Voltage Transformer Supervision (VTS) directionality. The operation of the VTS will block the stage or will revert to Non- directional upon operation of the VTS.				
38	0E	IN>2 Current Set	0.3*I1	0.08*I1 to 10.0*I1 step 0.01*I1
Sets the value for the negative sequence current threshold.				
38	0F	IN>2 Time delay	2s	From 0s to 200s step 10ms
Sets the time delay associated with IN>2. The setting is available only when DT function is selected.				
38	10	IN>2 Time VTS	2s	From 0s to 200s step 10ms
If VTS Block is set to Non-Directional the element will operate with this time delay under VTS conditions				
38	11	IN>2 TMS	1	0.025 to 1.2 step 0.005
Sets the Time Multiplier Setting (TMS), to adjust the operating time of the IEC/UK IDMT characteristics.				
38	12	IN>2 Time Dial	7	0.5 to 15 step 0.1
Sets the time dial settings, to adjust the operating time of the IEEE/ US IDMT curves. The Time Dial is a multiplier of the standard curve equation, in order to achieve the required tripping time. The reference curve is based on Time Dial = 1. Care: Certain manufacturer's use a mid-range value of time dial = 5 or 7. So; it may be necessary to divide by 5 or 7 to achieve parity.				
38	13	IN>2 Reset Char	DT	DT, Inverse
Setting that determines the reset / release time reset characteristics.				
38	14	IN>2 tReset	0s	From 0s to 100s step 10ms
Setting that determines the reset/release time for definite time reset characteristic.				
38	15	IN>3 Status	Enabled	Disabled, Enabled
The third element can be used for instantaneous or definite time delayed tripping.				
38	16	IN>3 Directional	Non-Directional	Non Directional, Directional FWD, Directional REV
Sets the directional control for the third stage earth fault element				
38	17	IN>3 VTS Block	Block	Block, Non Directional

Col	Row	Courier Text	Default Setting	Available Setting
Description				
When the directional control for the ‘IN>3’ is set, sets the Voltage Transformer Supervision (VTS) directionality. The operation of the VTS will block the stage or will revert to Non- directional upon operation of the VTS.				
38	18	IN>3 Current Set	0.3*I1	0.08*I1 to 32*I1 step 0.01*I1
Sets the value for the negative sequence current threshold.				
38	19	IN>3 Time delay	2s	From 0s to 200s step 10ms
Sets the time delay associated with IN>3. The setting is available only when DT function is selected.				
38	1A	IN>3 Time VTS	2s	From 0s to 200s step 10ms
If VTS Block is set to Non-Directional the element will operate with this time delay under VTS conditions				
38	1B	IN>4 Status	Enabled	Disabled, Enabled
The fourth element can be used for instantaneous or definite time delayed tripping.				
38	1C	IN>4 Directional	Non-Directional	Non Directional, Directional FWD, Directional REV
Sets the directional control for the fourth stage earth fault element				
38	1D	IN>4 VTS Block	Block	Block, Non Directional
When the directional control for the ‘IN>4’ is set, sets the Voltage Transformer Supervision (VTS) directionality. The operation of the VTS will block the stage or will revert to Non- directional upon operation of the VTS.				
38	1E	IN>4 Current Set	0.3*I1	0.08*I1 to 32*I1 step 0.01*I1
Sets the value for the negative sequence current threshold.				
38	1F	IN>4 Time delay	2s	From 0s to 200s step 10ms
Sets the time delay associated with IN>4. The setting is available only when DT function is selected.				
38	20	IN>4 Time VTS	2s	From 0s to 200s step 10ms
If VTS Block is set to Non-Directional the element will operate with this time delay under VTS conditions				
38	21	IN> DIRECTIONAL		
This setting determines the direction of measurement for the earth fault overcurrent element.				
38	22	IN Char Angle	-45°	From -95° to 95° step 1°
Earth fault (or, if set in “Polarisation” cell, negative sequence) relay characteristic angle. Comparison of the angle between the earth fault voltage and the earth fault current to achieve directionality (see section P44x/EN AP). It should be set equal to the phase angle of the earth fault current, with respect to the inverted earth fault voltage (–VN)				
38	23	Polarisation	Zero sequence	Zero sequence, Neg sequence
Sets earth fault or negative sequence for relay characteristic angle setting.				
38	24	IN> BLOCKING		
Neutral overcurrent blocking setting				
38	25	Block Pole Dead	Enabled	Disabled, Enabled
When enabled, neutral (residual) overcurrent element will block pole dead detection.				

Table 10 - Earth Fault Overcurrent settings

4.11 Aided Directional Earth Fault (DEF) Protection

The relay has aided scheme settings as shown in the following table:

Col	Row	Courier Text	Default Setting	Available Setting
Description				
39	00	GROUP 1: AIDED DEF		
GROUP1: Aided DEF				
39	01	Aided ch. Status	Enabled	Disabled, Enabled
To enable (activate) or disable (turn off) the Directional Earth Fault Element that is used in an aided scheme.				
39	02	Polarisation	Zero sequence	Zero sequence, Neg sequence
Setting that defines the method of DEF polarisation. Either zero, or negative sequence voltage can be taken as the directional reference. The applications of zero sequence and negative sequence polarisation are described in section P44x/EN AP, section Directional Directional and non directional Earth Fault Protection).				
39	03	V> Voltage Set	1V	From 0.5V to 20V step 0.01V
The V> threshold defines the minimum residual voltage required to enable the aided DEF directional decision. A residual voltage measured below this setting would block the directional decision, and hence there would be no tripping from the scheme.				
39	04	IN Forward	0.1*I1	0.05*I1 to 4*I1 step 0.01*I1
Setting of the netural current threshold in forward direction.				
39	05	Time Delay	0s	From 0s to 10s step 2ms
Setting of the time delay				
39	06	Scheme Logic	Shared	Shared, Blocking, Permissive
To select shared, blocking or permissive scheme logic.				
39	07	Tripping	Three Phase	Any phase, Three phase
Setting of tripping type, three phase or single phase.				
39	08	Tp	20ms	From 0s to 1s step 2ms
Aid Dist Delay (if blocking scheme not shared) Transmission time in blocking scheme. The Aided distribution time-delay (in the case of a blocking scheme covering the transmission time) settings will appear in the relay menu. Further customising of distance schemes can be achieved using the Programmable Scheme Logic to condition send and receive logic.				
39	09	IN Rev Factor	0.6	0.1 to 1 step 0.1
‘IN Rev Factor’ enhances the sensitivity for the residual current in case of reverse fault (for instance to create a faster blocking logic scheme).				
39	0A	Block. Time Add.	150ms	From 0s to 10s step 10ms
“Block. Time Add.” is an additional time-delay, set to extend a pole dead or convergence detection.				

Table 11 - Aided DEF settings

4.12 Thermal Overload

The following table shows the menu settings for the thermal protection element:

Col	Row	Courier Text	Default Setting	Available Setting
Description				
3A	00	GROUP 1: THERMAL OVERLOAD		
GROUP1: Thernal Overload				
3A	01	Characteristic	Single	Disabled, Single, Dual
Thermal characteristic setting. Available choices are: 'Disabled", 'Single' (for line and cable protection) and 'Dual' (for oil-filled transformers with natural air cooling protection)				
3A	02	Thermal Trip	1*I1	0.08*I1 to 3.2*I1 step 0.01*I1
Sets the full load current (IFLC) allowed and the pick-up threshold of the thermal characteristic.				
3A	03	Thermal Alarm	0.7	From 50% to 100% step 1%
An alarm can be raised on reaching a thermal state corresponding to a percentage of the trip threshold. A typical setting might be 'Thermal Trip' = 70% of thermal capacity.				
3A	04	Time Constant 1	10	From 1 to 200 step 1
Setting in minutes for the thermal time constant (τ1) for a single time constant characteristic, or the first time constant for the dual time constant characteristic.				
3A	05	Time Constant 2	5	From 1 to 200 step 1
Setting in minutes for the second time constant (τ2) for the dual time constant characteristic.				

Table 12 - Thermal Overload settings

4.13 Residual Overvoltage (Neutral Displacement) Protection

Col	Row	Courier Text	Default Setting	Available Setting
Description				
3B	00	GROUP 1: RESIDUAL O/V NVD		
GROUP1: Residual Over Voltage				
3B	01	VN Type	Residual	Residual, Homopolar
Select VN> settings as residual (3V0) or homopolar (V0) voltage				
3B	02	VN>1 Function	DT	Disabled, DT, IDMT
Select the residual overvoltage stage 1 as either Inverse Definite Minimum Time (IDMT), Definite Time (DT) or disabled. The following submenus are visible according to this setting.				
3B	03	VN>1 Voltage Set	5V	From 1V to 180V step 1V
Setting for the voltage threshold of the first stage VN> protection.				
3B	04	VN>1 Voltage Set	1.5V	From 0.5V to 60V step 0.5V
Setting for the voltage threshold of the first stage VN> protection.				
3B	05	VN>1 Time Delay	5s	From 0s to 100s step 10ms
Operating time delay setting for the first stage definite time residual overvoltage element.				
3B	06	VN>1 TMS	1	0.5 to 100 step 0.5
Setting for the Time Multiplier Setting to adjust the operating time of the IDMT characteristic. where K = Time Multiplier Setting (TMS), K = Operating time (in second) and M = measured voltage / relay setting voltage (V<).				
3B	07	VN>1 tReset	0s	From 0s to 100s step 10ms
Setting to determine the reset/release definite time for the first stage characteristic.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
3B	08	VN>2 Status	Disabled	Disabled or Enabled
Setting to enable or disable the second stage definite time residual overvoltage element.				
3B	09	VN>2 Voltage Set	10V	From 1V to 180V step 1V
Setting for the voltage threshold of the second stage VN> protection.				
3B	0A	VN>2 Voltage Set	3V	From 0.5V to 60V step 0.5V
Setting for the voltage threshold of the second stage VN> protection.				
3B	0B	VN>2 Time Delay	10s	From 0s to 100s step 10ms
Operating time delay setting for the second stage residual overvoltage element				

Table 13 - Resdidual Overvoltage settings

4.14 Undercurrent Protection

The undercurrent protection included within the relays consists of two independent stages.

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 current dip.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
3D	00	GROUP 1: I< PROTECTION		
GROUP1: I< Protection				
3D	01	I< Operate Mode	00(bin)	Bit 00=I<1 Trip Bit 01=I<2 Trip
Determines whether the stage will operate the "Any Trip" signal. Visible if either element is Enabled				
3D	02	I<1 Status	Disabled	Disabled / Enabled
Activates or deactivates the first stage undercurrent status. The two following submenus are visible when I<1 status is enabled.				
3D	03	I<1 Current Set	0.1*I1	0.08*I1 to 4*I1 step 0.01*I1
Pick-up setting for first stage undercurrent element.				
3D	04	I<1 Time delay	1s	From 0s to 100s step 10ms
Setting for the first stage undercurrent time-delay.				
3D	05	I<2 Status	Disabled	Disabled / Enabled
Activates or deactivates the second stage undercurrent status. The two following submenus are visible when I<2 status is enabled.				
3D	06	I<2 Current Set	0.15*I1	0.08*I1 to 4*I1 step 0.01*I1
Pick-up setting for second stage undercurrent element.				
3D	07	I<2 Time delay	2s	From 0s to 100s step 10ms
Setting for the first stage undercurrent time-delay.				

Table 14 - I< Protection settings

4.15 Voltage Protection Menu

This protection menu contains undervoltage and overvoltage protection.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
42	00	GROUP 1: VOLT PROTECTION		
GROUP1: Voltage Protection				
42	01	V< & V> MODE	00000000(bin)	Bit 00=V<1 Trip Bit 01=V<2 Trip Bit 02=V<3 Trip Bit 03=V<4 Trip Bit 04=V>1 Trip Bit 05=V>2 Trip Bit 06=V>3 Trip Bit 07=V>4 Trip
Determines whether the stage will operate the "Any Trip" signal. Visible if either element is Enabled				
42	02	UNDER VOLTAGE		
Set the parameters for V< protection in the following settings				
42	03	V< Measur't Mode	Phase_Neutral	Phase_Neutral, Phase_Phase
Select the undervoltage protection to operate from a phase to phase voltage or phase to neutral measurement.				
42	04	V<1 Function	DT	Disabled, DT, IDMT
Select the first undervoltage threshold as either Inverse Definite Minimum Time (IDMT), Definite Time (DT) or disabled. The three following submenus (Voltage, time delay and time multiplier setting) are visible according to this setting.				
42	05	V<1 Voltage Set	50V	From 10V to 120V step 1V
Sets the pick-up setting for first stage undervoltage element.				
42	06	V<1 Time Delay	10s	From 0s to 100s step 10ms
Setting for the operating time-delay for the first stage definite time undervoltage element.				
42	07	V<1 TMS	1	0.5 to 100 step 0.5
"The following formula defines the IDMT characteristics: $t = K / (1 – M)$, where K = Time Multiplier Setting (TMS), t = Operating time (in seconds) and M = measured voltage / relay setting voltage (V<)."				
42	08	V<2 Status	Disabled	Disabled, Enabled
Enable or disable the second undervoltage threshold. The voltage and time-delay (following submenus) are settable when V<2 status is enabled. Stage 2 is DT only.				
42	09	V<2 Voltage Set	38V	From 10V to 120V step 1V
Sets the pick-up setting for second stage undervoltage element.				
42	0A	V<2 Time Delay	500ms	From 0s to 100s step 10ms
Setting for the operating time-delay for the second stage definite time undervoltage element.				
42	0B	V<3 Status	Disabled	Disabled, Enabled
Enable or disable 3rd undervoltage threshold. The voltage and time-delay (following submenus) are settable when V<3 status is enabled. Stage 3 is DT only.				
42	0C	V<3 Voltage Set	30V	From 10V to 120V step 1V
Sets the pick-up setting for third stage undervoltage element.				
42	0D	V<3 Time Delay	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for the third stage definite time undervoltage element.				
42	0E	V<4 Status	Disabled	Disabled, Enabled
Enable or disable 4th undervoltage threshold. The voltage and time-delay (following submenus) are settable when V<4 status is enabled. Stage 4 is DT only.				
42	0F	V<4 Voltage Set	25V	From 10V to 120V step 1V
Sets the pick-up setting for fourth stage undervoltage element.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
42	10	V<4 Time Delay	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for the fourth stage definite time undervoltage element.				
42	11	OVERVOLTAGE		
Set the parameters for V> protection in the following settings				
42	12	V> Measur't Mode	Phase_Neutral	Phase-phase, Phase-neutral
Select the overvoltage protection to operate from a phase to phase voltage or phase to neutral measurement.				
42	13	V>1 Function	DT	Disabled, DT, IDMT
Select the first overvoltage threshold as either Inverse Definite Minimum Time (IDMT), Definite Time (DT) or disabled (see setting guidelines, section 2.4). The three following submenus (Voltage, time delay and time multiplier setting) are visible according to this setting.				
42	14	V>1 Voltage Set	75V	From 40V to 185V step 1V
Sets the pick-up setting for first stage overvoltage element.				
42	15	V>1 Time Delay	10s	From 0s to 100s step 10ms
Setting for the operating time-delay for the first stage definite time overvoltage element.				
42	16	V>1 TMS	1	0.5 to 100 step 0.5
"The following formula defines the IDMT characteristics: t = K / (M – 1), where K = Time Multiplier Setting (TMS), t = Operating time (in seconds) and M = measured voltage / relay setting voltage (V>)." 4604 Sets maximum I> threshold. The setting is used to override a voltage supervision block in the event of a phase fault occurring on the system (where 3 voltages are lost and the line is energized) that could trigger the voltage supervision logic.				
42	17	V>2 Status	Disabled	Disabled, Enabled
Enable or disable the second overvoltage threshold. The voltage and time-delay (following submenus) are settable when V>2 status is enabled. Stage 2 is DT only.				
42	18	V>2 Voltage Set	90V	From 40V to 185V step 1V
Sets the pick-up setting for second stage overvoltage element.				
42	19	V>2 Time Delay	500ms	From 0s to 100s step 10ms
Setting for the operating time-delay for the second stage definite time overvoltage element.				
42	1A	V>3 Status	Disabled	Disabled, Enabled
Enable or disable 3rd overvoltage threshold. The voltage and time-delay (following submenus) are settable when V>3 status is enabled. Stage 3 is DT only.				
42	1B	V>3 Voltage Set	100V	From 40V to 185V step 1V
Sets the pick-up setting for third stage overvoltage element.				
42	1C	V>3 Time Delay	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for the third stage definite time overvoltage element.				
42	1D	V>4 Status	Disabled	Disabled, Enabled
Enable or disable 4th overvoltage threshold. The voltage and time-delay (following submenus) are settable when V>4 status is enabled. Stage 4 is DT only.				
42	1E	V>4 Voltage Set	105V	From 40V to 185V step 1V
Sets the pick-up setting for fourth stage overvoltage element.				
42	1F	V>4 Time Delay	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for the fourth stage definite time overvoltage element.				

Table 15 – Under and Overvoltage Protection settings

4.16 Frequency Protection

This protection menu contains underfrequency and overfrequency protection.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
43	00	GROUP 1: FREQ PROTECTION		
GROUP1: Frequency Protection				
43	01	UNDER FREQUENCY		
Set the parameters for F< protection in the following settings				
43	02	F<1 Status	Disabled	Disabled / Enabled
Setting to enable or disable the first underfrequency element. The F<1 threshold setting and time-delay (following submenus) are settable when F<1 status is enabled.				
43	03	F<1 Freq Set	49.5Hz	From 45Hz to 65Hz step 0.01Hz
Setting that determines the pick-up threshold for the first stage underfrequency element.				
43	04	F<1 Time Delay	4s	From 0s to 100s step 10ms
Setting that determines the minimum operating time-delay for the first stage underfrequency element.				
43	05	F<2 Status	Disabled	Disabled / Enabled
Setting to enable or disable the second underfrequency threshold (same setting as stage 1).				
43	06	F<2 Freq Set	49Hz	From 45Hz to 65Hz step 0.01Hz
Setting that determines the pick-up threshold for the second stage underfrequency element.				
43	07	F<2 Time Delay	3s	From 0s to 100s step 10ms
Setting that determines the minimum operating time-delay for the second stage underfrequency element.				
43	08	F<3 Status	Disabled	Disabled / Enabled
Setting to enable or disable the 3rd underfrequency threshold (same setting as stage 1).				
43	09	F<3 Freq Set	48.5Hz	From 45Hz to 65Hz step 0.01Hz
Setting that determines the pick-up threshold for the third stage underfrequency element.				
43	0A	F<3 Time Delay	2s	From 0s to 100s step 10ms
Setting that determines the minimum operating time-delay for the third stage underfrequency element.				
43	0B	F<4 Status	Disabled	Disabled / Enabled
Setting to enable or disable the 4th underfrequency threshold (same setting as stage 1).				
43	0C	F<4 Freq Set	48Hz	From 45Hz to 65Hz step 0.01Hz
Setting that determines the pick-up threshold for the fourth stage underfrequency element.				
43	0D	F<4 Time Delay	1s	From 0s to 100s step 10ms
Setting that determines the minimum operating time-delay for the fourth stage underfrequency element.				
43	0E	OVER FREQUENCY		
Set the parameters for F> protection in the following settings				
43	0F	F>1 Status	Disabled	Disabled / Enabled
Setting to enable or disable the first overfrequency element. The F>1 threshold setting and time-delay (following submenus) are settable when F>1 status is enabled.				
43	10	F>1 Freq Set	50.5Hz	From 45Hz to 65Hz step 0.01Hz
Setting that determines the pick-up threshold for the first stage overfrequency element.				
43	11	F>1 Time Delay	2s	From 0s to 100s step 10ms
Setting that determines the minimum operating time-delay for the first stage overfrequency element.				
43	12	F>2 Status	Disabled	Disabled / Enabled
Setting to enable or disable the second overfrequency threshold (same setting as stage 1).				
43	13	F>2 Freq Set	51Hz	From 45Hz to 65Hz step 0.01Hz

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Setting that determines the pick-up threshold for the second stage overfrequency element.				
43	14	F>2 Time Delay	1s	From 0s to 100s step 10ms
Setting that determines the minimum operating time-delay for the second stage overfrequency element.				

Table 16 – Under and Overfrequency settings

4.17 Circuit Breaker Fail (CBF) Protection

Col	Row	Courier Text	Default Setting	Available Setting
Description				
45	00	GROUP 1: CB FAIL & I<		
GROUP1: CB Fail & I<				
45	01	BREAKER FAIL		
Set the parameters for Circuit Breaker Failure in the following settings				
45	02	CB Fail 1 Status	Enabled	Enabled, Disabled
Setting to enable or disable the first stage of the circuit breaker function.				
45	03	CB Fail 1 Timer	200ms	From 0s to 10s step 5ms
Setting for the circuit breaker fail timer stage 1, during which breaker opening must be detected.				
45	04	CB Fail 2 Status	Disabled	Disabled / Enabled
Setting to enable or disable the second stage of the circuit breaker function.				
45	05	CB Fail 2 Timer	400ms	From 0s to 10s step 5ms
Setting for the circuit breaker fail timer stage 2, during which breaker opening must be detected.				
45	06	CBF Non I Reset	CB open & I<	I< Only, CB open & I<, Prot Reset & I<, Disable, Prot Reset or I<
Setting which determines the elements that will reset the circuit breaker fail time for undercurrent protection function initiated circuit breaker fail conditions.				
45	07	CBF Ext Reset	CB open & I<	I< Only, CB open & I<, Prot Reset & I<, Disable, Prot Reset or I<
Setting which determines the elements that will reset the circuit breaker fail time for external protection function initiated circuit breaker fail conditions.				
45	08	UNDERCURRENT		
Set the parameter for Under Current in the following settings				
45	09	I < Current Set	0.05*I1	0.05*I1 to 3.2*I1 step 0.1*I1
Setting that determines the circuit breaker fail timer reset current for overcurrent based protection circuit breaker fail initiation.				

Table 17 - CB FAIL & I<settings

5 CONTROL AND SUPPORT SETTINGS

5.1 System Data

Col	Row	Courier Text	Default Setting	Available Setting
Description				
00	00	SYSTEM DATA		
This column contains general system settings				
00	01	Language	English	English, French, German, Italian, Spanish, Chinese (UI only)
The default language used by the device. Selectable as English, French, German, Spanish, Italian and Chinese. Chinese is UI only.				
00	04	Description	MiCOM	32 to 234 step 1
Editable 16-character description of the unit				
00	05	Plant Reference	MiCOM	32 to 234 step 1
Plant description: Can be edited				
00	06	Model Number	Model number	<Model number>
Displays the model number. This can not be edited				
00	08	Serial Number	Serial number	<Serial number>
Displays the serial number. This can not be edited.				
00	09	Frequency	50 Hz	50Hz or 60 Hz
Sets the main frequency				
00	0A	Comms Level	2	<conformance level displayed>
Displays the conformance of the relay to the Courier Level 2 comms				
00	0B	Relay Address	255 1 1 1	0 to 255 step 1 (Courier) 1 to 247 step 1 (Modbus) 0 to 254 step 1 (CS103) 0 to 65519 step 1 (DNP3)
Sets the first rear port relay address. Build = Courier (Address available via LCD) Build = Modbus (Address available via LCD) Build = CS103 (Address available via LCD) Build = DNP3.0 (Address available via LCD)				
00	0C	Plant Status		Not Settable
Displays the circuit breaker plant status.				
00	0D	Control Status		Not Settable
Not used				
00	0E	Active Group	1	Not Settable
Displays the active settings group				
00	10	CB Trip/Close	No Operation	0 = No Operation, 1 = Trip, 2 = Close
Supports trip and close commands if enabled in the Circuit Breaker Control menu.				
00	11	Software Ref. 1		<Software Ref. 1>
Displays the relay software version including protocol and relay model.				
00	12	Software Ref. 2		<Software Ref. 2>
Relay Ethernet card software reference. Visible when Ethernet card fitted.				
00	14	NIC Platform Ref		<NIC platform reference>
Displays the relay NIC platform reference. Visible when Ethernet card fitted.				
00	15	IEC61850 Edition	2	1 or 2

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Selects IEC 61850 Editions, Edition 1 or Edition 2. This setting can only be changed via HMI and the changes will cause the Ethernet board to reboot.				
00	16	ETH COMM Mode	Dual IP	Dual IP, PRP, HSR
Sets the redundancy protocol. This setting can only be changed via the HMI and the changes will cause the Ethernet board to reboot.				
00	20	Opto I/P Status		Not Settable
Display the status of the available opto inputs fitted.				
00	21	Relay Status 1		Not Settable
Displays the status of the first 32 output relays.				
00	22	Alarm Status 1		Not Settable
This menu cell displays the status of the first 32 alarms as a binary string. 1 indicates an ON state and 0 an OFF state. Includes fixed and user settable alarms.				
00	40	Relay Status 1		Not Settable
Displays the status of the first 32 relay outputs.				
00	41	Relay Status 2		Not Settable
Displays the status of the next 32 relay outputs. This setting does not apply to P442 relays.				
00	50	Alarm Status 1		Not Settable
This menu cell displays the status of the first 32 alarms as a binary string. 1 indicates an ON state and 0 an OFF state. Includes fixed and user settable alarms.				
00	51	Alarm Status 2		Not Settable
This menu cell displays the status of the second 32 alarms as a binary string.1 indicates an ON state and 0 an OFF state.				
00	52	Alarm Status 3		Not Settable
This menu cell displays the status of the third 32 alarms as a binary string. 1 indicates an ON state and 0 an OFF state. Assigned specifically for platform alarms.				
00	53	Usr Alarm Status		Not Settable
This menu cell displays the status of the 32 user alarms as a binary string. 1 indicates an ON state and 0 an OFF state.				
00	D0	Access Level	ENGINEER	Not Settable
Display the Role(s) of the current logged in user, if no one logged in, it shall be "NONE".				
00	D3	New Eng.Level PW		ASCII 33 to 122
Allows user to change password for EngineerLevel. Visible on UI only.				
00	D4	New Op.Level PW		ASCII 33 to 122
Allows user to change password for OperatorLevel. Visible on UI only.				
00	DF	Security Feature	3	Not Settable
Displays the level of cyber security inmplemented.				
00	E1	Password		<Password>
Used to send encrypted password. Not visible on UI				
00	E5	Encryption Salt		<Encryption Salt>
Random data used with encrypted password. Not visible on UI				
00	F1	Enter username		<User Name>
User selection for login. Not visible on UI				
00	F2	Number of users	2	Not Settable
Shows the number of users configured within the relays RBAC				
00	F3	New UI pwd		<Second Simple Password>
Hidden cell reserved for second password modification. Not in use currently.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
00	F4	New password		<Encrpted Password>
Allow password change if engineer or operator logged in and CSL0 model. Not visible on UI.				

Table 18 - System Data settings

5.2 View Records

Col	Row	Courier Text	Default Setting	Available Setting
Description				
01	00	VIEW RECORDS		
This column contains event, fault and maintenance records				
01	01	Select Event	0	From 0 to 511 step 1
This selects the required event record from all the possible ones that may be stored. A value of 0 corresponds to the latest event, with the maximum value the oldest.				
01	02	Menu Cell Ref		Not Settable
Indicates type of event				
01	03	Time & Date		Not Settable
Time & Date Stamp for the event given by the internal Real Time Clock.				
01	04	Event Text		Not Settable
Up to 16 Character description of the Event (refer to following sections).				
01	05	Event Value		Not Settable
Up to 32 Bit Binary Flag or integer representative of the Event (refer to following sections).				
01	06	Select Fault	0	From 0 to 4 step 1
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.				
01	07	Active Group		Not Settable
Displays the active setting group when fault occurred.				
01	08	Faulted Phase		Not Settable
Indicates whether measurements and fault location are valid				
01	09	Start Elements		Not Settable
Displays the status of the first 32 start signals.				
01	0A	Trip Elements		Not Settable
Displays the status of the first 32 trip signals.				
01	0B	Validities		Not Settable
Validaty of the fault record				
01	0C	Time Stamp		Not Settable
Displays fault time and date.				
01	0D	Fault Alarms		Not Settable
Displays the status of the fault alarm signals.				
01	0E	System Frequency		Not Settable
Displays the system frequency				
01	0F	Fault Duration		Not Settable
Displays time from the start or trip until the undercurrent elements indicate the CB is open				
01	10	Relay Trip Time		Not Settable

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Displays time from protection start to protection trip				
01	11	Fault Location		Not Settable
Displays fault location in meters.				
01	12	Fault Location		Not Settable
Displays fault location in miles.				
01	13	Fault Location		Not Settable
Displays fault location in ohms.				
01	14	Fault Location		Not Settable
Displays fault location in percentage.				
01	15	IA		Not Settable
Measured parameter				
01	16	IB		Not Settable
Measured parameter				
01	17	IC		Not Settable
Measured parameter				
01	1B	VAN		Not Settable
Measured parameter				
01	1C	VBN		Not Settable
Measured parameter				
01	1D	VCN		Not Settable
Measured parameter				
01	1E	Fault Resistance		Not Settable
Measured parameter				
01	1F	Fault in Zone		Not Settable
Measured parameter				
01	20	Trip Elements 2		Not Settable
Displays the status of the next 32 trip signals.				
01	21	Start Elements 2		Not Settable
Displays the status of the next 32 start signals.				
01	F0	Select Maint [0…n]	0	From 0 to 9 step 1
This selects the required maintenance report from those stored. A value of 0 corresponds to the latest report and so on.				
01	F1	Maint Text		Not Settable
Up to 16 Character description of the occurrence (refer to following sections).				
01	F2	Maint Type		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.				
01	F3	Maint Data		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.				
01	FA	Evt Iface Source		Not Settable
Interface on which the event was logged				
01	FB	Evt Access Level		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.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
01	FC	Evt Extra Info		Not Settable
This cell provides supporting information for the event and can vary between the different event types.				
01	FE	Evt Unique Id		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				
01	FF	Reset Indication	No	0=No 1=Yes
This serves to reset the trip LED indications provided that the relevant protection element has reset, to reset all LED and relays latched in the PSL, and to reset the latched alarms.				

Table 19 – View Records settings

5.3 Measurements 1 Settings

Col	Row	Courier Text	Default Setting	Available Setting
Description				
02	00	MEASUREMENTS 1		
This column contains measurement parameters				
02	01	IA Magnitude		Not Settable
IA Magnitude				
02	02	IA Phase Angle		Not Settable
IA Phase Angle				
02	03	IB Magnitude		Not Settable
IB Magnitude				
02	04	IB Phase Angle		Not Settable
IB Phase Angle				
02	05	IC Magnitude		Not Settable
IC Magnitude				
02	06	IC Phase Angle		Not Settable
IC Phase Angle				
02	09	IN Derived Mag		Not Settable
IN Derived Mag				
02	0A	IN Derived Ang		Not Settable
IN Derived Angle				
02	0D	I1 Magnitude		Not Settable
I1 Magnitude				
02	0E	I2 Magnitude		Not Settable
I2 Magnitude				
02	0F	I0 Magnitude		Not Settable
I0 Magnitude				
02	14	VAB Magnitude		Not Settable
VAB Magnitude				
02	15	VAB Phase Angle		Not Settable
VAB Phase Angle				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
02	16	VBC Magnitude		Not Settable
VBC Magnitude				
02	17	VBC Phase Angle		Not Settable
VBC Phase Angle				
02	18	VCA Magnitude		Not Settable
VCA Magnitude				
02	19	VCA Phase Angle		Not Settable
VCA Phase Angle				
02	1A	VAN Magnitude		Not Settable
VAN Magnitude				
02	1B	VAN Phase Angle		Not Settable
VAN Phase Angle				
02	1C	VBN Magnitude		Not Settable
VBN Magnitude				
02	1D	VBN Phase Angle		Not Settable
VBN Phase Angle				
02	1E	VCN Magnitude		Not Settable
VCN Magnitude				
02	1F	VCN Phase Angle		Not Settable
VCN Phase Angle				
02	22	VN Derived Mag		Not Settable
VN Derived Mag VN Measured Mag				
02	23	VN Derived Ang		Not Settable
VN Derived Ang VN Measured Ang				
02	24	V1 Magnitude		Not Settable
V1 Magnitude				
02	25	V2 Magnitude		Not Settable
V2 Magnitude				
02	26	V0 Magnitude		Not Settable
V0 Magnitude				
02	2A	Frequency		Not Settable
Frequency				
02	2B	C/S Voltage Mag		Not Settable
C/S Voltage Mag				
02	2C	C/S Voltage Ang		Not Settable
C/S Voltage Ang				
02	2F	IM Magnitude		Not Settable
IM Magnitude				
02	30	IM Angle		Not Settable
IM Phase Angle				
02	31	Slip Frequency		Not Settable
Slip Frequency				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
02	32	Z Magnitude		Not Settable
Impedance Module				
02	33	Z Angle		Not Settable
Impedance Argument				
02	34	To Ph-Ph Zone		Not Settable
% Zone bi				
02	35	To Ph-Gd Zone		Not Settable
% Zone mono				

Table 20 – Measurements 1 settings

5.4 Measurements 2 Settings

Col	Row	Courier Text	Default Setting	Available Setting
Description				
03	00	MEASUREMENTS 2		
This column contains measurement parameters				
03	01	A Phase Watts		Not settable
A Phase Watts				
03	02	B Phase Watts		Not settable
B Phase Watts				
03	03	C Phase Watts		Not settable
C Phase Watts				
03	04	A Phase VArs		Not settable
A Phase VArs				
03	05	B Phase VArs		Not settable
B Phase VArs				
03	06	C Phase VArs		Not settable
C Phase VArs				
03	07	A Phase VA		Not settable
A Phase VA				
03	08	B Phase VA		Not settable
B Phase VA				
03	09	C Phase VA		Not settable
C Phase VA				
03	0A	3 Phase Watts		Not settable
3 Phase Watts				
03	0B	3 Phase VArs		Not settable
3 Phase VArs				
03	0C	3 Phase VA		Not settable
3 Phase VA				
03	0D	Zero Seq Power		Not settable
Zero Seq Power				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
03	0E	3Ph Power Factor		Not settable
3Ph Power Factor				
03	0F	APh Power Factor		Not settable
APh Power Factor				
03	10	BPh Power Factor		Not settable
BPh Power Factor				
03	11	CPh Power Factor		Not settable
CPh Power Factor				
03	16	3Ph W Fix Dem		Not settable
3Ph W Fix Demand				
03	17	3Ph VArs Fix Dem		Not settable
3Ph VArs Fix Dem				
03	20	3Ph W Peak Dem		Not settable
3Ph W Peak Demand				
03	21	3Ph VArs Peak Dem		Not settable
3Ph VArs Peak Demand				
03	25	Reset Demand	No	0 = No or 1 = Yes
Reset Demand				

Table 21 – Measurements 2 settings

5.5 Measurements 3 Settings

Col	Row	Courier Text	Default Setting	Available Setting
Description				
04	00	MEASUREMENTS 3		
This column contains measurement parameters				
04	02	Thermal State		Not Settable
Displays thermal State				
04	03	Reset Thermal	No	0 = No or 1 = Yes
Send reset thermal state command				

Table 22 – Measurements 3 settings

5.6 Date and Time Settings

Col	Row	Courier Text	Default Setting	Available Setting
Description				
08	00	DATE AND TIME		
This column contains Date and Time settings				
08	01	Date/Time		<Date/Time>
Displays the IED’s current date and time.				
08	02	Date		<Date>
Front Panel Menu only				
08	03	Time		<Time>
Front Panel Menu only				
08	04	IRIG-B Sync	Disabled	0 = Disabled or 1 = Enabled
Enable IRIG-B time synchronization.				
08	05	IRIG-B Status		Not Settable
Displays the status of IRIG-B				
08	06	Battery Status		Not Settable
Displays whether the battery is healthy or not				
08	07	Battery Alarm	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				
08	13	SNTP Status		Not Settable
IEC61850 or DNP3.0 over Ethernet versions only. Displays information about the SNTP time synchronization status				
08	20	LocalTime Enable	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.				
08	21	LocalTime Offset	0min	From -720min to 720min step 15min
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				
08	22	DST Enable	Enabled	0 = Disabled or 1 = Enabled
Setting to turn on/off daylight saving time adjustment to local time.				
08	23	DST Offset	60min	From 30min to 60min step 30min
Setting to specify daylight saving offset which will be used for the time adjustment to local time.				
08	24	DST Start	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				
08	25	DST Start Day	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				
08	26	DST Start Month	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

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Setting to specify the month in which daylight saving time adjustment starts				
08	27	DST Start Mins	60min	From 0min to 1425min step 15min
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				
08	28	DST End	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				
08	29	DST End Day	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				
08	2A	DST End Month	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				
08	2B	DST End Mins	60min	From 0min to 1425min step 15min
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				
08	30	RP1 Time Zone	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				
08	31	RP2 Time Zone	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				
08	32	DNPOE Time Zone	UTC	0 = UTC or 1 = Local
IEC61850+DNP3oE versions only. Setting to specify if time synchronisation received will be local or universal time co-ordinated.				
08	33	Tunnel Time Zone	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				

Table 23 – Date and Time settings

6 NON-PROTECTION FUNCTIONS

6.1 Circuit Breaker Condition Features

For each circuit breaker trip and autoreclose operation the relay, records statistics. The ‘CB condition’ and ‘CB monitor setup’ menu cells are counter values only. The Min/Max values show the range of the counter values. These cells can be disabled:

Col	Row	Courier Text	Default Setting	Available Setting
Description				
06	00	CB CONDITION		
This column contains CB Condition Monitoring Measured Parameters				
06	01	CB A Operations		Not Settable
Number of Circuit Breaker Operations of Phase A				
06	02	CB B Operations		Not Settable
Number of Circuit Breaker Operations of Phase B				
06	03	CB C Operations		Not Settable
Number of Circuit Breaker Operations of Phase C				
06	04	Total IA Broken		Not Settable
Total Broken Current of Phase A				
06	05	Total IB Broken		Not Settable
Total Broken Current of Phase B				
06	06	Total IC Broken		Not Settable
Total Broken Current of Phase C				
06	07	CB Operate Time		Not Settable
Circuit Breaker operating time				
06	08	Reset CB Data	No	0 = No or 1 = Yes
Reset all CB values				
06	09	Total 1P Reclose		Not Settable
No of single phase Autoreclosures				
06	0A	Total 3P Reclose		Not Settable
No of 3 phases Autoreclosures				
06	0B	Reset Total A/R	No	0 = No or 1 = Yes
Reset No of Autoreclosures				

Table 24 - CB Condition settings

6.2 CB 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.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
10	00	CB MONITOR SETUP		
This column contains Circuit Breaker monitoring parameters				
10	01	Broken I^	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. NM1 = [0A08]^[1001]				
10	02	I^ Maintenance	Alarms Disabled	0 = Alarms Disabled or 1 = Alarms Enabled
Setting which determines if an alarm will be raised or not when the cumulative I^ maintenance counter threshold is exceeded.				
10	03	I^ Maintenance	1000	From 1*NM1 to 25000*NM1 step 1*NM1
Setting that determines the threshold for the cumulative I^ maintenance counter monitors.				
10	04	I^ Lockout	Alarms Disabled	0 = Alarms Disabled or 1 = Alarms Enabled
Setting which determines if an alarm will be raised or not when the cumulative I^lockout counter threshold is exceeded.				
10	05	I^ Lockout	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.				
10	06	No CB Ops Maint	Alarms Disabled	0 = Alarms Disabled or 1 = Alarms Enabled
Setting to activate the number of circuit breaker operations maintenance alarm.				
10	07	No CB Ops Maint	10	1 to 10000 step 1
Sets the threshold for number of circuit breaker operations maintenance alarm, indicating when preventative maintenance is due.				
10	08	No CB Ops Lock	Alarms Disabled	0 = Alarms Disabled or 1 = Alarms Enabled
Setting to activate the number of circuit breaker operations lockout alarm.				
10	09	No CB Ops Lock	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.				
10	0A	CB Time Maint	Alarms Disabled	0 = Alarms Disabled or 1 = Alarms Enabled
Setting to activate the circuit breaker operating time maintenance alarm.				
10	0B	CB Time Maint	100ms	From 5mss to 500mss step 1mss
Setting for the circuit operating time threshold which is set in relation to the specified interrupting time of the circuit breaker.				
10	0C	CB Time Lockout	Alarms Disabled	0 = Alarms Disabled or 1 = Alarms Enabled
Setting to activate the circuit breaker operating time lockout alarm.				
10	0D	CB Time Lockout	200ms	From 5mss to 500mss step 1mss
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.				
10	0E	Fault Freq Lock	Alarms Disabled	0 = Alarms Disabled or 1 = Alarms Enabled
Enables the excessive fault frequency alarm.				
10	0F	Fault Freq Count	10	From 0 to 9999 step 1
Sets a circuit breaker frequent operations counter that monitors the number of operations over a set time period				
10	10	Fault Freq Time	3600s	From 0s to 9999s step 1s

Col	Row	Courier Text	Default Setting	Available Setting
Description				
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).				
10	11	Lockout Reset	No	0 = No or 1 = Yes
Resets Lockout				
10	12	Reset Lockout By	CB Close	0 = User Interface or 1 = CB Close
Select the way to reset lockout				
10	13	Man Close RstDly	5s	From 10ms to 600s step 10ms
Sets the delay time for a manual close reset command				

Table 25 - CB Monitor Setup settings

6.3 Circuit Breaker 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

The following table shows the available settings and commands associated with circuit breaker control. Depending on the relay model some of the cells may not be visible:

Col	Row	Courier Text	Default Setting	Available Setting
Description				
07	00	CB CONTROL		
This column controls the circuit Breaker Control configuration				
07	01	CB Control by	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				
07	02	Close Pulse Time	500ms	From 100ms to 10s step 10ms
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.				
07	03	Trip Pulse Time	500ms	From 100ms to 5s step 10ms
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.				
07	04	Man Close Delay	10s	From 10ms to 600s step 10ms
This defines the delay time before the close pulse is executed.				
07	05	Healthy Windows	5s	From 10ms to 9999s step 10ms
Healthy window				
07	06	C/S Window	5s	From 10ms to 9999s step 10ms
Check synchronization window				
07	07	A/R Single Pole	Enabled	0 = Disabled or 1 = Enabled

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Autoreclose for single pole				
07	08	A/R Three Pole	Enabled	0 = Disabled or 1 = Enabled
Autoreclose for 3 poles				

Table 26 - CB Control settings

6.4 CT and VT Ratio

Col	Row	Courier Text	Default Setting	Available Setting
Description				
0A	00	CT AND VT RATIOS		
This column contains settings for Current and Voltage Transformer ratios				
0A	01	Main VT Primary	110V	From 100V to 1MV step 1V
Sets the main voltage transformer input primary voltage.				
0A	02	Main VT Sec'y	110V	From 80V to 140V step 1V
Sets the main voltage transformer input secondary voltage. Multiplier M1=[0A01]/[0A02]				
0A	03	C/S VT Primary	110V	From 100V to 1MV step 1V
Sets the System Check Synchronism voltage transformer input primary voltage.				
0A	04	C/S VT Secondary	110V	From 80V to 140V step 1V
Sets the System Check Synchronism voltage transformer input secondary voltage. Multiplier M2=[0A03]/[0A04]				
0A	07	Phase CT Primary	1A	From 1A to 30kA step 1A
Sets the phase current transformer input primary current rating. I1=Phase CT secondary rating.				
0A	08	Phase CT Sec'y	1A	From 1A to 5A step 4A
Sets the phase current transformer input secondary current rating. Multiplier M4=[0A07]/[0A08]				
0A	0D	Mcomp CT Primary	1A	From 1A to 30kA step 1A
Sets the mutual compensation current transformer input primary current rating.				
0A	0E	Mcomp CT Sec'y	1A	From 1A to 5A step 4A
Sets the mutual compensation current transformer input secondary current rating. Multiplier M6=[0A0D]/[0A0E]				
0A	0F	C/S Input	A-N	A-N, B-N, C-N, A-B, B-C, C-A
Selects the System Check Synchronism Input voltage measurement.				
0A	10	Main VT Location	Line	0 = Line or 1 = Bus
Sets the Main VT Location.				
0A	11	CT Polarity	Standard	0 = Standard or 1 = Inverted
Sets standard or reverse CT polarity.				

Table 27 - CT and VT Ratios settings

6.5 Record Control Menu

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:

This column is visible when the “Record Control” setting (“Configuration” column) = “visible”.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
0B	00	RECORD CONTROL		
This column contains settings for Record Controls				
0B	01	Clear Events	No	0 = No or 1 = Yes
Selecting “Yes” will cause the existing event log to be cleared and an event will be generated indicating that the events have been erased.				
0B	02	Clear Faults	No	0 = No or 1 = Yes
Selecting “Yes” will cause the existing fault records to be erased from the relay.				
0B	03	Clear Maint	No	0 = No or 1 = Yes
Selecting “Yes” will cause the existing maintenance records to be erased from the relay.				
0B	04	Alarm Event	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event is generated for alarms				
0B	05	Relay O/P Event	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any change in logic output state.				
0B	06	Opto Input Event	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any change in logic input state.				
0B	07	General Event	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no General Events are generated				
0B	08	Fault Rec Event	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any fault that produces a fault record				
0B	09	Maint Rec Event	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any occurrence that produces a maintenance record.				
0B	0A	Protection Event	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that any operation of protection elements will not be logged as an event				
0B	30	Clear Dist Recs	No	0 = No or 1 = Yes
Selecting “Yes” will cause the existing disturbance records to be cleared and an event will be generated indicating that the disturbance records have been erased.				
0B	31	Security Event	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that any operation of security elements will not be logged as an event				
0B	40	DDB 31 - 0	11111111111111111111111111111111(bin)	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.				
0B	41	DDB 63 - 32	11111111111111111111111111111111(bin)	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.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
0B	42	DDB 95 - 64	11111111111111111111111111111111(bin)	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.				
0B	43	DDB 127 - 96	11111111111111111111111111111111(bin)	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.				
0B	44	DDB 159 - 128	11111111111111111111111111111111(bin)	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.				
0B	45	DDB 191 - 160	11111111111111111111111111111111(bin)	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.				
0B	46	DDB 223 - 192	11111111111111111111111111111111(bin)	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.				
0B	47	DDB 255 - 224	11111111111111111111111111111111(bin)	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.				
0B	48	DDB 287 - 256	11111111111111111111111111111111(bin)	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.				
0B	49	DDB 319 - 288	11111111111111111111111111111111(bin)	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.				
0B	4A	DDB 351 - 320	11111111111111111111111111111111(bin)	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.				
0B	4B	DDB 383 - 352	11111111111111111111111111111111(bin)	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.				
0B	4C	DDB 415 - 384	11111111111111111111111111111111(bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Choose 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.				
0B	4D	DDB 447 - 415	11111111111111111111111111111111(bin)	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.				
0B	4E	DDB 479 - 448	11111111111111111111111111111111(bin)	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.				
0B	4F	DDB 511 - 480	11111111111111111111111111111111(bin)	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.				
0B	50	DDB 543 - 512	11111111111111111111111111111111(bin)	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.				
0B	51	DDB 575 - 544	11111111111111111111111111111111(bin)	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.				
0B	52	DDB 607 - 575	11111111111111111111111111111111(bin)	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.				
0B	53	DDB 639 - 608	11111111111111111111111111111111(bin)	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.				
0B	54	DDB 671 - 640	11111111111111111111111111111111(bin)	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.				
0B	55	DDB 703 - 672	11111111111111111111111111111111(bin)	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.				
0B	56	DDB 735 - 704	11111111111111111111111111111111(bin)	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.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
0B	57	DDB 767 - 736	11111111111111111111111111111111(bin)	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.				
0B	58	DDB 799 - 768	11111111111111111111111111111111(bin)	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.				
0B	59	DDB 831 - 800	11111111111111111111111111111111(bin)	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.				
0B	5A	DDB 863 - 832	11111111111111111111111111111111(bin)	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.				
0B	5B	DDB 895 - 864	11111111111111111111111111111111(bin)	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.				
0B	5C	DDB 927 - 896	11111111111111111111111111111111(bin)	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.				
0B	5D	DDB 959 - 928	11111111111111111111111111111111(bin)	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.				
0B	5E	DDB 991 - 960	11111111111111111111111111111111(bin)	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.				
0B	5F	DDB 1023 - 992	11111111111111111111111111111111(bin)	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.				
0B	60	DDB 1055 -1024	11111111111111111111111111111111(bin)	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.				
0B	61	DDB 1087 - 1056	11111111111111111111111111111111(bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled

Col	Row	Courier Text	Default Setting	Available Setting
Description				
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.				
0B	62	DDB 1119 - 1088	11111111111111111111111111111111(bin)	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.				
0B	63	DDB 1151 - 1120	11111111111111111111111111111111(bin)	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.				
0B	64	DDB 1183 - 1152	11111111111111111111111111111111(bin)	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.				
0B	65	DDB 1215 - 1184	11111111111111111111111111111111(bin)	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.				
0B	66	DDB 1247 - 1216	11111111111111111111111111111111(bin)	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.				
0B	67	DDB 1279 - 1248	11111111111111111111111111111111(bin)	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.				
0B	68	DDB 1311 - 1280	11111111111111111111111111111111(bin)	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.				
0B	69	DDB 1343 - 1312	11111111111111111111111111111111(bin)	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.				
0B	6A	DDB 1375 - 1344	11111111111111111111111111111111(bin)	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.				
0B	6B	DDB 1407 - 1376	11111111111111111111111111111111(bin)	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.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
0B	6C	DDB 1439 - 1408	11111111111111111111111111111111(bin)	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.				
0B	6D	DDB 1471 - 1440	11111111111111111111111111111111(bin)	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.				
0B	6E	DDB 1503 - 1472	11111111111111111111111111111111(bin)	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.				
0B	6F	DDB 1535 - 1504	11111111111111111111111111111111(bin)	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.				
0B	70	DDB 1567 - 1536	11111111111111111111111111111111(bin)	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.				
0B	71	DDB 1599 - 1568	11111111111111111111111111111111(bin)	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.				
0B	72	DDB 1631 - 1600	11111111111111111111111111111111(bin)	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.				
0B	73	DDB 1663 - 1632	11111111111111111111111111111111(bin)	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.				
0B	74	DDB 1695 - 1664	11111111111111111111111111111111(bin)	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.				
0B	75	DDB 1727 - 1696	11111111111111111111111111111111(bin)	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.				
0B	76	DDB 1759 - 1728	11111111111111111111111111111111(bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Choises 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.				
0B	77	DDB 1791 - 1760	11111111111111111111111111111111(bin)	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.				
0B	78	DDB 1823 - 1792	11111111111111111111111111111111(bin)	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.				
0B	79	DDB 1855 - 1824	11111111111111111111111111111111(bin)	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.				
0B	7A	DDB 1887 - 1856	11111111111111111111111111111111(bin)	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.				
0B	7B	DDB 1919 - 1888	11111111111111111111111111111111(bin)	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.				
0B	7C	DDB 1951 - 1920	11111111111111111111111111111111(bin)	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.				
0B	7D	DDB 1983 - 1952	11111111111111111111111111111111(bin)	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.				
0B	7E	DDB 2015 - 1984	11111111111111111111111111111111(bin)	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.				
0B	7F	DDB 2047 - 2016	01111111111111111111111111111111(bin)	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 28 - Record Control settings

6.6 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".

The integral disturbance recorder has an area of memory specifically set aside for record storage. The number of records that may be stored is dependent upon the selected recording duration but the relays typically have the capability of storing a minimum of 20 records, each of 10.5 second duration.

Note 1	*Compressed Disturbance Recorder used for Kbus/Modbus/DNP3 reach that typical size value (10.5 sec duration)*
Note 2	*Uncompressed Disturbance Recorder used for IEC 60870-5/103 could be limited to 2 or 3 seconds.*

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 which are taken at a rate of 24 samples per cycle.

Each disturbance record consists of eight analogue data channels and thirty-two digital data channels. Note that the relevant CT and VT ratios for the analogue channels are also extracted to enable scaling to primary quantities).

Col	Row	Courier Text	Default Setting	Available Setting
Description				
0C	00	DISTURB RECORDER		
This column contains settings for the Disturbance Recorder				
0C	01	Duration	1.5s	From 100 ms to 10.5 s step 10 ms
This sets the overall recording time.				
0C	02	TriggerPosition	33.30 %	From 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.				
0C	03	TriggerMode	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.				
0C	04	AnalogChannel1	VA	0 - VA, 1 - VB, 2 - VC, 3 - VN, 4 - IA, 5 - IB, 6 - IC, 7 - IN, 8 - IM, 9 - V Checksync1, 10 - unassigned, 11 - V Checksync 2
Selects any available analogue input to be assigned to this channel.				
0C	05	AnalogChannel2	VB	0 - VA, 1 - VB, 2 - VC, 3 - VN, 4 - IA, 5 - IB, 6 - IC, 7 - IN, 8 - IM, 9 - V Checksync1, 10 - unassigned, 11 - V Checksync 2
Selects any available analogue input to be assigned to this channel.				
0C	06	AnalogChannel3	VC	0 - VA, 1 - VB, 2 - VC, 3 - VN, 4 - IA, 5 - IB, 6 - IC, 7 - IN, 8 - IM, 9 - V Checksync1, 10 - unassigned, 11 - V Checksync 2
Selects any available analogue input to be assigned to this channel.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
0C	07	AnalogChannel4	VN	0 - VA, 1 - VB, 2 - VC, 3 - VN, 4 - IA, 5 - IB, 6 - IC, 7 - IN, 8 - IM, 9 - V Checksync1, 10 - unassigned, 11 - V Checksync 2
Selects any available analogue input to be assigned to this channel.				
0C	08	AnalogChannel5	IA	0 - VA, 1 - VB, 2 - VC, 3 - VN, 4 - IA, 5 - IB, 6 - IC, 7 - IN, 8 - IM, 9 - V Checksync1, 10 - unassigned, 11 - V Checksync 2
Selects any available analogue input to be assigned to this channel.				
0C	09	AnalogChannel6	IB	0 - VA, 1 - VB, 2 - VC, 3 - VN, 4 - IA, 5 - IB, 6 - IC, 7 - IN, 8 - IM, 9 - V Checksync1, 10 - unassigned, 11 - V Checksync 2
Selects any available analogue input to be assigned to this channel.				
0C	0A	AnalogChannel7	IC	0 - VA, 1 - VB, 2 - VC, 3 - VN, 4 - IA, 5 - IB, 6 - IC, 7 - IN, 8 - IM, 9 - V Checksync1, 10 - unassigned, 11 - V Checksync 2
Selects any available analogue input to be assigned to this channel.				
0C	0B	AnalogChannel8	IN	0 - VA, 1 - VB, 2 - VC, 3 - VN, 4 - IA, 5 - IB, 6 - IC, 7 - IN, 8 - IM, 9 - V Checksync1, 10 - unassigned, 11 - V Checksync 2
Selects any available analogue input to be assigned to this channel.				
0C	0C	DigitalInput1	Any Start	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.				
0C	0D	Input1Trigger	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.				
0C	0E	DigitalInput2	Any Trip	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.				
0C	0F	Input2Trigger	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.				
0C	10	DigitalInput3	DIST Trip A	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.				
0C	11	Input3Trigger	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.				
0C	12	DigitalInput4	DIST Trip B	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.				
0C	13	Input4Trigger	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.				
0C	14	DigitalInput5	DIST Trip C	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.				
0C	15	Input5Trigger	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L

Col	Row	Courier Text	Default Setting	Available Setting
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.				
0C	16	DigitalInput6	DIST Fwd	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.				
0C	17	Input6Trigger	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.				
0C	18	DigitalInput7	DIST Rev	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.				
0C	19	Input7Trigger	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.				
0C	1A	DigitalInput8	Z1	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.				
0C	1B	Input8Trigger	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.				
0C	1C	DigitalInput9	Z2	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.				
0C	1D	Input9Trigger	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.				
0C	1E	DigitalInput10	Z3	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.				
0C	1F	Input10Trigger	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.				
0C	20	DigitalInput11	Z4	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.				
0C	21	Input11Trigger	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.				
0C	22	DigitalInput12	Any Pole Dead	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.				
0C	23	Input12Trigger	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.				
0C	24	DigitalInput13	All Pole Dead	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.				
0C	25	Input13Trigger	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L

Col	Row	Courier Text	Default Setting	Available Setting
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.				
0C	26	DigitalInput14	SOTF Enable	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.				
0C	27	Input14Trigger	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.				
0C	28	DigitalInput15	SOTF/TOR Trip	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.				
0C	29	Input15Trigger	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.				
0C	2A	DigitalInput16	S. Swing Conf	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.				
0C	2B	Input16Trigger	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.				
0C	2C	DigitalInput17	Out Of Step	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.				
0C	2D	Input17Trigger	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.				
0C	2E	DigitalInput18	Out of Step Conf	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.				
0C	2F	Input18Trigger	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.				
0C	30	DigitalInput19	Man. Close CB	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.				
0C	31	Input19Trigger	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.				
0C	32	DigitalInput20	I A/R Close	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.				
0C	33	Input20Trigger	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.				
0C	34	DigitalInput21	DIST. Chan Recv	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.				
0C	35	Input21Trigger	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L

Col	Row	Courier Text	Default Setting	Available Setting
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.				
0C	36	DigitalInput22	MCB/VTS Main	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.				
0C	37	Input22Trigger	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.				
0C	38	DigitalInput23	MCB/VTS Synchro	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.				
0C	39	Input23Trigger	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.				
0C	3A	DigitalInput24	DEF. Chan Recv	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.				
0C	3B	Input24Trigger	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.				
0C	3C	DigitalInput25	DEF Rev	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.				
0C	3D	Input25Trigger	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.				
0C	3E	DigitalInput26	DEF Fwd	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.				
0C	3F	Input26Trigger	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.				
0C	40	DigitalInput27	DEF Start A	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.				
0C	41	Input27Trigger	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.				
0C	42	DigitalInput28	DEF Start B	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.				
0C	43	Input28Trigger	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.				
0C	44	DigitalInput29	DEF Start C	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.				
0C	45	Input29Trigger	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L

Col	Row	Courier Text	Default Setting	Available Setting
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.				
0C	46	DigitalInput30	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.				
0C	47	Input30Trigger	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.				
0C	48	DigitalInput31	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.				
0C	49	Input31Trigger	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.				
0C	4A	DigitalInput32	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.				
0C	4B	Input32Trigger	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.				

Table 29 - Disturb Recorder settings

Note	*The available analogue and digital signals differ between relay types and models.*

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 1.5s with the trigger point being at 33.3% of this, giving 0.5s pre-fault and 1s post fault recording times.

If a further trigger occurs whilst a recording is taking place, the recorder will ignore the trigger if the ‘Trigger Mode’ has been set to ‘Single’. However, if this has been set to ‘Extended’, the post trigger timer will be reset to zero, thereby extending the recording time.

As can be seen from the menu, each of the analogue channels is selectable from the available analogue inputs to the relay. The digital channels may be mapped to any of the opto isolated inputs or output contacts, in addition to a number of internal relay digital signals, such as protection starts, LEDs etc. The complete list of these signals may be found by viewing the available settings in the relay menu or via 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, via the ‘Input Trigger’ cell. The default trigger settings are that any dedicated trip output contacts (e.g. relay 3) will trigger the recorder.

6.7 Measurements Menu

This column is visible when the "Measure't Setup" setting ("Configuration" column) = "visible".

Col	Row	Courier Text	Default Setting	Available Setting
Description				
0D	00	MEASURE'T SETUP		
This column contains settings for the measurement setup				
0D	01	Default Display	Banner	0 = Banner, 1 = Date & Time, 2 = Description, 3 = PlanReference, 4 = U - I - Freq, 5 = P - Q, 6 = Access Level
This indicates the default display which can only be changed whilst at the default display using the arrow keys for operator or higher level roles. Only visible on UI.				
0D	02	Local Values	Secondary	0 = Primary or 1 = Secondary
Local Measurement Values.This setting controls whether measured values via the front panel user interface and the front courier port are displayed as primary or secondary quantities.				
0D	03	Remote Values	Primary	0 = Primary or 1 = Secondary
Remote Measurement Values.This setting controls whether measured values via the rear communication port are displayed as primary or secondary quantities.				
0D	04	Measurement Ref	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				
0D	05	Measurement Mode	0	0 to 3 step 1
This setting is used to control the signing of the real and reactive power quantities.				
0D	06	Demand Interval	30min	From 1min to 99min step 1min
This setting defines the length of the fixed demand window				
0D	07	Distance Unit	Kilometres	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				
0D	08	Fault Location	Distance	0 = Distance, 1 = Ohms, 2 = % of Line
The calculated fault location can be displayed using one of several options selected using this setting				

Table 30 - Measurement Setup settings

Measurement Mode	Parameter	Signing
0 (Default, P = VI*)	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	–

Measurement Mode	Parameter	Signing
	Import Power	+
	Lagging VArs	–
	Leading VArs	+

Table 31 - Measurement Modes, Parameters and Signs

6.8 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:

- Settings for Courier Protocol
- Settings for IEC60870-5-103
- Settings for MODBUS Protocol
- Settings for DNP3.0 Protocol
- Settings for Ethernet port - IEC61850 Protocol
- Settings for Rear Port 2 Connection

Col	Row	Courier Text	Default Setting	Available Setting
Description				
0E	00	COMMUNICATIONS		
This column contains general communications settings				
0E	01	RP1 Protocol		Not Settable
Indicates the communications protocol that will be used on the rear communications port.				
0E	02	RP1 Address	255 1 1 1	0 to 255 step 1 (Courier) 1 to 247 step 1 (Modbus) 0 to 254 step 1 (CS103) 0 to 65519 step 1 (DNP3)
Rear Port 1 Courier Protocol device address. This cell sets the unique address for the relay such that only one relay is accessed by master station software.				
0E	03	RP1 InactivTimer	15min	From 1min to 30min step 1min
Rear Port 1 Protocol inactivity timer. This cell controls how long the relay 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.				
0E	04	RP1 Baud Rate	19200 bits/s	0=9600 bits/s 1=19200 bits/s 2=38400 bits/s (Modbus) 0=9600 bits/s 1=19200 bits/s (CS103) 0=1200 bits/s 1=2400 bits/s 2=4800 bits/s 3=9600 bits/s 4=19200 bits/s 5=38400 bits/s (DNP3)
Rear Port 1 Modbus Protocol serial bit/baud rate. 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.				
0E	05	RP1 Parity	None	0 = Odd, 1 = Even, 2 = None
Rear Port 1 Modbus Protocol parity. 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.				
0E	06	Measure't Period	10s	From 1s to 60s step 1s
Rear Port 1 IEC60870-5-103 Protocol measurment period. IEC60870-5-103 versions only. This cell controls the time interval that the IED will use between sending measurement data to the master station.				
0E	07	Physical Link	Copper	0 = Copper or 1 = Fibre Optic
Rear Port 1 Physical link selector. 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.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
0E	08	DNP Time Synch	Disabled	0 = Disabled or 1 = Enabled
Rear Port 1 DNP 3.0 Protocol time sync configuration. 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.				
0E	09	Modbus IEC Time	Standard IEC	0=Standard IEC or 1=Reverse IEC
Controls the format of the time-date G12 data type. Modbus Only. 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.				
0E	0A	CS103 Blocking	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.				
0E	0B	RP1 Status		Not Settable
Rear Port 1 Courier Protocol Status. This cell indicates the status of the communication card.				
0E	0C	RP1 Port Config	K Bus	0 = K Bus or 1 = EIA485 (RS485)
Rear Port 1 Courier Protocol copper port configuration; K-Bus or EIA485. This cell defines whether an electrical KBus or EIA(RS)485 is being used for communication between the master station and relay.				
0E	0D	RP1 Comms Mode	IEC60870 FT1.2	0 = IEC60870 FT1.2 Frame or 1 = 10-bit no parity
Rear Port 1 Courier Protocol EIA485 mode. The choice is either IEC60870 FT1.2 for normal operation with 11-bit modems, or 10-bit no parity.				
0E	0E	RP1 Baud Rate	19200 bits/s	0 = 9600 bits/s, 1 = 19200 bits/s, 2 = 38400 bits/s
Rear Port 1 Courier Protocol EIA485 bit/baud rate. This cell controls the communication speed between relay and master station. It is important that both relay and master station are set at the same speed setting.				
0E	0F	Meas Scaling	Primary	0 = Normalised, 1 = Primary, 2 = Secondary
DNP 3.0 and IEC61850+DNP3OE only. Setting to report analogue values in terms of primary, secondary or normalized (with respect to the CT/VT ratio setting) values.				
0E	10	Message Gap (ms)	0	From 0 to 50 step 1
DNP 3.0 and IEC61850+DNP3OE only. This setting determines the gap between reply fragments				
0E	11	DNP Need Time	10min	From 1min to 30min step 1min
DNP 3.0 and IEC61850+DNP3OE only. The duration of time waited before requesting another time sync from the master.				
0E	12	DNP App Fragment	2048	100 to 2048 step 1
DNP 3.0 and IEC61850+DNP3OE only. The maximum message length (application fragment size) transmitted by the IED.				
0E	13	DNP App Timeout	2s	From 1s to 120s step 1s
DNP 3.0 and IEC61850+DNP3OE only. Duration of time waited, after sending a reply and awaiting a confirmation from the master.				
0E	14	DNP SBO Timeout	10s	From 1s to 10s step 1s
DNP 3.0 and IEC61850+DNP3OE only. Duration of time waited, after receiving a select command and awaiting an operate confirmation from the master.				
0E	15	DNP Link Timeout	0s	From 0s to 120s step 1s

Col	Row	Courier Text	Default Setting	Available Setting
Description				
DNP 3.0 and IEC61850+DNP3OE 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.				
0E	1F	ETH Protocol		Not Settable
Indicates the protocol used on the Network Interface Card. Visible when Ethernet card fitted				
0E	22	MAC Addr 1		This is a factory setting
Shows the MAC address of the 1st Ethernet port. Visible when Ethernet card fitted.				
0E	23	MAC Addr 2		This is a factory setting
Shows the MAC address of the 2nd Ethernet port. Visible when Ethernet card fitted.				
0E	64	ETH Tunl Timeout	15 min	From 1min to 30min step 1min
Duration of time to wait before an inactive tunnel to Easergy Studio is reset. Visible when Ethernet card fitted.				
0E	70	Redundancy Conf		
NIOS PARAMETERS. The redundant agency device configuration is used for SNMP server. This does not affect IEC61850 communications. Visible when redundant Ethernet card fitted and Comm Mode=PRP or HSR				
0E	71	MAC Address		Not Settable
MAC address for the NIOS. The redundant agency device configuration is used for SNMP server. This does not affect IEC61850 communications. Visible when redundant Ethernet card fitted and Comm Mode=PRP or HSR				
0E	72	IP Address	169.254.2.zzz	<IP address of relay>
A default IP address which is encoded from MAC address 169.254.2.zzz, zzz = mod (The last byte of MAC address % 128 + 1) The redundant agency device configuration is used for SNMP server. This does not affect IEC61850 communications. Visible when redundant Ethernet card fitted and Comm Mode=PRP or HSR.				
0E	73	Subnet Mask	255.255.255.0	<Subnet mask of relay>
Subnet Mask for the NIOS. The redundant agency device configuration is used for SNMP server. This does not affect IEC61850 communications. Visible when redundant Ethernet card fitted and Comm Mode=PRP or HSR				
0E	74	Gateway	169.254.2.250	<Gateway address>
Gateway for the NIOS. The redundant agency device configuration is used for SNMP server. This does not affect IEC61850 communications. Visible when redundant Ethernet card fitted and Comm Mode=PRP or HSR				
0E	80	REAR PORT2 (RP2)		
Visible when Rear Port 2 fitted.				
0E	81	RP2 Protocol	Courier	Not Settable
Rear Port 2 Protocol - "Courier". Indicates the communications protocol that will be used on the rear communications port.				
0E	84	RP2 Card Status		Not Settable
Rear Port 2 Courier Protocol Status				
0E	88	RP2 Port Config	EIA232 (RS232)	0 = EIA232 (RS232), 1 = EIA485 (RS485), 2 = K-Bus
Rear Port 2 Courier Protocol port configuration. This cell defines whether an electrical EIA(RS)232, EIA(RS)485 or KBus is being used for communication.				
0E	8A	RP2 Comms Mode	IEC60870 FT1.2	0 = IEC60870 FT1.2 Frame or 1 = 10-bit no parity
Rear Port 2 Courier Protocol EIA485 mode. The choice is either IEC60870 FT1.2 for normal operation with 11-bit modems, or 10-bit no parity.				
0E	90	RP2 Address	255	0 to 255 step 1
Rear Port 2 Courier Protocol device address. This cell sets the unique address for the relay such that only one relay is accessed by master station software.				
0E	92	RP2 InactivTimer	15 min	From 1min to 30min step 1min
Rear Port 2 Courier Protocol inactivity timer. This cell controls how long the relay 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.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
0E	94	RP2 Baud Rate	19200 bits/s	0 = 9600 bits/s, 1 = 19200 bits/s, 2 = 38400 bits/s
Rear Port 2 Courier Protocol EIA485 bit/baud rate. This cell controls the communication speed between relay and master station. It is important that both relay and master station are set at the same speed setting.				
0E	B1	DNP Need Time	10min	From 1min to 30min step 1min
Standalone DNP3oE versions only (already obsolete). The duration of time waited before requesting another time sync from the master.				
0E	B2	DNP App Fragment	2048	100 to 2048 step 1
Standalone DNP3oE versions only (already obsolete). The maximum message length (application fragment size) transmitted by the IED.				
0E	B3	DNP App Timeout	2s	From 1s to 120s step 1s
Standalone DNP3oE versions only (already obsolete). Duration of time waited, after sending a message fragment and awaiting a confirmation from the master.				
0E	B4	DNP SBO Timeout	10s	From 1s to 10s step 1s
Standalone DNP3oE versions only (already obsolete). Duration of time waited, after receiving a select command and awaiting an operate confirmation from the master.				

Table 32 - Communications settings

Important	**The settings shown are those configurable for the second rear port which is only available with the Courier protocol.**

6.9 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".

Col	Row	Courier Text	Default Setting	Available Setting
Description				
0F	00	COMMISSION TESTS		
This column contains commissioning test settings				
0F	01	Opto I/P Status		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.				
0F	02	Relay Status 1		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.				
0F	03	Relay Status 2		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. This setting does not apply to P442 relays.				
0F	04	Test Port Status		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.				
0F	06	Monitor Bit 1	Relay Label 01	All DDB Points
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.				
0F	07	Monitor Bit 2	Relay Label 02	All DDB Points
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.				
0F	08	Monitor Bit 3	Relay Label 03	All DDB Points
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.				
0F	09	Monitor Bit 4	Relay Label 04	All DDB Points
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.				
0F	0A	Monitor Bit 5	Relay Label 05	All DDB Points
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.				
0F	0B	Monitor Bit 6	Relay Label 06	All DDB Points
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.				
0F	0C	Monitor Bit 7	Relay Label 07	All DDB Points

Col	Row	Courier Text	Default Setting	Available Setting
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.				
0F	0D	Monitor Bit 8	Relay Label 08	All DDB Points
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.				
0F	0E	Test Mode	Disable	0 = Disable, 1 = Test Mode, 2 = 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 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. In IEC61850 models using edition 2 mode, selecting Test Mode or Blocked will change the behaviour of all active logical nodes to test. The quality of all data will also indicate test.				
0F	0F	Test Pattern 1	00000000000000000000000000000000 (bin)	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'.				
0F	10	Test Pattern 2	0000000000000000000000000000000 (bin)	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'. This setting does not apply to P442 relays.				
0F	11	Contact Test	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 changestate. After the test has been applied the command text on the LCD will change to 'No Operation' and the contacts will remainin 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.				
0F	12	Test LEDs	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'.				
0F	13	Autoreclose Test	No Operation	0=No Operation 1=3 Pole Test 2=Pole A Test 3=Pole B Test 4=Pole C Test
This is a command used to simulate tripping in order to test Auto-reclose cycle.				
0F	16	Red LED Status		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.				
0F	17	Green LED Status		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.				
0F	20	DDB 31 - 0		Not Settable
Displays the status of DDB signals				
0F	21	DDB 63 - 32		Not Settable
Displays the status of DDB signals				
0F	22	DDB 95 - 64		Not Settable
Displays the status of DDB signals				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
0F	23	DDB 127 - 96		Not Settable
Displays the status of DDB signals				
0F	24	DDB 159 - 128		Not Settable
Displays the status of DDB signals				
0F	25	DDB 191 - 160		Not Settable
Displays the status of DDB signals				
0F	26	DDB 223 - 192		Not Settable
Displays the status of DDB signals				
0F	27	DDB 255 - 224		Not Settable
Displays the status of DDB signals				
0F	28	DDB 287 - 256		Not Settable
Displays the status of DDB signals				
0F	29	DDB 319 - 288		Not Settable
Displays the status of DDB signals				
0F	2A	DDB 351 - 320		Not Settable
Displays the status of DDB signals				
0F	2B	DDB 383 - 352		Not Settable
Displays the status of DDB signals				
0F	2C	DDB 415 - 384		Not Settable
Displays the status of DDB signals				
0F	2D	DDB 447 - 415		Not Settable
Displays the status of DDB signals				
0F	2E	DDB 479 - 448		Not Settable
Displays the status of DDB signals				
0F	2F	DDB 511 - 480		Not Settable
Displays the status of DDB signals				
0F	30	DDB 543 - 512		Not Settable
Displays the status of DDB signals				
0F	31	DDB 575 - 544		Not Settable
Displays the status of DDB signals				
0F	32	DDB 607 - 575		Not Settable
Displays the status of DDB signals				
0F	33	DDB 639 - 608		Not Settable
Displays the status of DDB signals				
0F	34	DDB 671 - 640		Not Settable
Displays the status of DDB signals				
0F	35	DDB 703 - 672		Not Settable
Displays the status of DDB signals				
0F	36	DDB 735 - 704		Not Settable
Displays the status of DDB signals				
0F	37	DDB 767 - 736		Not Settable
Displays the status of DDB signals				
0F	38	DDB 799 - 768		Not Settable

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Displays the status of DDB signals				
0F	39	DDB 831 - 800		Not Settable
Displays the status of DDB signals				
0F	3A	DDB 863 - 832		Not Settable
Displays the status of DDB signals				
0F	3B	DDB 895 - 864		Not Settable
Displays the status of DDB signals				
0F	3C	DDB 927 - 896		Not Settable
Displays the status of DDB signals				
0F	3D	DDB 959 - 928		Not Settable
Displays the status of DDB signals				
0F	3E	DDB 991 - 960		Not Settable
Displays the status of DDB signals				
0F	3F	DDB 1023 - 992		Not Settable
Displays the status of DDB signals				
0F	40	DDB 1055 - 1024		Not Settable
Displays the status of DDB signals				
0F	41	DDB 1087 - 1056		Not Settable
Displays the status of DDB signals				
0F	42	DDB 1119 - 1088		Not Settable
Displays the status of DDB signals				
0F	43	DDB 1151 - 1120		Not Settable
Displays the status of DDB signals				
0F	44	DDB 1183 - 1152		Not Settable
Displays the status of DDB signals				
0F	45	DDB 1215 - 1184		Not Settable
Displays the status of DDB signals				
0F	46	DDB 1247 - 1216		Not Settable
Displays the status of DDB signals				
0F	47	DDB 1279 - 1248		Not Settable
Displays the status of DDB signals				
0F	48	DDB 1311 - 1280		Not Settable
Displays the status of DDB signals				
0F	49	DDB 1343 - 1312		Not Settable
Displays the status of DDB signals				
0F	4A	DDB 1375 - 1344		Not Settable
Displays the status of DDB signals				
0F	4B	DDB 1407 - 1376		Not Settable
Displays the status of DDB signals				
0F	4C	DDB 1439 - 1408		Not Settable
Displays the status of DDB signals				
0F	4D	DDB 1471 - 1440		Not Settable
Displays the status of DDB signals				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
0F	4E	DDB 1503 - 1472		Not Settable
Displays the status of DDB signals				
0F	4F	DDB 1535 - 1504		Not Settable
Displays the status of DDB signals				
0F	50	DDB 1567 - 1536		Not Settable
Displays the status of DDB signals				
0F	51	DDB 1599 - 1568		Not Settable
Displays the status of DDB signals				
0F	52	DDB 1631 - 1600		Not Settable
Displays the status of DDB signals				
0F	53	DDB 1663 - 1632		Not Settable
Displays the status of DDB signals				
0F	54	DDB 1695 - 1664		Not Settable
Displays the status of DDB signals				
0F	55	DDB 1727 - 1696		Not Settable
Displays the status of DDB signals				
0F	56	DDB 1759 - 1728		Not Settable
Displays the status of DDB signals				
0F	57	DDB 1791 - 1760		Not Settable
Displays the status of DDB signals				
0F	58	DDB 1823 - 1792		Not Settable
Displays the status of DDB signals				
0F	59	DDB 1855 - 1824		Not Settable
Displays the status of DDB signals				
0F	5A	DDB 1887 - 1856		Not Settable
Displays the status of DDB signals				
0F	5B	DDB 1919 - 1888		Not Settable
Displays the status of DDB signals				
0F	5C	DDB 1951 - 1920		Not Settable
Displays the status of DDB signals				
0F	5D	DDB 1983 - 1952		Not Settable
Displays the status of DDB signals				
0F	5E	DDB 2015 - 1984		Not Settable
Displays the status of DDB signals				
0F	5F	DDB 2047 - 2016		Not Settable
Displays the status of DDB signals				

Table 33 - Communications for Commission settings

6.10 Opto Inputs Configuration

Col	Row	Courier Text	Default Setting	Available Setting
Description				
11	00	OPTO CONFIG		
This column contains opto-input configuration settings				
11	01	Global Nominal V	24/27V	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.				
11	02	Opto Input 1	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	03	Opto Input 2	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	04	Opto Input 3	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	05	Opto Input 4	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	06	Opto Input 5	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	07	Opto Input 6	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	08	Opto Input 7	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	09	Opto Input 8	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	0A	Opto Input 9	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	0B	Opto Input 10	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	0C	Opto Input 11	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 4 = 220/250V

Col	Row	Courier Text	Default Setting	Available Setting
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 40, depending on the IED and I/O configuration.				
11	0D	Opto Input 12	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	0E	Opto Input 13	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	0F	Opto Input 14	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	10	Opto Input 15	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	11	Opto Input 16	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration.				
11	12	Opto Input 17	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	13	Opto Input 18	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	14	Opto Input 19	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	15	Opto Input 20	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	16	Opto Input 21	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	17	Opto Input 22	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
11	18	Opto Input 23	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	19	Opto Input 24	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	1A	Opto Input 25	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	1B	Opto Input 26	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	1C	Opto Input 27	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	1D	Opto Input 28	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	1E	Opto Input 29	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	1F	Opto Input 30	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	20	Opto Input 31	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	21	Opto Input 32	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V, 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 40, depending on the IED and I/O configuration. This setting does not apply to P442 relays.				
11	50	Opto Filter Cntl	11111111111111111111111111111111 (bin)	32-bit binary setting: 0=disable filtering or 1=enable filtering

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Selects each of the first 32 inputs with a pre-set filter of ½ cycle that renders the input immune to induced noise on the wiring. The number of available bits depends on the I/O configuration.				
11	80	Characteristic	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 34 - Universal Inputs settings

6.11 Control Inputs

There are three setting columns associated with the control inputs which are: "CTRL INPUTS", "CTRL I/P CONFIG" and "CTRL I/P LABELS".

The "CTRL INPUTS" column is visible when the "Commission tests" setting ("Configuration" column) = "visible".

Col	Row	Courier Text	Default Setting	Available Setting
Description				
12	00	CONTROL INPUTS		
This column contains settings for the type of control input (32 in all)				
12	01	Ctrl I/P Status	00000000000000000000000000000000(bin)	32-bit binary setting: 0=Reset or 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:				
12	02	Control Input 1	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 1 set/ reset.				
12	03	Control Input 2	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 2 set/ reset.				
12	04	Control Input 3	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 3 set/ reset.				
12	05	Control Input 4	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 4 set/ reset.				
12	06	Control Input 5	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 5 set/ reset.				
12	07	Control Input 6	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 6 set/ reset.				
12	08	Control Input 7	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 7 set/ reset.				
12	09	Control Input 8	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 8 set/ reset.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
12	0A	Control Input 9	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 9 set/ reset.				
12	0B	Control Input 10	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 10 set/ reset.				
12	0C	Control Input 11	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 11 set/ reset.				
12	0D	Control Input 12	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 12 set/ reset.				
12	0E	Control Input 13	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 13 set/ reset.				
12	0F	Control Input 14	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 14 set/ reset.				
12	10	Control Input 15	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 15 set/ reset.				
12	11	Control Input 16	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 16 set/ reset.				
12	12	Control Input 17	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 17 set/ reset.				
12	13	Control Input 18	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 18 set/ reset.				
12	14	Control Input 19	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 19 set/ reset.				
12	15	Control Input 20	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 20 set/ reset.				
12	16	Control Input 21	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 21 set/ reset.				
12	17	Control Input 22	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 22 set/ reset.				
12	18	Control Input 23	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 23 set/ reset.				
12	19	Control Input 24	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 24 set/ reset.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
12	1A	Control Input 25	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 25 set/ reset.				
12	1B	Control Input 26	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 26 set/ reset.				
12	1C	Control Input 27	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 27 set/ reset.				
12	1D	Control Input 28	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 28 set/ reset.				
12	1E	Control Input 29	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 29 set/ reset.				
12	1F	Control Input 30	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 30 set/ reset.				
12	20	Control Input 31	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 31 set/ reset.				
12	21	Control Input 32	No operation	0 = No Operation, 1 = SET , 2 = RESET
Setting to allow Control Inputs 32 set/ reset.				

Table 35 - Control Inputs settings

6.12 Control Input Config

The “CTRL I/P CONFIG” column is visible when the “Control I/P Config” setting (“Configuration” column) = “visible”.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
13	00	CTRL I/P CONFIG		
This column contains settings for the type of control input (32 in all)				
13	01	Hotkey Enabled	11111111111111111111111111111111 (bin)	32-bit binary setting: 0=Not accessible via Hotkey Menu or 1=Accessible via Hotkey Menu
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. Not available on Chinese version relays.				
13	10	Control Input 1	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).				
13	11	Ctrl Command 1	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED

Col	Row	Courier Text	Default Setting	Available Setting
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.				
13	14	Control Input 2	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).				
13	15	Ctrl Command 2	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.				
13	18	Control Input 3	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).				
13	19	Ctrl Command 3	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.				
13	1C	Control Input 4	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).				
13	1D	Ctrl Command 4	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.				
13	20	Control Input 5	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).				
13	21	Ctrl Command 5	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.				
13	24	Control Input 6	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).				
13	25	Ctrl Command 6	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.				
13	28	Control Input 7	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).				
13	29	Ctrl Command 7	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.				
13	2C	Control Input 8	Latched	0 = Latched or 1 = Pulsed

Col	Row	Courier Text	Default Setting	Available Setting
Description				
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).				
13	2D	Ctrl Command 8	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.				
13	30	Control Input 9	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).				
13	31	Ctrl Command 9	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.				
13	34	Control Input 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).				
13	35	Ctrl Command 10	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.				
13	38	Control Input 11	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).				
13	39	Ctrl Command 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.				
13	3C	Control Input 12	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).				
13	3D	Ctrl Command 12	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.				
13	40	Control Input 13	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).				
13	41	Ctrl Command 13	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.				
13	44	Control Input 14	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).				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
13	45	Ctrl Command 14	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.				
13	48	Control Input 15	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).				
13	49	Ctrl Command 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.				
13	4C	Control Input 16	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).				
13	4D	Ctrl Command 16	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.				
13	50	Control Input 17	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).				
13	51	Ctrl Command 17	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.				
13	54	Control Input 18	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).				
13	55	Ctrl Command 18	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.				
13	58	Control Input 19	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).				
13	59	Ctrl Command 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.				
13	5C	Control Input 20	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).				
13	5D	Ctrl Command 20	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED

Col	Row	Courier Text	Default Setting	Available Setting
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.				
13	60	Control Input 21	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).				
13	61	Ctrl Command 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.				
13	64	Control Input 22	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).				
13	65	Ctrl Command 22	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.				
13	68	Control Input 23	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).				
13	69	Ctrl Command 23	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.				
13	6C	Control Input 24	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).				
13	6D	Ctrl Command 24	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.				
13	70	Control Input 25	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).				
13	71	Ctrl Command 25	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.				
13	74	Control Input 26	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).				
13	75	Ctrl Command 26	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.				
13	78	Control Input 27	Latched	0 = Latched or 1 = Pulsed

Col	Row	Courier Text	Default Setting	Available Setting
Description				
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).				
13	79	Ctrl Command 27	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.				
13	7C	Control Input 28	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).				
13	7D	Ctrl Command 28	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.				
13	80	Control Input 29	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).				
13	81	Ctrl Command 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.				
13	84	Control Input 30	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).				
13	85	Ctrl Command 30	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.				
13	88	Control Input 31	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).				
13	89	Ctrl Command 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.				
13	8C	Control Input 32	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).				
13	8D	Ctrl Command 32	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 36 - Ctrl I/P Config settings

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”.

6.13 InterMiCOM Teleprotection

6.13.1 InterMiCOM Communication Channel

The “INTERMICOM COMMS” column contains all the information to configure the communication channel and also contains the channel statistics and diagnostic facilities.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
15	00	INTERMiCOM COMMS		
This column contains settings for InterMiCOM Communications (second rear comms board is fitted)				
15	01	IM Input Status		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.				
15	02	IM Output Status		Not Settable
Displays the status of each InterMiCOM output signal.				
15	10	Source Address	1	From 0 to 10 step 1
Setting for the unique IED address that is encoded in the InterMiCOM sent message.				
15	11	Received Address	2	From 0 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				
15	12	Baud Rate	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.				
15	20	Ch Statistics	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.				
15	21	Rx Direct Count		Not Settable
Displays the number of valid Direct Tripping messages since last counter reset.				
15	22	Rx Perm Count		Not Settable
Displays the number of valid Permissive Tripping messages since last counter reset.				
15	23	Rx Block Count		Not Settable
Displays the number of valid Blocking messages since last counter reset.				
15	24	Rx NewDataCount		Not Settable
Displays the number of different messages (change events) since last counter reset.				
15	25	Rx ErroredCount		Not Settable
Displays the number of invalid received messages since last counter reset.				
15	26	Lost Messages		Not Settable

Col	Row	Courier Text	Default Setting	Available Setting
Description				
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.				
15	30	Elapsed Time		Not Settable
Displays the time in seconds since last counter reset.				
15	31	Reset Statistics	No	0 = No, 1 = Yes
Command that allows all Statistics and Channel Diagnostics to be reset.				
15	40	Ch Diagnostics	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.				
15	41	Data CD Status		Not Settable
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				
15	42	FrameSync Status		Not Settable
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				
15	43	Message Status		Not Settable
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				
15	44	Channel Status		Not Settable
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				
15	45	IM H/W Status		Not Settable
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.				
15	50	Loopback Mode	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.				
15	51	Test Pattern	11111111(bin)	Allows specific bit statuses to be inserted directly into the InterMiCOM message, to substitute real data. This is used for testing purposes.
Allows specific bit statuses to be inserted directly into the InterMiCOM message, to substitute real data. This is used for testing purposes.				
15	52	Loopback Status		Not Settable

Col	Row	Courier Text	Default Setting	Available Setting
Description				
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 37 - InterMiCOM Comms settings

6.13.2 InterMiCOM Configuration

The "INTERMICOM CONF" column selects the format of each signal and its fallback operation mode.

InterMiCOM provides 8 commands over a single communications link, with the mode of operation of each command being individually selectable within the "IM# Cmd Type" cell (# = 1 to 8).

Col	Row	Courier Text	Default Setting	Available Setting
Description				
16	00	INTERMiCOM CONF		
This column contains settings for InterMiCOM Configuration (second rear comms board is fitted)				
16	01	IM Msg Alarm Lvl	0.25	From 0% to 100% step 0.1%
Setting that is used to alarm for poor channel quality. If during the fixed 1.6s window the ratio of invalid messages to the total number of messages that should be received (based upon the 'Baud Rate' setting) exceeds the above threshold, a 'Message Fail' alarm will be issued.				
16	10	IM1 Cmd Type	Direct	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_1 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
16	11	IM1 FallBackMode	Default	0 = Default or 1 = Latched
Setting that defines the status of IM1 signal in case of heavy noise and message synchronization being lost. If set to 'Latching' the last valid IM1 status will be maintained until the new valid message is received. If set to 'Default', the IM1 status, pre-defined by the user in 'IM1 DefaultValue' cell will be set. A new valid message will replace 'IM1 DefaultValue', once the channel recovers.				
16	12	IM1 DefaultValue	1	0 to 1 step 1
Setting that defines the IM1 fallback status.				
16	13	IM1 FrameSyncTim	20ms	From 10ms to 1.5s step 10ms
Time delay after which 'IM1 DefaultValue' is applied, providing that no valid message is received in the meantime.				
16	18	IM2 Cmd Type	Direct	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_2 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
16	19	IM2 FallBackMode	Default	0 = Default or 1 = Latched
Setting that defines the status of IM2 signal in case of heavy noise and message synchronization being lost. If set to 'Latching' the last valid IM2 status will be maintained until the new valid message is received. If set to 'Default', the IM2 status, pre-defined by the user in 'IM2 DefaultValue' cell will be set. A new valid message will replace 'IM2 DefaultValue', once the channel recovers.				
16	1A	IM2 DefaultValue	1	0 to 1 step 1
Setting that defines the IM2 fallback status.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
16	1B	IM2 FrameSyncTim	20ms	From 10ms to 1.5s step 10ms
Time delay after which 'IM2 DefaultValue' is applied, providing that no valid message is received in the meantime.				
16	20	IM3 Cmd Type	Direct	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_3 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
16	21	IM3 FallBackMode	Default	0 = Default or 1 = Latched
Setting that defines the status of IM3 signal in case of heavy noise and message synchronization being lost. If set to 'Latching' the last valid IM3 status will be maintained until the new valid message is received. If set to 'Default', the IM3 status, pre-defined by the user in 'IM3 DefaultValue' cell will be set. A new valid message will replace 'IM3 DefaultValue', once the channel recovers.				
16	22	IM3 DefaultValue	1	0 to 1 step 1
Setting that defines the IM3 fallback status.				
16	23	IM3 FrameSyncTim	20ms	From 10ms to 1.5s step 10ms
Time delay after which 'IM3 DefaultValue' is applied, providing that no valid message is received in the meantime.				
16	28	IM4 Cmd Type	Direct	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_4 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
16	29	IM4 FallBackMode	Default	0 = Default or 1 = Latched
Setting that defines the status of IM4 signal in case of heavy noise and message synchronization being lost. If set to 'Latching' the last valid IM4 status will be maintained until the new valid message is received. If set to 'Default', the IM4 status, pre-defined by the user in 'IM4 DefaultValue' cell will be set. A new valid message will replace 'IM4 DefaultValue', once the channel recovers.				
16	2A	IM4 DefaultValue	1	0 to 1 step 1
Setting that defines the IM4 fallback status.				
16	2B	IM4 FrameSyncTim	20ms	From 10ms to 1.5s step 10ms
Time delay after which 'IM4 DefaultValue' is applied, providing that no valid message is received in the meantime.				
16	30	IM5 Cmd Type	Direct	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_5 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
16	31	IM5 FallBackMode	Default	0 = Default or 1 = Latched
Setting that defines the status of IM5 signal in case of heavy noise and message synchronization being lost. If set to 'Latching' the last valid IM5 status will be maintained until the new valid message is received. If set to 'Default', the IM5 status, pre-defined by the user in 'IM5 DefaultValue' cell will be set. A new valid message will replace 'IM5 DefaultValue', once the channel recovers.				
16	32	IM5 DefaultValue	0	0 to 1 step 1
Setting that defines the IM5 fallback status.				
16	33	IM5 FrameSyncTim	10ms	From 10ms to 1.5s step 10ms
Time delay after which 'IM5 DefaultValue' is applied.				
16	38	IM6 Cmd Type	Direct	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_6 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
16	39	IM6 FallBackMode	Default	0 = Default or 1 = Latched

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Setting that defines the status of IM6 signal in case of heavy noise and message synchronization being lost. If set to 'Latching' the last valid IM6 status will be maintained until the new valid message is received. If set to 'Default', the IM6 status, pre-defined by the user in 'IM6 DefaultValue' cell will be set. A new valid message will replace 'IM6 DefaultValue', once the channel recovers.				
16	3A	IM6 DefaultValue	0	0 to 1 step 1
Setting that defines the IM6 fallback status.				
16	3B	IM6 FrameSyncTim	10ms	From 10ms to 1.5s step 10ms
Time delay after which 'IM6 DefaultValue' is applied.				
16	40	IM7 Cmd Type	Direct	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_7 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
16	41	IM7 FallBackMode	Default	0 = Default or 1 = Latched
Setting that defines the status of IM7 signal in case of heavy noise and message synchronization being lost. If set to 'Latching' the last valid IM7 status will be maintained until the new valid message is received. If set to 'Default', the IM7 status, pre-defined by the user in 'IM7 DefaultValue' cell will be set. A new valid message will replace 'IM7 DefaultValue', once the channel recovers.				
16	42	IM7 DefaultValue	0	0 to 1 step 1
Setting that defines the IM7 fallback status.				
16	43	IM7 FrameSyncTim	10ms	From 10ms to 1.5s step 10ms
Time delay after which 'IM7 DefaultValue' is applied.				
16	48	IM8 Cmd Type	Direct	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_8 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
16	49	IM8 FallBackMode	Default	0 = Default or 1 = Latched
Setting that defines the status of IM8 signal in case of heavy noise and message synchronization being lost. If set to 'Latching' the last valid IM8 status will be maintained until the new valid message is received. If set to 'Default', the IM8 status, pre-defined by the user in 'IM8 DefaultValue' cell will be set. A new valid message will replace 'IM8 DefaultValue', once the channel recovers.				
16	4A	IM8 DefaultVa+C358ue	0	0 to 1 step 1
Setting that defines the IM8 fallback status.				
16	4B	IM8 FrameSyncTim	10ms	From 10ms to 1.5s step 10ms
Time delay after which 'IM8 DefaultValue' is applied.				

Table 38 - InterMiCOM Conf settings

6.14 Programmable Function Keys and Tricolour LEDs

The lock setting allows a function key output that is set to toggle mode to be locked in its current active state. 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 relay functions. In the normal mode the function key output will remain high as long as the key is pressed. The Fn. Key label allows the text of the function key to be changed to something more suitable for the application.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
17	00	FUNCTION KEYS		
This column contains the function key definitions				
17	01	Fn Key Status		Not Settable
Displays the status of each function key.				
17	02	Fn Key 1	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.				
17	03	Fn Key 1 Mode	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.				
17	04	Fn Key 1 Label	Function Key 1	From 32 to 234 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
17	05	Fn Key 2	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				
17	06	Fn Key 2 Mode	Normal	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
17	07	Fn Key 2 Label	Function Key 2	From 32 to 234 step 1
Same description as Fn Key 1 Label				
17	08	Fn Key 3	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				
17	09	Fn Key 3 Mode	Normal	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
17	0A	Fn Key 3 Label	Function Key 3	From 32 to 234 step 1
Same description as Fn Key 1 Label				
17	0B	Fn Key 4	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				
17	0C	Fn Key 4 Mode	Normal	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
17	0D	Fn Key 4 Label	Function Key 4	From 32 to 234 step 1
Same description as Fn Key 1 Label				
17	0E	Fn Key 5	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
17	0F	Fn Key 5 Mode	Normal	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
17	10	Fn Key 5 Label	Function Key 5	From 32 to 234 step 1
Same description as Fn Key 1 Label				
17	11	Fn Key 6	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				
17	12	Fn Key 6 Mode	Normal	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
17	13	Fn Key 6 Label	Function Key 6	From 32 to 234 step 1
Same description as Fn Key 1 Label				
17	14	Fn Key 7	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				
17	15	Fn Key 7 Mode	Normal	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
17	16	Fn Key 7 Label	Function Key 7	From 32 to 234 step 1
Same description as Fn Key 1 Label				
17	17	Fn Key 8	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				
17	18	Fn Key 8 Mode	Normal	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
17	19	Fn Key 8 Label	Function Key 8	From 32 to 234 step 1
Same description as Fn Key 1 Label				
17	1A	Fn Key 9	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				
17	1B	Fn Key 9 Mode	Normal	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
17	1C	Fn Key 9 Label	Function Key 9	From 32 to 234 step 1
Same description as Fn Key 1 Label				
17	1D	Fn Key 10	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				
17	1E	Fn Key 10 Mode	Normal	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
17	1F	Fn Key 10 Label	Function Key 10	From 32 to 234 step 1
Same description as Fn Key 1 Label				

Table 39 - Function Keys settings

6.15 IED Configurator

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.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
19	00	IED CONFIGURATOR		
This column contains IED Configurator settings (IEC61850 builds)				
19	05	Switch Conf.Bank	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.				
19	0A	Restore Conf.	No action	0 = No action or 1 = Restore Conf.
Used to restore data from MCL(MiCOM Configuration Language)/CID (Configured IED Descriptor) file. This file is specific, containing a single devices IEC61850 configuration information, and used for transferring data to/from the MiCOM IED.				
19	10	Active Conf.Name		Not Settable
The name of the configuration in the Active Memory Bank, usually taken from the SCL file.				
19	11	Active Conf.Rev		Not Settable
Configuration Revision number of the configuration in the Active Memory Bank, usually taken from the SCL file.				
19	20	Inact.Conf.Name		Not Settable
The name of the configuration in the Inactive Memory Bank, usually taken from the SCL file.				
19	21	Inact.Conf.Rev		Not Settable
Configuration Revision number of the configuration in the Inactive Memory Bank, usually taken from the SCL file.				
19	30	IP PARAMETERS		
IP PARAMETERS				
19	31	IP Address 1		Not Settable
Displays the unique network IP address that identifies the relay on interface 1. A default IP address is encoded from MAC address 169.254.0.xxx, xxx = mod (The last byte of MAC1, 128) + 1.				
19	32	Subnet Mask 1		Not Settable
Displays the sub-network mask for interface 1.				
19	33	Gateway 1		Not Settable
Displays the IP address of the gateway (proxy) that interface 1 is connected to.				
19	34	IP Address 2		Not Settable
Displays the unique network IP address that identifies the relay on interface 2. A default IP address is encoded from MAC address 169.254.0.xxx, xxx = mod (The last byte of MAC1, 128) + 1. Visible when redundant Ethernet card fitted.				
19	35	Subnet Mask 2		Not Settable
Displays the sub-network mask for interface 2. Visible when redundant Ethernet card fitted.				
19	36	Gateway 2		Not Settable
Displays the IP address of the gateway (proxy) that interface 2 is connected to. Visible when redundant Ethernet card fitted.				
19	40	SNTP PARAMETERS		
SNTP PARAMETERS				
19	41	SNTP Server 1		Not Settable
Displays the IP address of the primary SNTP server.				
19	42	SNTP Server 2		Not Settable

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Displays the IP address of the secondary SNTP server. Visible when Ethernet card fitted.				
19	50	IEC 61850 SCL		
IEC 61850 SCL				
19	51	IED Name		Not Settable
IED name, which is the unique name on the IEC 61850 network for the IED, usually taken from the SCL (Substation Configuration Language for XML) file.				
19	60	IEC 61850 GOOSE		
IEC 61850 GOOSE				
19	70	GoEna	0000000000000000(bin)	Bit 0000=gcb01 GoEna to Bit FFFF=gcb16 GoEna
Setting to enable GOOSE publisher settings.				
19	71	Pub.Simul.Goose	0000000000000000(bin)	Bit 0000=gcb01 Sim Mode to Bit FFFF=gcb16 Sim Mode
The Pub.Simul.GOOSE cell controls whether GOOSE are sent as Normal or Simulated GOOSE. When a GOOSE control block is set to Sim Mode its GOOSE is published as simulated. Simulated GOOSE are usually published by test equipment and this setting allows a test IED to be set up to simulate the IEDs in a substation.				
19	73	Sub.Simul.Goose	No	0 = No or 1 = Yes
In edition 2 mode when Sub.Simul.GOOSE is set to Yes the relay will look for simulated GOOSE. If a simulated GOOSE is found the relay will subscribe to it and will not respond to its normal GOOSE until Sub.Simul.GOOSE is set to No. Other GOOSE signals that are not being simulated will remain subscribing to normal GOOSE. In edition 1 mode the relay will respond to both normal and test GOOSE.				

Table 40 - IED Configurator settings

6.16 Supervision Menu

The “Supervision” menu contains three sections:

- Voltage Transformer Supervision (VTS) for analog ac voltage inputs failures supervision
- Current Transformer Supervision (CTS) for ac phase current inputs failures supervision

Capacitive Voltage Transformer Supervision (CVT) for voltage dividers capacitors supervision.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
46	00	GROUP 1: SUPERVISION		
GROUP1: Supervision				
46	01	VT SUPERVISION		
Set the parameters for Voltage Transformer Supervision in the following settings				
46	02	VTS Time Delay	5s	From 1s to 20s step 1s
The VTS function issues an alarm signal when the Voltage Transformer is lost, when the VTS time-delay has elapsed. If an opto input is used to detect a VT failure, the blocking protection is instantaneous.				
46	03	VTS I2 & I0 Inh	0.05*I1	0 to 1.0*I1 step 0.01*I1
Sets negative sequence current and zero sequence current thresholds. If negative sequence and zero sequence currents exceed the threshold, the VTS alarm is inhibited (see section “Supervision / Loss of one or two phases voltages” – P44x/EN AP).				
46	04	VTS Imax Inhibit	2.5*I1	0 to 5.0*I1 step 0.01*I1
Sets maximum I> threshold (software version D6.x). The setting is used to override a voltage supervision block in the event of a phase fault occurring on the system (where 3 voltages are lost and the line is energized) that could trigger the voltage supervision logic.				
46	05	Detect 3P	Disabled	Enabled / Disabled
Disables or enables the loss of the three phase voltages.				
46	06	Threshold 3P	30V	From 10V to 70V step 1V
Sets the phase voltage level.				
46	07	Delta I>	0.1*I1	0.01*I1 to 5*I1 step 0.01*I1
Sets the sensitivity of the superimposed current elements.				
46	08	CT SUPERVISION		
Set the parameters for Circuit Transformer Supervision in the following settings				
46	09	CTS Status	Disabled	Enabled / Disabled
Enables or disables the Circuit Transformer Supervision.				
46	0A	CTS VN< Inhibit	1V	From 0.5V to 22V step 0.5V
Sets the VN< inhibition threshold. The CTS alarm is inhibited if the residual voltage is higher than this value.				
46	0B	CTS IN> Set	0.1*I1	0.08*I1 to 4*I1 step 0.01*I1
Sets the residual current threshold.				
46	0C	CTS Time Delay	5s	From 0s to 10s step 1s
Sets the time delay alarm.				
46	0D	CVT SUPERVISION		
46	0E	CVTS Status	Disabled	Enabled / Disabled

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Enables or disables the capacitive voltage transformers supervision				
46	0F	CVTS VN>	1V	From 0.5V to 22V step 0.5V
Sets the residual overvoltage threshold. A CVTS alarm will be issued if residual voltage is greater than this value.				
46	10	CVTS Time Delay	100s	From 0s to 300s step 1s
Sets the CVTS alarm time delay				

Table 41 - Supervision settings

6.17 Check Synchronisation Menu

The SYSTEM CHECKS menu contains all of the check synchronism settings for auto (“A/R”) and manual (“Man”) reclosure and is shown in the table below along with the relevant default settings:

Col	Row	Courier Text	Default Setting	Available Setting
Description				
48	00	GROUP 1: SYSTEM CHECKS		
GROUP1: System Checks				
48	01	Chk scheme A/R	111(bin)	Bit 00 (last bit)=Live B/ Dead L Bit 01=Dead B/Live L Bit 02 (first bit)=Live B/Live L
Check synchronism scheme for Autoreclosure. At least, one condition must be selected to activate the synchronism check logic. The Dead Bus / Dead Line can only be created using PSL.				
48	02	Chk scheme ManCB	111(bin)	Bit 00 (last bit)=Live B/ Dead L Bit 01=Dead B/Live L Bit 02 (first bit)=Live B/Live L
Check synchronism scheme for Manual CB Closure. At least, one condition must be selected to activate the synchronism check logic. The Dead Bus / Dead Line can only be created using PSL. The check synchronism condition is only taken into account if a SOTF condition has been enabled. otherwise, a dedicated PSL can be created using DDB (live line or live bus/dead line) – live/live cannot be managed – in that case.				
48	03	V< Dead Line	13V	From 5V to 30V step 1V
The Live Line and Dead Line settings define the thresholds which dictate whether or not the line is determined as being live or dead by the relay logic.				
48	04	V> Live Line	32V	From 30V to 120V step 1V
The Live Line and Dead Line settings define the thresholds which dictate whether or not the line is determined as being live or dead by the relay logic.				
48	05	V< Dead Bus	13V	From 5V to 30V step 1V
The Live Bus and Dead Bus settings define the thresholds which dictate whether or not the bus is determined as being live or dead by the relay logic.				
48	06	V> Live Bus	32V	From 30V to 120V step 1V
The Live Bus and Dead Bus settings define the thresholds which dictate whether or not the bus is determined as being live or dead by the relay logic.				
48	07	Diff Voltage	6.5V	From 0.5V to 40V step 0.1V
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				
48	08	Diff Frequency	0.05Hz	From 0.02Hz to 1Hz step 0.01Hz
Sets the maximum frequency difference between the line and bus voltage for the check sync. element slip frequency to be satisfied.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
48	09	Diff Phase	20°	From 5° to 90° step 2.5°
Sets the maximum phase angle difference between the line and bus voltage for the check sync. element phase angle criteria to be satisfied.				
48	0A	Bus-Line Delay	200ms	From 100ms to 2s step 100ms
Sets the time the check synch conditions must be met before a close signal can be issued				

Table 42 - System Check settings

6.18 Autoreclose Menu

Col	Row	Courier Text	Default Setting	Available Setting
Description				
49	00	GROUP 1: AUTORECLOSE		
GROUP1: Auto-Reclose				
49	01	AUTORECLOSE MODE		
49	02	1P Trip Mode	1/3	1 – Single 1/3 – Single/Three 1/3/3 – Single/Three/Three 1/3/3/3 – Single/Three/Three/Three
Number of shots, single pole trip mode (displayed if “A/R single pole” is enabled (‘CB Control’ column)). This setting is enabled if the first fault is a single phase fault. The first shot is a single mode high speed autoreclose shot and, if the relay has been set to allow more than one reclose, then the second, third and fourth shots are converted to three-pole time-delayed autoreclose trips.				
49	03	3P Trip Mode	3/3	3 – Three 3/3 – Three/Three 3/3/3 – Three/Three/Three 3/3/3/3 – Three/Three/Three/Three
Number of shots, three-pole trip mode (displayed if “A/R Three pole” is enabled (‘CB Control’ column)). This cell sets three-pole autoreclose shots. Up to four three-pole autoreclose shots are settable (1 high speed and three time-delayed autoreclose shots).				
49	04	1P Dead Time 1	1s	From 100ms to 5s step 10ms
Single-/ Three-pole dead time is displayed if “A/R single / Three pole” is enabled (‘CB Control’ column). This setting is enabled if the first fault is a single phase fault. Dead Times 1 (1P or 3P) set the dead time for the first high speed shot of the single pole or three-pole reclosure				
49	05	3P Dead Time 1	1s	From 100ms to 60s step 10ms
Single-/ Three-pole dead time is displayed if “A/R single / Three pole” is enabled (‘CB Control’ column). This setting is enabled if the first fault is a multi phase fault. Dead Times 1 (1P or 3P) set the dead time for the first high speed shot of the single pole or three-pole reclosure.				
49	06	Dead Time 2	60s	From 1s to 3600s step 1s
Dead Times for second, 3rd and 4th shot (when set). The dead times are independently adjustable. The CB close signal is given at the end of this time-delay.				
49	07	Dead Time 3	180s	From 1s to 3600s step 1s
Dead Times for second, 3rd and 4th shot (when set). The dead times are independently adjustable. The CB close signal is given at the end of this time-delay.				
49	08	Dead Time 4	180s	From 1s to 3600s step 1s
Dead Times for second, 3rd and 4th shot (when set). The dead times are independently adjustable. The CB close signal is given at the end of this time-delay.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
49	09	Reclaim Time	180s	From 1s to 600s step 1s
Set the reclaim time. The reclaim time starts when the CB is closed. The reclaim time should be set according to the fault incidence, the CB spring charging time, the switgear maintenance and the tZ2 zone delay.				
49	0A	Close Pulse Time	0.1s	From 100ms to 10s step 10ms
Set the time-delay before CB reclosure. The Reclose time-delay maintains the linked reclose contact closed for a time sufficient to ensure reliable CB mechanism operation				
49	0B	Discrim. Time	5s	From 100ms to 5s step 10ms
The discrimination time-delay is used to differentiate between an evolving fault from a second fault in the power system and a long circuit breaker operation.				
49	0C	A/R Inhbit Wind	5s	From 1s to 3600s step 1s
The "A/R Inhibit Wind" timer setting can be used to prevent autoreclose being initiated when the CB is manually closed onto a fault. Autoreclose is disabled for the AR Inhibit Wind following manual CB Closure.				
49	0D	C/S 3P Rcl DT1	Enabled	Enabled, Disabled
Check synchronism on 3-pole reclosure during Dead Time 1 Enables or disables the control by the check synchronism logic of the 3P high speed autoreclosure (HSAR) cycle during dead time 1 (check synchro 3P HSAR).				
49	0E	AUTORCLE LOCKOUT		
49	0F	Block A/R	1111111111111111111111111111111(bin)	Bit 00=At T2 Bit 01=At T3 Bit 02=At TZp Bit 03=LoL Trip Bit 04=I>1 Trip Bit 5=I>2 Trip Bit 6=V<1 Trip Bit 7=V<2 Trip Bit 8=V>1 Trip Bit 9=V>2 Trip Bit 0A=IN>1 Trip Bit 0B=IN>2 Trip Bit 0C=Aided DEF Trip Bit 0D=ZSP Trip Bit 0E=IN>3 Trip Bit 0F=IN>4 Trip Bit 10=PAP Trip Bit 11 Therm. Over Trip Bit 12=I2>1 Trip Bit 13=I2>2 Trip Bit 14=I2>3 Trip 15=I2>4 Trip Bit 16=VN>1 Trip Bit 17=VN>2 Trip Bit 18=At TZq Bit 19=V<3 Trip Bit 1A=V<4 Trip Bit 1B=V>3 Trip Bit 1C=V>4 Trip Bit 1D=I<1 Trip Bit 1E=I<2 Trip 4910 Bit 00=F<1 Trip Bit 01=F<2 Trip Bit 02=F<3 Trip Bit 03=F<4 Trip Bit 04=F>1 Trip Bit 5=F>2 Trip
Set to 1 the relevant bit to block the autoreclose when the relevant fault occurs. It will cause a lockout if autoreclose is in progress.				
49	10	Block A/R 2	111111(bin)	Bit 0: block for F<1 Trip Bit 1: block for F<2 Trip Bit 2: block for F<3 Trip Bit 3: block for F<4 Trip Bit 4: block for F>1 Trip Bit 5: block for F>2 Trip
Set to 1 the relevant bit to block the autoreclose when the relevant fault occurs. It will cause a lockout if autoreclose is in progress.				

Table 43 - Autoreclose settings

6.19 Security Configuration (if Option Available)

The SECURITY CONFIG column contains the main configuration settings for Security functions. This column is used to set the password attempts number and duration. When these limits expire, access to the interface is blocked until the timer has expired. This setting enables or disables port access.

Important	**The SECURITY CONFIG column is ACCESS ONLY BY AUTHORISED USERS**

Col	Row	Courier Text	Default Setting	Available Setting
Description				
25	00	SECURITY CONFIG		
This column contains settings for Security Configuration				
25	01	User Banner	ACCESS ONLY FOR AUTHORISED USERS	Not Settable
This banner is one of the default display options				
25	02	Attempts Limit	5	Special cells, not settable except for configuring via SAT for CSL1 models
Adjust the number of attempts to enter a valid password. Fixed at 5 for CSL0 models. SAT can configure from 1 to 99 for CSL1 models.				
25	04	Blocking Timer	4	Special cells, not settable except for configuring via SAT for CSL1 models
Adjust the blocking timer (minutes) after a password blocking. Once the password is blocked, this blocking timer is initiated. Only after the blocking timer has expired will access to the interface be unblocked, whereupon the attempts counter is reset to zero. Fixed at 4 for CSL0 models. SAT can configure from 1 to 1440 for CSL1 models.				
25	05	Front Port	Enabled	0 = Disabled or 1 = Enabled
Enable or disable the front port access. To prevent accidental disbling of a port, a warning message “FRONT PORT TO BE DISABLED, CONFIRM” is required to be disabled.				
25	06	Rear Port 1	Enabled	0 = Disabled or 1 = Enabled
Enable or disable the rear port 1 access. To prevent accidental disbling of a port, a warning message “REAR PORT 1 TO BE DISABLED, CONFIRM” is required to be disabled.				
25	07	Rear Port 2	Enabled	0 = Disabled or 1 = Enabled
When fitted, enable or disable the rear port 2 access. To prevent accidental disabling of a port, a warning message “REAR PORT 2 TO BE DISABLED, CONFIRM” is required to be disabled.				
25	08	ETH Port 1	Enabled	0 = Disabled or 1 = Enabled
Enable or disable Ethernet logical port 1 access. Note: if this port is enabled or disabled, the Ethernet card will reboot. Single port Ethernet card or Redundant Ethernet card with Comm Mode=PRP or HSR				
25	09	ETH Port 1/2	Enabled	0 = Disabled or 1 = Enabled
Enable or disable the Ethernet logical port 1/2 access. Note: if these ports are enabled or disabled, the Ethernet card will reboot. Redundant Ethernet card with Comm Mode=Dual IP				
25	0A	ETH Port 2/3	Enabled	0 = Disabled or 1 = Enabled
Enable or disable the Ethernet logical port 2/3 access. Note: if these ports are enabled or disabled, the Ethernet card will reboot. Redundanct Ethernet card with Comm Mode=PRP or HSR				
25	0B	ETH Port 3	Enabled	0 = Disabled or 1 = Enabled
Enable or disable the Ethernet logical port 3 access. Note: if this port is enabled or disabled, the Ethernet card will reboot. Redundant Ethernet card with Comm Mode=Dual IP				
25	0C	Courier Tunnel	Enabled	0 = Disabled or 1 = Enabled

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Enable or disable Logical Tunnelled Courier Port				
25	0D	IEC61850 or IEC61850+DNPoE	Enabled	0 = Disabled or 1 = Enabled
Enable or disable IEC61850 (and DNPoE for protocol option B or L) services				
25	11	Attempts Remain	5	Not Settable
Indicates the number of attempts to enter a password.				
25	12	Blk Time Remain	0	Not Settable
Indicates the blocking time remaining (in minutes).				
25	21	Username 1		Not Settable
User Name, visible in authorized courier client, only.				
25	22	Username 2		Not Settable
User Name, visible in authorized courier client, only.				
25	23	Username 3		Not Settable
User Name, visible in authorized courier client, only.				
25	24	Username 4		Not Settable
User Name, visible in authorized courier client, only.				
25	25	Username 5		Not Settable
User Name, visible in authorized courier client, only.				
25	26	Username 6		Not Settable
User Name, visible in authorized courier client, only.				
25	27	Username 7		Not Settable
User Name, visible in authorized courier client, only.				
25	28	Username 8		Not Settable
User Name, visible in authorized courier client, only.				
25	29	Username 9		Not Settable
User Name, visible in authorized courier client, only.				
25	2A	Username 10		Not Settable
User Name, visible in authorized courier client, only.				
25	2B	Username 11		Not Settable
User Name, visible in authorized courier client, only.				
25	2C	Username 12		Not Settable
User Name, visible in authorized courier client, only.				
25	2D	Username 13		Not Settable
User Name, visible in authorized courier client, only.				
25	2E	Username 14		Not Settable
User Name, visible in authorized courier client, only.				
25	2F	Username 15		Not Settable
User Name, visible in authorized courier client, only.				
25	FE	READ SEC. CODE		Not Settable
Indicates the security code (user interface only). The security code is a read-only random 12-digit number. This Security Code should be noted for password recovery and the relay should not be power cycled until the reset RBAC code is entered.				
25	FF	Reset RBAC		33 to 122 step 1
User interface only. Used to enter recovery password.				

Table 44 - Security Config settings

6.20 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.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
4A	00	GROUP 1: INPUT LABELS		
This column contains settings for Opto Input Labels				
4A	01	Opto Input 1	Opto Label 01	From 32 to 234 step 1
Label for Opto Input 1				
4A	02	Opto Input 2	Opto Label 02	From 32 to 234 step 1
Label for Opto Input 2				
4A	03	Opto Input 3	Opto Label 03	From 32 to 234 step 1
Label for Opto Input 3				
4A	04	Opto Input 4	Opto Label 04	From 32 to 234 step 1
Label for Opto Input 4				
4A	05	Opto Input 5	Opto Label 05	From 32 to 234 step 1
Label for Opto Input 5				
4A	06	Opto Input 6	Opto Label 06	From 32 to 234 step 1
Label for Opto Input 6				
4A	07	Opto Input 7	Opto Label 07	From 32 to 234 step 1
Label for Opto Input 7				
4A	08	Opto Input 8	Opto Label 08	From 32 to 234 step 1
Label for Opto Input 8				
4A	09	Opto Input 9	Opto Label 09	From 32 to 234 step 1
Label for Opto Input 9				
4A	0A	Opto Input 10	Opto Label 10	From 32 to 234 step 1
Label for Opto Input 10				
4A	0B	Opto Input 11	Opto Label 11	From 32 to 234 step 1
Label for Opto Input 11				
4A	0C	Opto Input 12	Opto Label 12	From 32 to 234 step 1
Label for Opto Input 12				
4A	0D	Opto Input 13	Opto Label 13	From 32 to 234 step 1
Label for Opto Input 13				
4A	0E	Opto Input 14	Opto Label 14	From 32 to 234 step 1
Label for Opto Input 14				
4A	0F	Opto Input 15	Opto Label 15	From 32 to 234 step 1
Label for Opto Input 15				
4A	10	Opto Input 16	Opto Label 16	From 32 to 234 step 1
Label for Opto Input 16				
4A	11	Opto Input 17	Opto Label 17	From 32 to 234 step 1
Label for Opto Input 17 This setting does not apply to P442 relays.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
4A	12	Opto Input 18	Opto Label 18	From 32 to 234 step 1
Label for Opto Input 18 This setting does not apply to P442 relays.				
4A	13	Opto Input 19	Opto Label 19	From 32 to 234 step 1
Label for Opto Input 19 This setting does not apply to P442 relays.				
4A	14	Opto Input 20	Opto Label 20	From 32 to 234 step 1
Label for Opto Input 20 This setting does not apply to P442 relays.				
4A	15	Opto Input 21	Opto Label 21	From 32 to 234 step 1
Label for Opto Input 21 This setting does not apply to P442 relays.				
4A	16	Opto Input 22	Opto Label 22	From 32 to 234 step 1
Label for Opto Input 22 This setting does not apply to P442 relays.				
4A	17	Opto Input 23	Opto Label 23	From 32 to 234 step 1
Label for Opto Input 23 This setting does not apply to P442 relays.				
4A	18	Opto Input 24	Opto Label 24	From 32 to 234 step 1
Label for Opto Input 24 This setting does not apply to P442 relays.				

Table 45 - Input Labels settings

6.21 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.

Col	Row	Courier Text	Default Setting	Available Setting
Description				
4B	00	GROUP 1: OUTPUT LABEL		
This column contains settings for Output Relay Labels				
4B	01	Relay 1	Relay Label 01	From 32 to 234 step 1
Label for Output Relay 1				
4B	02	Relay 2	Relay Label 02	From 32 to 234 step 1
Label for Output Relay 2				
4B	03	Relay 3	Relay Label 03	From 32 to 234 step 1
Label for Output Relay 3				
4B	04	Relay 4	Relay Label 04	From 32 to 234 step 1
Label for Output Relay 4				
4B	05	Relay 5	Relay Label 05	From 32 to 234 step 1
Label for Output Relay 5				
4B	06	Relay 6	Relay Label 06	From 32 to 234 step 1
Label for Output Relay 6				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
4B	07	Relay 7	Relay Label 07	From 32 to 234 step 1
Label for Output Relay 7				
4B	08	Relay 8	Relay Label 08	From 32 to 234 step 1
Label for Output Relay 8				
4B	09	Relay 9	Relay Label 09	From 32 to 234 step 1
Label for Output Relay 9				
4B	0A	Relay 10	Relay Label 10	From 32 to 234 step 1
Label for Output Relay 10				
4B	0B	Relay 11	Relay Label 11	From 32 to 234 step 1
Label for Output Relay 11				
4B	0C	Relay 12	Relay Label 12	From 32 to 234 step 1
Label for Output Relay 12				
4B	0D	Relay 13	Relay Label 13	From 32 to 234 step 1
Label for Output Relay 13				
4B	0E	Relay 14	Relay Label 14	From 32 to 234 step 1
Label for Output Relay 14				
4B	0F	Relay 15	Relay Label 15	From 32 to 234 step 1
Label for Output Relay 15				
4B	10	Relay 16	Relay Label 16	From 32 to 234 step 1
Label for Output Relay 16				
4B	11	Relay 17	Relay Label 17	From 32 to 234 step 1
Label for Output Relay 17				
4B	12	Relay 18	Relay Label 18	From 32 to 234 step 1
Label for Output Relay 18				
4B	13	Relay 19	Relay Label 19	From 32 to 234 step 1
Label for Output Relay 19				
4B	14	Relay 20	Relay Label 20	From 32 to 234 step 1
Label for Output Relay 20				
4B	15	Relay 21	Relay Label 21	From 32 to 234 step 1
Label for Output Relay 21				
4B	16	Relay 22	Relay Label 22	From 32 to 234 step 1
Label for Output Relay 22 This setting does not apply to P442 relays.				
4B	17	Relay 23	Relay Label 23	From 32 to 234 step 1
Label for Output Relay 23 This setting does not apply to P442 relays.				
4B	18	Relay 24	Relay Label 24	From 32 to 234 step 1
Label for Output Relay 24 This setting does not apply to P442 relays.				
4B	19	Relay 25	Relay Label 25	From 32 to 234 step 1
Label for Output Relay 25 This setting does not apply to P442 relays.				
4B	1A	Relay 26	Relay Label 26	From 32 to 234 step 1
Label for Output Relay 26 This setting does not apply to P442 relays.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
4B	1B	Relay 27	Relay Label 27	From 32 to 234 step 1
Label for Output Relay 27 This setting does not apply to P442 relays.				
4B	1C	Relay 28	Relay Label 28	From 32 to 234 step 1
Label for Output Relay 28 This setting does not apply to P442 relays.				
4B	1D	Relay 29	Relay Label 29	From 32 to 234 step 1
Label for Output Relay 29 This setting does not apply to P442 relays.				
4B	1E	Relay 30	Relay Label 30	From 32 to 234 step 1
Label for Output Relay 30 This setting does not apply to P442 relays.				
4B	1F	Relay 31	Relay Label 31	From 32 to 234 step 1
Label for Output Relay 31 This setting does not apply to P442 relays.				
4B	20	Relay 32	Relay Label 32	From 32 to 234 step 1
Label for Output Relay 32 This setting does not apply to P442 relays.				
4B	21	Relay 33	Relay Label 33	From 32 to 234 step 1
Label for Output Relay 33 This setting does not apply to P442 relays.				
4B	22	Relay 34	Relay Label 34	From 32 to 234 step 1
Label for Output Relay 34 This setting does not apply to P442 relays.				
4B	23	Relay 35	Relay Label 35	From 32 to 234 step 1
Label for Output Relay 35 This setting does not apply to P442 relays.				
4B	24	Relay 36	Relay Label 36	From 32 to 234 step 1
Label for Output Relay 36 This setting does not apply to P442 relays.				
4B	25	Relay 37	Relay Label 37	From 32 to 234 step 1
Label for Output Relay 37 This setting does not apply to P442 relays.				
4B	26	Relay 38	Relay Label 38	From 32 to 234 step 1
Label for Output Relay 38 This setting does not apply to P442 relays.				
4B	27	Relay 39	Relay Label 39	From 32 to 234 step 1
Label for Output Relay 39 This setting does not apply to P442 relays.				
4B	28	Relay 40	Relay Label 40	From 32 to 234 step 1
Label for Output Relay 40 This setting does not apply to P442 relays.				
4B	29	Relay 41	Relay Label 41	From 32 to 234 step 1
Label for Output Relay 41 This setting does not apply to P442 relays.				
4B	2A	Relay 42	Relay Label 42	From 32 to 234 step 1
Label for Output Relay 42 This setting does not apply to P442 relays.				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
4B	2B	Relay 43	Relay Label 43	From 32 to 234 step 1
Label for Output Relay 43 This setting does not apply to P442 relays.				
4B	2C	Relay 44	Relay Label 44	From 32 to 234 step 1
Label for Output Relay 44 This setting does not apply to P442 relays.				
4B	2D	Relay 45	Relay Label 45	From 32 to 234 step 1
Label for Output Relay 45 This setting does not apply to P442 relays.				
4B	2E	Relay 46	Relay Label 46	From 32 to 234 step 1
Label for Output Relay 46 This setting does not apply to P442 relays.				

Table 46 - Output Labels settings

6.22 Virtual Input Labels

Col	Row	Courier Text	Default Setting	Available Setting
Description				
26	00	VIR I/P LABELS		
This column contains settings for Virtual Input Labels				
26	01	Virtual Input 1	Virtual Input 1	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	02	Virtual Input 2	Virtual Input 2	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	03	Virtual Input 3	Virtual Input 3	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	04	Virtual Input 4	Virtual Input 4	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	05	Virtual Input 5	Virtual Input 5	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	06	Virtual Input 6	Virtual Input 6	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	07	Virtual Input 7	Virtual Input 7	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	08	Virtual Input 8	Virtual Input 8	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	09	Virtual Input 9	Virtual Input 9	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	0A	Virtual Input 10	Virtual Input 10	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	0B	Virtual Input 11	Virtual Input 11	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	0C	Virtual Input 12	Virtual Input 12	From 32 to 234 step 1
Text label to describe each individual Virtual input				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
26	0D	Virtual Input 13	Virtual Input 13	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	0E	Virtual Input 14	Virtual Input 14	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	0F	Virtual Input 15	Virtual Input 15	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	10	Virtual Input 16	Virtual Input 16	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	11	Virtual Input 17	Virtual Input 17	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	12	Virtual Input 18	Virtual Input 18	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	13	Virtual Input 19	Virtual Input 19	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	14	Virtual Input 20	Virtual Input 20	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	15	Virtual Input 21	Virtual Input 21	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	16	Virtual Input 22	Virtual Input 22	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	17	Virtual Input 23	Virtual Input 23	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	18	Virtual Input 24	Virtual Input 24	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	19	Virtual Input 25	Virtual Input 25	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	1A	Virtual Input 26	Virtual Input 26	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	1B	Virtual Input 27	Virtual Input 27	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	1C	Virtual Input 28	Virtual Input 28	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	1D	Virtual Input 29	Virtual Input 29	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	1E	Virtual Input 30	Virtual Input 30	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	1F	Virtual Input 31	Virtual Input 31	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	20	Virtual Input 32	Virtual Input 32	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	21	Virtual Input 33	Virtual Input 33	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	22	Virtual Input 34	Virtual Input 34	From 32 to 234 step 1

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Text label to describe each individual Virtual input				
26	23	Virtual Input 35	Virtual Input 35	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	24	Virtual Input 36	Virtual Input 36	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	25	Virtual Input 37	Virtual Input 37	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	26	Virtual Input 38	Virtual Input 38	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	27	Virtual Input 39	Virtual Input 39	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	28	Virtual Input 40	Virtual Input 40	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	29	Virtual Input 41	Virtual Input 41	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	2A	Virtual Input 42	Virtual Input 42	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	2B	Virtual Input 43	Virtual Input 43	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	2C	Virtual Input 44	Virtual Input 44	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	2D	Virtual Input 45	Virtual Input 45	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	2E	Virtual Input 46	Virtual Input 46	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	2F	Virtual Input 47	Virtual Input 47	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	30	Virtual Input 48	Virtual Input 48	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	31	Virtual Input 49	Virtual Input 49	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	32	Virtual Input 50	Virtual Input 50	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	33	Virtual Input 51	Virtual Input 51	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	34	Virtual Input 52	Virtual Input 52	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	35	Virtual Input 53	Virtual Input 53	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	36	Virtual Input 54	Virtual Input 54	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	37	Virtual Input 55	Virtual Input 55	From 32 to 234 step 1
Text label to describe each individual Virtual input				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
26	38	Virtual Input 56	Virtual Input 56	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	39	Virtual Input 57	Virtual Input 57	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	3A	Virtual Input 58	Virtual Input 58	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	3B	Virtual Input 59	Virtual Input 59	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	3C	Virtual Input 60	Virtual Input 60	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	3D	Virtual Input 61	Virtual Input 61	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	3E	Virtual Input 62	Virtual Input 62	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	3F	Virtual Input 63	Virtual Input 63	From 32 to 234 step 1
Text label to describe each individual Virtual input				
26	40	Virtual Input 64	Virtual Input 64	From 32 to 234 step 1
Text label to describe each individual Virtual input				

Table 47 – Virtual input label settings

6.23 Virtual Output Labels

Col	Row	Courier Text	Default Setting	Available Setting
Description				
27	00	VIR O/P LABELS		
This column contains settings for Virtual Output Labels				
27	01	Virtual Output 1	Virtual Output 1	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	02	Virtual Output 2	Virtual Output 2	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	03	Virtual Output 3	Virtual Output 3	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	04	Virtual Output 4	Virtual Output 4	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	05	Virtual Output 5	Virtual Output 5	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	06	Virtual Output 6	Virtual Output 6	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	07	Virtual Output 7	Virtual Output 7	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	08	Virtual Output 8	Virtual Output 8	From 32 to 234 step 1
Text label to describe each individual Virtual output				

Col	Row	Courier Text	Default Setting	Available Setting
Description				
27	09	Virtual Output 9	Virtual Output 9	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	0A	Virtual Output10	Virtual Output10	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	0B	Virtual Output11	Virtual Output11	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	0C	Virtual Output12	Virtual Output12	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	0D	Virtual Output13	Virtual Output13	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	0E	Virtual Output14	Virtual Output14	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	0F	Virtual Output15	Virtual Output15	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	10	Virtual Output16	Virtual Output16	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	11	Virtual Output17	Virtual Output17	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	12	Virtual Output18	Virtual Output18	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	13	Virtual Output19	Virtual Output19	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	14	Virtual Output20	Virtual Output20	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	15	Virtual Output21	Virtual Output21	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	16	Virtual Output22	Virtual Output22	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	17	Virtual Output23	Virtual Output23	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	18	Virtual Output24	Virtual Output24	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	19	Virtual Output25	Virtual Output25	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	1A	Virtual Output26	Virtual Output26	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	1B	Virtual Output27	Virtual Output27	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	1C	Virtual Output28	Virtual Output28	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	1D	Virtual Output29	Virtual Output29	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	1E	Virtual Output30	Virtual Output30	From 32 to 234 step 1

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Text label to describe each individual Virtual output				
27	1F	Virtual Output31	Virtual Output31	From 32 to 234 step 1
Text label to describe each individual Virtual output				
27	20	Virtual Output32	Virtual Output32	From 32 to 234 step 1
Text label to describe each individual Virtual output				

Table 48 – Virtual output label settings

6.24 User Alarm Labels

Col	Row	Courier Text	Default Setting	Available Setting
Description				
28	00	USR ALARM LABELS		
This column contains User Alarm Labels				
28	01	SR User Alarm 1	SR User Alarm 1	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	02	SR User Alarm 2	SR User Alarm 2	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	03	SR User Alarm 3	SR User Alarm 3	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	04	SR User Alarm 4	SR User Alarm 4	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	05	SR User Alarm 5	SR User Alarm 5	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	06	SR User Alarm 6	SR User Alarm 6	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	07	SR User Alarm 7	SR User Alarm 7	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	08	SR User Alarm 8	SR User Alarm 8	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	09	SR User Alarm 9	SR User Alarm 9	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	0A	SR User Alarm 10	SR User Alarm 10	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	0B	SR User Alarm 11	SR User Alarm 11	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	0C	SR User Alarm 12	SR User Alarm 12	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	0D	SR User Alarm 13	SR User Alarm 13	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	0E	SR User Alarm 14	SR User Alarm 14	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	0F	SR User Alarm 15	SR User Alarm 15	From 32 to 234 step 1

Col	Row	Courier Text	Default Setting	Available Setting
Description				
Text label to describe each individual User Alarm				
28	10	SR User Alarm 16	SR User Alarm 16	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	11	MR User Alarm 17	MR User Alarm 17	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	12	MR User Alarm 18	MR User Alarm 18	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	13	MR User Alarm 19	MR User Alarm 19	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	14	MR User Alarm 20	MR User Alarm 20	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	15	MR User Alarm 21	MR User Alarm 21	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	16	MR User Alarm 22	MR User Alarm 22	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	17	MR User Alarm 23	MR User Alarm 23	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	18	MR User Alarm 24	MR User Alarm 24	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	19	MR User Alarm 25	MR User Alarm 25	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	1A	MR User Alarm 26	MR User Alarm 26	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	1B	MR User Alarm 27	MR User Alarm 27	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	1C	MR User Alarm 28	MR User Alarm 28	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	1D	MR User Alarm 29	MR User Alarm 29	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	1E	MR User Alarm 30	MR User Alarm 30	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	1F	MR User Alarm 31	MR User Alarm 31	From 32 to 234 step 1
Text label to describe each individual User Alarm				
28	20	MR User Alarm 32	MR User Alarm 32	From 32 to 234 step 1
Text label to describe each individual User Alarm				

Table 49 – User alarm label settings

6.25 Control Input Labels

Col	Row	Courier Text	Default Setting	Available Setting
Description				
29	00	CTRL I/P LABELS		
This column contains settings for Control Input Labels				
29	01	Control Input 1	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				
29	02	Control Input 2	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				
29	03	Control Input 3	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				
29	04	Control Input 4	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				
29	05	Control Input 5	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				
29	06	Control Input 6	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				
29	07	Control Input 7	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				
29	08	Control Input 8	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				
29	09	Control Input 9	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				
29	0A	Control Input 10	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				
29	0B	Control Input 11	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				
29	0C	Control Input 12	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				
29	0D	Control Input 13	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				
29	0E	Control Input 14	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				
29	0F	Control Input 15	Control Input 15	From 32 to 234 step 1

Col	Row	Courier Text	Default Setting	Available Setting
Description				
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				
29	10	Control Input 16	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				
29	11	Control Input 17	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				
29	12	Control Input 18	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				
29	13	Control Input 19	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				
29	14	Control Input 20	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				
29	15	Control Input 21	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				
29	16	Control Input 22	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				
29	17	Control Input 23	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				
29	18	Control Input 24	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				
29	19	Control Input 25	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				
29	1A	Control Input 26	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				
29	1B	Control Input 27	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				
29	1C	Control Input 28	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				
29	1D	Control Input 29	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				
29	1E	Control Input 30	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				
29	1F	Control Input 31	Control Input 31	From 32 to 234 step 1

Col	Row	Courier Text	Default Setting	Available Setting
Description				
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				
29	20	Control Input 32	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				

Table 50 – Control input labels settings

6.26 Ethernet NCIT Settings

Col	Row	Courier Text	Default Setting	Available Setting
Description				
18	00	ETHERNET NCIT		
This column contains the ethernet NCIT definitions				
18	01	Physical Link	Copper	0 = Copper, 1 = Fibre Optic
This cell defines whether an electrical connection ("Copper" selection) or fiber optic connection is being used for communication.				
18	02	AntiAlaising Fil	Disabled	0 = Disabled, 1 = Enabled
This cell activates or deactivates the anti-aliasing filter.				
18	03	Merge Unit Delay	0s	From 0s to 3ms step 250us
This cell adjusts the maximum time-delay starting at the reception of the Ethernet message from the "first" Merging Units (MU) to the reception of the Ethernet message from the "last" Merging Units (MU). This time-delay should be adjusted to receive the messages from all the MUs on time. The signal processing will start at the end of the Merge Unit delay. If a message is not received in that specified time, a synchronisation alarm will appear.				
18	04	L.N. Arrangement	VL,IL,IN	VL,IL,IN or VL,IL,IN2 or VL,Sum(2xIL) or VL,IL,IN,VB or VL,IL,IN,2xVB or VL,IL,IN2,VB or VL,IL,IN2,2xVB
This cell is used to select the logical node arrangement.				
18	20	Logical Node 1	Logical Node 1	From 65 to 90 step 1
Name of the Logical Nodes LNx, in order to identify it (up to 34 characters). Note: It is important for each Logical Node name to be exactly the same as the one set in the Merging Unit that broadcasts it.				
18	21	Logical Node 2	Logical Node 2	From 65 to 90 step 1
Name of the Logical Nodes LNx, in order to identify it (up to 34 characters). Note: It is important for each Logical Node name to be exactly the same as the one set in the Merging Unit that broadcasts it.				
18	22	Logical Node 3	Logical Node 3	From 65 to 90 step 1
Name of the Logical Nodes LNx, in order to identify it (up to 34 characters). Note: It is important for each Logical Node name to be exactly the same as the one set in the Merging Unit that broadcasts it.				
18	23	Logical Node 4	Logical Node 4	From 65 to 90 step 1
Name of the Logical Nodes LNx, in order to identify it (up to 34 characters). Note: It is important for each Logical Node name to be exactly the same as the one set in the Merging Unit that broadcasts it.				
18	24	Logical Node 5	Logical Node 5	From 65 to 90 step 1
Name of the Logical Nodes LNx, in order to identify it (up to 34 characters). Note: It is important for each Logical Node name to be exactly the same as the one set in the Merging Unit that broadcasts it.				
18	25	Logical Node 6	Logical Node 6	From 65 to 90 step 1
Name of the Logical Nodes LNx, in order to identify it (up to 34 characters). Note: It is important for each Logical Node name to be exactly the same as the one set in the Merging Unit that broadcasts it.				
18	30	NCIT Synchro	0(bin)	Bit 00=No SYNC CLK
Loss of the synchronization alarm in accordance with the following values. 'Global 1 PPS' = the Sample Values (SV) are synchronized with a global area clock (GPS like clock). 'Local 1 PPS' = the SV are synchronized with a local area clock signal (substation). No Sync clk' the SV are not synchronized with an external clock signal (internal synchronization)."				

Table 51 – Ethernet NCIT settings

7 PROGRAMMABLE SCHEME LOGIC DEFAULT SETTINGS

The relay includes Programmable Scheme Logic (PSL) - one PSL by Group of settings enabled (maximum 4 groups of PSL can be assigned in the relay).

The purpose of this logic is multi-functional and includes the following:

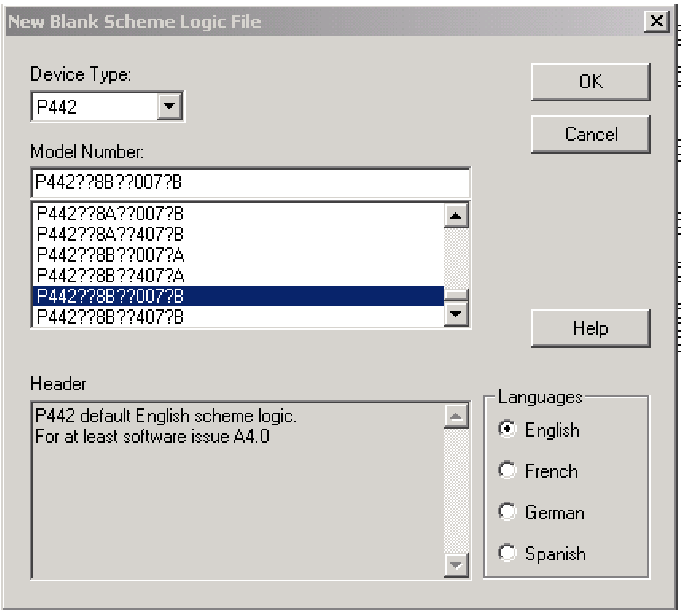
- Mapping of opto-isolated inputs, relay output contacts and the programmable LEDs.
- Relay output conditioning (delay on pick-up/drop-off, dwell time, latching or self-reset).
- Fault Recorder start mapping, i.e. which internal signals initiate a fault record.
- Generation of customer specific scheme logic through the use of the PSL Editor inbuilt into the MiCOM S1 Studio support software (Section P44x/EN PL).

Further information regarding editing and using PSL can be found in the MiCOM S1 Editor help menu. The following section details the default settings of the PSL. Note that changes to these default settings can only be carried out using the PSL Editor and not via the relay front panel.

7.1 How to use PSL Editor

Off-Line method:

- Launch the free application software (PSL Editor application or, using MiCOM S1 Studio, “Tools > PSL Editor” menu) provided with the relay: MiCOM S1 Studio (also downloadable from the internet).
- Launch the PSL Editor application.
- Open a blank scheme or a default scheme with the correct model / version number (File\New\Default Scheme or Blank Scheme)



P0468ENa

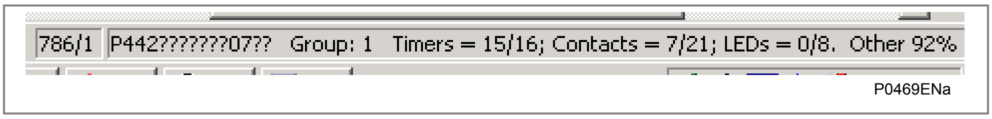
- Select the relay type and model number (software version is displayed for compatibility) - Italian is available with model ?40X?

On-Line method:

- Communication with the relay can be started (Device \ open connection \ address1 \ pword AAAA) and the PSL activated in the internal logic of the relay can be extracted, displayed, modified and uploaded again to the relay.
- Any group from 1 to 4 can be modified (ref of group must be validated before resenting the file from PC to relay)

  Before creating a dedicated PSL for covering customised applications, please see the DDB description cell by cell (set & reset conditions) in the table at the end of the technical guide (Courier Database).

  The type of model used by the relay in the settings or in the PSL is displayed at the bottom of the screen in the status bar:



It indicates:

- Model number used (last 2 digits:???07??)
- PSL activated for Group1 logic
- Number of timers still available (15 out of a total of 16)
- Number of contacts still available (7 out of a total of 21 for P442 model)
- Number of LEDs still available (0 to 8 if all already assigned in the PSL)
- Memory capacity still available (decreases with the numbers of cells and logic gates linked in the dedicated PSL)

(See also the section Commissioning document for further information on the tools)

7.2 Logic Input Mapping

The default mapping for each of the opto-isolated inputs are as shown in the following table:

- Version A: Opto inputs are in 48VDC polarised (can be energised with the internal field voltage offered by the relay
- Version B: Opto inputs are universal and opto input range can be selected in MiCOM S1 Studio by:

Opto A - 48VDC:

The opto inputs are specified to operate between 30 and 60V to ensure there is enough current flowing through the optocoupler diode to guarantee operation with component tolerances, temperature and CTR (Current Transfer Ratio) downgrading over time.

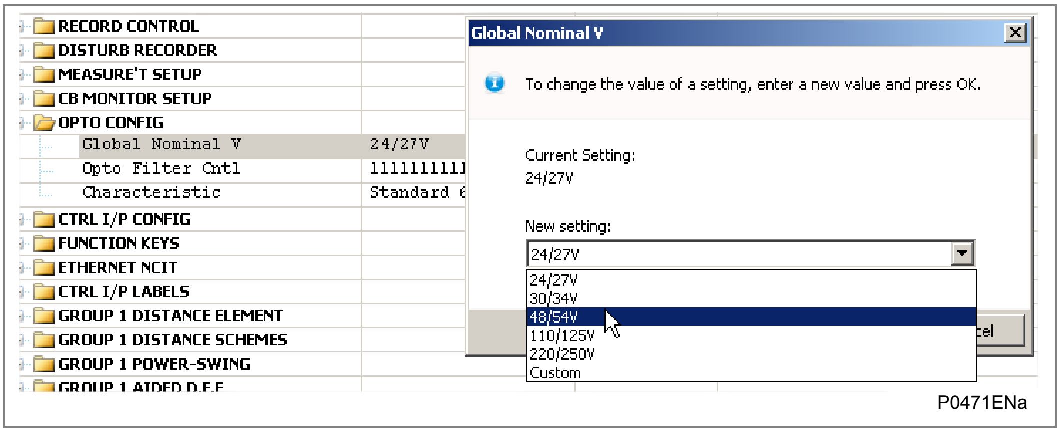
Between 13-29V lies the uncertainty band. Below 12V, the guaranteed logic state is Off

Opto B - Universal opto inputs:

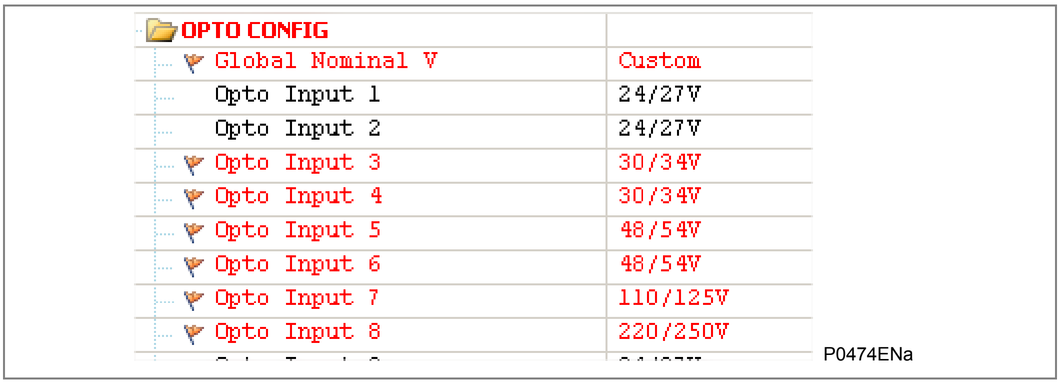
Setting	Guaranteed No Operation	Guaranteed Operation
24/27	<16.2	>19.2
30/34	<20.4	>24.0
48/54	<32.4	>38.4
110/125	<75.0	>88.0

Setting	Guaranteed No Operation	Guaranteed Operation
220/250	<150	>176.0

These margins ensure that ground faults on substation batteries do not cause maloperation of the opto inputs.



Or "Custom" can be selected in the menu to set a different voltage pick-up for any opto inputs:



The default mappings for each of the inputs are shown in section P44x/EN PL.

7.3 Relay Output Contact Mapping

The default mappings and conditioning for each of the relay output contacts are shown in the following table:

Relay Contact No	P442 Relay	P444 Relay
1	TripA+B+C & Z1 [straight]	TripA+B+C & Z1 [straight]
2	Any Trip Phase A [straight]	Any Trip Phase A [straight]
3	Any Trip Phase B [straight]	Any Trip Phase B [straight]
4	Any Trip Phase C [straight]	Any Trip Phase C [straight]
5	Signal send (Dist. or DEF) [straight]	Signal send (Dist. or DEF) [straight]
6	Any Protection Start [straight]	Any Protection Start [straight]
7	Any Trip [straight]	Any Trip [straight]

Relay Contact No	P442 Relay	P444 Relay
8	General Alarm [straight]	General Alarm [straight]
9	DEF A+B+C Trip + IN>1Trip + IN>2Trip [straight]	DEF A+B+C Trip + IN>1Trip + IN>2Trip [straight]
10	Dist. Trip &Any Zone&DistUnb CR [straight]	Dist. Trip &Any Zone&DistUnb CR [straight]
11	Autoreclose lockout [straight]	Autoreclose lockout [straight]
12	Autoreclose 1P+3P cycle in progress [straight]	Autoreclose 1P+3P cycle in progress [straight]
13	A/R Close [straight]	A/R Close [straight]
14	Power Swing Detected [straight]	Power Swing Detected [straight]
15	Not allocated	Not allocated
16	Not allocated	Not allocated
17	Not allocated	Not allocated
18	Not allocated	Not allocated
19	Not allocated	Not allocated
20	Not allocated	Not allocated
21	Not allocated	Not allocated
22	Not allocated	Not allocated
23		Not allocated
24		Not allocated
25		Not allocated
26		Not allocated
27		Not allocated
28		Not allocated
29		Not allocated
30		Not allocated
31		Not allocated
32		Not allocated

Note that when 3-pole tripping is selected in the relay's menu, all trip contacts: Trip A, Trip B, Trip C, and Any Trip close simultaneously.

Note	*Other relay logic conditions are available in the PSL relay design:*

- Pulse Timer
- Pick UP/Drop Off Timer
- Dwell Timer
- Pick Up Timer
- Drop Off Timer
- Latching
- Straight (Transparent)

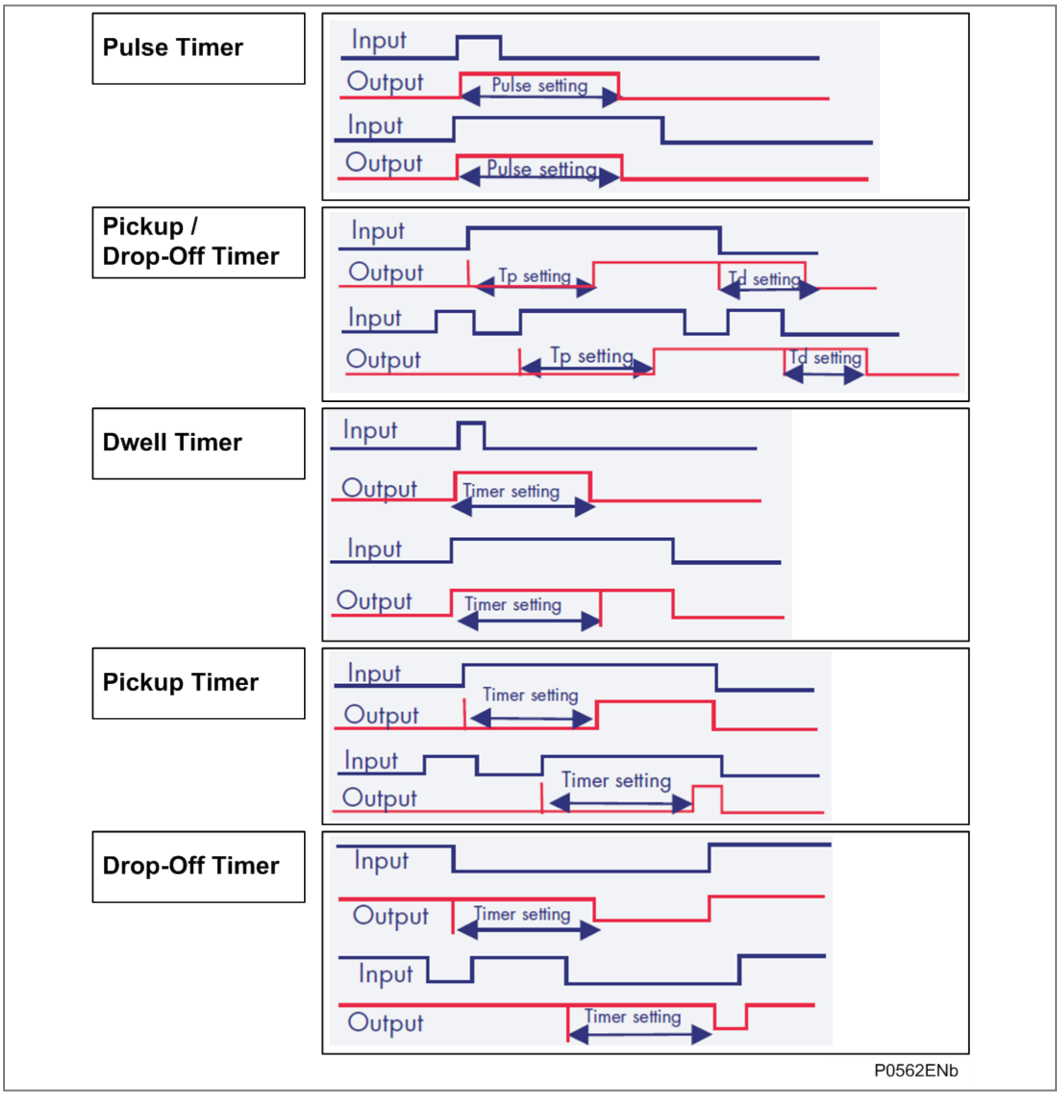


Figure 4 - Time-delay definition in PSL

7.4 Programmable LED Output Mapping

The default mappings for each of the programmable LEDs are as shown in this table:

LED No.	P442 Relay	P444 Relay
1	Any Trip A	Any Trip A
2	Any Trip B	Any Trip B
3	Any Trip C	Any Trip C
4	Any Start	Any Start
5	Z1+Aided Trip	Z1+Aided Trip
6	Dist Fwd	Dist Fwd
7	Dist Rev	Dist Rev
8	A/R Enable	A/R Enable

Note *All the LEDs are latched in the default PSL*

Table 52 - Programmable LED mappings

7.5 Fault Recorder Trigger

The default PSL trigger which initiates a fault record is shown in the following table:

P442 Relay	P444 Relay
Any Start	Any Start
Any Trip	Any Trip

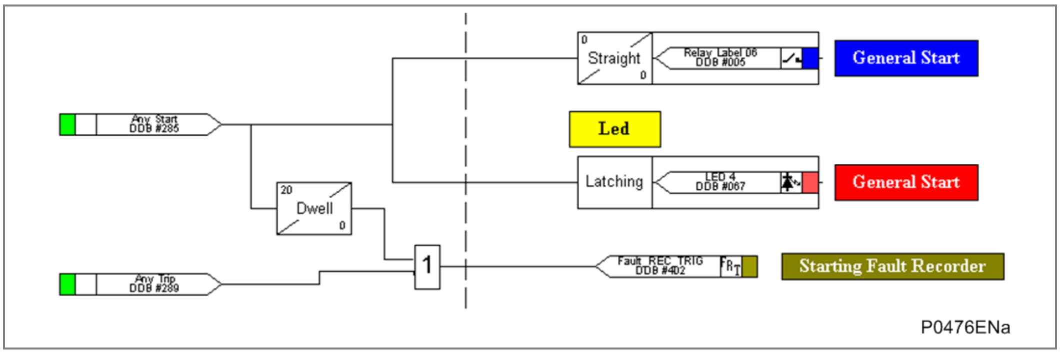


Figure 5 - Default PSL trigger which initiates a fault record

If the fault recorder trigger is not assigned in the PSL, no Fault recorder can be initiated and displayed in the list by the LCD front panel.

8 CURRENT TRANSFORMER REQUIREMENTS

Two calculations must be performed - one for the three phase fault current at the zone 1 reach, and one for earth (ground) faults. The higher of the two calculated Vk voltages must be used:

8.1 CT Knee Point Voltage for Phase Fault Distance Protection

Vk ≥ KRPA x IF Z1 x (1+ X/R) . (RCT + RL)

Where:

Vk = Required CT knee point voltage (volts),

KRPA = Fixed dimensioning factor = always 0.6

IF Z1 = Max. secondary phase fault current at Zone 1 reach point (A),

X/R = Primary system reactance / resistance ratio,

RCT = CT secondary winding resistance (Ω),

RL = Single lead resistance from CT to relay (Ω).

8.2 CT Knee Point Voltage for Earth Fault Distance Protection

Vk ≥ KRPA x IFe Z1 x (1+ Xe/Re) . (RCT + 2RL) Where:

KRPA = Fixed dimensioning factor = always 0.6

IFe Z1 = Max. secondary earth fault current at Zone 1 reach point (A),

Xe/Re = Primary system reactance / resistance ratio for earth loop.

8.3 Recommended CT classes (British and IEC)

Class X current transformers with a knee point voltage greater than or equal to the calculated one can be used.

Class 5P protection CTs can be used, noting that the equivalent knee point voltage they offer can be approximated from:

Vk = (VA x ALF) / In + (RCT x ALF x In)

Where:

VA = Volt-ampere load rating,

ALF = Accuracy Limit Factor,

In = CT nominal secondary current.

8.4 Determining Vk for an IEEE “C" class CT

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 the IEC). The equivalence formula is:

Vk = [(C rating in volts) x 1.05] + [100 x RCT]

APPLICATION NOTES

CHAPTER 5

Date:	01/2017
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:	M
Software version:	E1
Connection diagrams:	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)

CONTENTS

FIGURES

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TABLES

1 INTRODUCTION

1.1 Protection of Overhead Lines and Cable Circuits

Overhead lines, typically ranging from 10 kV distribution lines to 800 kV transmission lines, are probably the most fault susceptible items of plant in a modern power system. It is therefore essential that the protection associated with them provides secure and reliable operation.

For distribution systems, continuity of supply is of paramount importance. The majority of faults on overhead lines are transient or semi-permanent in nature. Multi-shot auto-reclose cycles are therefore commonly used in conjunction with instantaneous tripping elements to increase system availability. For permanent faults it is essential that only the faulted section of plant is isolated. As such, high speed, discriminative fault clearance is often a fundamental requirement of any protection scheme on a distribution network.

The requirements for a transmission network must also take into account system stability. Where systems are not highly interconnected the use of single phase tripping and high speed auto-reclosure is often required. This in turn dictates the need for very high speed protection to reduce overall fault clearance times.

Underground cables are vulnerable to mechanical damage, such as disturbance by construction work or ground subsidence. Also, faults can be caused by ingress of ground moisture into the cable insulation, or its buried joints. Fast fault clearance is essential to limit extensive damage, and avoid the risk of fire, etc.

Many power systems use earthing arrangements designed to limit the passage of earth fault current. Methods such as resistance earthing make the detection of earth faults difficult. Special protection elements are often used to meet such onerous protection requirements.

Physical distance must be taken into account. Some EHV transmission lines can be up to several hundred kilometers in length. If high speed, discriminative protection is to be applied, it will be necessary to transfer information between line ends. This not only puts the onus on the security of signaling equipment but also on the protection in the event of loss of this signal.

Back-up protection is also an important feature of any protection scheme. In the event of equipment failure, such as signaling equipment or switchgear, for example, it is necessary to provide alternative forms of fault clearance. It is desirable to provide back-up protection which can operate with minimum time delay and yet discriminate with both the main protection and protection elsewhere on the system.

1.2 MiCOM Distance Relay

MiCOM relays are a range of products from Schneider Electric. Using advanced numerical technology, MiCOM relays include devices designed for application to a wide range of power system plant such as motors, generators, feeders, overhead lines and cables.

Each relay is designed around a common hardware and software platform in order to achieve a high degree of commonality between products. One such product in the range is the series of distance relays. The relay series has been designed to cater for the protection of a wide range of overhead lines and underground cables from distribution to transmission voltage levels.

The relay also includes a comprehensive range of non-protection features to aid with power system diagnosis and fault analysis. All these features can be accessed remotely from one of the relays remote serial communications options.

1.2.1 Protection Features

The distance relays offer a comprehensive range of protection functions, for application to many overhead line and underground cable circuits. There are separate models available, the P442 and P444. Both the P442 and P444 models provide single and three pole tripping. The protection features of each model are summarised below:

- 21G/21P: Phase and earth fault distance protection, each with up to 6 independent zones of protection. Standard and customised signalling schemes are available to give fast fault clearance for the whole of the protected line or cable.
- 50/51: Instantaneous and time-delayed overcurrent protection - Four elements are available, with independent directional control for the 1st and 2nd element. The 3rd element can be used for SOFT/TOR logic. The fourth element can be configured for stub bus protection in 1½ circuit breaker arrangements.
- 50N/51N: Instantaneous and time-delayed neutral overcurrent protection. Four elements are available.
- 67N: Directional Earth Fault (DEF) protection - This can be configured for channel aided protection, plus two elements are available for backup DEF.
- 67 / 46: Directional or non-directional negative sequence overcurrent protection - This element can provide backup protection for many unbalanced fault conditions.
- 32N: Maximum of Residual Power Protection - Zero sequence Power Protection This element provides protection against high resistance faults, cleared without using a communications channel.
- 27 / 59: Undervoltage and overvoltage protections - Four-stage, configurable as either phase to phase or phase to neutral measuring. Stage 1 may be selected as either Inverse Definite Minimum Time (IDMT) or Definite Time (DT) and stage 2 is DT only.
- 37: Undercurrent Protection – this element consists of two independ stages protection, with two independent time-delay setting.
- 81U / 81O: Underfrequency and overfrequency protection – This element can provides a four-stage time-delayed underfrequency protection and two-stage time-delayed overfrequency protection.
- 49: Thermal overload Protection - with dual time constant. This element provides separate alarm and trip thresholds.
- 50 / 27: Switch On To Fault (SOTF) and Trip On Reclose (TOR) protections - These settings enhance the protection applied for manual circuit breaker closure.
- 78 / 68: Power swing blocking - Selective blocking of distance protection zones ensures stability during the power swings experienced on sub-transmission and transmission systems (stable swing or Out of Step condition = loss of synchronism). The relay can differentiate between a stable power swing and a loss of synchronism (out-of-step).
- 85: Channel Aided schemes with basic schemes, Permissive Underreach (PUP) and Permissive Overreach (POP) transfer trip schemes and Blocking schemes.
- Weak infeed echo logic.
- Accelerated Trip features (Loss of Load – Zx extension).
- 46 BC: Broken conductor detection - To detect network faults such as open circuits, where a conductor may be broken but not in contact with another conductor or the earth.

- 50 BF: Circuit breaker failure protection - Generally set to backtrip upstream circuit breakers, should the circuit breaker at the protected terminal fail to trip. Two stages are provided.
- VTS: Voltage Transformer Supervision (VTS). - To detect VT fuse failures. This prevents maloperation of voltage dependent protection on AC voltage input failure.
- CTS: Current Transformer Supervision - To raise an alarm should one or more of the connections from the phase CTs become faulty.
- CVTS: Capacitive Voltage Transformer Supervision – to supervise voltage divider capacitors supervision when residual voltage is greater than the set value.

1.2.2 Non-Protection Features

The P442 and P444 relays have the following non-protection features:

- 79/25: Autoreclosure with Check synchronism - This permits up to 4 reclose shots, with voltage synchronism, differential voltage, live line/dead bus, and dead bus/live line interlocking available. Check synchronism is optional.
- Measurements - Selected measurement values polled at the line/cable terminal, available for display on the relay or accessed from the serial communications facility.
- Fault/Event/Disturbance Records - Available from the serial communications or on the relay display (fault and event records only).
- Distance to fault locator - Reading in km, miles or % of line length.
- Four Setting Groups - Independent setting groups to cater for alternative power system arrangements or customer specific applications.
- Remote Serial Communications - To allow remote access to the relays. The following communications protocols are supported: Courier, MODBUS, IEC60870-5/103 and DNP3.
- Continuous Self Monitoring - Power on diagnostics and self checking routines to provide maximum relay reliability and availability.
- Circuit Breaker State Monitoring - Provides indication of any discrepancy between circuit breaker auxiliary contacts.
- Circuit Breaker Control - Opening and closing of the circuit breaker can be achieved either locally via the user interface / opto inputs, or remotely via serial communications.
- Circuit Breaker Condition Monitoring - Provides records / alarm outputs regarding the number of CB operations, sum of the interrupted current and the breaker operating time.
- Commissioning Test Facilities.

1.2.3 Features for the P442 Model

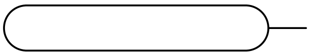
- Single pole tripping and autoreclose.
- Real Time Clock Synchronisation - Time synchronisation is possible from the relay IRIG-B input. (IRIG-B must be specified as an option).
- Fibre optic converter for IEC60870-5/103 communication (optional).
- Second rear port in Courier Protocol (KBus/RS232/RS485)
- 16 Logic Inputs - For monitoring of the circuit breaker and other plant status.
- Up to 21 Output relay contacts - For tripping, alarming, status indication and remote control.
- Communication protocols available (ordering specification): K-Bus/Courier, MODBUS, VDEW (IEC 60870-5-103), DNP3.0., IEC61850 + Courier, IEC61850 + IEC60870-5-103), DNP3.0 + Courier or IEC61850+DNP3oE+DNP3 serial.

1.2.4 Features for the P444 Model

- Single pole tripping and autoreclose.
- Real Time Clock Synchronisation - Time synchronisation is possible from the relay IRIG-B input. (IRIG-B must be specified as an option).
- Fibre optic converter for IEC60870-5/103 communication (optional).
- Second rear port in Courier Protocol (KBus/RS232/RS485)
- 24 Logic Inputs - For monitoring of the circuit breaker and other plant status.
- Up to 46 output relay contacts (with 12 high break relays)- For tripping, alarming, status indication and remote control:
- Communication protocols available: K-Bus/Courier, MODBUS, VDEW (IEC 60870-5-103), DNP3.0, IEC61850 + Courier, IEC61850 + IEC60870-5-103), DNP3.0 + Courier or IEC61850+DNP3oE+DNP3 serial.

1.3 Explanation about Specific Symbols used in the Logic Diagrams

The following specific symbols are used in the logic diagrams. General symbols are shown in the *Symbols and Glossary* chapter.



2 DISTANCE ALGORITHMS

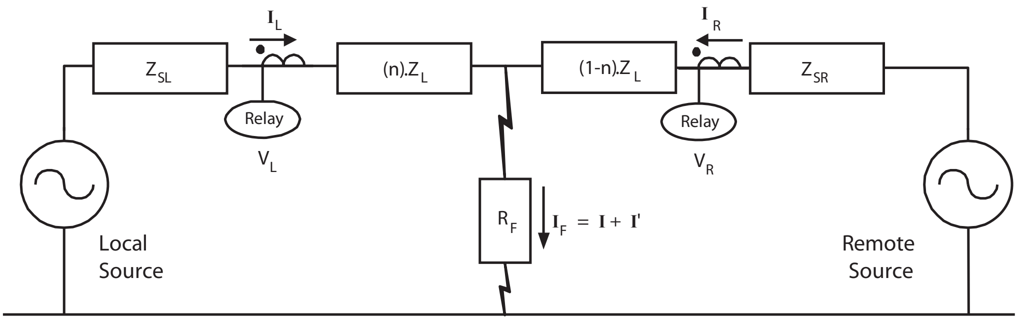
The operation is based on the combined use of two types of algorithms:

- "Delta" algorithms, also called High Speed algorithms, using the superimposed current and voltage values that are characteristic of a fault. These are used for phase selection and directional determination. The fault distance calculation is performed by the "impedance measurement algorithms" using Gauss-Seidel.
- "Conventional" algorithms using the impedance values measured while the fault occurs. These are also used for phase selection and directional determination. The fault distance calculation is performed by the "impedance measurement algorithms" using Gauss-Seidel.

The fastest algorithm will give the immediate directional decision.

2.1 Distance and Resistance Measurement

MiCOM P44x distance protection is a full scheme distance relay. To measure the distance and apparent resistance of a fault, the following equation is solved on the faulted loop:



$$V_L = (Z_L x\ I\ x\ D) + R_F x\ I_F$$
$$= ((r + jx)\ x\ I\ x\ D) + R_F x\ I_F \quad \text{where}$$

V_L = local terminal relay voltage
r = line resistance (ohm/mile)
x = line reactance (ohm/mile)
I_F = current flowing in the fault ($I + I'$)
I = current measured by the relay on the faulty phase
= current flowing into the fault from local terminal
I' = current flowing into the fault from remote terminal
D = fault location (permile or km from relay to the fault)
R = fault resistance
R_F = apparent fault resistance at relay; R x (1 + I'/I)

Assumed Fault Currents:
For Phase to Ground Faults (ex., A-N), $I_F = 3\ I_0$ for 40ms, then I_A after 40 ms
For Phase to Phase Faults (ex., A-B), $I_F = I_{AB}$

P3030ENa

Figure 1 - Distance and fault resistance estimation

The impedance measurements are used by High Speed and Conventional Algorithms.

The following describes how to solve the above equation (determination of D fault distance and R fault resistance). The line model used will be the 3×3 matrix of the symmetrical line impedances (resistive and inductive) of the three phases, and mutual values between phases.

$$\begin{vmatrix} Raa + j\omega\, Laa & Rab + j\omega\, Lab & Rac + j\omega\, Lac \\ Rab + j\omega\, Lab & Rbb + j\omega\, Lbb & Rbc + j\omega\, Lbc \\ Rac + j\omega\, Lac & Rbc + j\omega\, Lbc & Rcc + j\omega\, Lcc \end{vmatrix}$$

Where:

Raa=Rbb=Rcc and Rab=Rbc=Rac

$$\omega Laa = \omega Lbb = \omega Lcc = \frac{2.X_1 + X_0}{3}$$ and

$$\omega Lab = \omega Lbc = \omega Lac = \frac{X_0 - X_1}{3}$$ and

X1: positive sequence reactance

X0: zero-sequence reactance

The line model is obtained from the positive and zero-sequence impedance. Four different residual compensation factor settings can be used on the relay, as follows:

kZ1: residual compensation factor used to calculate faults in zones 1 and 1X.

kZ2: residual compensation factor used to calculate faults in zone 2.

kZp: residual compensation factor used to calculate faults in zone p.

kZ3/4: residual compensation factor used to calculate faults in zones 3 and 4.

The solutions "Dfault" and "Rfault" solutions are obtained by solving the system of equations (one equation per step of the calculation) using the Gauss Seidel method.

$$\text{Rfault}(n) = \frac{\sum_{n0}^{n}(V_L.I_{fault}) - D_{fault}.(n-1).\sum_{n0}^{n}(Z_1.I_1.I_{fault})}{\sum_{n0}^{n}(I_{1fault})^2}$$

$$\text{Dfault}(n) = \frac{\sum_{n0}^{n}(V_L.Z_1.I_1) - R_{fault}.(n-1).\sum_{n0}^{n}(Z_1.I_1.I_{fault})}{\sum_{n0}^{n}(Z_1.I_1)^2}$$

Rfault and Dfault are computed for every sample (24 samples per cycle).

Note	*See also the **Convergence Analysis** section for the Rn and Dn (Xn) conditions of convergence.*

With IL equal to $I\alpha$ + k0 x 3I0 for phase-to-earth loop or IL equal to $I\alpha\beta$ for phase-to-phase loop.

2.1.1 Phase-to-Earth Loop Impedance

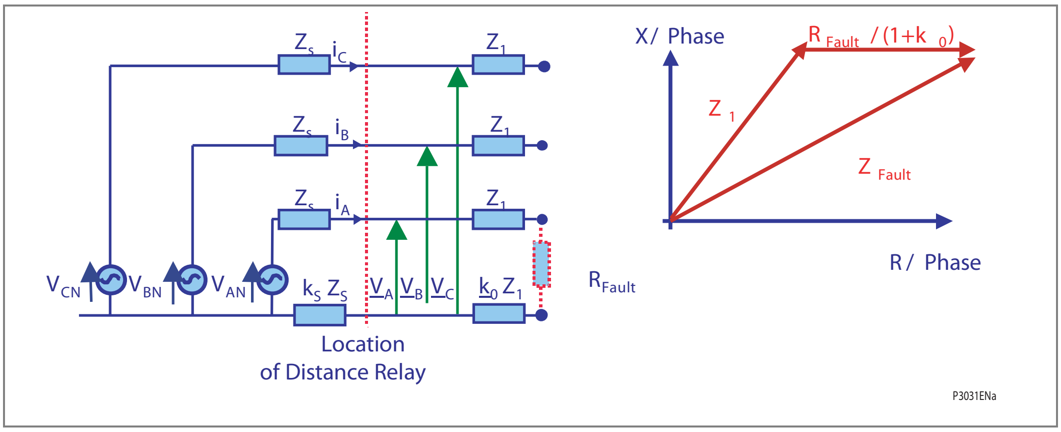


Figure 2 - Phase-to-earth loop impedance

The impedance model for the phase-to-earth loop is:

$V_{\alpha}N$ = Z1 x Dfault x (I_{α} + k_0 x $3I_0$) + Rfault x Ifault

with $_{\alpha}$ = phase A, B or C

The ($3I_0$) current is used for the first 40ms to model the fault current, thus eliminating the load current before the circuit breakers are operated during the 40ms (one pole tripping). After the 40ms, the phase current is used.

$$V_{AN} = Z_1.Dfault.(I_A+k_0 \text{ x } 3I_0)+R_{fault}.I_{fault}$$

$$V_{BN} = Z_1.Dfault.(I_B+k_0 \text{ x}.3I_0)+R_{fault}.I_{fault}$$

$$V_{CN} = Z_1.Dfault.(I_C+k_0 \text{ x } 3I_0)+R_{fault}.I_{fault}$$

x 5 k_0 residual compensation factors

= 15 phase-to-earth loops are continuously monitored and computed for each samples.

$$V_{\alpha N} = Z_1.D_{fault}.(I_{\alpha} + k_0.3I_0) + R_{fault}.I_{fault}$$

$$V_{\alpha N} = Z_1.D_{fault}.(I_{\alpha} + \frac{Z_0 - Z_1}{3}.3I_0) + R_{fault}.I_{fault}$$

$$V_{\alpha N} = (R_1+j.X_1).D_{fault}.(I_{\alpha} + \frac{R_0 - R_1 + j.(X_0 - X_1)}{3.(R_1 - jX_1)}.3I_0) + R_{fault}.I_{fault}$$

$$V_{\alpha N} = (R_1+j.X_1).D_{fault}.I_{\alpha} + \frac{R_0 - R_1 + j.(X_0 - X_1)}{3.(R_1 - jX_1)}.D_{fault}.3I0 + R_{fault}.I_{fault}$$

$$V_N = R_1.D_{fault}.I_{\alpha} + \frac{R_0 - R_1}{3}.D_{fault}.3I0 + j.X1.\ D_{fault}.I_{\alpha} + \frac{j.(X_0 - X_1)}{3}.D_{fault}.3I0 + R_{fault}.I_{fault}$$

$$V_{\alpha N} = R_1.D_{fault}.I_{\alpha} + \frac{R_0 - R_1}{3}.D_{fault}.3I0 + j.X1.\ D_{fault}.I_{\alpha} + \frac{j.(X_0 - X_1)}{3}.D_{fault}.(I_A+I_B+I_C) + R_{fault}.I_{fault}$$

$$V_{AN} = R_1.D_{fault}.I_A + \frac{R_0 - R_1}{3}.D_{fault}.3I0 + .D_{fault}.I_A + \frac{j.(X_0 - X_1)}{3}.D_{fault}.(I_B+I_C) + R_{fault}.I_{fault}$$

$$V_{AN} = R_1.D_{fault}.I_A + \frac{R_0 - R_1}{3}.D_{fault}.3I_0 + \frac{(X_0 + 2.X_1)}{3}.D_{fault}.\frac{dI_A}{dt} + \frac{(X_0 - X_1)}{3}.D_{fault}.\frac{dI_B}{dt} + \frac{(X_0 - X_1)}{3}.D_{fault}.\frac{dI_C}{dt} + R_{fault}.I_{fault}$$

$$V_{AN} = R_1.D_{fault}.I_A + \frac{R_0\text{-}R_1}{3}.D_{fault}.3I_0 + L_{AA}.D_{fault}.\frac{dI_A}{dt} + L_{AB}.D_{fault}.\frac{dI_B}{dt} + L_{AC}.D_{fault}.\frac{dI_C}{dt} + R_{fault}.I_{fault}$$

$$V_{BN} = R_1.D_{fault}.I_B + \frac{R_0\text{-}R_1}{3}.D_{fault}.3I_0 + L_{AB}.D_{fault}.\frac{dI_A}{dt} + L_{BB}.D_{fault}.\frac{dI_B}{dt} + L_{BC}.D_{fault}.\frac{dI_C}{dt} + R_{fault}.I_{fault}$$

$$V_{CN} = R_1.D_{fault}.I_C + \frac{R_0\text{-}R_1}{3}.D_{fault}.3I_0 + L_{AC}.D_{fault}.\frac{dI_A}{dt} + L_{BC}.D_{fault}.\frac{dI_B}{dt} + L_{CC}.D_{fault}.\frac{dI_C}{dt} + R_{fault}.I_{fault}$$

2.1.2 Impedance Measurement Algorithms Work with Instantaneous Values (Current and Voltage)

The derived current value $\frac{dI}{dt}$ is obtained by using a FIR filter.

2.1.3 Phase-to-Phase Loop Impedance

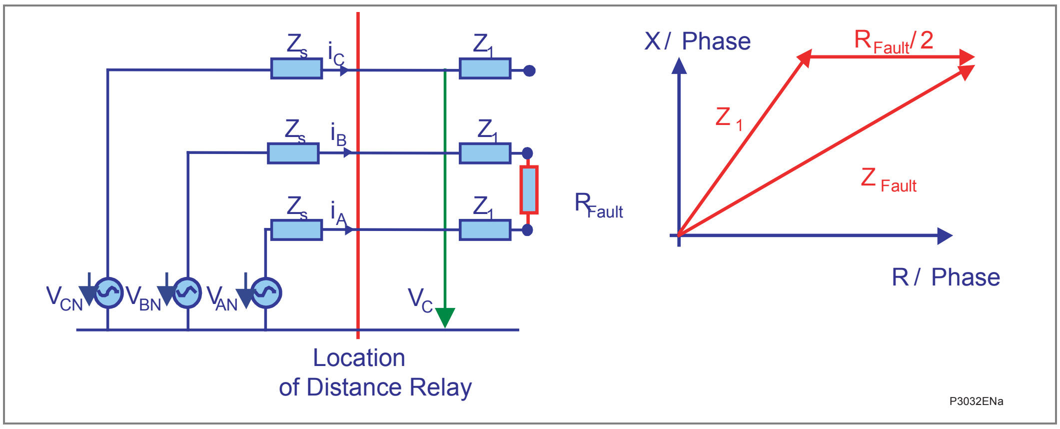


Figure 3 - Phase-to-phase loop impedance

The impedance model for the phase-to-phase loop is:

$V\alpha\beta$ = ZL x Dfault x $I\alpha\beta$ + Rfault /2 x Ifault

with $\alpha\beta$ = phase AB, BC or CA

The model for the current Ifault circulating in the fault $I\alpha\beta$.

$$V_{AB} = 2Z_1.D_{fault}.I_{AB} + R_{fault}.I_{fault}$$
$$V_{BC} = 2Z_1.D_{fault}.I_{BC} + R_{fault}.I_{fault}$$
$$V_{CA} = 2Z_1.D_{fault}.I_{CA} + R_{fault}.I_{fault}$$

= 3 phase-to-phase loops are continuously monitored and computed for each sample.

$$V_{\alpha\beta} = 2Z_1.D_{fault}.I_{\alpha\beta} + R_{fault}.I_{fault}$$

$$V_{\alpha\beta} = 2(R_1 + j.X_1).D_{fault}.I_{\alpha\beta} + R_{fault}.I_{fault}$$

$$V_{\alpha\beta} = 2R_1.D_{fault}.I_{\alpha\beta} + 2j.X_1.D_{fault}.I_{\alpha\beta} + R_{fault}.I_{fault}$$

$$V_{\alpha\beta} = 2R_1.D_{fault}.I_{\alpha\beta} + 2j.X_1.D_{fault}.\frac{dI_{\alpha\beta}}{dt} + R_{fault}.I_{fault}$$

$$V_{AB} = R_1.D_{fault}.(I_A - I_B) + (L_{AA}\text{-}L_{AB}).D_{fault}.\frac{dI_A}{dt} + (L_{AB}\text{-}L_{BB}).D_{fault}.\frac{dI_B}{dt} + (L_{AC}\text{-}L_{BC}).D_{fault}.\frac{dI_C}{dt} + \frac{R_{fault}}{2}.I_{fault}$$

$$V_{BC} = R_1.D_{fault}.(I_B - I_C) + (L_{AB}-L_{AC}).D_{fault}.\frac{dI_A}{dt} + (L_{BB}-L_{BC}).D_{fault}.\frac{dI_B}{dt} + (L_{BC}-L_{CC}).D_{fault}.\frac{dI_C}{dt} + \frac{R_{fault}}{2}.I_{fault}$$

$$V_{CA} = R_1.D_{fault}.(I_C - I_A) + (L_{AC}-L_{AA}).D_{fault}.\frac{dI_A}{dt} + (L_{BC}-L_{AB}).D_{fault}.\frac{dI_B}{dt} + (L_{CC}-L_{AC}).D_{fault}.\frac{dI_C}{dt} + \frac{R_{fault}}{2}.I_{fault}$$

Impedance measurement algorithms work with instantaneous values (current and voltage).

The derived current value $\frac{dI}{dt}$ is obtained by using a FIR filter.

2.2 "Delta" Algorithm

The patented high-speed algorithm has been proven with 10 years of service at all voltage levels from MV to EHV networks. The P44x relay has ultimate reliability of phase selection and directional decision far superior to standard distance techniques using superimposed algorithms. These algorithms or delta algorithms are based on transient components and they are used for the following functions which are computed in parallel:

Detection of the Fault

By comparing the superimposed values to a threshold which is low enough to be crossed when a fault occurs and high enough not to be crossed during normal switching outside of the protected zones.

Establishing the Fault Direction

Only a fault can generate superimposed values; therefore, it is possible to determine direction by measuring the transit direction of the superimposed energy.

Phase Selection

As the superimposed values no longer include the load currents, it is possible to make high-speed phase selection.

2.2.1 Fault Modelling

Consider a stable network status-the steady-state load flow prior to any start. When a fault occurs, a new network is established. If there is no other modification, the differences between the two networks (before and after the fault) are caused by the fault. The network after the fault is equivalent to the sum of the values of the status before the fault and the values characteristic of the fault. The fault acts as a source for the latter, and the sources act as passive impedance in this case.

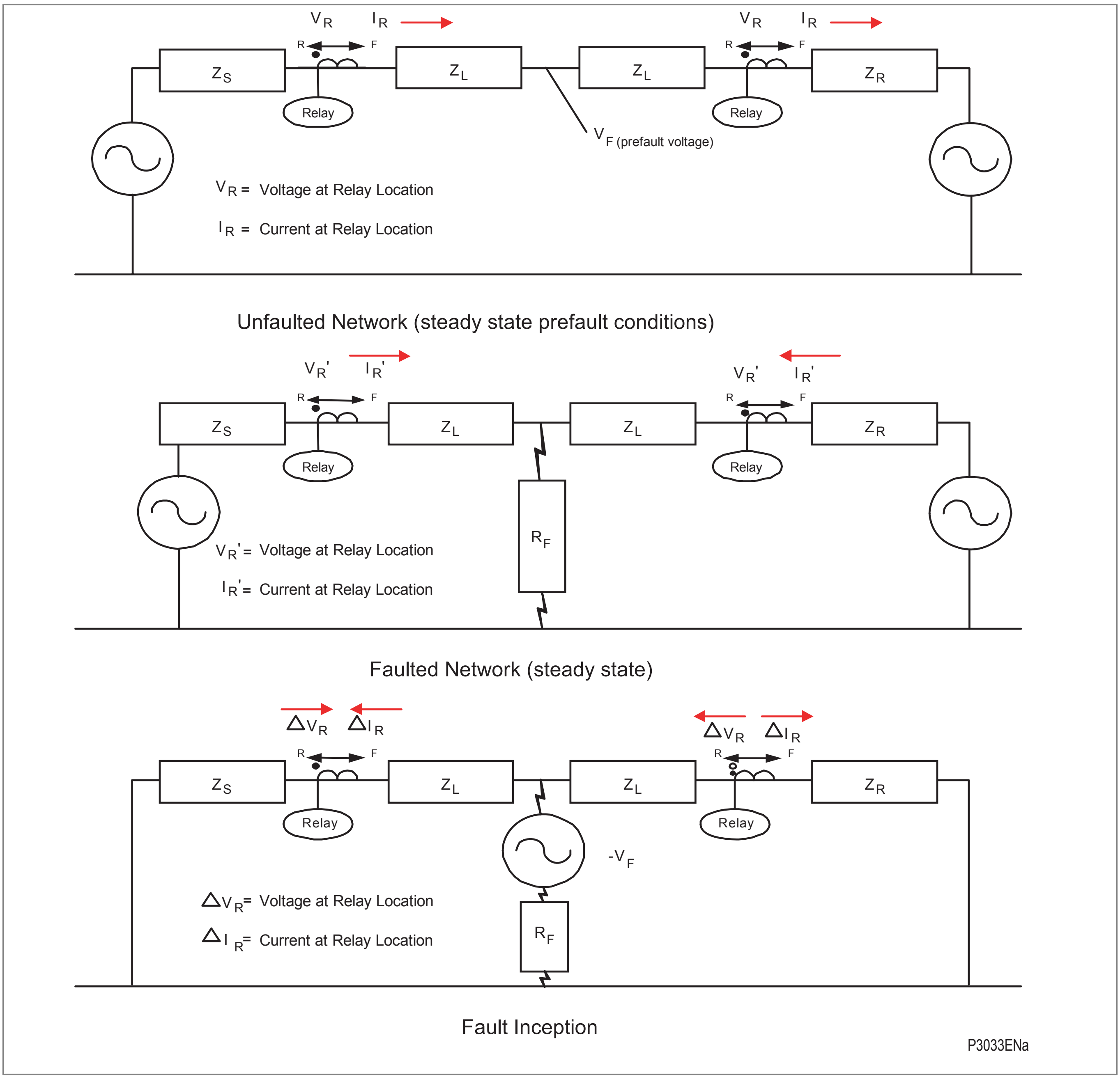


Figure 4 - Pre, Fault and Fault Inception Value

Network Status Monitoring

The network status is monitored continuously to determine whether the "Deltas" algorithms may be used. To do so, the network must be "healthy" which is characterised by the following:

- The circuit breaker(s) should be closed just prior to fault inception (2 cycles of healthy pre-fault data should be stored) – the line is energised from one or both ends,
- The source characteristics should not change noticeably (there is no power swing or out-of-step detected).
- Power System Frequency is being measured and tracked (48 samples per cycle at 50 or 60Hz).

No fault is detected:

- all nominal phase voltages are between 70% and 130% of the nominal value.
- the residual voltage (3V0) is less than 10% of the nominal value
- the residual current (3I0) is less than 10% of the nominal value + 3.3% of the maximum load current flowing on the line

The measured loop impedance is outside the characteristics, when these requirements are fulfilled, the superimposed values are used to determine the fault inception (start), faulty phase selection and fault direction. The network is then said to be "healthy" before the fault occurrence.

2.2.2 Detecting a Transition

In order to detect a transition, the MiCOM P442 and P444 compares sampled current and voltage values at the instant "t" with the values predicted from those stored in the memory one period and two periods earlier.

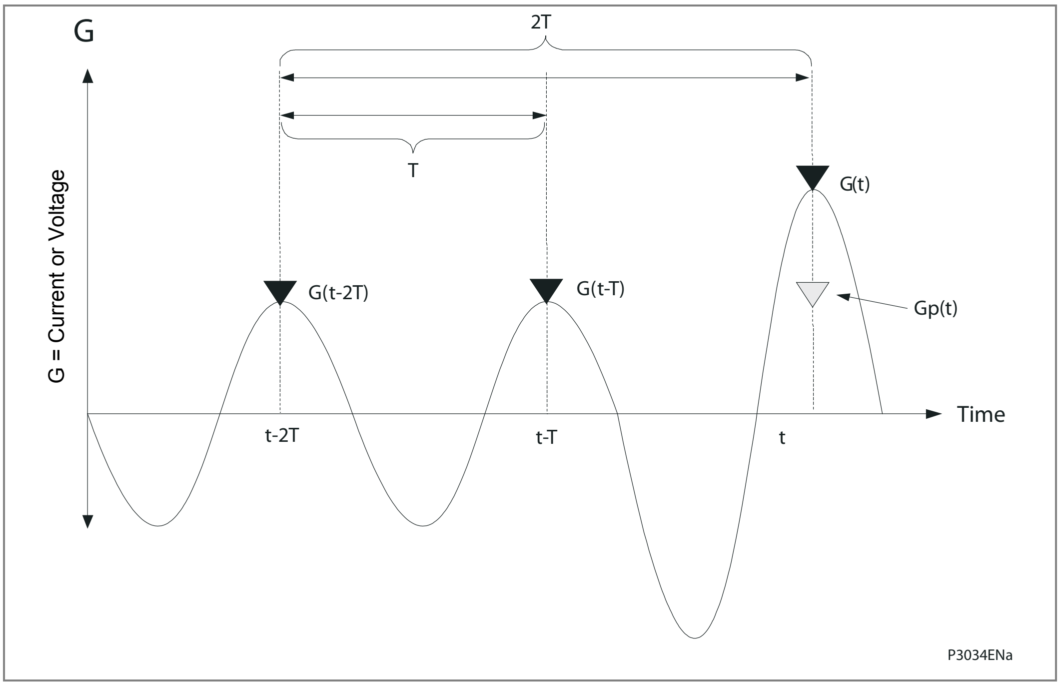


Figure 5 - Transition detection

Gp(t) = 2G(t-T) - G(t-2T) where Gp(t) are the predicted values of either the sampled current or voltage.

A transition is detected on one of the current or voltage input values if the absolute value of (G(t) - Gp(t)) exceeds a threshold of 0.2 x IN (nominal current) or 0.1 x UN / √3 = 0.1x VN (nominal voltage).

With: U = phase-to-phase voltage

V = phase-to-ground voltage = U / √3

G(t) = G(t) - Gp(t) is the transition value of the reading G.

The high-speed algorithms will start if either ΔU OR ΔI is detected on one sample.

Example: Isolated AC fault

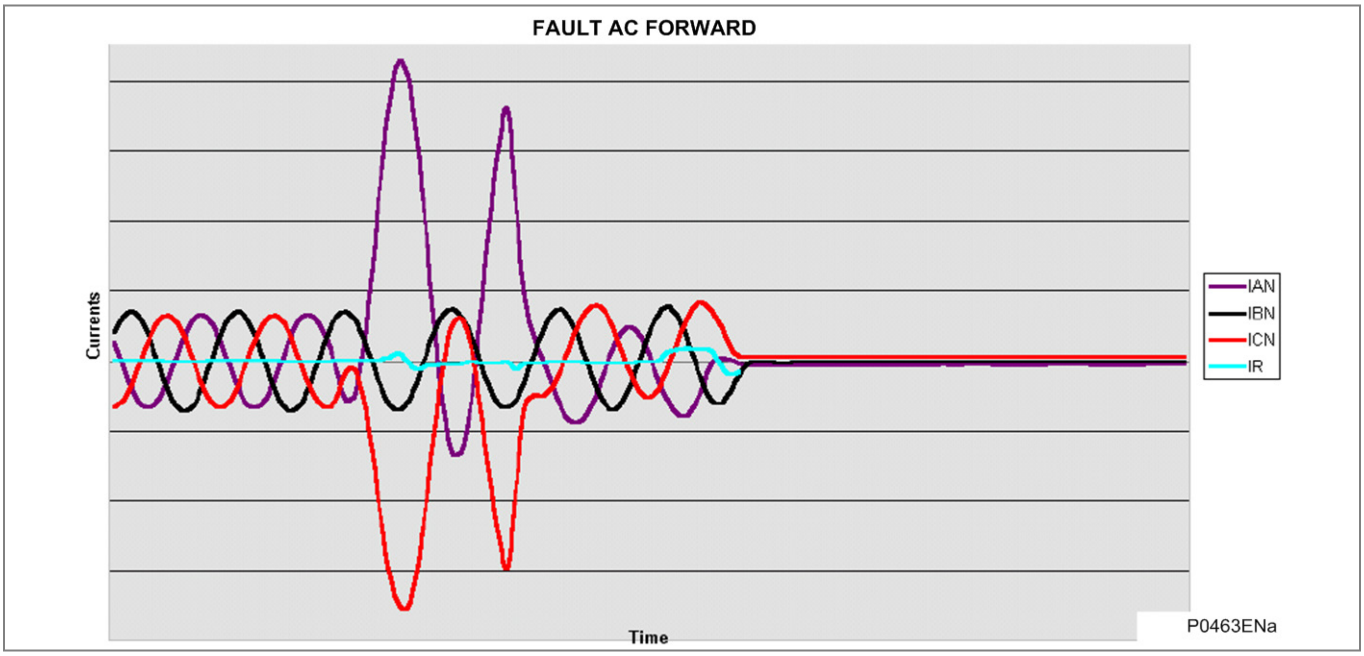


Figure 6 – Fault ac forward – I_{AN}, I_{BC}, I_{CN} and I_R

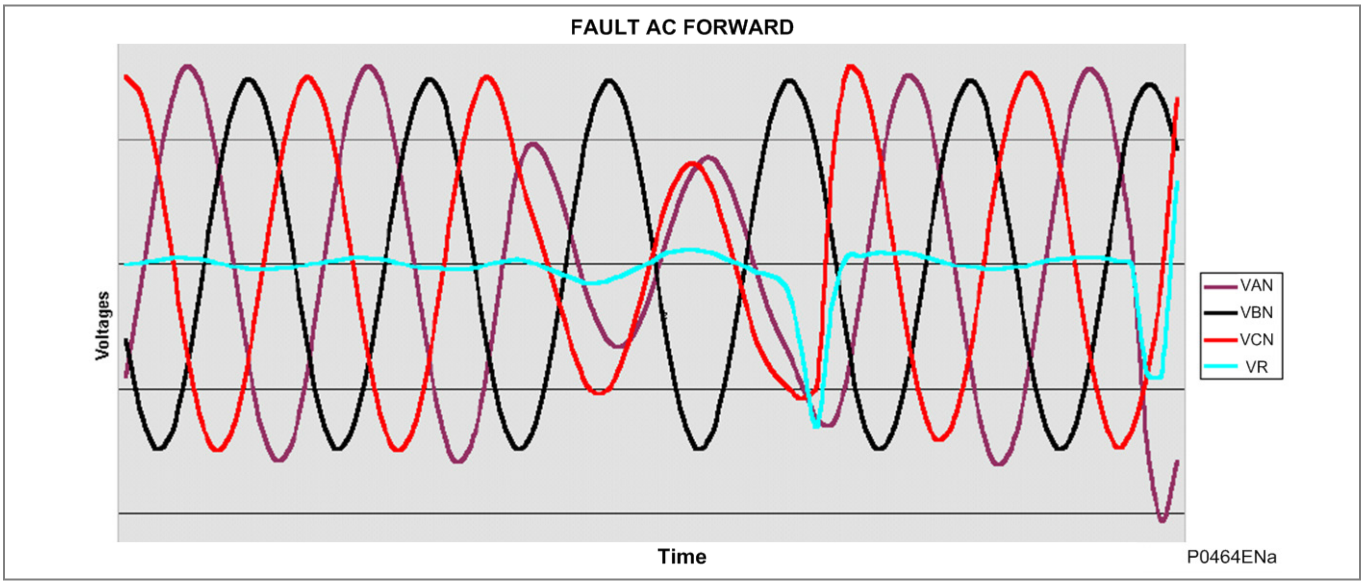


Figure 7 – Fault ac forward – V_{AN}, V_{BC}, V_{CN} and V_R

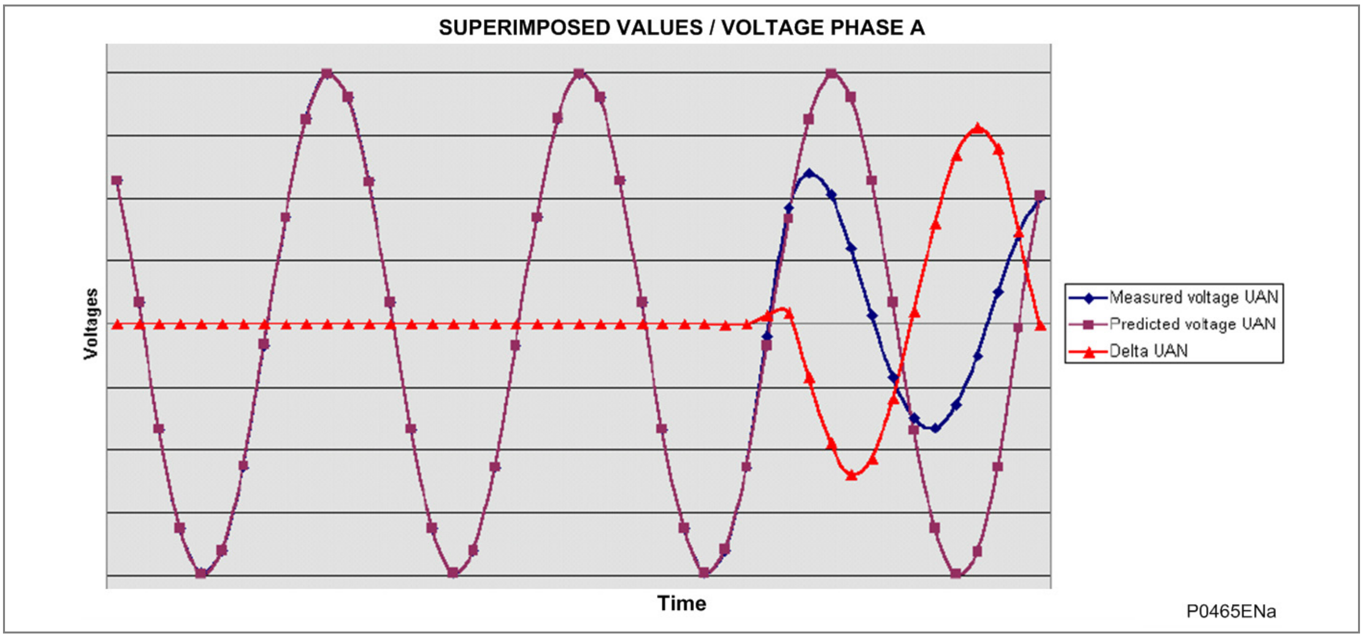


Figure 8 – Superimposed values / Voltage Phase A

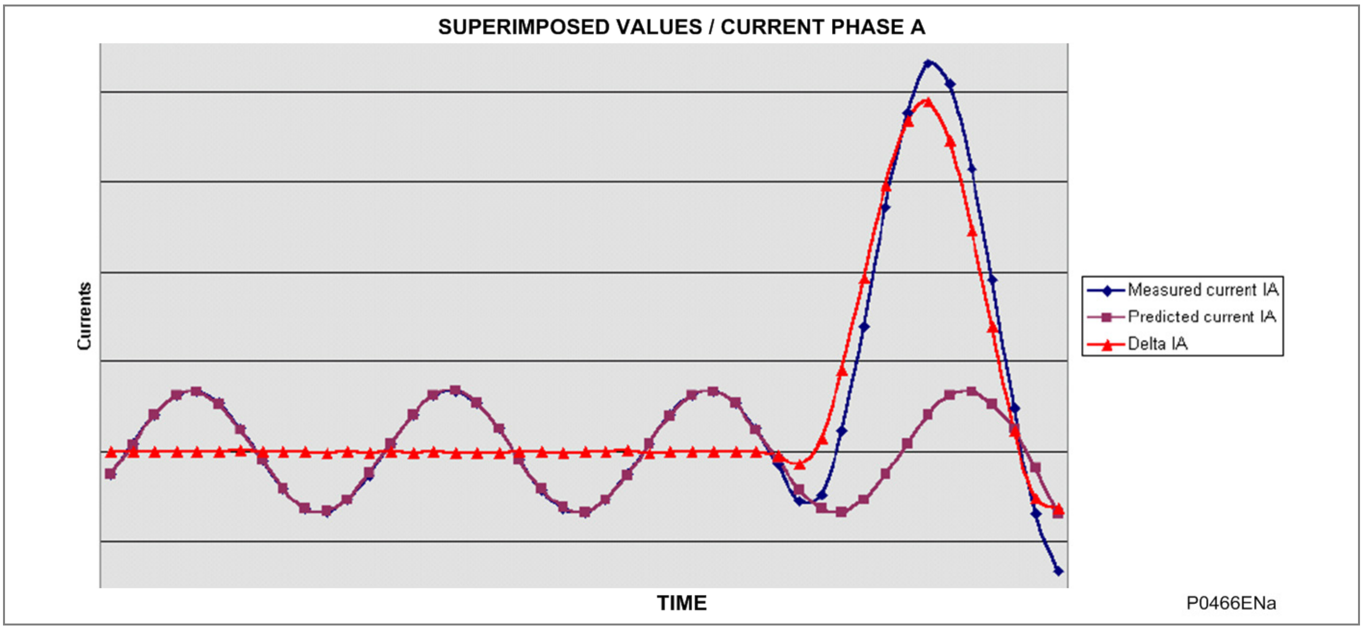


Figure 9 – Superimposed values / Current Phase A

2.2.3 Confirmation

In order to eliminate the transitions generated by possible operations or by high frequencies, the transition detected over a succession of three sampled values is confirmed by checking for at least one loop for which the two following conditions are met:

- ΔV > threshold V, where threshold V = 0.1 Un /√3 = 0.1 Vn

and

- ΔI > threshold I, where threshold I = 0.2 In.

The start-up of the high-speed algorithms will be confirmed if ΔU AND ΔI are detected on three consecutive samples.

2.2.4 Directional Decision

The "Delta" detection of the fault direction is determined from the sign of the energy per phase for the transition values characterising the fault.

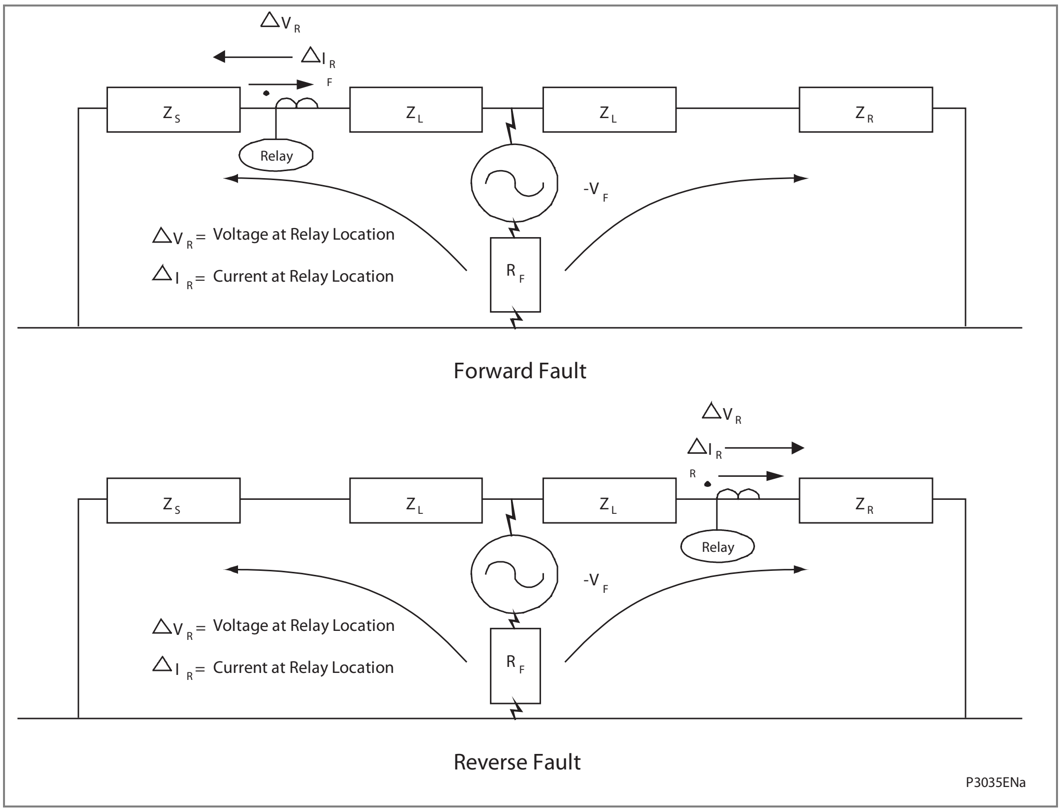


Figure 10 - Directional determination using superimposed values

To do this, the following sum per phase is calculated:

$$S_A = \sum_{n0}^{ni \geq n0+5} (\Delta V_{ANi}.\Delta I_{Ai}) \qquad S_B = \sum_{n0}^{ni \geq n0+5} (\Delta V_{BNi}.\Delta I_{Bi}) \qquad S_C = \sum_{n0}^{ni \geq n0+5} (\Delta V_{CNi}.\Delta I_{Ci})$$

where n0 is the instant at which the fault is detected, ni is the instant of the calculation and S is the calculated transition energy.

If the fault is in the forward direction, then S i <0 (i = A, B or C phase).

If the fault is in the reverse direction, then S i >0.

The directional criterion is valid if

S >5 x (10% x Vn x 20% x In x cos (85°)

This sum is calculated on five successive samples.

The RCA angle of the delta algorithms is equal to 60° (-30°) if the protected line is not series compensated (otherwise RCA is equal to 0°).

2.2.5 Phase Selection

Phase selection is made on the basis of a comparison between the transition values for the derivatives of currents IA, IB and IC:

$\Delta I'A$, $\Delta I'B$, $\Delta I'C$, $\Delta I'AB$, $\Delta I'BC$, $\Delta I'CA$

Note	The derivatives of the currents are used to eliminate the effects of the DC current component.

Hence:

$$S_{AN}=\sum_{n0}^{ni \geq n0+4} (\Delta I'A_i)^2 \qquad S_{BN}=\sum_{n0}^{ni \geq n0+4} (\Delta I'B_i)^2 \qquad S_{CN}=\sum_{n0}^{ni \geq n0+4} (\Delta I'C_i)^2$$

$$S_{AB} \sum_{n0}^{ni \geq n0+4} (\Delta I'AB_i)^2 \qquad S_{BC}=\sum_{n0}^{ni \geq n0+4} (\Delta I'BC_i)^2 \qquad S_{CA}=\sum_{n0}^{ni \geq n0+4} (\Delta I'CA_i)^2$$

The phase selection is valid if the sum ($S_{AB}+S_{BC}+S_{CA}$) is higher than a threshold. This sum is not valid if the positive sequence impedance on the source side is far higher than the zero sequence impedance. In this case, the conventional algorithms are used to select the faulted phase(s).

Sums on one-phase and two-phase loops are performed. The relative magnitudes of these sums determine the faulted phase(s).

For example, assume:

If $S_{AB}<S_{BC}<S_{CA}$ and If $S_{AB}<<S_{BC}$, the fault has had little effect on the loop A to B. If $S_{AN}<S_{BN}<S_{CN}$, the fault declared as single phase fault C.

If the fault is not detected as single-phase by the previous criterion, the fault conditions are multi-phase.

If $S_{AN}<S_{BN}<S_{CN}$ and If $S_{AB}<<S_{BC}$, the fault is B to C.

If $S_{AN}<S_{BN}<S_{CN}$ and If $S_{AB}\approx S_{BC}\approx S_{CA}$ and if $S_{AN}\approx S_{BN}\approx S_{CN}$, the fault is three-phase (the fault occurs on the three phases).

2.2.6 Summary

A transition is detected if ΔI > 20% x In or ΔV >10% x Vn

Then three tasks are starting in parallel:

- Fault confirmation: ΔI and ΔV (3 consecutive samples)
- Faulty phase selection (4 consecutive samples)
- Fault directional decision (5 consecutive samples)

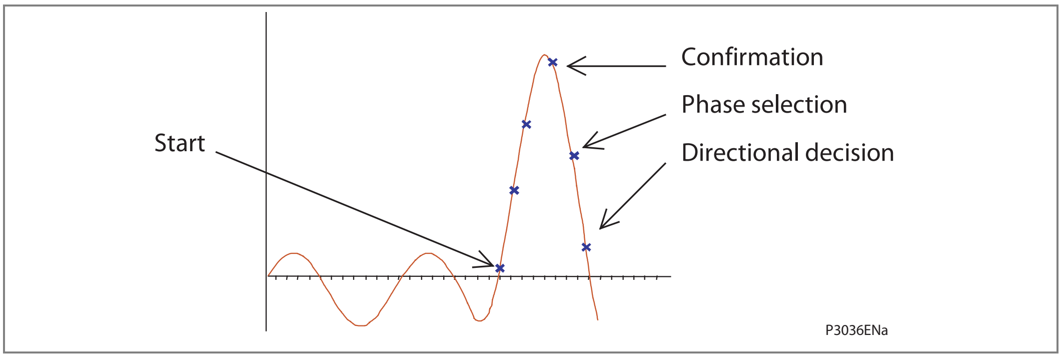


Figure 11 - Deltas algorithms

High speed algorithms are used only during the first 2 cycles following a fault detection.

2.3 "Conventional" Algorithms

These algorithms do not use the superimposed values but use the impedance values measured under fault conditions. They are based on fault distance and resistance measurements.

They are used in the following circumstances:

- The condition before the fault could not be modelled.
- The superimposed values are not exclusively generated by the fault.

This may be true if the following occurs:

- A circuit breaker closing occurs during a fault. For SOTF, only the Conventional Algorithms can be used as there are not 2 cycles of healthy network stored.
- The fault is not recent and so the operating conditions of the generators have changed, or corrective action has been taken, i.e., opening the circuit breakers. This occurs generally after the first trip. High Speed algorithms are used only during the first 2 cycles after the fault detection.
- operating conditions are not linear.

The conventional algorithms are also suited to detect low current faults that do not have the required changes in current and voltage for the "high-speed" (superimposed) algorithms. Therefore, their use assures improved coverage.

The "Conventional" algorithms run continuously with "high-speed" algorithms. If the "high speed" algorithms cannot declare faulted phase(s) and direction, the conventional algorithms will.

Note	*The distance measurement of the fault is taken on the loop selected by the "Delta" or "conventional" phase selection algorithms. This measurement uses the fault values which are computed by Gauss Seidel method.*

2.3.1 Convergence Analysis

This analysis is based on the measurements of distance and resistance of the fault. These measurements are taken on each phase-ground and phase-phase loops (18 loops in total). They determine the convergence of these loops within a parallelogram-shaped, start-up characteristic.

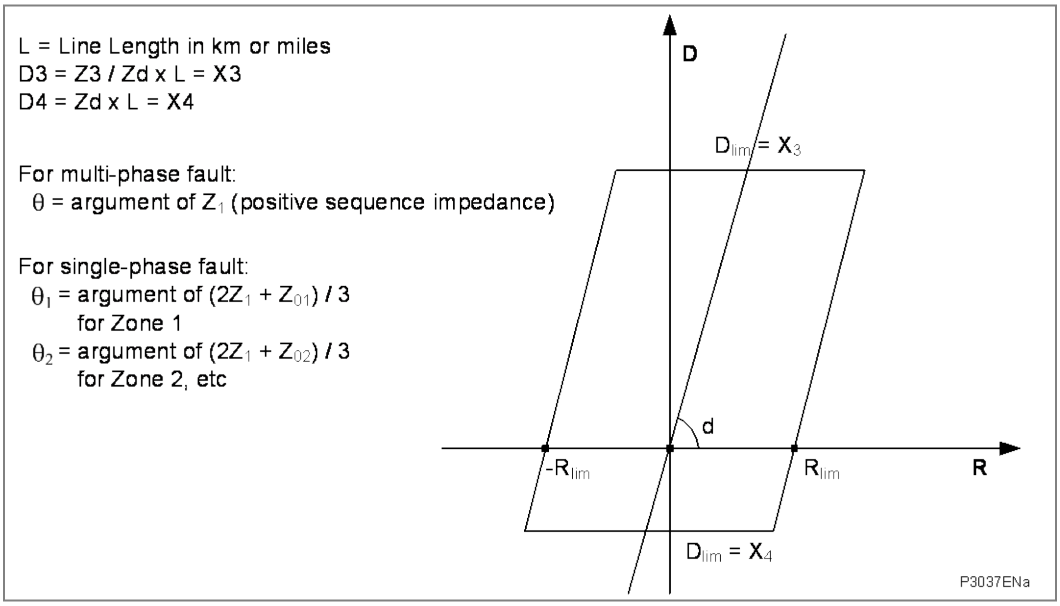


Figure 12 - Start-up characteristic

Let R_{lim} and D_{lim} be the limits of the starting characteristic.

The pair of solutions (D_{fault} (n-1), R_{fault} (n-1)) and (D_{fault} (n), R_{fault} (n)):

- R_{fault} (n-1)< R_{lim}, and R_{fault} (n)< R_{lim}, and R_{fault} (n-1) - R_{fault} (n)< 10% x R_{lim}
- D_{fault} (n-1)< D_{lim} and D_{fault} (n) < D_{lim} and D_{fault} (n-1) - D_{fault} (n) < 10% x D_{lim}

where R_{lim} is the resistance limit for the single and multi phase faults. This convergence requires the equations to be collinear, thus allowing the terms in D_{fault} and R_{fault} to be discriminated.

Theoretically, zone limits are Z3, Z4, +/- R3G-R4G or +/- R3Ph-R4Ph, if zones 3 and 4 are enabled. The slope of the characteristic mimics the characteristic of the line.

To model the fault current:

- Phase-phase loops: the values (I_A - I_B), (I_B - I_C), or (I_C - I_A) are used.
- Phase-ground loops: (I_A+ k_0 x $3I_0$), (I_B + k_0 x $3I_0$), or (I_C + k_0 x $3I_0$) are used.

The results of these algorithms are mainly used as a backup; consequently, the circuit breaker located at the other end is assumed to be open.

2.3.2 Start-Up

Start-up is initiated when at least one of the six measuring loops converges within the characteristic (Z_{AN}, Z_{BN}, Z_{CN}, Z_{AB}, Z_{BC}, Z_{CA}).

2.3.3 Phase Selection

If the fault currents are high enough with respect to the maximum load currents current-based phase selection is used; if not, impedance-based phase selection is required.

2.3.3.1 Current Phase Selection

Amplitudes I'A, I'B, I'C are derived from the three measured phase currents IA, IB, IC. These values are then compared to each other and to the two thresholds S1 and S2:

- First threshold is S1= 3 x I'n
- Second threshold is S2 = 5 x I'n

Example:
If I'A< I'B < I' C:

- If I'_C > S2 and I'_A > S1, the fault is three-phase.
- If I'_C > S2, I'B > S1 and I'_A < S1, the fault is two-phase, on phases B and C.
- If I'_C > S2 and I'_B < S1, the fault is single-phase, on phase C.

If I'_C < S2, the current phase selection cannot be used. Impedance phase selection should then be used.

2.3.3.2 Impedance Phase Selection

Impedance phase selection is obtained by checking the convergence of the various measuring loops within the start-up characteristic, as follows:

- T = Presence of zero-sequence voltage or current (logic Information: 0 or 1).
- Z_{AN} = Convergence within the characteristic of the loop A (logic Information).
- Z_{BN} = Convergence within the characteristic of the loop B (logic Information).
- Z_{CN} = Convergence within the characteristic of the loop C (logic Information).
- Z_{AB} = Convergence within the characteristic of the loop AB (logic Information).
- Z_{BC} = Convergence within the characteristic of the loop BC (logic Information).
- Z_{CA} = Convergence within the characteristic of the loop CA (logic Information).

In addition, the following are also defined:

- $R_{AN} = Z_{AN} \times \overline{Z_{BC}}$ where ZBC = convergence within the characteristic of the loop BC (Logic Information).
- $R_{BN} = Z_{BN} \times \overline{Z_{CA}}$ where ZCA = convergence within the characteristic of the loop CA (Logic Information).
- $R_{CN} = Z_{CN} \times \overline{Z_{AB}}$ where ZAB = convergence within the characteristic of the loop AB (Logic Information).
- $R_{AB} = Z_{AB} \times \overline{Z_{CN}}$ where ZCN = convergence within the characteristic of the loop C (Logic Information).
- $R_{BC} = Z_{BC} \times \overline{Z_{AN}}$ where ZAN = convergence within the characteristic of the loop A (Logic Information).
- $R_{CA} = Z_{CA} \times \overline{Z_{BN}}$ where ZBN= convergence within the characteristic of the loop B (Logic Information).

Following are the different phase selections:

- $S_{AN} = T \times R_{AN} \times \overline{R_{BN}} \times \overline{R_{CN}}$ single-phase A to earth fault
- $S_{BN} = T \times R_{BN} \times \overline{R_{AN}} \times \overline{R_{CN}}$ single-phase B to earth fault
- $S_{CN} = T \times R_{CN} \times \overline{R_{BN}} \times \overline{R_{CN}}$ single-phase C to earth fault
- $S_{ABN} = T \times R_{AB} \times Z_{AN} \times Z_{BN}$ double-phase A to B to earth fault
- $S_{BCN} = T \times R_{BC} \times Z_{BN} \times Z_{CN}$ double-phase B to C to earth fault
- $S_{CAN} = T \times R_{CA} \times Z_{AN} \times Z_{CN}$ double-phase C to A to earth fault
- $S_{AB} = \overline{T} \times R_{AB} \times \overline{R_{BC}} \times \overline{R_{CA}}$ double-phase A to B fault
- $S_{BC} = \overline{T} \times R_{BC} \times \overline{R_{AB}} \times \overline{R_{CA}}$ double-phase B to C fault
- $S_{CA} = \overline{T} \times R_{CA} \times \overline{R_{AB}} \times \overline{R_{BC}}$ double-phase B to C fault
- $S_{ABC} = Z_{AN} \times Z_{BN} \times Z_{CN} \times Z_{AB} \times Z_{BC} \times Z_{CA}$ three-phase fault

For a three-phase fault, if the fault resistance of one of the two-phase loops is less than half of the fault resistances of the other two-phase loops, it will be used for the directional and distance measuring function. If not, the loop AB will be used.

Note	Impedance phase selection is used only if current phase selection is unable to make a decision.

2.3.4 Directional Decision

The fault direction is defined on the basis of the calculation of the phase shift between the stored voltage and the derivative of a current. The current and the voltage used are those of the measuring loop(s) defined by the phase selection.

For the two-phase loops, the calculation of the phase shift between the stored voltage and the derivative of the current on the faulty two-phases.

For the single-phase loops, the calculation of the phase shift between the stored voltage and the current (I'x + k0 x 3I'0), where:

I'x = derivative of current on the faulted single-phase where x = A, B, or C

3I’0 = derivative of residual current

k0 = residual compensation factor, where for example k01 = (Z0–Z1)/3Z1

The directional angle is fixed between-30° and +150° (RCA =60°).

2.3.5 Directional Decision during SOTF-TOR (Switch On To Fault/Trip On Reclose)

The directional information is calculated from the stored voltage values if the network is detected as healthy. The calculations vary depending on the type of fault, i.e., single-phase or multiphase.

If the network frequency cannot be measured and tracked, the directional element cannot be calculated from the stored voltage. A zero sequence directional will be calculated if there are enough zero-sequence voltage and current. If the zero-sequence directional is not valid, a negative-sequence directional will be calculated if there are enough negative sequence voltage and current. If both directions cannot be calculated, the directional element will be forced forward.

2.3.5.1 Single-Phase Fault

The reference voltage is stored in memory when the fault appears. When the fault is eliminated by single-phase tripping, the High-Speed single-phase Auto-Reclose (HSAR) is started.

If a fault appears less than three cycles after the AR starts, the stored voltage value remains valid as the reference and is used to calculate direction.

If no fault appears during the three cycles after the AR starts, the reference voltage value becomes that of one of the healthy phases.

If a fault appears during the continuation of the AR cycle or reclosure occurs, the stored voltage value remains valid for 10 seconds.

If a stored voltage does not exist (SOTF) when one or more loops are convergent within the start-up characteristic, the directional is forced forward and the trip is instantaneous (if “SOTF All Zones“ is set or according to the zone location if SOTF Zone 2, etc. is set). If the settable switch on to fault current threshold I>3 is exceeded on reclosure, the relay instantaneously trips three-phase (No timer I>3 is applied).

2.3.5.2 Two-Phase or Three-Phase Fault

The reference voltage is stored in memory when the fault appears. When the fault is cleared, the stored voltage value remains valid for 10 seconds. If reclosure occurs during these 10 seconds, the direction is calculated using the stored voltage value.

If a stored voltage does not exist when one or more loops are convergent within the start-up characteristic, the forward direction is forced and the trip is instantaneous when protection starts (SOTF All Zones). If the switch on to fault current threshold I>3 is exceeded on reclosure, the relay instantaneously trips three-phase (TOR All Zones).

The distance element trips immediately as soon as one or more loops converge within the start-up characteristic during SOTF (SOTF All Zones).

Other modes can be selected to trip selectively by SOTF or TOR according to the fault location. There are 15 bits of settings in TOR-SOTF logic.

2.4 Faulted Zone Decision

The Decision of the faulted zone is determined by either the zone "Deltas" or "Conventional" algorithms.

The zones are defined for a convergence between the Dfault and Rfault limits related to each zone. So, the solution pair (Rfault, Dfault) is said to be convergent if:

- R_{fault} (n-1) < R_{fault} (i) and R_{fault} (n) < R_{fault} (i) and $|R_{fault}$ (n-1) – R_{fault} (n)$|$ < 10% x R_{fault} (i)
- D_{fault} (n-1) < D_{fault} (i) and D_{fault} (n) < D_{fault} (i) and $|D_{fault}$ (n-1) - D_{fault} (n)$|$ < k% x D_{fault} (i)

where:

k= 5% for zones Z1 and Z1X
and 10% for other zones Z2, Z3, Zp, Zq and Z4.

i= 1, 1X, 2, p, q, 3 and 4.

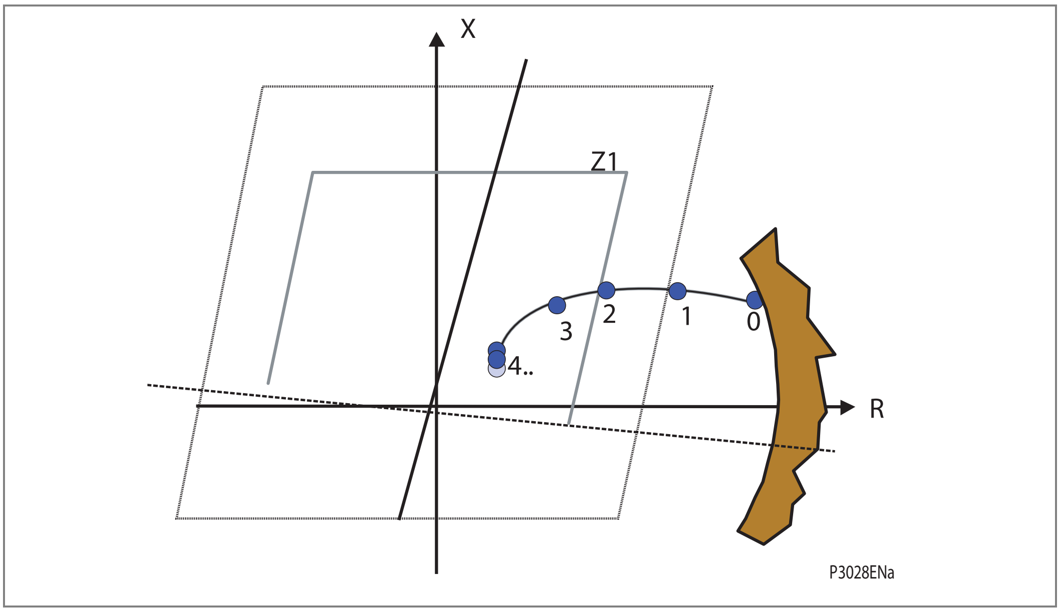


Figure 13 - Phase-to-earth loop impedance

2.5 Tripping Logic

2.5.1 General

Three tripping modes can be selected ('Distance Scheme\Trip Mode' setting):

Single-pole trip at T1 (if “1P. Z1 & CR” is set): Single-pole trip for fault in zone 1 at T1 and channel-aided trip at T1. All other zones trip three-phase at their respective times for any fault types (∅-G, ∅-∅, ∅-∅-G, ∅-∅-∅, ∅-∅-∅-G).

Single-pole trip at T1 and T2 (if “1P. Z1Z2 & CR” is set): Single-pole trip for Z1 at T1, channel-aided trip at T1, and Z2 at T2. All other zones trip three-phase at their respective times for any fault types (∅-G, ∅-∅, ∅-∅-G, ∅-∅-∅, ∅-∅-∅-G).

Three-pole trip for all zones (Forces 3 poles): Three-phase trip for all zones at their respective times for all fault types (∅-G, ∅-∅, ∅-∅-G, ∅-∅-∅, ∅-∅-∅-G). Channel-aided trips will be three-phase with times corresponding to the pilot logic applied.

Zone	Time
Z1	T1
Z1X	T1
Z2	T2
Zp	Tp
Zq	Tq
Z3	T3
Z4	T4

There are six time delays associated with the seven zones present. Zone 1 and extended zone 1 have the same time delay.

Note	*All the timers are initiated when the general start of the relay picks up (Z3Z4 convergence)*

2.5.2 DDB Inputs / Outputs for General Trip Logic

The following DDB are available for CB monitoring (see section P44x/EN PL):

Inputs

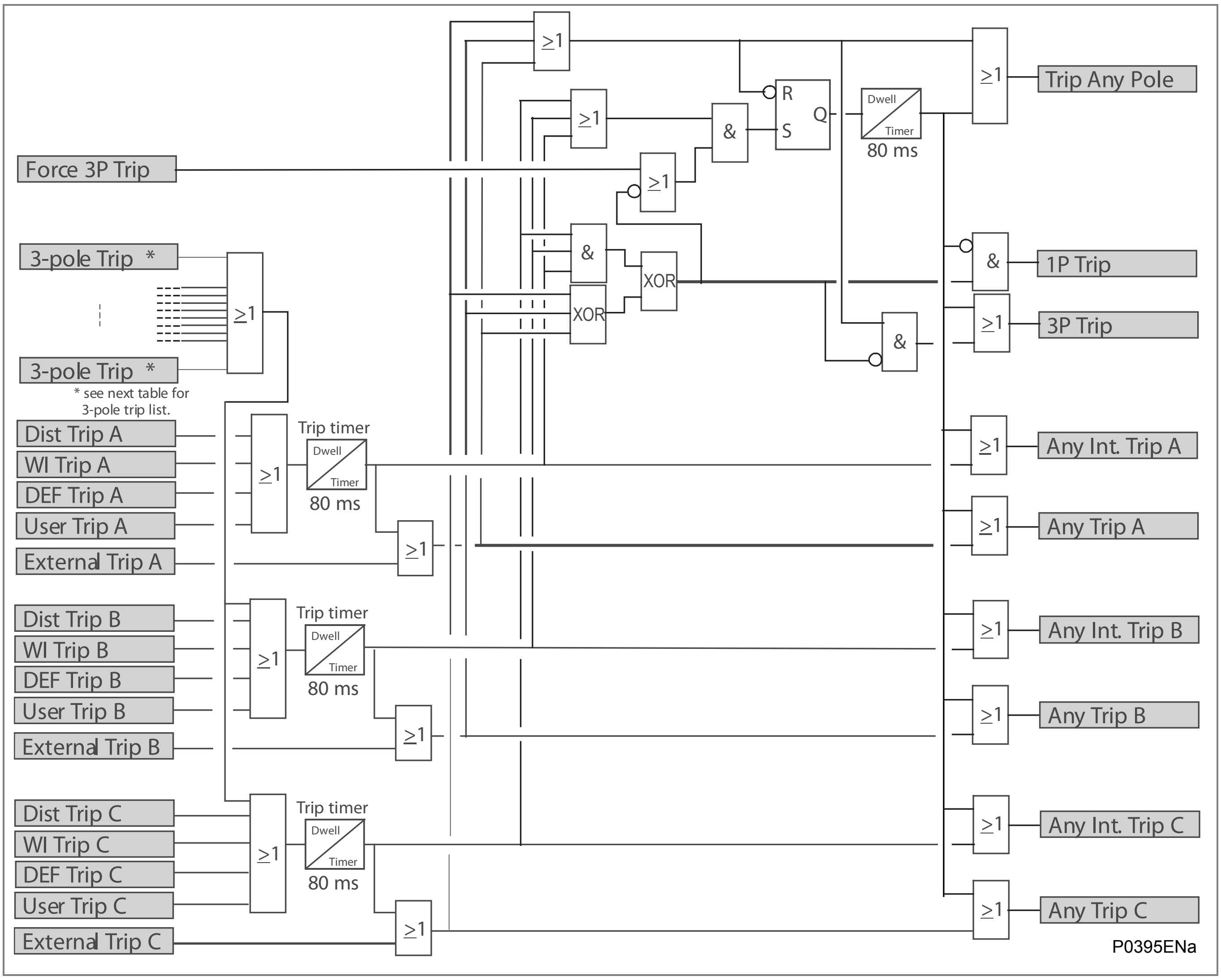
- Three-pole trips (refer to the list in the logic diagram
- Force 3P trip (see autoreclose section)
- Dist trip a, Dist Trip B and Dist Trip C (see section “distance protection”),
- WI trip A, WI Trip B and WI trip C (see section “weak infeed”)
- DEF Trip A, DEF Trip B and DEF Trip C (Directional Earth fault section),
- User Trip A, User Trip B and User Trip C (trip logic),
- External Trip A, External Trip B and External trip C (PSL)

Outputs:

- 1P Trip,
- 3P Trip,
- Any Trip A, Any Trip B and Any Trip C,
- Any Int. TripA, Any Int. TripB and Any Int. TripC.

2.5.2.1 Logic Diagram

The next diagram illustrates general trip logic:



3-pole trip list:						
IN>1 Trip		IN>2 Trip		I2> Trip		SOTF/TOR Trip
Loss. Load Trip		I>1 Trip		I>2 Trip		I>3 Trip
I>4 Trip		V<1 Trip		V<2 Trip		V<3 Trip
V<4 Trip		V>1 Trip		V>2 Trip		V>3 Trip
V>4 Trip		ZSP Trip		F<1 Trip		F<2 Trip
F<3 Trip		F<4 Trip		F>1 Trip		F>2 Trip

Figure 14 - General trip logic

2.6 Fault Locator

The relay has an integral fault locator that uses information from the current and voltage inputs to provide a distance-to-fault measurement. The fault locator measures the distance by applying the same distance calculation principle as that used for the fault-clearing, distance-measurement algorithm.

The dedicated fault locator measurement is more accurate as it is based on a greater number of samples, and it uses the fault currents Ifault as models, as shown below:

• For a single-phase fault	AN	:	IfaultΔ (IA – I0)
	BN	:	IfaultΔ (IB – I0)
	CN	:	IfaultΔ (IC – I0)
• For a two-phase fault	AB	:	IfaultΔ (IA–IB)
	BC	:	IfaultΔ (IB–IC)
	CA	:	IfaulΔ (IC–IA)
• For a three-phase fault	ABC	:	IfaultΔ (IA–IB)

The sampled data from the analogue input circuits is written to a cyclic buffer until a fault condition is detected. The data in the input buffer is then held to allow the fault calculation to be made. When the fault calculation is complete the fault location information is available in the relay fault record.

When applied to parallel circuits, mutual flux coupling can alter the impedance seen by the fault locator. The coupling will contain positive, negative and zero sequence components. In practice the positive and negative sequence coupling is insignificant. The effect on the fault locator of the zero sequence mutual coupling can be eliminated by using the mutual compensation feature provided. This requires that the residual current on the parallel line is measured, as shown in Appendix B.

The calculation for single phase loop is based on the following equation:

$$V_{AN}=R_1.D_{fault}.I_A+\frac{R_0-R_1}{3}.D_{fault}.3I_0+L_{AA}.D_{fault}.\frac{dI_A}{dt}+L_{AB}.D_{fault}.\frac{dI_B}{dt}+L_{AC}.D_{fault}.\frac{dI_C}{dt}+R_{fault}.I_{fault}+R_M.L_M+L_M.\frac{dI_M}{dt}$$

$$V_{BN}=R_1.D_{fault}.I_B+\frac{R_0-R_1}{3}.D_{fault}.3I_0+L_{AB}.D_{fault}.\frac{dI_A}{dt}+L_{BB}.D_{fault}.\frac{dI_B}{dt}+L_{BC}.D_{fault}.\frac{dI_C}{dt}+R_{fault}.I_{fault}+R_M.L_M+L_M.\frac{dI_M}{dt}$$

$$V_{CN}=R_1.D_{fault}.I_C+\frac{R_0-R_1}{3}.D_{fault}.3I_0+L_{AC}.D_{fault}.\frac{dI_A}{dt}+L_{BC}.D_{fault}.\frac{dI_B}{dt}+L_{CC}.D_{fault}.\frac{dI_C}{dt}+R_{fault}.I_{fault}+R_M.L_M+L_M.\frac{dI_M}{dt}$$

Where:

R_m: zero-sequence mutual resistance

L_m: zero-sequence mutual inductance

I_m: zero-sequence mutual current

I_{fault}: fault current = ΔI – I0

The calculation for phase-to-phase loop is based on the following equation:

$$V_{AB}=R_1.D_{fault}.(I_A-I_B)+(L_{AA}-L_{AB}).D_{fault}.\frac{dI_A}{dt}+(L_{AB}-L_{BB}).D_{fault}.\frac{dI_B}{dt}+(L_{AC}-L_{BC}).D_{fault}.\frac{dI_C}{dt}+\frac{R_{fault}}{2}.I_{fault}$$

$$V_{BC}=R_1.D_{fault}.(I_B-I_C)+(L_{AB}-L_{AC}).D_{fault}.\frac{dI_A}{dt}+(L_{BB}-L_{BC}).D_{fault}.\frac{dI_B}{dt}+(L_{BC}-L_{CC}).D_{fault}.\frac{dI_C}{dt}+\frac{R_{fault}}{2}.I_{fault}$$

$$V_{AC}=R_1.D_{fault}.(I_C-I_A)+(L_{AC}-L_{AA}).D_{fault}.\frac{dI_A}{dt}+(L_{BC}-L_{AB}).D_{fault}.\frac{dI_B}{dt}+(L_{CC}-L_{AC}).D_{fault}.\frac{dI_C}{dt}+\frac{R_{fault}}{2}.I_{fault}$$

Where:

I_{fault}= ΔI (ΔI = ΔI' - ΔI")
$\Delta I_A - \Delta I_B$
$\Delta I_B - \Delta I_C$
$\Delta I_C - \Delta I_A$

2.6.1 Selecting the Fault Location Data

Selection of the analogue data that is used depends on:

- How the fault is processed by the algorithms.
- The line model.

2.6.2 Processing Algorithms

Distance to fault calculation will use the high speed algorithms if:

- A fault is detected by the high-speed algorithms
- The tripping occurred within the T1 or T2 time delays
- The distance to the fault is less than 105% of the line.

In this case, the distance to fault saved in the fault report will be displayed as:

Distance to the fault = 24.48km (L) accuracy 3%

If all three of these conditions are not met, the distance to fault value will be the same value used by the distance protection. The format of the display will then be as follows:

Distance to the fault = 31.02km accuracy 5%

Note	*The more accurate fault location will be post scripted with an (L). This will occur when conditions are favourable for using the more accurate algorithm for distance to fault calculation.*

2.6.2.1 Line Model Selection

The fault locator can distinguish between two types of line, as follows:

- Single lines
- Parallel lines with mutual coupling

Mutual coupling between transmission lines is common on power systems. Significant effects on distance relay operation during faults involving earth may occur. Typically, the positive and negative, mutual-sequence impedances are negligible, but zero-sequence mutual coupling may be large, and either must be factored into the settings, or accommodated by measurement of the parallel, mutually-coupled lines residual (earth) current, where zero-sequence current information is available. The value of the residual currents from parallel lines is then integrated into the distance measurement equation.

The relay is capable of measuring and using mutually-coupled residual current information from parallel lines. The mutual current is measured by a dedicated analogue input.

2.7 Double Circuit Lines

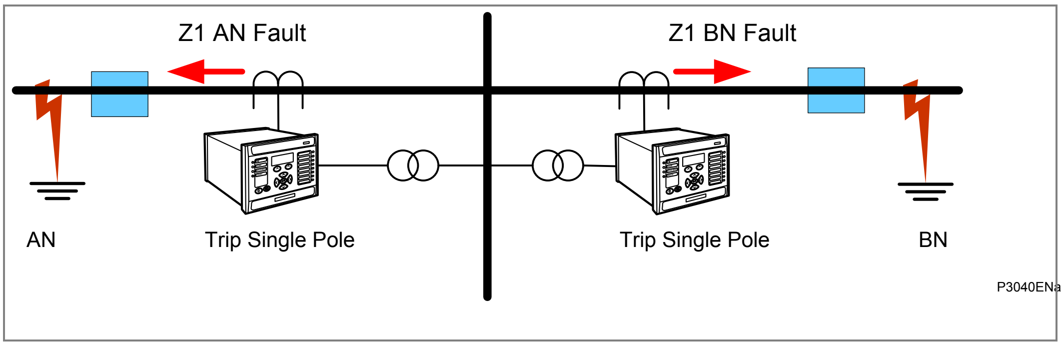
Double circuit lines must be taken into account in the operating principle of the protection scheme to avoid unwanted tripping of “sound” phases, which could be the result of an excessively general phase selection.

2.7.1 Phase selection for an inter-circuit fault

During a two-phase fault selection, for example on loop AB, the P44x checks direction on the two adjacent earth loops, (A to Neutral and B to Neutral). The direction is determined using either the conventional algorithm or the high-speed algorithm (using superimposed quantities), depending on fault severity. If superimposed components are used, the transient (fault) energy is summated phase by phase.

$$\text{FaultDirectionLoop\_AN} = \sum_{n0}^{n} (\Delta V_{AN} . \Delta I_A) \quad \text{and}$$

$$\text{FaultDirectionLoop\_BN} = \sum_{n0}^{n} (\Delta V_{BN} . \Delta I_B)$$



The directions of the two adjacent ground loops are compared, as follows:

- If the two directions are forward, the fault is a two-phase fault on the protected line.
- If only one of the directions is forward, for instance Sa, the fault is single-phase (A to Neutral) on the protected line.

If the two directions are reverse, the fault is not on the protected line.

2.7.2 Protection against Current Reversal (Transient Blocking)

When a fault occurs on a line, which is parallel to the protected line, the pilot schemes on the protected line may be subjected current reversals from sequential clearing on the parallel line. A fault on the parallel line may start by appearing external to the protected line in the reverse direction, and then, after a sequential operation of one of the parallel line circuit-breakers, the fault appears forward. This situation can affect security of certain channel-aided schemes on the protected line.

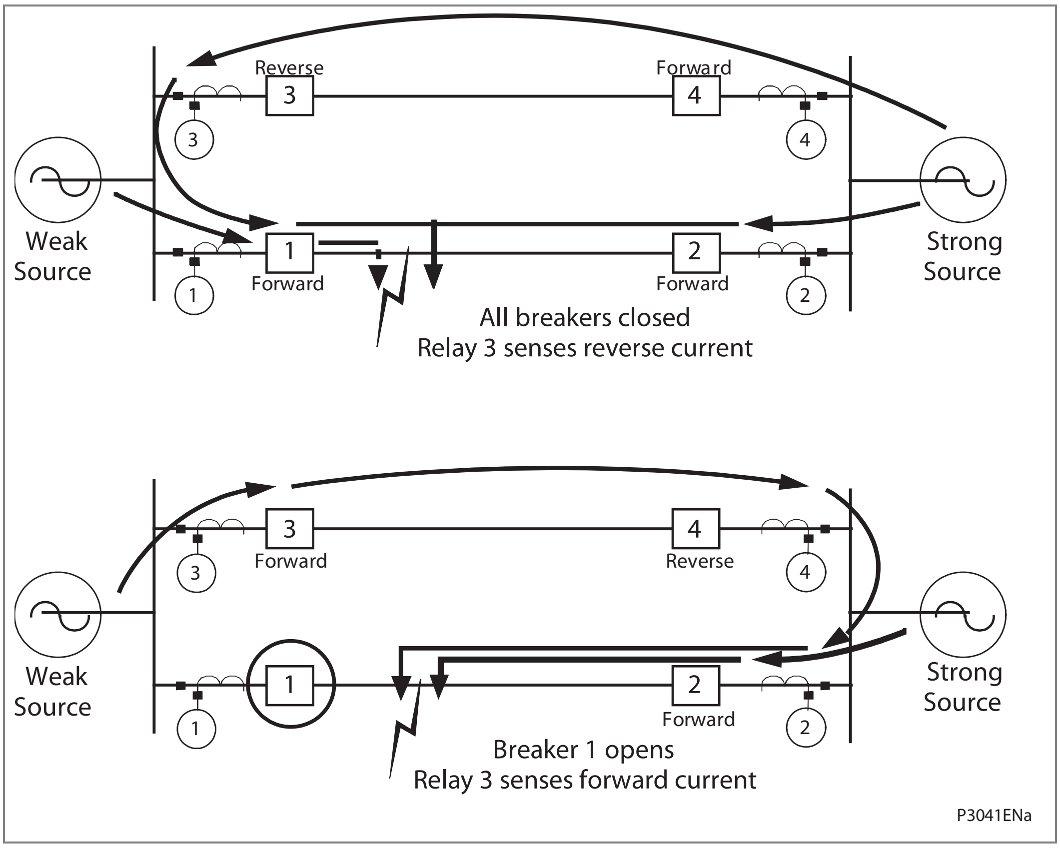


Figure 15 - Direction reversal from sequential clearing of parallel lines

The P44x provides protection against the effects of this phenomenon by employing transient blocking. An adjustable timer is available that will block direct and permissive transfer trip signals from being used in the P44x logic, and will also block the P44x from sending direct or permissive transfer trip signals. This timer is designated as “Reverse Guard Timer”.

This provides protection against fault current reversal and will still allow fast tripping in the event of faults occurring in zone 1, if zone 1 is independent (not used as overreach zone).

3 DISTANCE PROTECTION AND DISTANCE SCHEME FUNCTIONS

The following sections detail the individual protection functions in addition to where and how they may be applied.

The following section details the individual distance protection functions, in addition to where they may be applied. It completes the P44x/EN ST section, where distance settings are detailed. This section details:

- The “distance protection” menu setting: This section explains how the line characteristics and the protection zones settings are applied to the relay,
- The “distance scheme” menu setting, where scheme setting are explained,
- Distance protection settings example, where:
  - A double circuit line protection is illustrated,
  - Additional details are given for three terminal lines applications,
- Internal logic and an overview of the distance protection.

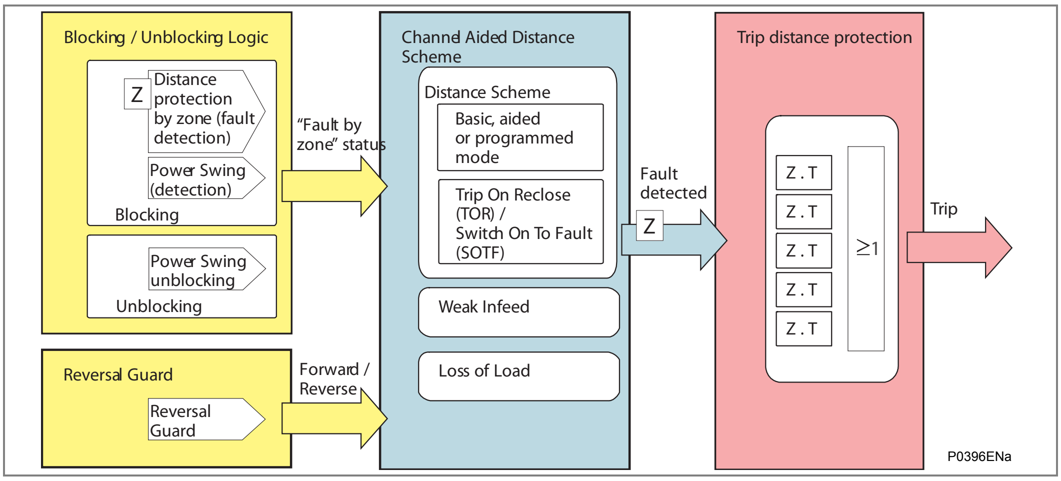


Figure 16 – Distance protection

3.1 Fault Distance Characteristics ("Distance Elements" Menu Setting)

This section explains in detail the "Distance elements" menu setting. This menu is used to set the line protection. The following sections contain line and zone setting application. A general example of setting (distance elements and schemes) is presented in the *Other Protection Considerations - Settings Example* section. The *Distance Protection Logic* section presents the logic of the distance protection (expert section).

The fault protection principle by zone is illustrated in the following diagram (basic distance fault protection). Relay A and relay B cover the line protection by zone. In general, zones 1 and 2 provide main protection for the line or cable, with zone 3 (or zone 4) reaching further to provide back up protection for faults on adjacent circuits.

Figure 17 - Main Protection principle

3.1.1 Line Setting

All impedance reaches for phase fault protection are calculated in polar form: $Z \angle\theta$, where Z is the reach in ohms, and θ is the line angle setting in degrees, common to all zones.

The line parameters can be set in polar or rectangular form to give the total positive impedance of the protected line:

3.1.2 Zone Setting

As shown in the following figure, the blocking/unblocking logic is based on a distance protection by zone:

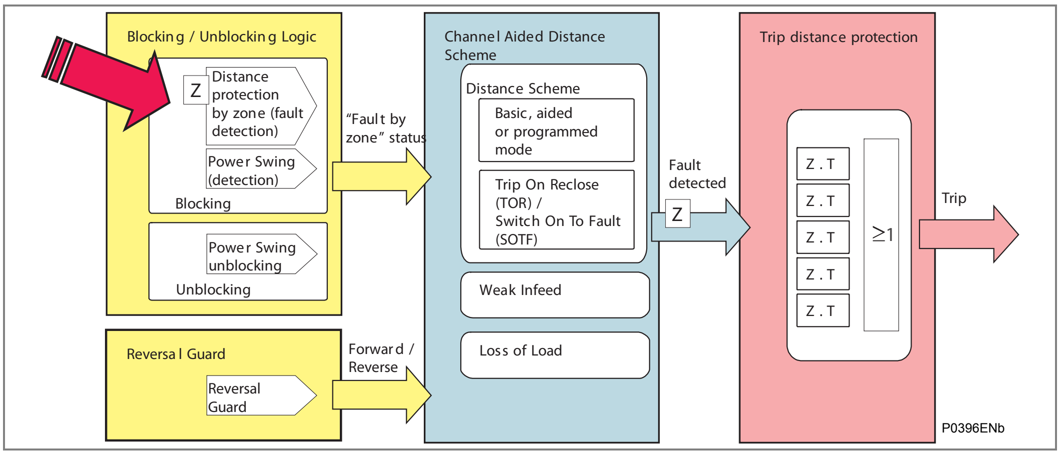


Figure 18 – Fault detection by Zone in the Distance protection Diagram

The Zone setting menu of the relay allows 6 zones setting.

3.1.2.1 Zone Setting – Zone Status

The P442 and P444 relays have 6 zones of phase or earth fault protection, as shown in the impedance plots below. The fault protections are completed by a tilt characteristic (tilt angle).

The following impedance plot illustrates the phase fault characteristics:

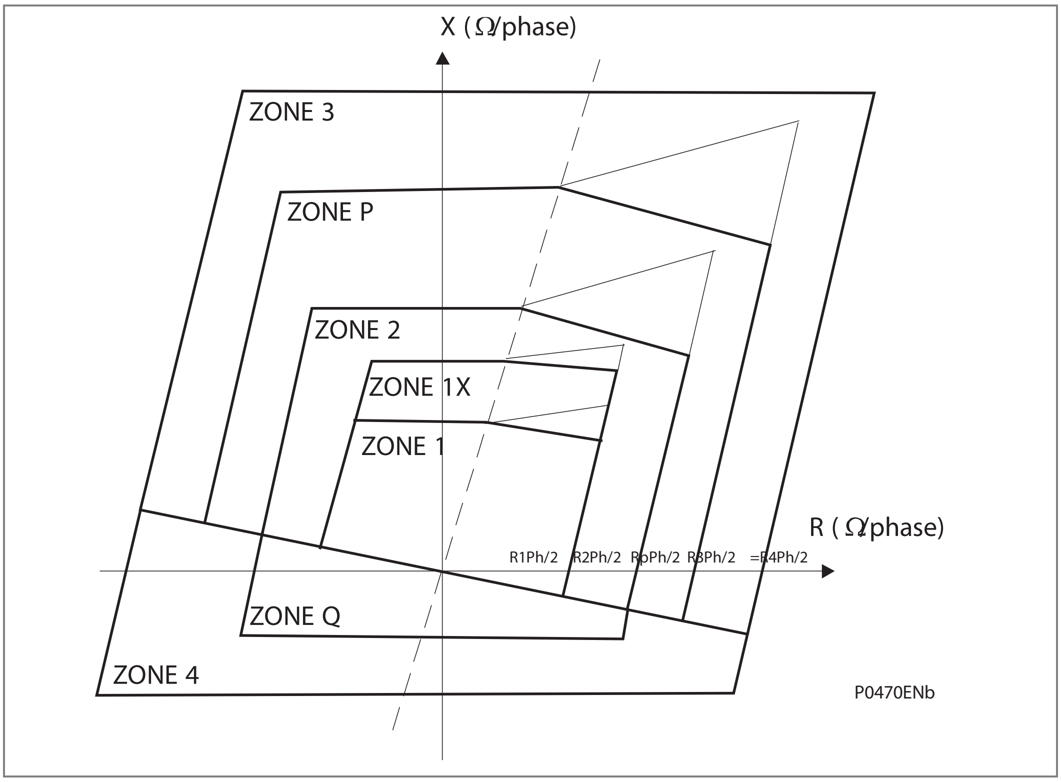


Figure 19 – Phase/phase Fault Quadrilateral Characteristics (Ω/phase scheme)

Note 1	*Z1 (zone 1) is programmed in ohm/loop.* *R limit setting is in ohms* <u>*loop and Z limit setting is in ohms phase*</u>*.*
Note 2	*In a Ω/phase scheme, R must be divided by 2 (for a phase/phase diagram).*
Note 3	*The angle of the start element (Quad) is the angle of the positive impedance of the line (settable).*
Note 4	*TILT angle protection is only applied with conventional protection*

The earth fault characteristic is illustrated with the following impedance plot:

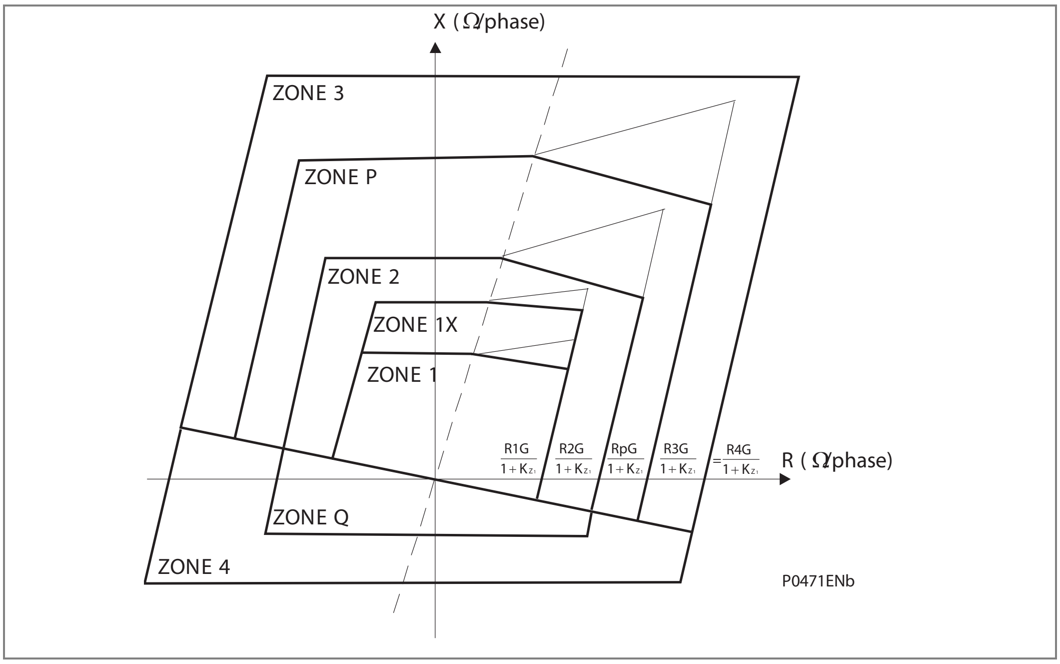


Figure 20 – phase/ground Fault Quadrilateral Characteristics (Ω/phase scheme)

Note 1	*In a Ω/phase scheme, R must be divided by 1+K_Z (for a phase/ground diagram.*
Note 2	*The angle of the start element (Quad) is the angle of the $2Z_1+Z_0$ (Z_1: positive sequence Z, Z_0: zero sequence Z).*

3.1.2.1.1 Setting

"Zone Setting" menu is used to activate or deactivate individually the 6 zones. The following text will help you to set the zones:

- The zone 1 elements of a distance relay should be set to cover as much of the protected line as possible, allowing instantaneous tripping for as many faults as possible. In most applications the zone 1 reach (Z1) should not be able to respond to faults beyond the protected line. For an underreaching application the zone 1 reach must therefore be set to account for any possible overreaching errors. These errors come from the relay, the VTs and CTs and inaccurate line impedance data. It is therefore recommended that the reach of the zone 1 distance elements is restricted to 80 - 85% of the protected line impedance (positive phase sequence line impedance), with zone 2 elements set to cover the final 20% of the line. (Note: Two of the channel aided distance schemes described later, schemes POP Z1 and BOP Z1 use overreaching zone 1 elements, and the previous setting recommendation does not apply).

- The zone 2 elements should be set to cover the 20% of the line not covered by zone 1. Allowing for underreaching errors, the zone 2 reach (Z2) should be set in excess of 120% of the protected line impedance for all fault conditions. Where aided tripping schemes are used, fast operation of the zone 2 elements is required. It is therefore beneficial to set zone 2 to reach as far as possible, such that faults on the protected line are well within reach. A constraining requirement is that, where possible, zone 2 does not reach beyond the zone 1 reach of adjacent line protection. Where this is not possible, it is necessary to time grade zone 2 elements of relays on adjacent lines. For this reason the zone 2 reach should be set to cover ≤50% of the shortest adjacent line impedance, if possible. When setting zone 2 earth fault elements on parallel circuits, the effects of zero sequence mutual coupling will need to be accounted for. The mutual coupling will result in the Zone 2 ground fault elements underreaching. To ensure adequate coverage an extended reach setting may be required, this is covered in the *Zone 1 Extension Scheme* section.
- The zone 3 elements would usually be used to provide overall back-up protection for adjacent circuits. The zone 3 reach (Z3) is therefore set to approximately 200% of the combined impedance of the protected line plus the longest adjacent line. A higher apparent impedance of the adjacent line may need to be allowed where fault current can be fed from multiple sources or flow via parallel paths.
- Zones p and q are reversible directional zones. The setting chosen for zone p (q), if used at all, will depend upon its application. Typical applications include its use as an additional time delayed zone or as a reverse back-up protection zone for busbars and transformers. Use of zone p(q) as an additional forward zone of protection may be required by some users to line up with any existing practice of using more than three forward zones of distance protection. Zone p(q) may also be useful for dealing with some mutual coupling effects when protecting a double circuit line, which will be discussed in the *Zone 1 Extension Scheme* section.
- The zone 4 elements would typically provide back-up protection for the local busbar, where the offset reach is set to 25% of the zone 1 reach of the relay for short lines (<30km) or 10% of the zone 1 reach for long lines. Setting zone 4 in this way would also satisfy the requirements for Switch on to Fault, and Trip on Reclose protection, as described in later sections. Where zone 4 is used to provide reverse directional decisions for Blocking or Permissive Overreach schemes, zone 4 must reach further behind the relay than zone 2 for the remote relay. This can be achieved by setting: Z4 ≥ ((Remote zone 2 reach) x 120%) minus the protected line impedance.

In order to understand the distance zones interactions, it should be considered:

- If Zp is a forward zone:
  - Z1 ⩽ Z2 < Zp < Z3
  - T1 < T2 < tZp < T3 (
  - R1G < R2G < RpG < R3G = R4G
  - R1Ph < R1extPh < R2Ph < RpPh < R3Ph

- If Zp is a reverse zone:
  - Z1 < Z2 < Z3
  - Zp > Z4
  - T1 < T2 < T3
  - tZp < T4
  - R1G < R2G < R3G
  - RpG < R3G = R4G
  - R1Ph < R2Ph < R3Ph
  - RpPh < R3Ph = R4Ph
  - $R3G < U_N / (1.2 \times \sqrt{3} I_N)$
  - $R3Ph < U_N / (1.2 \times \sqrt{3} I_N)$

Note 1	*If Z3 is disabled, the forward limit element becomes the smaller zone Z2 (or Zp if selected forward).*
Note 2	*If Z4 is disabled, the directional limit for the forward zone is 30°.*

3.1.2.1.2 Zone 1 Extension Scheme

Auto-reclosure is widely used on radial overhead line circuits to re-establish supply following a transient fault. A Zone 1 extension scheme may therefore be applied to a radial overhead feeder to provide high speed protection for transient faults along the whole of the protected line. The *Zone 1 Extension Scheme* diagram shows the alternative reach selections for zone 1: Z1 or the extended reach Z1X.

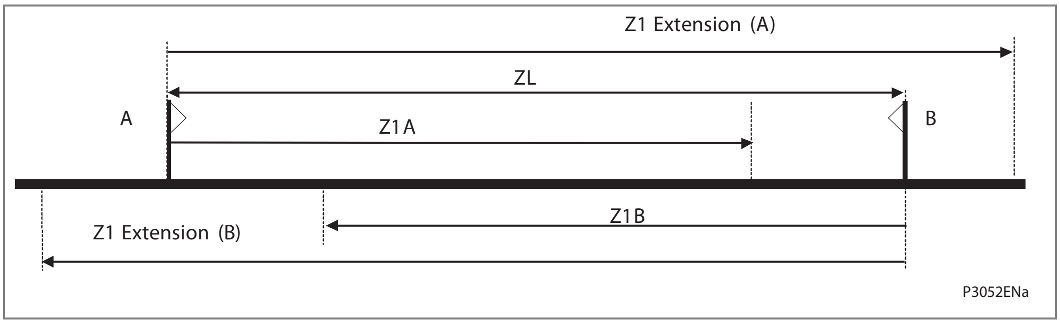


Figure 21 - Zone 1 Extension Scheme

Z1 < Z1X < Z2 or Z1 < Z2 < Z1X

(with Z1 < ZL < Z1X)

In this scheme, zone 1X is enabled and set to overreach the protected line. A fault on the line, including one in the end 20% not covered by zone 1, will now result in instantaneous tripping followed by autoreclosure. Zone 1X has resistive reaches and residual compensation similar to zone 1. The autorecloser in the relay is used to inhibit tripping from zone 1X such that upon reclosure the relay will operate with Basic scheme logic only, to co-ordinate with downstream protection for permanent faults. Thus, transient faults on the line will be cleared instantaneously, which will reduce the probability of a transient fault becoming permanent. The scheme can, however, operate for some faults on an adjacent line, although this will be followed by autoreclosure with correct protection discrimination. Increased circuit breaker operations would occur, together with transient loss of supply to a substation.

The time delays associated with extended zone Z1X are:

Scenario	Z1X Time delay
First fault trip	= tZ1
Fault trip for persistent fault on autoreclose	= tZ2

Table 1 - Trip Time Delays Associated with Zone 1X

The Zone 1 Extension scheme is selected by setting the **Z1X Enable** bit in the Zone Status (distance scheme menu) function links to 1.

Note	*To enable the Z1X logic (see the* ***Channel Aided Distance Scheme Logic*** *section), the DDB:* ***'Z1X extension'*** *cell must be linked in the PSL (to an opto input or to reclaim time…)*

3.1.2.1.3 Effects of Mutual Coupling on Distance Settings

Where overhead lines are connected in parallel or run in close proximity for the whole or part of their length, mutual coupling exists between the two circuits. The positive and negative sequence coupling is small and can be neglected. The zero sequence coupling is more significant and will affect relay measurement during earth faults with parallel line operation.

Zero sequence mutual coupling will cause a distance relay to underreach or overreach, depending on the direction of zero sequence current flow in the parallel line. However, it can be shown that this underreach or overreach will not affect relay discrimination during parallel line operation (ie. it is not be possible to overreach for faults beyond the protected line and neither will it be possible to underreach to such a degree that no zone 1 overlap exists). A channel-aided scheme will therefore still respond to faults within the protected line and remain secure during external faults. Some applications exist, however, where the effects of mutual coupling should be addressed.

3.1.2.1.4 Effect of Mutual Coupling on Zone 1 Setting:

For the case shown in the *Zone 1 Reach Considerations* diagram, where one circuit of a parallel line is out of service and earthed at both ends, an earth fault at the remote bus may result in incorrect operation of the zone 1 earth fault elements. It may be desirable to reduce the zone 1 earth loop reach for this application. This can be achieved using an alternative setting group within the relay, in which the residual compensation factor kZ1 is set to a lower value than normal (typically ≤ 80% of normal kZ1).

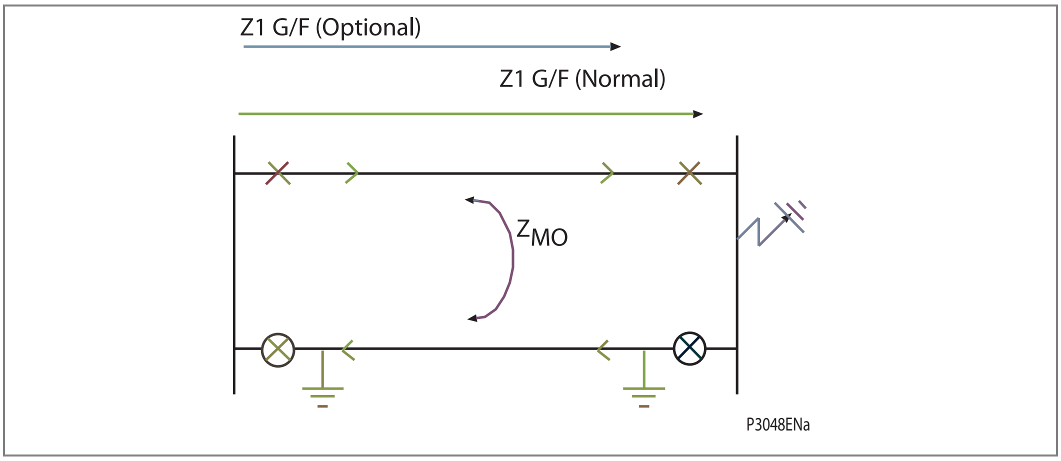


Figure 22 - Zone 1 Reach Considerations

3.1.2.1.5 Effect of Mutual Coupling on Zone 2 Setting:

If the double circuit line to be protected is long and there is a relatively short adjacent line, it is difficult to set the reach of the zone 2 elements to cover 120% of the protected line impedance for all faults, but not more than 50% of the adjacent line. This problem can be exacerbated when a significant additional allowance has to be made for the zero-sequence mutual impedance in the case of earth faults. For parallel circuit operation the relay Zone 2 earth fault elements will tend to underreach. Therefore, it is desirable to boost the setting of the earth fault elements such that they will have a comparable reach to the phase fault elements. Increasing the residual compensation factor kZ2 for zone 2 will ensure adequate fault coverage.

Under single circuit operation, no mutual coupling exists, and the zone 2 earth fault elements may overreach beyond 50% of the adjacent line, necessitating time discrimination with other Zone 2 elements. Therefore, it is desirable to reduce the earth fault settings to that of the phase fault elements for single circuit operation, as shown in the *Mutual Coupling Example - Zone 2 Reach Considerations* diagram. Changing between appropriate settings can be achieved by using the alternative setting groups available in the relay series relays.

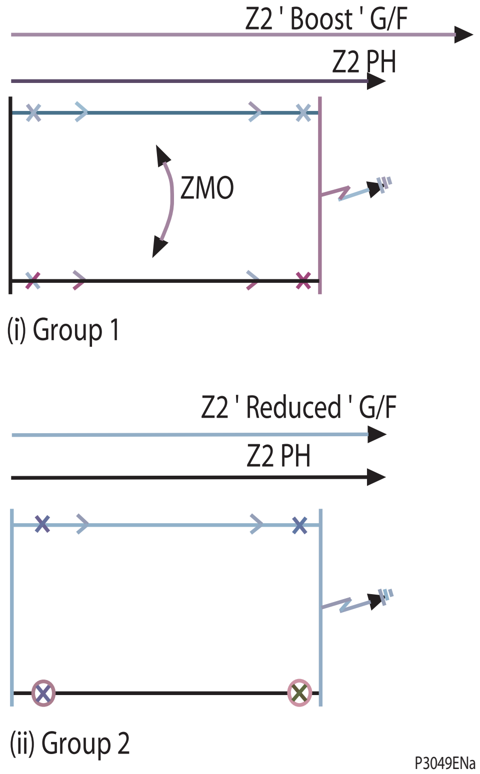


Figure 23 - Mutual Coupling Example - Zone 2 Reach Considerations

3.1.2.2 Zone Setting – KZ Residual Compensation for Earth Fault Elements and KZ Angle

The reaches of the earth fault elements use residual compensation of the corresponding phase fault reach. The residual compensation factors are:

- kZ1 - For zone 1 and zone 1X;
- kZ2 - For zone 2;
- kZ3/4 - Shared by zones 3 and 4;
- kZp - For zone p;
- kZq - For zone q.

For earth faults, residual current (derived as the vector sum of phase current inputs (Ia + Ib + Ic) is assumed to flow in the residual path of the earth loop circuit. Thus, the earth loop reach of any zone must generally be extended by a multiplication factor of (1 + kZ0) compared to the positive sequence reach for the corresponding phase fault element. kZ0 is designated as the residual compensation factor, and is calculated as:

kZ0 Res. Comp, $|kZ0| = (Z_0 - Z_1) / 3.Z_1$ Set as a ratio.

kZ0 Angle, $\angle kZ0 = \angle (Z_0 - Z_1) / 3.Z_1$ Set in degrees.

Where:

Z_1 = Positive sequence impedance for the line or cable;

Z_0 = Zero sequence impedance for the line or cable.

kZ0 CALCULATION DESCRIPTION

If we consider a phase to earth fault AN with analogue values VA and IA.

Using symmetrical components, VA is described as follows:
(1) VA = V1 + V2 + V0 = Z1I1 + Z2I2 + Z0I0

On a line or on a cable, Z2 = Z1. It results:
(2) VA = Z1 (I1 + I2) + Z0I0

We can write also: IA = I1 + I2 + I0
(3) (I1 + I2) = IA – I0

If equation (3) is combined with equation (2), we obtain:
(4) VA = Z1 (IA – I0) + Z0I0

The physical fault current is IR = 3I0. The equation (4) becomes:
VA = Z1 [IA – IR/3 + Z0IR/3Z1] = Z1 [IA + IR (Z0–Z1)/3Z1]

With: (Z0 – Z1)/3Z1 = kZ0
(5) VA = Z1 [IA + kZ0 IR]
(6) Z1 = VA/(IA + kZ0 IR)

Special cases:

Resistive fault where:
Rfault = fault resistance (loop) (Rfault = Rloop)
Ifault: current crossing the fault resistance

(7) VA = Z1 [IA + kZ0 IR] + Rfault . Ifault

(8) Z1 = (VA – Rfault . Ifault) / (IA + kZ0 IR)

Open line (Ifault = IR = IA):

(9) VA = Z1 . IA (1 + kZ0) + Rfault . IA

(10) Z1 = (VA / IA – Rfault) / (1 + kZ0)

The detected impedance will be:
Z = Z1 (1 + kZ0) + Rfault

This is the form used for the result of Z measured with an injector providing U, I, φ

Separate compensation for each zone (KZ1, KZ2, KZ3/4, KZp and KZq) allows more accurate earth fault reach control for elements which are set to overreach the protected line, such that they cover other circuits that may have different zero sequence to positive sequence impedance ratios (example: underground cable and overhead line in the protected line).

3.1.2.3 Zone Setting – Z

All phase or earth fault protection elements are quadrilateral shaped, and are directionalised as follows:

- Zones 1, 2 and 3 - Directional forward zones, as used in conventional three zone distance schemes. Note that Zone 1 can be extended to Zone 1X when required in zone 1 extension schemes.
- Zone p and q - Programmable. Selectable (Distance scheme\Fault type) as a directional forward or reverse zone.
- Zone 4 - Directional reverse zone. Note that zone 3 and zone 4 can be set with same Rloop value so as to provide a general start of the relay.

Note	*If any zone i presents an Rloop i greater than R3=R4, the limit of the start is always given by R3. See also the "Commissioning Test" section.*

3.1.2.4 Zone Setting – Resistive Reach Calculation

3.1.2.4.1 Resistive Reach Calculation – Phase Fault Element

Resistances are Set per Loop

The P441, P442 and P444 relays have quadrilateral distance elements, thus the resistive reach (RPh) is set independently of the impedance reach along the protected line/cable. RPh defines the maximum amount of fault resistance additional to the line impedance for which a distance zone will trip, regardless of the location of the fault within the zone. Thus, the right hand and left hand resistive reach constraints of each zone are displaced by +RPh and -RPh either side of the characteristic impedance of the line, respectively. RPh is generally set on a per zone basis, using R1Ph, R2Ph, RpPh and RqPh. Note that zones 3 and 4 share the resistive reach R3Ph-R4Ph.

When the relay is set in primary impedance terms, RPh must be set to cover the maximum expected phase-to-phase fault resistance. In general, RPh must be set greater than the maximum fault arc resistance for a phase-phase fault, e.g. calculated as follows:

$R_a = (28710 \times L) / I_f^{1.4}$

$RPh \geq R_a$

Where:

I_f = Minimum expected phase-phase fault current (A);

L = Maximum phase conductor spacing (m);

R_a = Arc resistance, calculated from the van Warrington formula (Ω).

Typical figures for R_a are given in the following table, for different values of minimum expected phase fault current.

Conductor spacing (m)	Typical system voltage (kV)	I_f = 1kA	I_f = 5kA	I_f = 10kA
2	33	3.6Ω	0.4Ω	0.2Ω
5	110	9.1Ω	1.0Ω	0.4Ω
8	220	14.5Ω	1.5Ω	0.6Ω

Table 2 - Typical Arc Resistances Calculated Using the van Warrington Formula

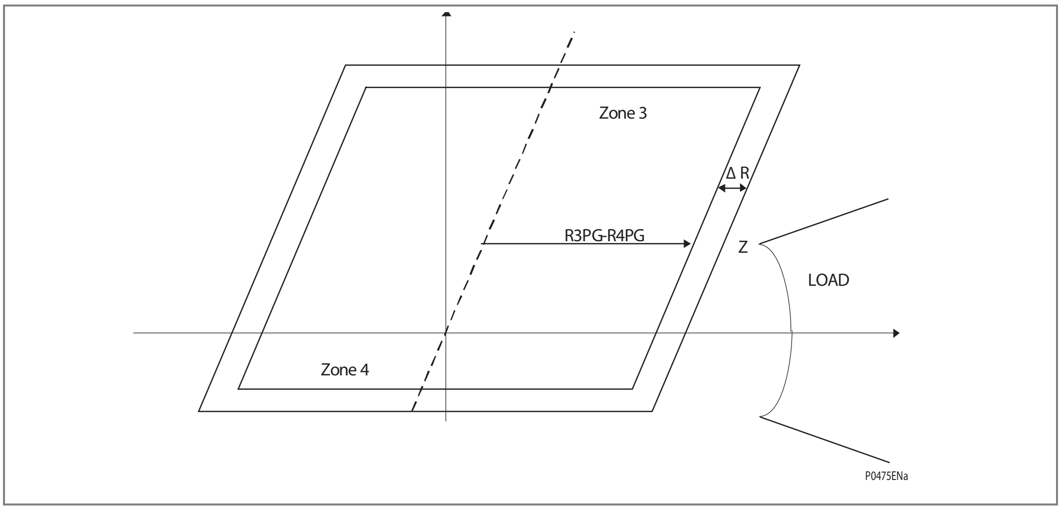


Figure 24 - Resistive Reaches for Load Avoidance

As shown in the above diagram, R3Ph-R4Ph is set such as to avoid point Z by a suitable margin. Zone 3 must never reach more than 80% of the distance from the line characteristic impedance (shown dotted), towards Z. However, where power swing blocking is used, a larger impedance (including ΔR) characteristic surrounds zones 3 and 4, and it is essential also that load does not encroach upon this characteristic. For this reason, R3Ph would be set ≤ 60% of the distance from the line characteristic impedance towards Z. A setting between the calculated minimum and maximum should be applied.

R/Z ratio: For best zone reach accuracy, the resistive reach of each zone would not normally be set greater than 10 times the corresponding zone reach. This avoids relay overreach or underreach where the protected line is exporting or importing power at the instant of fault inception. The resistive reach of any other zone cannot be set greater than R3Ph, and where zone 4 is used to provide reverse directional decisions for Blocking or Permissive Overreach schemes, the zone 2 elements used in the scheme must satisfy R2Ph ≤ (R3Ph-R4Ph) x 80%.

3.1.2.4.2 Resistive Reach Calculation – Earth Fault Element

The resistive reach setting of the relay earth fault elements (RG) should be set to cover the desired level of earth fault resistance, but to avoid operation with minimum load impedance. Fault resistance would comprise arc-resistance and tower footing resistance. In addition, for best reach accuracy, the resistive reach of any zone of the relay would not normally be greater than 10 times the corresponding earth loop reach.

Expert Section

As shown in the *Resistive Reaches for Load Avoidance* diagram, R3G – R4G is set such as to avoid point Z (minimum load impedance) by a suitable margin.

R3G – R4G ≤ 80% Z minimum load impedance

$$\leq 80\% \ \frac{\text{Umin}/\sqrt{3;1}}{2 \times \text{Imax}}$$

- Vmin: minimum phase/phase voltage in normal conditions without fault
- Imax: maximum load current in normal conditions without fault

However, where Power swing blocking is used, a larger impedance surrounds zone 3 and zone 4, and it is also essential for the load not to encroach upon the characteristic.

The earth detection criteria (10% IN + 5% IphaseMax) blocks the relay starting if residual current is not detected (it secures the relay in case of load encroachment for Delta algorithms).

When Phase-Phase detectors are used, phase ground start could be higher compared to previous version, because ΔR is only applied to the phase-phase loops.

[(R3G – R4G) – ΔR] $\leq$ 80% Z min load

With ΔR = 0,032 x Δf x R load min
Δf: power swing frequency
R load min: minimum load resistance

A typical resistive reach coverage would be 40Ω on the primary system. The same load impedance as in the *Resistive Reach Calculation – Phase Fault Element* section must be avoided. Thus R3G is set such as to avoid point Z by a suitable margin. Zone 3 must never reach more than 80% of the distance from the line characteristic impedance (shown as dotted line in Figure 3), towards Z.
For high resistance earth faults, the situation may arise where no distance elements could operate. In this case it will be necessary to provide supplementary earth fault protection, for example using the relay Channel Aided DEF protection.

3.1.2.5 Zone Setting – Zone Time Delay

(initiated with CVMR (General Start Convergency))

- The zone 1 time delay (tZ1) is generally set to zero, giving instantaneous operation. However, a time delay might be employed in cases where a large transient DC component is expected in the fault current, and older circuit breakers may be unable to break the current until zero crossings appear.
- The zone 2 time delay (tZ2) is set to co-ordinate with zone 1 fault clearance time for adjacent lines. The total fault clearance time will consist of the downstream zone 1 operating time plus the associated breaker operating time. Allowance must also be made for the zone 2 elements to reset following clearance of an adjacent line fault and also for a safety margin. A typical minimum zone 2 time delay is of the order of 200ms. This time may have to be adjusted where the relay is required to grade with other zone 2 protection or slower forms of back-up protection for adjacent circuits.
- The zone 3, zone P or zone Q time delays (tZ3, tZp, tZq) are typically set with the same considerations made for the zone 2 time delay, except that the delay needs to co-ordinate with the downstream zone 2 fault clearance (or reverse busbar protection fault clearance). A typical minimum operating time would be about 400ms. Again, this may need to be modified to co-ordinate with slower forms of back-up protection for adjacent circuits.
- The zone 4 time delay (tZ4) needs to co-ordinate with any protection for adjacent lines in the relay's reverse direction. If zone 4 is required merely for use in a Blocking scheme, tZ4 may be set high.

Remark	**The DDBs corresponding to "tZi" (for zone i) time-delays are noted "Ti" in the PSL.**

The following conventional rules are applied:

- Distance timers are initiated as soon as the relay has picked up – CVMR pickup distance (**CVMR = Start & Convergence**)
- The minimum tripping time even with carrier receive is T1.
  This applies only for standard distance scheme, while in teleprotection schemes minimum tripping time is separately settable.
- Zone 4 is always reverse

3.1.3 Fault Locator

The relay has an integral fault locator that uses information from the current and voltage inputs to provide a distance to fault measurement. When the fault calculation is complete the fault location information is available in the relay fault record.

When applied to parallel circuits, mutual flux coupling (in the *Effects of Mutual Coupling on Distance Settings* section) can alter the impedance seen by the fault locator. The coupling will contain positive, negative and zero sequence components. In practice the positive and negative sequence coupling is insignificant. The effect on the fault locator of the zero sequence mutual coupling can be eliminated by using the mutual compensation feature provided. This requires that the residual current on the parallel line is measured. It is extremely important that the polarity of connection for the mutual CT input is correct, as shown.

The system assumed for the distance protection worked example will be used here, refer to the *Power Swing* section. The Green Valley – Blue River line is considered.

Line length: 100km

CT ratio: 1 200 / 5

VT ratio: 230 000 / 115

Line impedances: Z_1 = $0.089 + j0.476 = 0.484 / \underline{79.4°}\ \Omega/km$

ZM_0 = $0.107 + j0.571 = 0.581 / \underline{79.4°}\ \Omega/km$ (Mutual)

Ratio of secondary to primary impedance = $\frac{1200 / 5}{230000 / 115} = 0.12$

Line Impedance = $100 \times 0.484 / \underline{79.4°} \times 0.12$

= $5.81 / \underline{79.4°}\ \Omega$ secondary.

Relay Line Angle settings 0° to 360° in 1° steps. Therefore, select Line Angle = 80° for convenience.

Therefore set Line Impedance and Line Angle: = $5.81 / \underline{80°}\ \Omega$ (secondary).

No residual compensation needs to be set for the fault locator, as the relay automatically uses the kZ0 factor applicable to the distance zone which tripped.

Should a CT residual input be available for the parallel line, mutual compensation could be set as follows:

kZm Mutual Comp, $|kZm|$ = $ZM_0 / 3.Z_1$ Ie: As a ratio.

kZm Angle, $\angle kZm$ = $\angle ZM_0 / 3.Z_1$ Set in degrees.

The CT ratio for the mutual compensation may be different from the Line CT ratio. However, for this example we will assume that they are identical.

kZm = $ZM_0 / 3.Z_1$ = $0.581 / \underline{79.4°} / (3 \times 0.484 / \underline{79.4°})$

= $0.40 / \underline{0°}$

Therefore set **kZm Mutual Comp** = 0.40

kZm Angle = 0°

3.1.4 Smart Zone Alarm

The “Smart Zone” alarm (software version D6.x) setting is designed to give an alarm when the load impedance is too near to the start characteristic.

If a biphase loop is detected in the “On Load Zone” during 20 ms, an alarm is raised (alarm remains ‘unlatched’). This alarm will appear in the events file. The DDB ‘**On load Alarm**’ corresponds to the

“Smart Zone” alarm detection is based on the 3 biphase loops calculated by the distance algorithms and the phase to phase resistance limit. If the current is under 0.1×In, the loop is considered as external.

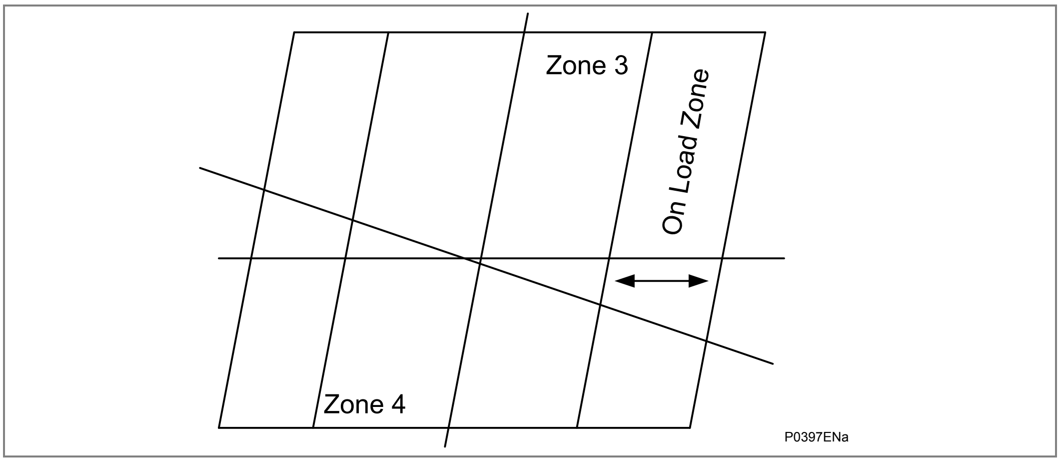


Figure 25 – Smart ZONE ALARM

The biphased loops are compared to R3Ph and (R3Ph + R3Ph × "Smart Zone" setting). If the loop is between the two values, and if no biphased loop is in the distance characteristic, an alarm is suspected.

If neither residual current nor negative sequence current is measured, "Smart Zone" alarm detection is only measured with on load current (that means calculation is not distorted by a current due to a fault). In this case, when alarm is suspected, the "On Load Alarm" is reached.

The "Smart Zone" can be set from 0 % to 100 % (menu 'DISTANCE').

3.2 Channel Aided Distance Schemes

The following diagram gives the logic of the distance protection:

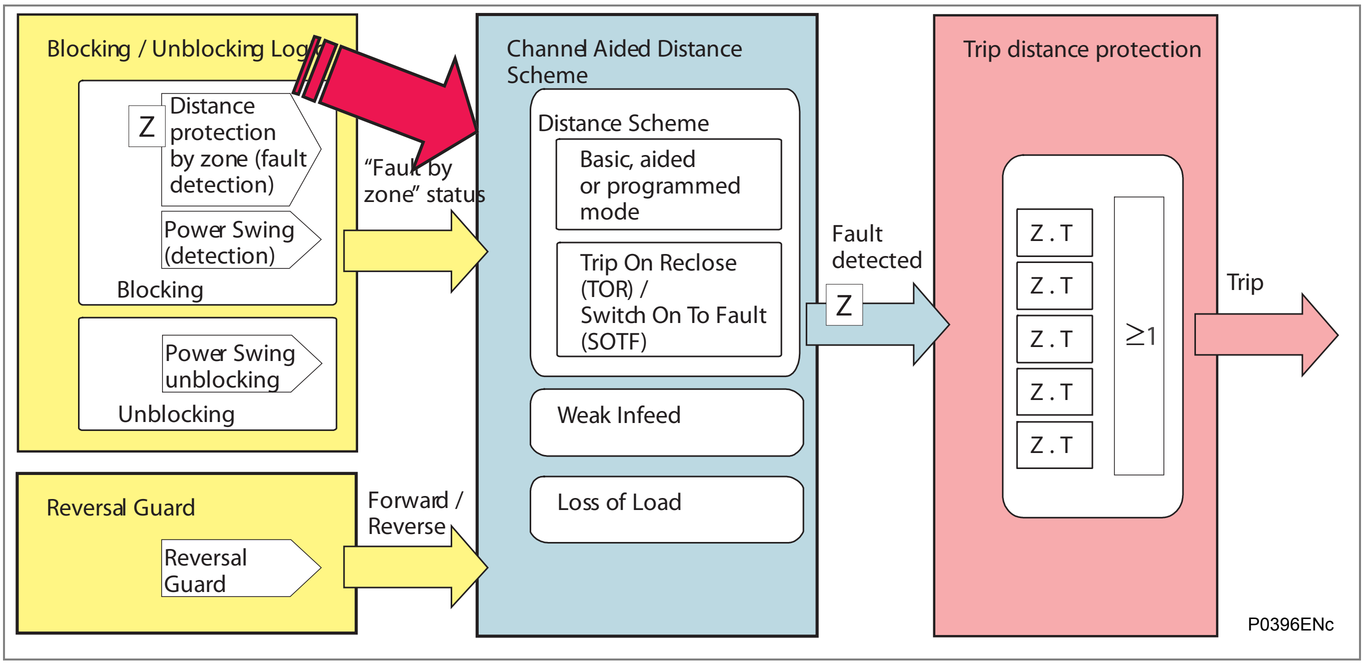


Figure 26 – Channel aided distance scheme in the Distance protection diagram

This section details the "Channel Aided Distance scheme" path.

The blocking / unblocking logic with power swing manages the distance protection logic.

- If enabled, the unblocking function carries out a function similar to Carrier receive logic,
- Weak infeed allows for the case where there may be no zone pick up from local end,
- TOR & SOTF (Trip On Reclose and Switch On To Fault) applies specific logic in case of manual closing or AR closing logic,
- Trip Distance Protection issues the trip order according to the distance algorithm outputs, the type of trip 1P (1-phase) or 3P (3-phases), the distance timers, and the logic data such as power swing blocking,
- Loss of Load manages a specific logic for tripping 3P in accelerated Z2 in the absence of a carrier,

This section details the scheme configuration of the distance protection.

3.2.1 Standard Scheme

The following channel aided distance tripping schemes are available when the Standard program mode is selected:

- Basic (+ zone 1 extended) schemes,
- Permissive Underreach Transfer Trip Schemes PUP Z2 and PUP Fwd;
- Permissive Overreach Transfer Trip Schemes POP Z2 and POP Z1;
- Weak infeed logic to supplement permissive overreach schemes;
- Unblocking logic to supplement permissive schemes;
- Blocking Schemes BOP Z2 and BOP Z1;
- Current reversal guard logic to prevent maloperation of any overreaching zone used in a channel aided scheme, when fault clearance is in progress on the parallel circuit of a double circuit line.

3.2.1.1 Standard Mode: Basic

The Basic distance scheme is suitable for applications where no signalling channel is available. Zones 1, 2 and 3 are set as described in this section. In general, zones 1 and 2 provide main protection for the line or cable as shown below, with zone 3 reaching further to provide back up protection for faults on adjacent circuits.

Figure 27 - Main Protection in the Basic Scheme (no Requirement for Signalling Channel)

Key:

A, B = Relay locations
ZL = Impedance of the protected line.

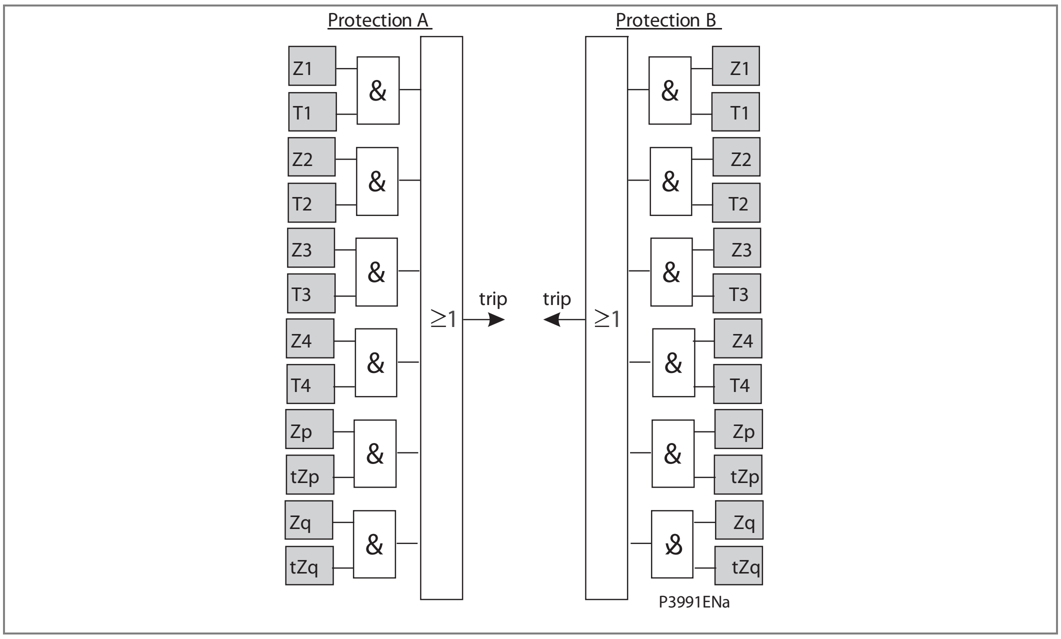


Figure 28 - Logic Diagram for the Basic Scheme

The *Main Protection in the Basic Scheme (no Requirement for Signalling Channel)* diagram shows the tripping logic for the Basic scheme. Note that for the P442 and P444 relays, Zone time-delays are started at the instant of fault detection (T1 to T4, tZp and tZq start at the end of this time delay). Protection zones are stabilised to avoid maloperation for transformer magnetising inrush current. The method used to achieve stability is based on second harmonic current detection.

The Basic scheme incorporates the following features:

- Instantaneous zone 1 tripping. Alternatively, zone 1 can have an optional time delay of 0 to 10s.
- Time delayed tripping by zones 2, 3, 4, p and q. Each with a time delay set between 0 and 10s.

The Basic scheme is suitable for single or double circuit lines fed from one or both ends. The limitation of the Basic scheme is that faults in the end 20% sections of the line will be cleared after the zone 2 time delay. Where no signalling channel is available, then improved fault clearance times can be achieved through the use of a zone 1 extension scheme or by using loss of load logic, as described below. Under certain conditions however, these two schemes will still result in time delayed tripping. Where high speed protection is required over the entire line, then a channel aided scheme will have to be employed.

3.2.1.2 Permissive Underreach Transfer Trip Schemes PUP Z2 and PUP Fwd

To provide fast fault clearance for all faults, both transient and permanent, along the length of the protected circuit, it is necessary to use a signal aided tripping scheme. The simplest of these is the Permissive Underreach Protection (PUP) scheme, of which two variants are offered in the P442 and P444 relays. The channel for a PUP scheme is keyed by operation of the underreaching zone 1 elements of the relay. If the remote relay has detected a forward fault upon receipt of this signal, the relay will operate with no additional delay. Faults in the last 20% of the protected line are therefore cleared with no intentional time delay.

Listed below are some of the main features/requirements for a permissive underreaching scheme:

- Only a simplex signalling channel is required.
- The scheme has a high degree of security since the signalling channel is only keyed for faults within the protected line.
- If the remote terminal of a line is open then faults in the remote 20% of the line will be cleared via the zone 2 time delay of the local relay.
- If there is a weak or zero infeed from the remote line end, (ie. current below the relay sensitivity), then faults in the remote 20% of the line will be cleared via the zone 2 time delay of the local relay.
- If the signalling channel fails, Basic distance scheme tripping will be available.

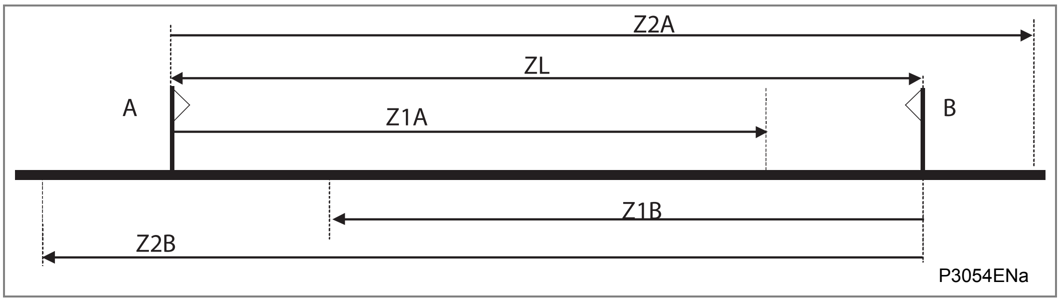


Figure 29 - Zone 1 and 2 Reaches for Permissive Underreach Schemes

3.2.1.2.1 Permissive Underreach Protection, Accelerating Zone 2 (PUP Z2)

This scheme allows an instantaneous Z2 trip on receipt of the signal from the remote end protection. The *PUP Z2 Permissive Underreach Scheme* diagram shows the simplified scheme logic.

Send logic: Zone 1

Permissive trip logic: Zone 2 plus Channel Received.

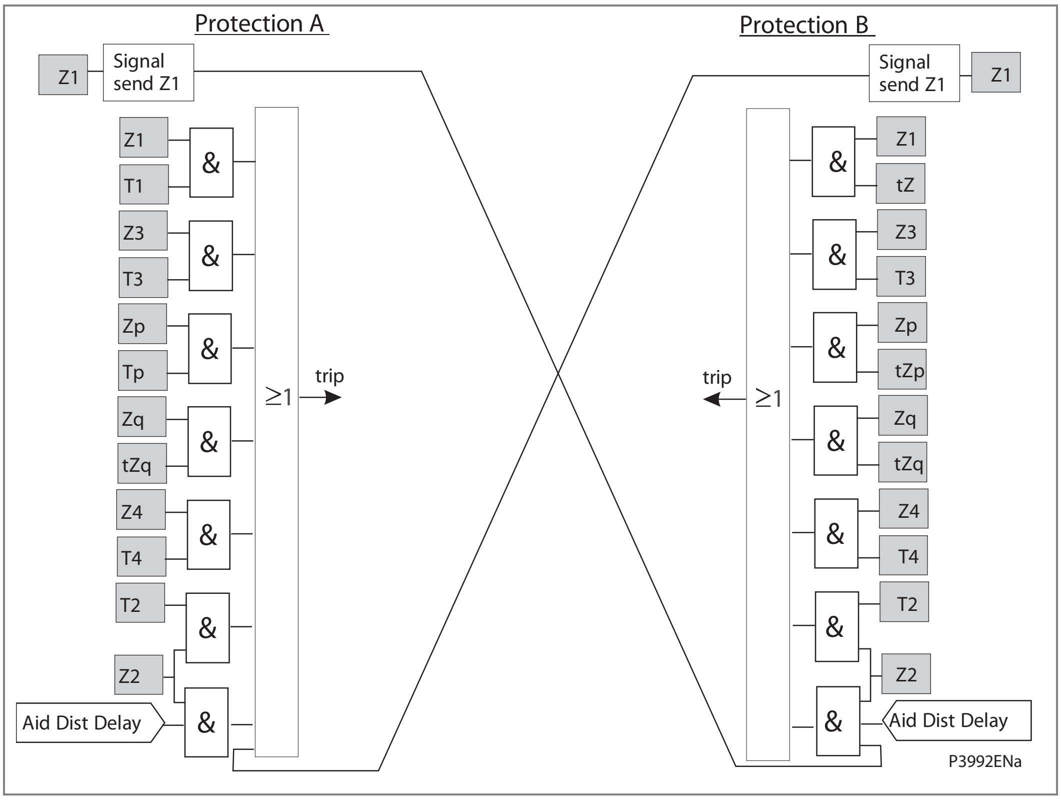


Figure 30 - PUP Z2 Permissive Underreach Scheme

Trip logic:

IEC Standard		Carrier Send	Trip Logic	Application	User setting
448.15.13	PUR or AUP	Z1	Z2.CR.'Aid Dist Delay' + Z1.T1 + Z2.T2 + Z3.T3...	Z1 = 80% ZL	PUP Z2

3.2.1.2.2 Permissive Underreach Protection Tripping via Forward Start (PUP Fwd)

This scheme allows an instantaneous Z2 or Z3 trip on receipt of the signal from the remote end protection. The *PUP Fwd Permissive Underreach Scheme* diagram shows the simplified scheme logic.

If the remote relay has picked up in a forward zone and the underimpedance element has started, then it will trip after the transmission time delay ('Distance schemes / Aid Dist Delay' setting) upon reception of the permissive signal from the other end of the line.

Send logic: Zone 1

Permissive trip logic: Underimpedance Start within any Forward Distance Zone, plus Channel Received.

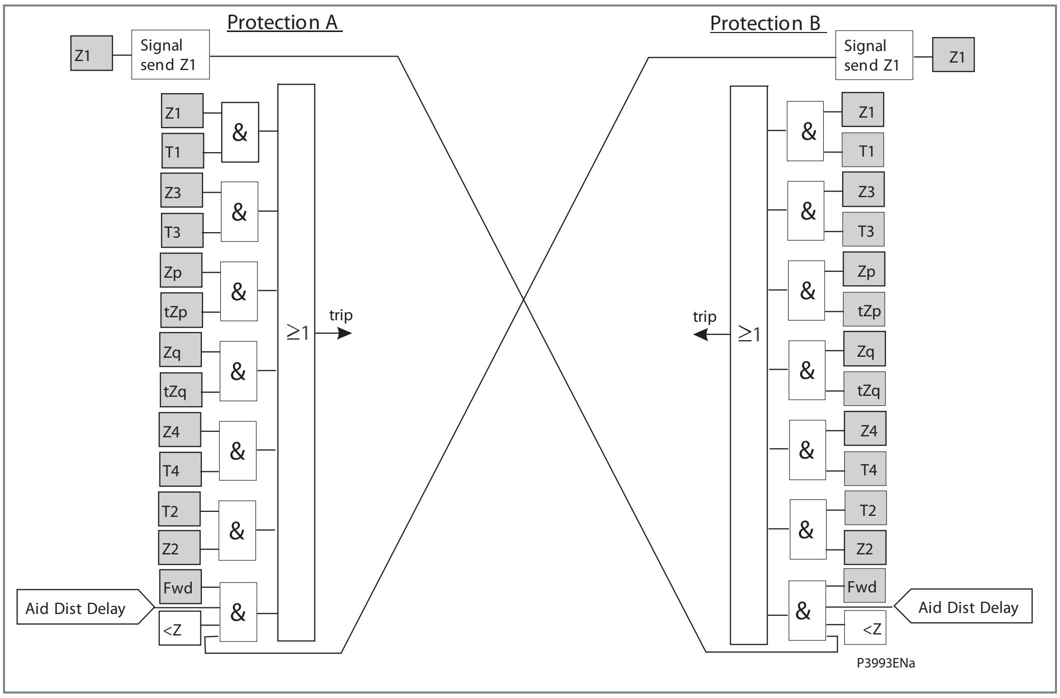


Figure 31 - PUP Fwd Permissive Underreach Scheme

Key:

Fwd = Forward fault detection (DDB: '**Dist Fwd**' or '**DEF Fwd**');

<Z = Underimpedance Started: Z2 or Z3.

Trip logic:

IEC Standard		Carrier Send	Trip Logic	Application	User setting
448.15.11	PUP or PUTT	Z1	Fwd.CR.'Aid Dist Delay' + Z1.T1 + Z2.T2 +...	Z1 = 80% ZL	PUP Fwd

3.2.1.3 Permissive Overreach Transfer Trip Schemes POP Z2 and POP Z1

- The P442 and P444 relays offer two variants of Permissive Overreach Protection (POP) schemes, having the following common features/requirements:
- The scheme requires a duplex signalling channel to prevent possible relay maloperation due to spurious keying of the signalling equipment. This is necessary due to the fact that the signalling channel is keyed for faults external to the protected line.
- The POP Z2 scheme may be more advantageous than permissive underreach schemes for the protection of short transmission lines, since the resistive coverage of the Zone 2 elements may be greater than that of the Zone 1 elements.
- Current reversal guard logic is used to prevent healthy line protection maloperation for the high speed current reversals experienced in double circuit lines, caused by sequential opening of circuit breakers.
- If the signalling channel fails, Basic distance scheme tripping will be available.

3.2.1.3.1 Permissive Overreach Protection with Overreaching Zone 2 (POP Z2)

The *Main Protection in the POP Z2 Scheme* diagram shows the zone reaches. The *Logic Diagram for the POP Z2 Scheme* shows the simplified scheme logic. The signalling channel is keyed from operation of the overreaching zone 2 elements of the relay. If the remote relay has picked up in zone 2, then it will operate with no additional delay upon receipt of this signal. The POP Z2 scheme also uses the reverse looking zone 4 of the relay as a reverse fault detector. This is used in the current reversal logic and in the optional weak infeed echo feature.

The signaling channel is keyed from operation of zone 2 elements of the relay. If the remote relay has picked up in zone 2, then it will operate with Transmission Time (‘Distance schemes / Aid Dist Delay’) delay upon reception of the permissive signal.

Send logic: Zone 2

Permissive trip logic: Zone 2 plus Channel Received.

Figure 32 - Main Protection in the POP Z2 Scheme

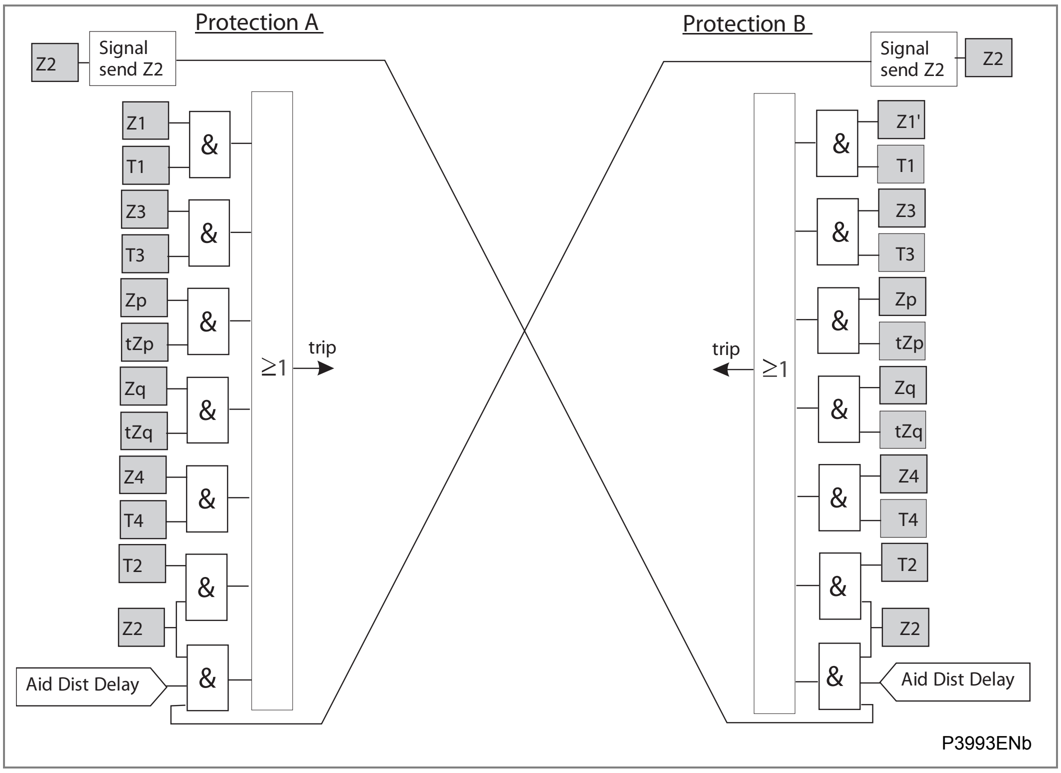


Figure 33 - Logic Diagram for the POP Z2 Scheme

Trip logic:

IEC Standard		Carrier Send	Trip Logic	Application	User setting
	PUR2 or POR2	Z2	Z2.CR.’Aid Dist Delay’ + Z1.T1 + Z2.T2 + Z3.T3...	Z1 = 80% ZL	POP Z2

3.2.1.3.2 Permissive Overreach Protection with Overreaching Zone 1 (POP Z1)

The *Main Protection in the POP Z1 Scheme* diagram shows the zone reaches. The *Logic Diagram for the POP Z1 Scheme* diagram shows the simplified scheme logic. The signalling channel is keyed from operation of zone 1 elements set to overreach the protected line. If the remote relay has picked up in zone 1, then it will operate with no additional delay upon receipt of this signal. The POP Z1 scheme also uses the reverse looking zone 4 of the relay as a reverse fault detector. This is used in the current reversal logic and in the optional weak infeed echo feature.

NOTE	*Should the signalling channel fail, the fastest tripping in the Basic scheme will be subject to the tZ2 time delay.*

The signaling channel is keyed from operation of zone 1 elements set to overreach the protected line. If the remote relay has picked up in zone 1, then it will operate with Transmission Time ('Distance schemes / Aid Dist Delay') delay upon reception of the permissive signal.

Send logic: Zone 1

Permissive trip logic: Zone 1 plus Channel Received.

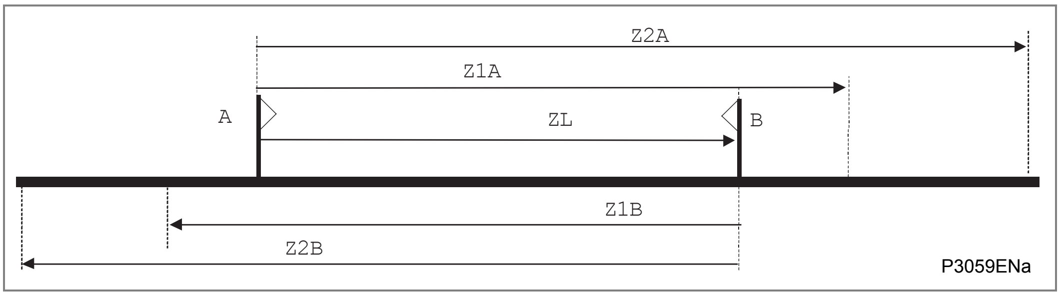


Figure 34 - Main Protection in the POP Z1 Scheme

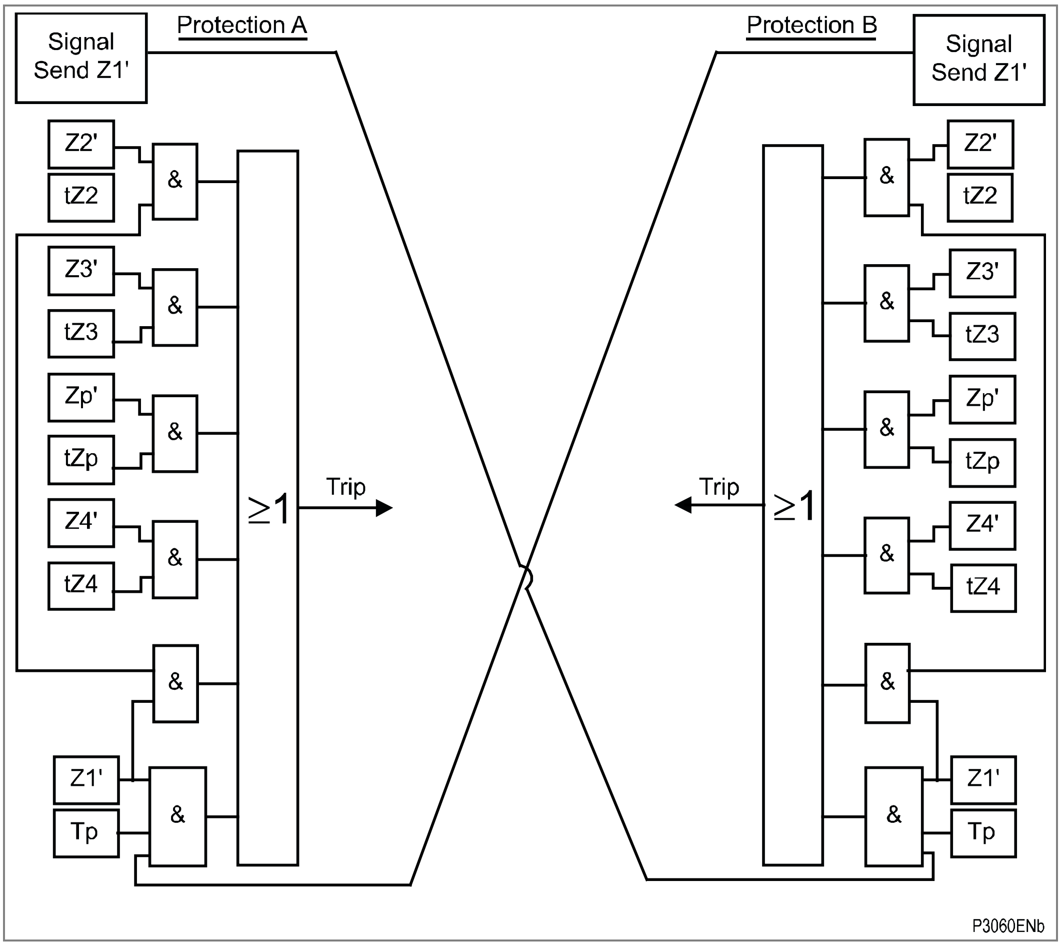


Figure 35 - Logic Diagram for the POP Z1 Scheme

Trip logic:

IEC Standard		Carrier Send	Trip Logic	Application	User setting
448.15.16	POR1 or POP or POTT	Z1	Z1.CR.'Aid Dist Delay' + Z1.T2 + Z2.T2 + Z3.T3...	Z1 > ZL	POP Z1

3.2.1.4 Blocking Schemes BOP Z2 and BOP Z1

The P442 and P444 relays offer two variants of Blocking Overreach Protection (BOP) schemes. With a blocking scheme, the signalling channel is keyed from the reverse looking zone 4 element, which is used to block fast tripping at the remote line end.

Features are as follows:

- BOP schemes require only a simplex signalling channel.
- Reverse looking Zone 4 is used to send a blocking signal to the remote end to prevent unwanted tripping.
- When a simplex channel is used, a BOP scheme can easily be applied to a multi-terminal line provided that outfeed does not occur for any internal faults.
- The blocking signal is transmitted over a healthy line, and so there are no problems associated with power line carrier signalling equipment.
- BOP schemes provide similar resistive coverage to the permissive overreach schemes.
- Fast tripping will occur at a strong source line end, for faults along the protected line section, even if there is weak or zero infeed at the other end of the protected line.
- If a line terminal is open, fast tripping will still occur for faults along the whole of the protected line length.
- If the signalling channel fails to send a blocking signal during a fault, fast tripping will occur for faults along the whole of the protected line, but also for some faults within the next line section.
- If the signalling channel is taken out of service, the relay will operate in the conventional Basic mode.
- A current reversal guard timer is included in the signal send logic to prevent unwanted trips of the relay on the healthy circuit, during current reversal situations on a parallel circuit.

To allow time for a blocking signal to arrive, a short time delay on aided tripping, Aided distribution transmission delay time, must be used, as follows:

- Recommended ‘Aid Dist Delay’ setting: Max. signalling channel operating time + 14ms.

3.2.1.4.1 Blocking Overreach Protection with Overreaching Zone 1 (BOP Z1)

This scheme is similar to that used in the Schneider Electric EPAC and PXLN relays. The *Main Protection in the BOP Z1 Scheme* diagram shows the zone reaches, and the *Logic Diagram for the BOP Z1 Scheme* diagram the simplified scheme logic. The signalling channel is keyed from operation of the reverse zone 4 elements of the relay. If the remote relay has picked up in overreaching zone 1, then it will operate after the Transmission Time (‘Distance schemes / Aid Dist Delay’) time-delay if no block is received.

Note	The fastest tripping is always subject to the aided distance time-delay (‘Aid Dist Delay’).

Send logic: Reverse Zone 4

Trip logic: Zone 1, plus Channel NOT Received, delayed by ‘Aid Dist Delay’.

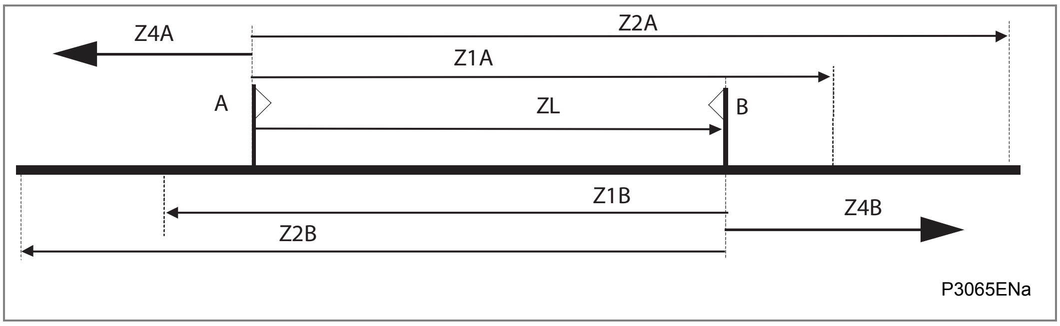


Figure 36 - Main Protection in the BOP Z1 Scheme

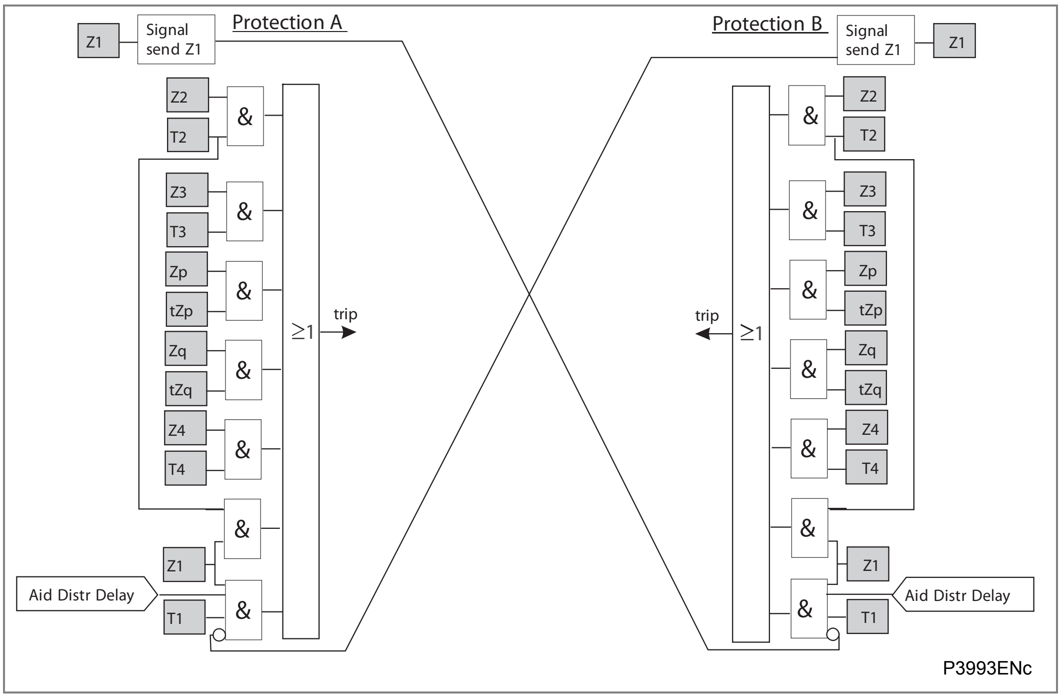


Figure 37 - Logic Diagram for the BOP Z1 Scheme

Trip logic:

IEC Standard		Carrier Send	Trip Logic	Application	User setting
448.15.14	BOR1 or BOP	Z4	Z1.$\overline{\text{CR}}$.T1.'Aid Dist Delay' + Z1.T2 + Z2.T2 + Z3.T3...	Z1 > ZL	BOP Z1

3.2.1.4.2 Blocking Overreach Protection with Overreaching Zone 2 (BOP Z2)

The *Main Protection in the BOP Z2 Scheme* diagram shows the zone reaches, and the *Logic Diagram for the BOP Z2 Scheme* diagram the simplified scheme logic. The signalling channel is keyed from operation of the reverse zone 4 elements of the relay. If the remote relay has picked up in zone 2, then it will operate after the aided distribution time-delay if no block is received.

Send logic: Reverse Zone 4

Trip logic: Zone 2, plus Channel NOT Received, delayed by 'Aid Dist Delay'.

Figure 38 - Main Protection in the BOP Z2 Scheme

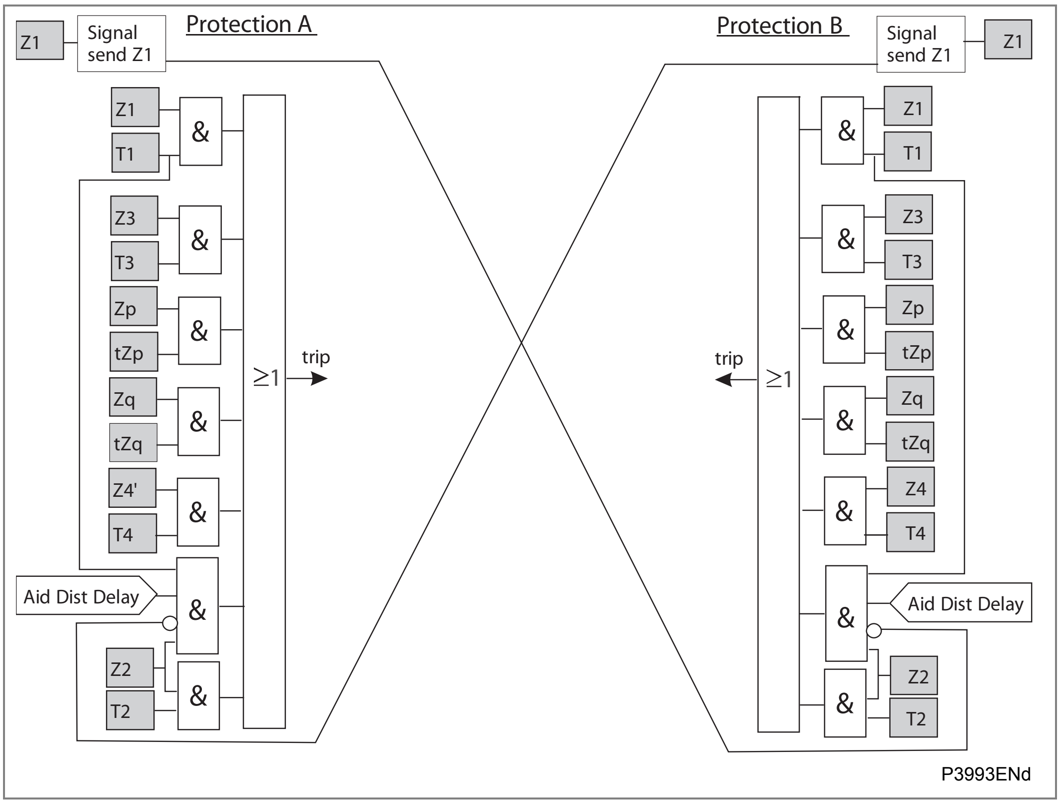


Figure 39 - Logic Diagram for the BOP Z2 Scheme

Trip logic:

IEC Standard		Carrier Send	Trip Logic	Application	User setting
	BOR2 or BLOCK2	Z4	Z2. $\overline{CR}$ .T1. 'Aid Dist Delay' + Z1.T1 + Z2.T2 + Z3.T3...	Z1 = 80% ZL	BOP Z2

3.2.2 Trip Mode

The tripping mode is settable using the following modes:

- **Force 3 Poles**: three-pole trip (in all cases)
- **1 Pole Z1 & CR**: single pole trip at T1 when a fault is detected in zone 1 (Z1) or at CR (Carrier Receive) reception. Otherwise, three pole trip.
- **1 Pole Z1 Z2 & CR**: single pole trip at T1 when a fault is detected in zone 1 (Z1) or in zone 2, or at CR (Carrier Receive) reception. Otherwise, three pole trip.

The following table summarizes the tripping zones:

Tripping mode	T1	T2	Tzp	T3	T4
1 Pole Z1 Z2 & CR	1P	1P	3P	3P	3P
1 Pole Z1 & CR	1P	3P	3P	3P	3P
Force 3 Poles	3P	3P	3P	3P	3P

1P: 1-pole trip , 3P: 3-pole trip.
T1…T4: End of distance time-delay for the zone

Several preset aided trip logic schemes can be selected or an open logic scheme can be designed by user.

3.2.3 Carrier Send Zone (Open Scheme)

When a fault is detected in zone 1 or zone 2, the CsZ1 or CsZ2 (Carrier Sent by Zone 1 or 2) signal is emitted from the zone to the relay. As shown in the following zone logic configuration diagram, zone 4, behind the relay, will provide a reverse directional decision faster than zone 2. So, the CsZ4 signal used for Carrier Send mode is a reverse signal.

The zone decision logic is described as below:

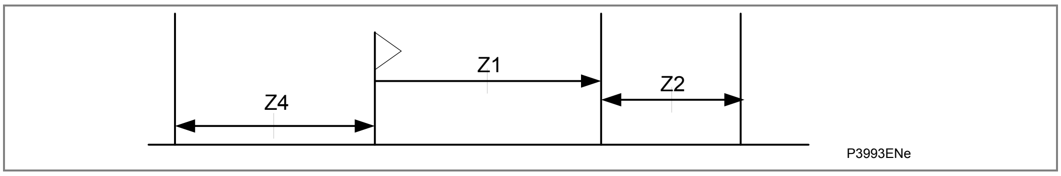


Figure 40 – "Carrier Send" zones

When a scheme is required which is not covered in the Standard modes above, the Open programming mode can be selected. The user then has the facility to decide which distance relay zone is to be used to key the signal, and what type of aided scheme runs when the signal is received.

Setting	Signal Send Zone	Function
None	No Signal Send	To configure a Basic scheme.
CsZ1	Zone 1	To configure a Permissive scheme.
CsZ2	Zone 2	To configure a Permissive scheme.
CsZ4	Zone 4	To configure a Blocking scheme.

Table 3 – Carrier Send Zones in Open Schemes

Carrier send can be triggered by Zone1 (CsZ1), Zone2 (CsZ2) or Zone4 (Reverse, CsZ4). The following decision logic

The "carrier send" signal drop off is time-delayed (10ms) in order to avoid an interaction with zone pick-up.

When activated, Z2 can overlap Z1. The following equation decribes the carrier send (CS) logic, including Weak Infeed Carrier Send (WI_CS) echo:

CS (Main channel Carrier send) = (Z1' + Z2').CsZ2 + Z1'.CsZ1 + Reverse.CsZ4 + WI_CS

Where:

- CsZ1, CsZ2 and CsZ4 = Carrier send for zone 1, zone 2 or zone 4,
- Reverse' = Reverse Fault detected,
- Z1 to Z4 = Zone 1 to 4 decision (blocked by Power swing or Reversal guard),
- WI_CS = Weak infeed carrier send (Echo)

3.2.4 Distance Carrier Received (Dist CR)

The aided scheme options on Distance carrier receipt are shown in the next table:

Setting	Aided Scheme	Function
None	None	To configure a Basic scheme.
PermZ1	To configure a Permissive scheme where Zone 1 can only trip if a Distance Carrier is received.	
PermZ2	To configure a Permissive scheme where Zone 2 can trip without waiting for tZ2 timeout if a Distance Carrier is received.	
PermFwd	To configure a Permissive scheme where any forward distance zone start will cause an aided trip if a Distance Carrier is received.	
BlkZ1	To configure a Blocking scheme where Zone 1 can only trip if a Distance Carrier is NOT received.	
BlkZ2	To configure a Blocking scheme where Zone 2 can trip without waiting for tZ2 timeout if a Distance Carrier is NOT received.	

Table 4 - Aided Scheme Options on Distance Carrier Receipt

3.2.5 Current Reversal Guard Logic

Where appropriate, the tReversal Guard and 'Aid Dist Delay' (transmission time in blocking scheme) time-delays (in the case of a blocking scheme covering the transmission time) settings will appear in the relay menu. Further customising of distance schemes can be achieved using the Programmable Scheme Logic to condition send and receive logic.

For double circuit lines, the fault current direction can change in one circuit when circuit breakers open sequentially to clear the fault on the parallel circuit. The change in current direction causes the overreaching distance elements to see the fault in the opposite direction to the direction in which the fault was initially detected (settings of these elements exceed 150% of the line impedance at each terminal). The race between operation and resetting of the overreaching distance elements at each line terminal can cause the Permissive Overreach, and Blocking schemes to trip the healthy line. A system configuration that could result in current reversals is shown in the following diagram. For a fault on line L1 close to circuit breaker B, as circuit breaker B trips it causes the direction of current flow in line L2 to reverse.

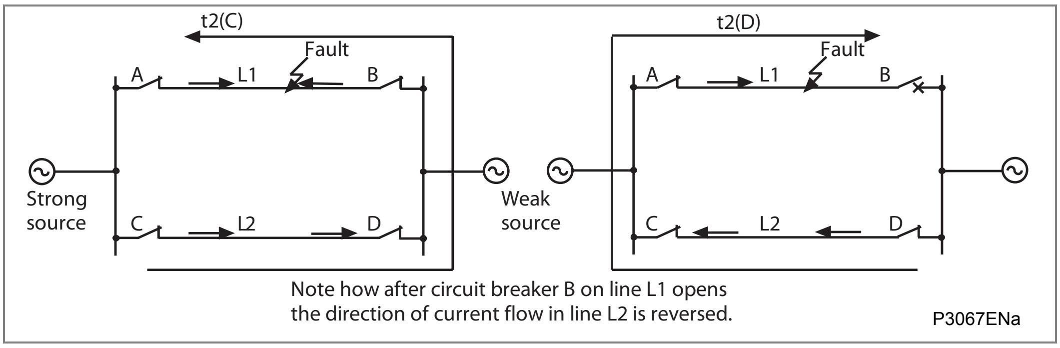


Figure 41 - Current Reversal in Double Circuit Lines

The basic unblocking / blocking logic scheme is detailed in the *Unblocking / Blocking Logic with Power Swing or Reversal Guard* section.

3.2.5.1 Permissive Overreach Schemes Current Reversal Guard

The current reversal guard incorporated in the POP scheme logic is initiated when the reverse looking Zone 4 elements operate on a healthy line. Once the reverse looking Zone 4 elements have operated, the relay's permissive trip logic and signal send logic are inhibited at substation D (circuit breaker D in the *Current Reversal in Double Circuit Lines* diagram). The reset of the current reversal guard timer is initiated when the reverse looking Zone 4 resets. A time delay tREVERSAL GUARD is required in case the overreaching trip element at end D operates before the signal sent from the relay at end C has reset. Otherwise this would cause the relay at D to over trip. Permissive tripping for the relays at D and C substations is enabled again, once the faulted line is isolated and the current reversal guard time has expired. The recommended setting is:

tREVERSAL GUARD = Maximum signal reset time + 35ms.

Note	*The reverse guard begins when "reverse" falls and not when the directional is reverse and immediately forward. It is validated if the directional becomes forward.*

3.2.5.2 Blocking Scheme Current Reversal Guard

The current reversal guard incorporated in the BOP scheme logic is initiated when a blocking signal is received to inhibit the channel-aided trip. When the current reverses and the reverse looking Zone 4 elements reset, the blocking signal is maintained by the timer tREVERSAL GUARD. Thus referring to the *Current Reversal in Double Circuit Lines* diagram, the relays in the healthy line are prevented from over tripping due to the sequential opening of the circuit breakers in the faulted line. After the faulty line is isolated, the reverse-looking Zone 4 elements at substation C –circuit breaker C) and the forward looking elements at substation D will reset. The recommended setting is:

Where Duplex signalling channels are used:
tREVERSAL GUARD = Maximum signalling channel operating time + 14ms.

Where Simplex signalling channels are used:
tREVERSAL GUARD = Maximum signalling channel operating time - minimum signalling channel reset time + 14ms.

3.2.6 Unblocking Logic (Permissive Scheme)

Two modes of unblocking logic are available with permissive schemes (blocking schemes are excluded).

The unblocking logic issues (see section P44x/EN PL for DDB description):

- The Main and Directional Earth Fault alarm ('**COS alarm**' digital output),
- The internal Carrier Received signal (main distance or Directional Earth Fault unblocking signal) (DDB '**DIST. UNB CR**' or '**DEF. UNB CR**').

The output DDBs '**COS alarm**' and '**DIST.** (or **DEF.**) **UNB CR**' depend on:

- The distance or DEF inputs signals: Carrier Received and Carrier Out of Service inputs, distance and DEF channel-aided trip settings,
- Shared or independent logic between the DEF and Distance functions,
- Carrier Out of Service (COS) detected.

Three settings are available in the menu:

- None (basic mode). In this case, the opto input state is copied directly,
- Loss of Guard mode,
- Loss of Carrier mode.

3.2.6.1 None

The Logic equations for this mode are:

- 'COS alarm' = 'DIST. COS' + 'DEF. COS' (main alarm when carrier is out of service),
- 'DIST. UNB CR' = 'DIST. Chan Recv' (CR unblocked when "distance carrier received" is present),
- 'DEF. UNB CR' = 'DEF. Chan Recv' (DEF CR unblocked when "DEF carrier received" is present).

3.2.6.2 Loss of Guard Mode

This mode is designed for use with Frequency Shift Keyed (FSK) Power Line Carrier (PLC) communications. When the protected line is healthy a guard frequency is sent between line ends, to verify that the channel is in service. However, when a line fault occurs and a permissive trip signal must be sent over the line, the power line carrier frequency is shifted to a new (trip) frequency. Thus, distance relays should receive either the guard, or trip frequency, but not both together. With any permissive scheme, the PLC communications are transmitted over the power line that may contain a fault. So, for certain fault types the line fault can attenuate the PLC signals, so that the permissive signal is lost and not received at the other line end. To overcome this problem, when the guard is lost and no "trip" frequency is received, the relay opens a window of time during which the permissive scheme logic acts as though a "trip" signal had been received. Two opto inputs to the relay need to be assigned, one is the Channel Receive opto input, the second is designated Loss of Guard (the inverse function to guard received). The function logic is summarised in the following table.

System Condition	Permissive Channel Received	Loss of Guard	Permissive Trip Allowed	Alarm Generated
Healthy Line	No	No	No	No
Internal Line Fault	Yes	Yes	Yes	No
Unblock	No	Yes	Yes, during a 150ms window	Yes, delayed on pickup by 150ms
Signalling Anomaly	Yes	No	No	Yes, delayed on pickup by 150ms

Table 5 - Logic for the Loss of Guard Function

The window of time during which the unblocking logic is enabled starts 10ms after the guard signal is lost, and continues for 150ms. The 10ms delay gives time for the signalling equipment to change frequency as in normal operation.

For the duration of any alarm condition (DDB: '**COS Alarm'**), the "zone 1 extension" trip logic will be invoked if the option 'Distance schemes / Z1 Ext on Chan. Fail' has been enabled.

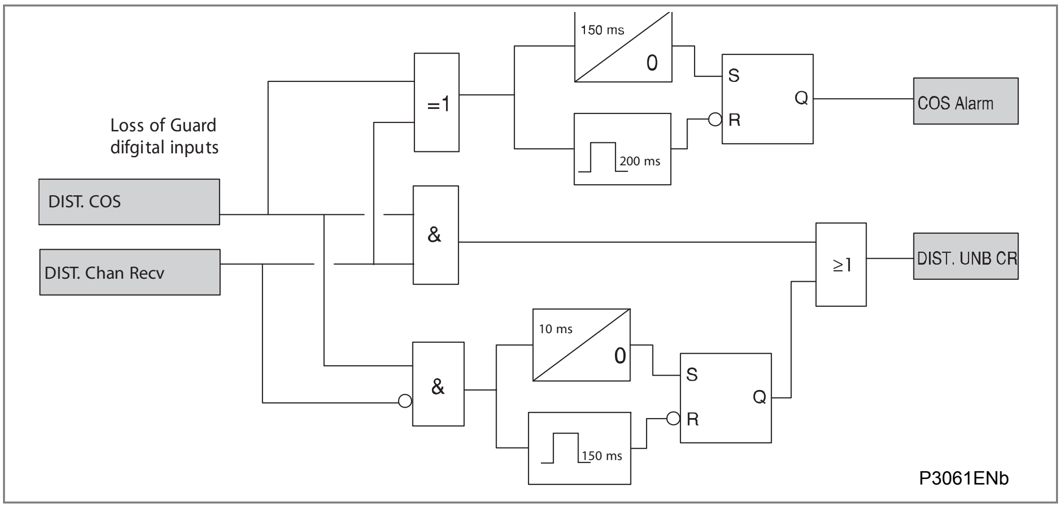


Figure 42 - Loss of guard logic

'DIST. Chan Recv' 'DEF. Chan Recv'	'DIST. COS' 'DEF. COS'	'DIST. UNB CR' 'DEF. UNB CR'	'COS alarm'
0	0	0	0
1	1	1	0
0	1	1 (Window)	1 (delayed)
1	0	0	1 (delayed)

3.2.6.3 Loss of Carrier

In this mode the signalling equipment used is such that a carrier/data messages are continuously transmitted across the channel, when in service. For a permissive trip signal to be sent, additional information is contained in the carrier (eg. a trip bit is set), such that both the carrier and permissive trip are normally received together. Should the carrier be lost at any time, the relay must open the unblocking window, in case a line fault has also affected the signalling channel. Two opto inputs to the relay need to be assigned, one is the Channel Receive opto input, the second is designated Loss of Carrier (the inverse function to carrier received). The function logic is summarised in the following table.

System Condition	Permissive Channel Received	Loss of Guard	Permissive Trip Allowed	Alarm Generated
Healthy Line	No	No	No	No
Internal Line Fault	Yes	No	Yes	No
Unblock	No	Yes	Yes, during a 150ms window	Yes, delayed on pickup by 150ms
Signalling Anomaly	No	Yes	No	Yes, delayed on pickup by 150ms

Table 6 - Logic for the Loss of Carrier Function

The window of time during which the unblocking logic is enabled starts 10ms after the guard signal is lost, and continues for 150ms.

For the duration of any alarm condition (DDB: '**COS Alarm**'), the "zone 1 extension" trip logic will be invoked if the option 'Distance schemes / Z1 Ext on Chan. Fail' has been enabled.

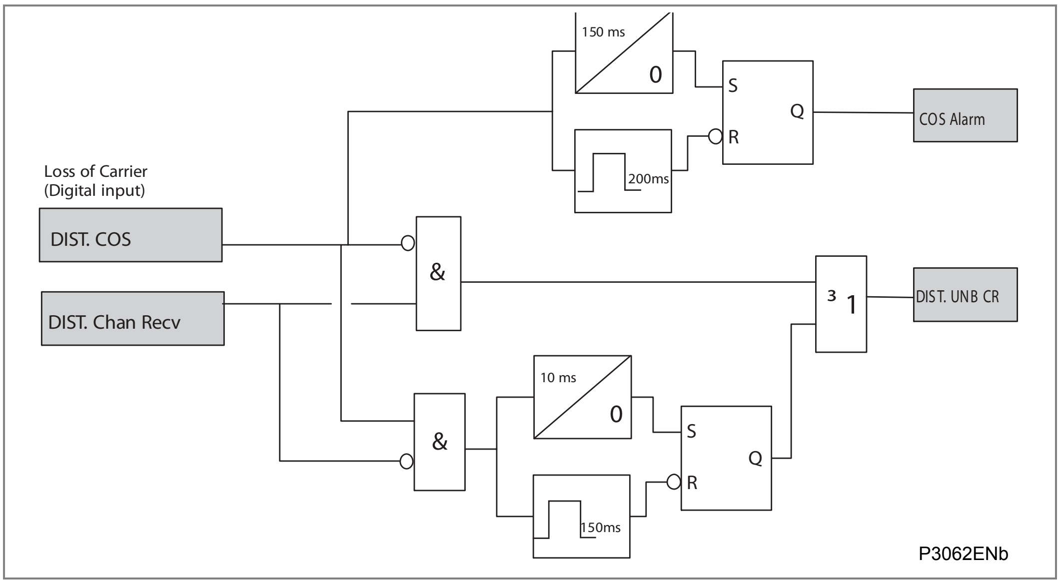


Figure 43 - Loss of carrier

'DIST. Chan Recv' 'DEF. Chan Recv'	'DIST. COS' 'DEF. COS'	'DIST. UNB CR' 'DEF. UNB CR'	'COS alarm'
0	0	0	0
0	1	1 (Window)	1 (delayed)
1	0	1	0
1	1	0	1 (delayed)

Note For DEF the logic used will depend upon which settings are enabled:

- Same channel (shared)

In this case, the DEF channel is the Main Distance channel signal (the scheme & contacts of carrier received will be identical)

- Independent channel (2 Different channels) – (2 independent contacts)

3.2.7 Trip on Reclose (TOR) / Switch On To Fault (SOTF) modes

Switch On To Fault (SOTF) protection is provided for high speed clearance of any detected fault immediately following **manual closure** of the circuit breaker. SOTF protection remains enabled for 500ms following circuit breaker closure, detected via the CB Man Close input or CB close with CB control or Internal detection with all poles dead (seethe SOTF-TOR Activation logic diagram), or for the duration of the close pulse on internal detection.

Instantaneous three pole tripping (and auto-reclose blocking) can also be selected

Trip On Reclose (TOR) protection is provided for high speed clearance of any fault detected immediately following **autoreclosure** of the circuit breaker.

Instantaneous three-pole tripping (TOR logic) can be selected for faults detected by various elements, (see the settings description above). TOR protection remains enabled for 500ms following circuit breaker closure. The use of a TOR scheme is usually advantageous for most distance schemes, since a persistent fault at the remote end of the line can be cleared instantaneously after reclosure of the breaker, rather than after the zone 2 time delay.

3.2.7.1 Setting Guidelines

When the overcurrent option is enabled, the I>3 current setting applied should be above load current, and > 35% of peak magnetising inrush current for any connected transformers as this element has no second harmonic blocking. Setting guidelines for the I>3 element are shown in more detail in Table below.

When a Zone 1 Extension scheme is used along with autoreclosure, it must be ensured that only Zone 1 distance protection can trip instantaneously for TOR. Typically, TOR-SOTF Mode bit 0 only would be set to “1”. Also the I>3 element must be disabled to avoid overreaching trips by level detectors.

3.2.7.2 Initiating TOR-SOTF Protection

SOTF-TOR Activation

The logic (as shown in the *SOTF-TOR Activation logic* diagram) issues 2 signals **TOR Enable - SOTF Enable**. There is a difference between these 2 signals as the autorecloser (whether internal or external) which must be blocked for the SOTF logic.

The detection of an open pole is enabled by the **Any Pole Dead** signal (at least one pole is open). It is an OR logic of the internal analogue detection (level detectors) and of the external detection (given by CB status: 52A/52B, which is required in the case of a VT on the Bus side).

The V< and I< Dead Pole Level Detectors are settable per phase as described belows:

- **V<** is either a fixed threshold **20% Vn** or equal to the **V Dead Line threshold** of the check synchronism function if enabled, (default value for V< dead line = 20% V_N)
- **I<** is either a fixed threshold **of 5% In** or equal to **the ‘I< Current Set’ threshold** of the Breaker Failure protection function (default value for I< CB fail = 5% I_N).

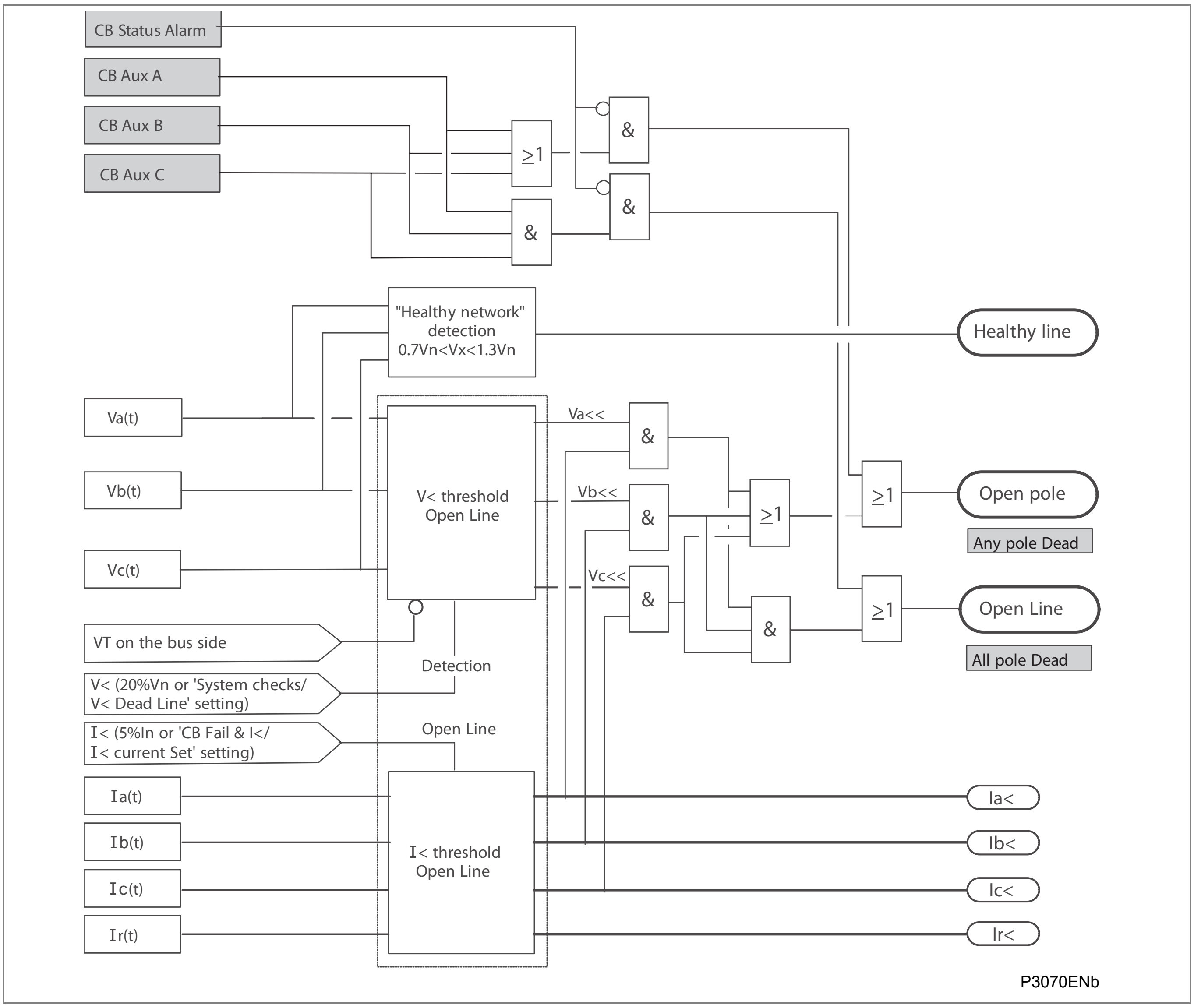


Figure 44 – SOTF-TOR Activation logic

TOR Enable logic is activated in 2 cases:

1. When the internal autorecloser is enabled or when the reclaim signal from an external autorecloser is connected to a logic input (opto input):

   As soon as the reclaim time starts, the “TOR Enable” is activated . It will be reset at the end of the internal or external reclaim time.

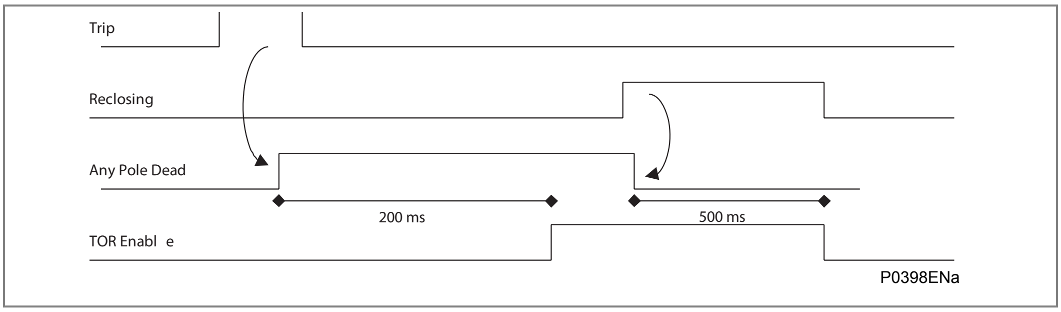
2. Without any reclaim time (internal AR disabled or external opto input Reclaim Time not assigned in the PSL):

TOR Enable will be activated during a 200ms time window, following the pole dead detection. The TOR logic will reset (TOR Enable) **ONLY** 500ms after the drop off of the "any pole dead" detection.

This behaviour has been designed to avoid any maloperation on a parallel line, in case of an incorrect Any Pole Dead detection performed by the internal level detectors (e.g. fault in front of a busbar on a parallel line and weak infeed at the other end of the line)

A 200ms delay will permit tripping of the adjacent line. The level detectors will then reset the timer:

- The **TOR protection logic** is enabled when any circuit breaker pole has been open for longer than 200ms but not longer than the 110s default value (ie. autoreclose first shot in progress) - the timer is settable. It allows a variation of time between the detection of a dead pole condition and when the internal logic detects a "dead line" and activates the SOTF logic or when the relay's logic detects that further time-delayed autoreclose shots are in progress.



- The SOTF protection is enabled when the circuit breaker has been open 3 pole for longer than 110s. This time-delay is settable. It allows a variation of the time between the detection of a dead pole condition and when the internal logic detects a "dead line" and activates the SOTF logic if no autoreclose cycle is in progress. Thus, the SOTF function is enabled for manual reclosures, not for autoreclosure.

The SOTF Enable logic is activated in 2 cases:

1. If no external close command (manual or by remote communications via a control system) is issued:

   When the internal leels detectors have detected a **three pole open condition for longer than SOTF Delay (default value is 110s**); when all the poles are closed, SOTF is enabled for a duration of 500 ms and then resets,

2. When an external close command (manual or by remote communications via a control system) is issued:

   The SOTF logic is activated immediately. When all the poles are closed (after the external close command if a check synchronism condition is used in the PSL); SOTF is enabled for 500ms and then resets.

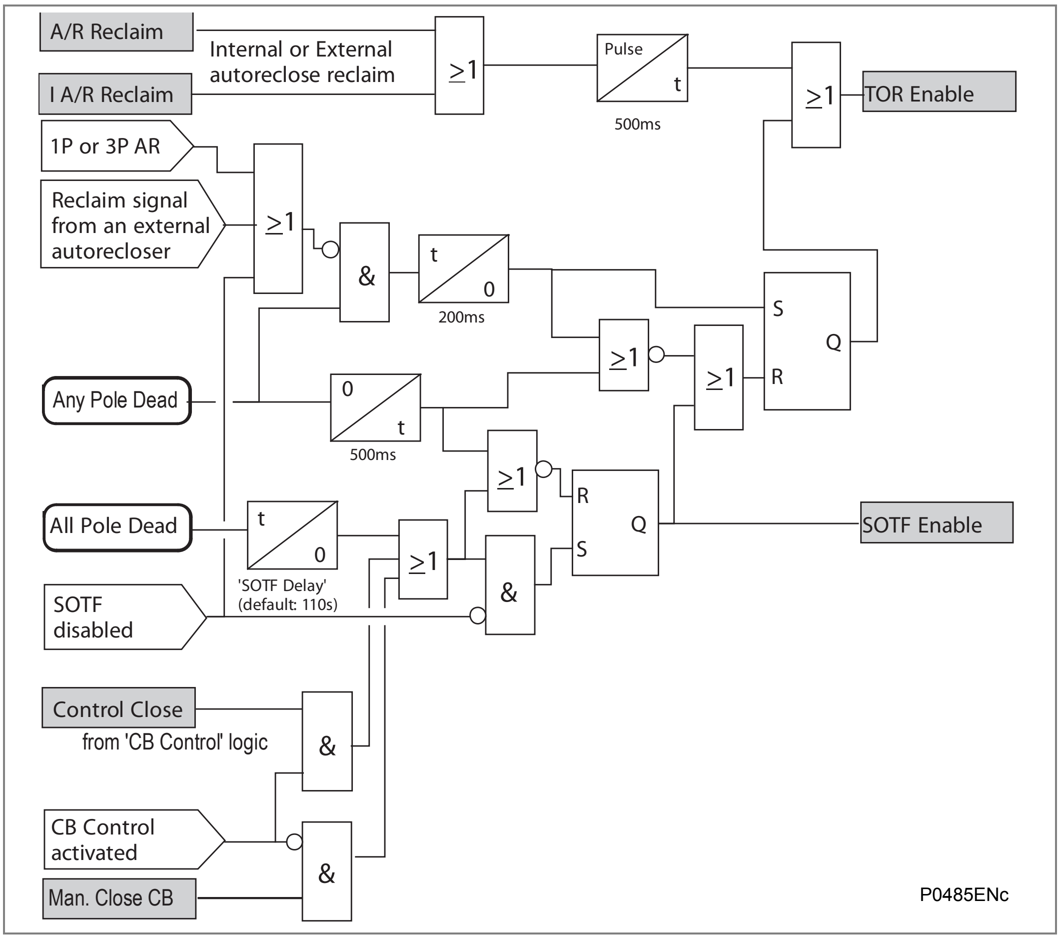


Figure 45 – SOTF-TOR logic - start

3.2.7.3 TOR-SOTF Trip Logic

During the TOR-SOTF 500ms window, individual distance protection zones can be enabled or disabled by means of the TOR-SOTF Mode (‘**Distance schemes**’ menu) function links (TOR logic Bit0 to Bit4 & SOTF logic Bit5 to Bit0E, see the *Switch on to Fault and Trip on Reclose Logic Diagram* diagram). Setting the relevant Bit to 1 will enable that zone, setting Bits to 0 will disable distance zones. When enabled (Bit = 1), the zones will trip without waiting for their usual time delays. Thus tripping can even occur for close-up three phase short circuits where line connected VTs are used, and memory voltage for a directional decision is unavailable. Setting “All Zones Enabled” allows instantaneous tripping to occur for all faults within the trip characteristic shown in the *“All Zones” Distance Characteristic Available for SOTF-TOR Tripping* diagram below. Note, the TOR-SOTF element has second harmonic current detection, to avoid maloperation where power transformers are connected in-zone, and inrush current would otherwise cause problems. Harmonic blocking of distance zones occurs when the magnitude of the second harmonic current exceeds **25%** of the fundamental.

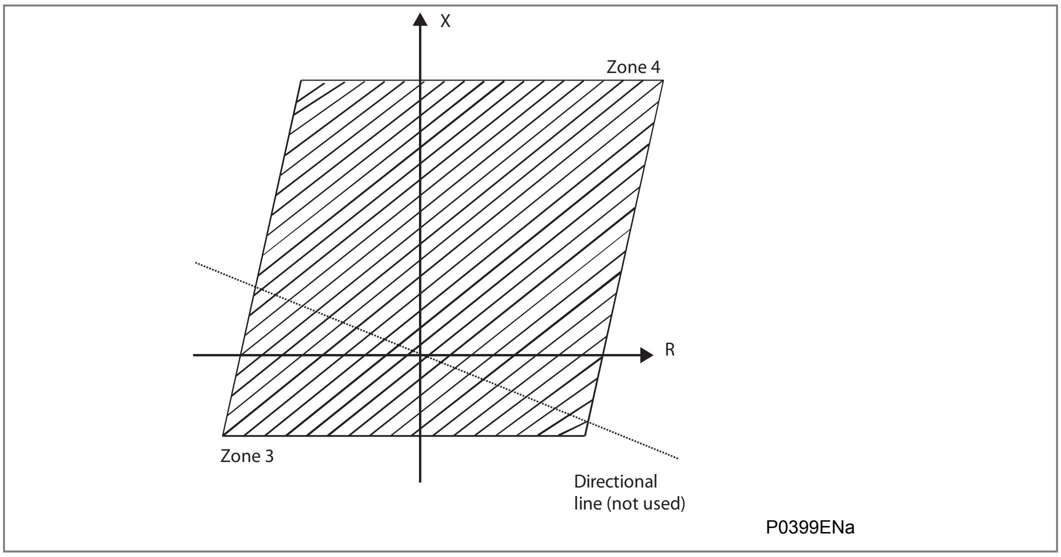


Figure 46 - "All Zones" Distance Characteristic Available for SOTF-TOR Tripping

Test results from different settings (see P44x/EN ST, '**Distance schemes / TOR-SOTF Mode'**).

Warning **Settings are not dynamically modified: one setting could affect another one.**

In the following trip logic results, the following acronyms are used:

	Type of Fault
Selected Logic	**Fault in Zone X**
TOR-SOTF	SOTF trip / TOR trip / Dist trip T0, T1, T2, Tzp (Tzq), T3, T4
Name of the selection and setting	SOTF trip (trip by SOTF (manual reclose)) / TOR trip (autoreclose): An instantaneous 3-pole trip will occur for a fault in a zone without waiting for the distance timer to expire Dist. Trip: trip by distance protection logic T0 (instantaneous trip) and T1, T2, Tzp (Tzq), T3, T4 (Distance time-delays, for a zone.

The fault is maintained with a duration higher than the 500ms SOTF time, until a trip occurs.

TOR Trip Logic Results

	Type of Fault					
TOR Selected Logic	**Fault in Z1**	**Fault in Z2**	**Fault in Zp (Zq) forward**	**Fault in Zp (Zq) reverse**	**Fault in Z3**	**Fault in Z4**
TOR Z1 Enabled	TOR trip T0	Dist trip T2	Dist trip TZp	Dist trip TZp	Dist trip T3	Dist trip T4
TOR Z2 Enabled	TOR trip T0	TOR trip T0	Dist trip TZp	Dist trip TZp	Dist trip T3	Dist trip T4
TOR Z3 Enabled	TOR trip T0	TOR trip T0	TOR trip T0	Dist trip TZp	TOR trip T0	Dist trip T4
TOR All Zone	TOR trip T0	TOR trip T0	TOR trip T0	TOR trip T0	TOR trip T0	TOR trip T0
TOR Dist.Scheme (logic POP/PUP)	Dist trip T1	Dist trip T2	Dist trip TZp	Dist trip TZp	Dist trip T3	Dist trip T4

SOTF Trip Logic Results

	Type of Fault					
SOTF Selected Logic	**Fault in Z1**	**Fault in Z2**	**Fault in Zp (Zq) forward**	**Fault in Zp (Zq) reverse**	**Fault in Z3**	**Fault in Z4**
SOTF All Zone	SOTF trip T0	SOTF trip T0	SOTF trip T0	SOTF trip T0	SOTF trip T0	SOTF trip T0
SOTF Z1 enabled	SOTF trip T0	DIST trip T2 [2]	DIST trip TZp [2]		DIST trip T3 [2]	DIST trip T4 [2]
SOTF Z2 enabled	SOTF trip T0	SOTF trip T0	DIST trip TZp [2]		DIST trip T3 [2]	DIST trip T4 [2]
SOTF Z3 enabled	SOTF trip T0	SOTF trip T0	SOTF trip T0		SOTF trip T0	DIST trip T4 [2]
SOTF Z1+Rev (with Zp forward)	SOTF trip T0	DIST trip T2 [2]	DIST trip TZp(TZq) [2]		DIST trip T3 [2]	SOTF trip T0
SOTF Z2+Rev (with Zp forward)	SOTF trip T0	SOTF trip T0	DIST trip TZp(TZq) [2]		DIST trip T3 [2]	SOTF trip T0
SOTF Z1+Rev (with Zp reverse)	SOTF trip T0	DIST trip T2		SOTF trip T0	DIST trip T3 [2]	DIST trip T4 [2]
SOTF Z2+Rev (with Zp reverse)	SOTF trip T0	SOTF trip T0		SOTF trip T0	DIST trip T3 [2]	DIST trip T4 [2]
SOTF Dist. Sch. (Zp fwd) (With a 3Plogic)	SOTF trip T1	SOTF trip T2	SOTF trip TZp(TZq)		SOTF trip T3	SOTF trip T4
SOTF Disabled (Dist. scheme & 1P)	DIST trip T1 [1]	DIST trip T2	DIST trip[1] TZp(TZq)		DIST trip T3	DIST trip T4

	Type of Fault					
SOTF Selected Logic	**Fault in Z1**	**Fault in Z2**	**Fault in Zp (Zq) forward**	**Fault in Zp (Zq) reverse**	**Fault in Z3**	**Fault in Z4**
No setting in SOTF (3) (All Bits at 0) & No I>3 0 0 0 | 0 0 0 0 | 0 0 0 0 | 0 0 0 0	DIST trip T1 (1)	DIST trip T2	DIST trip TZp(TZq)		DIST trip T3	DIST trip T4
Level detectors _ _ _ | _ _ _ _ | _ 1 _ _ | _ _ _ _	SOTF trip T0	SOTF trip T0	SOTF trip T0		SOTF trip T0	SOTF trip T0

(1): the distance trip logic is applied (trip 1 pole is authorized)
(2): if Tx < 500ms
(3): if SOTF-TOR by the I>3 overcurrents is deactivated (next section).

3.2.7.4 Switch-On-To-Fault and Trip-On-Reclose by the I>3 Overcurrent Element (Not Filtered for Inrush Current):

Inside the 500ms time window initiated by the SOTF-TOR logic, an instantaneous 3 phases trip logic signal will be issued if a fault current is measured exceeding the I>3 threshold value ('**Group 1/Back-up I>**' menu) is measured.

After the 500 ms TOR-SOTF time windows has ended, the I>3 overcurrent element remains in service with a trip time delay equal to the setting '**Group 1/Back-up I>/I>3 Time Delay**'. This element would trip for close-up high current faults, such as those where maintenance earth clamps are inadvertently left in position on line energisation.

The 'I>3 Time Delay' element can be permanently enabled, or enabled only for SOTF or TOR (see the *Switch on to Fault and Trip on Reclose Logic* diagram). It is also used to detect close-up faults (in SOTF-TOR tripping logic no time-delay is applied, DDB:'**I>3start**').

3.2.7.5 Switch on to Fault by Level Detectors

The SOTF level detectors (Bit 6 in the SOTF logic), allows an instantaneous 3-phase trip from any low set I< level detector ((see the *Switch on to Fault and Trip on Reclose Logic* diagram), provided that its corresponding Live Line level detector has not picked up within 20ms. When closing a circuit breaker to energise a healthy line, current would normally be detected above setting, but no trip results as the system voltage rapidly recovers to near nominal. Only when a line fault is present will the voltage fail to recover, resulting in a trip.

SOTF trip by level detectors per phase: If V_{phase}< 70% Vn **AND if** I_{phase} > 5% In for 20ms (to avoid any maloperation due to an unstable contact during the reclose command signal), an instantaneous trip command is issued.

3.2.7.6 Inputs /Outputs in TOR / SOTF Logic

The following DDB are used or available for TOR / SOTF logic (see section P44x/EN PL):

- Inputs:
  - Man Close CB,
  - AR Reclaim,
  - CB aux A,
  - CB aux B,
  - CB aux C.

- Outputs:
  - SOTF Enable,
  - TOR Enable,
  - TOC Start A,
  - TOC Start B,
  - TOC Start C,
  - Any Pole Dead,
  - All Pole Dead,
  - SOTF-TOR Trip.

3.2.7.7 **Logic Diagram**

In the SOTF-TOR logic diagram, the following logic name accronyms are used:

- Ia<, Ib< or Ic<: No current detected (I< threshold, by default 5% In, or I< CB Fail),
- Va>, Vb> or Vc>: Live voltage detected (V Live Line threshold, fixed at 70% Vn),
- Z1, Z1 + Z2, Z1 + Z2 + Z3, Z4, Zp, All Zones: Zones detected (+ = OR),
- '**Dist Trip A**', '**B**' or '**C**' (DDB): Trip (phase A, B or C) by distance logic,
- '**I3> Start**' (DDB): Detection by I>3 overcurrents (not filtered by inrush),
- '**TOC Start A**', '**B**' or '**C**' (DDB): Trip On Close on phase A, B or C,
- '**TOR** (or **SOTF**) **All Zones**': TOR (or SOTF) logic enabled for all zones (distance start).

Settings are set using 'Distance schemes / TOR-SOTF Mode' cell.

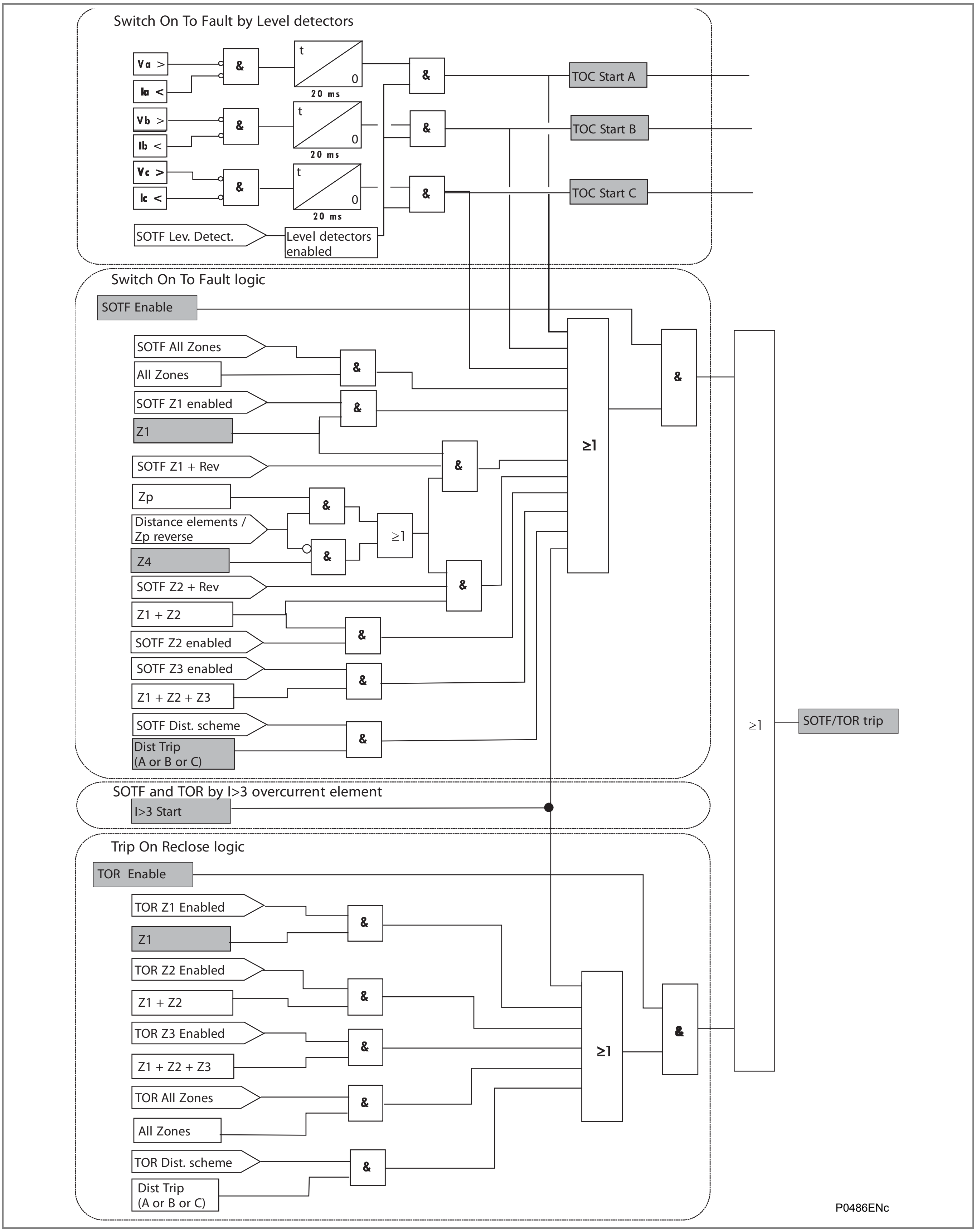


Figure 47 - Switch on to Fault and Trip on Reclose Logic Diagram

3.2.8 Zone 1 Ext. on Channel Fail

See the *Fault Distance Characteristics ("Distance Elements" Menu Setting)* section.

3.2.9 Permissive Overreach Schemes Weak Infeed (WI) Features

Weak Infeed (WI) logic can be enabled to run in parallel with all the permissive schemes. Two options are available: WI Echo, and WI Tripping.

Note	The 2 modes are blocked during Fuse failure conditions.

3.2.9.1 Weak Infeed Activation

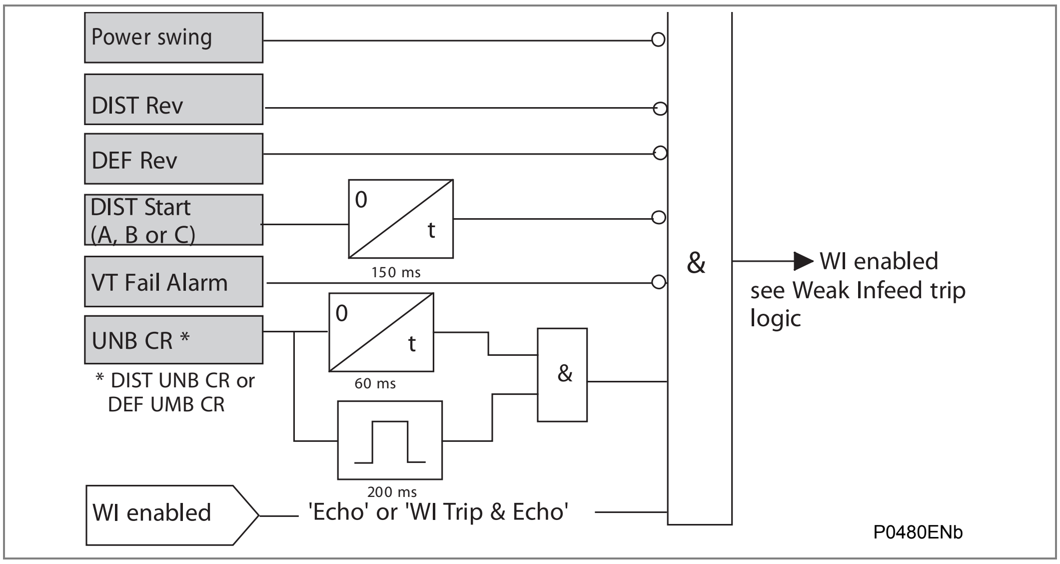


Figure 48 - Weak Infeed mode activation logic

3.2.9.2 Weak Infeed Echo

For permissive schemes, a signal would only be sent if the required signal send zone were to detect a fault. However, the fault current infeed at one line end may be so low as to be insufficient to operate any distance zones, and risks a failure to send the signal. Also, if one circuit breaker had already been left open, the current infeed would be zero. These are termed weak infeed conditions, and may result in slow fault clearance at the strong infeed line end (tripping after time tZ2). To avoid this slow tripping, the weak infeed relay can be set to "echo" back any channel received to the strong infeed relay (ie. to immediately send a signal once a signal has been received). This allows the strong infeed relay to trip instantaneously in its permissive trip zone. The additional signal send logic is ("UNB CR" for DDB: '**Dist UNB CR**' or DDB: '**DEF UNB CR**'):

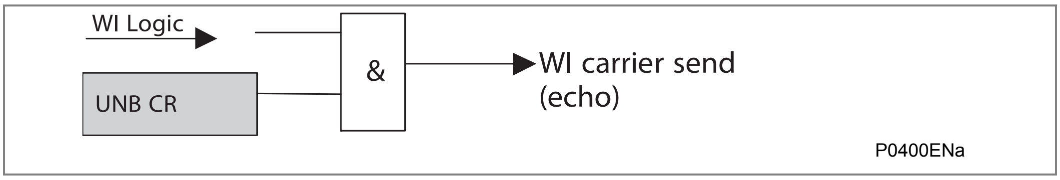


Figure 49 - Weak Infeed ECHO

3.2.9.3 Weak Infeed Tripping

Weak infeed echo logic ensures an aided trip at the strong infeed terminal but not at the weak infeed. The P442 and P444 relays also have a setting option to allow tripping of the weak infeed circuit breaker of a faulted line.

Three undervoltage elements, Va<, Vb< and Vc< are used to detect the line fault at the weak infeed terminal, with a common setting typically 70% of rated phase-neutral voltage. This voltage check prevents tripping during spurious operations of the channel or during channel testing.

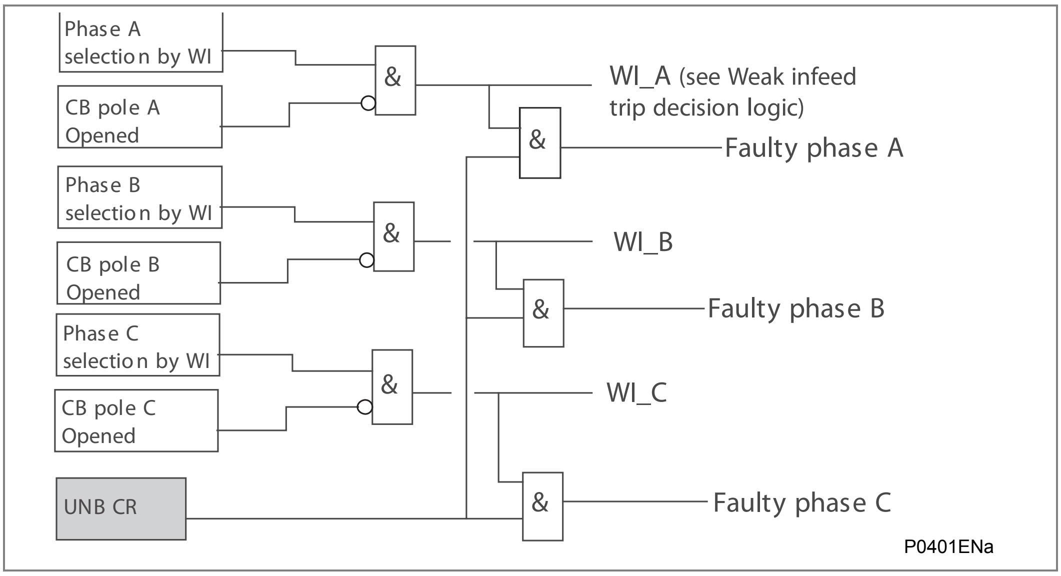


Figure 50 - Weak infeed phase selection logic

DDB: '**DIST. UNB CR**' (or '**DEF. UNB CR**') is used as a filter to avoid a permanent phase selection which could be maintained if CBaux signals are not mapped in the PSL (when line is opened).

The additional weak infeed trip logic is:

Weak infeed trip: No Distance Zone Operation, plus reverse directional decision, plus V<, plus Channel Received.

Weak infeed tripping is time delayed according to the 'WI: Trip time delay' value, usually set to 60ms. Due to the use of phase segregated undervoltage elements, single pole tripping can be enabled for WI trips (DDB: '**WI Trip A**', '**WI Trip B**' or '**WI Trip C**') if required. If single pole tripping is disabled a three pole trip will result after the time delay.

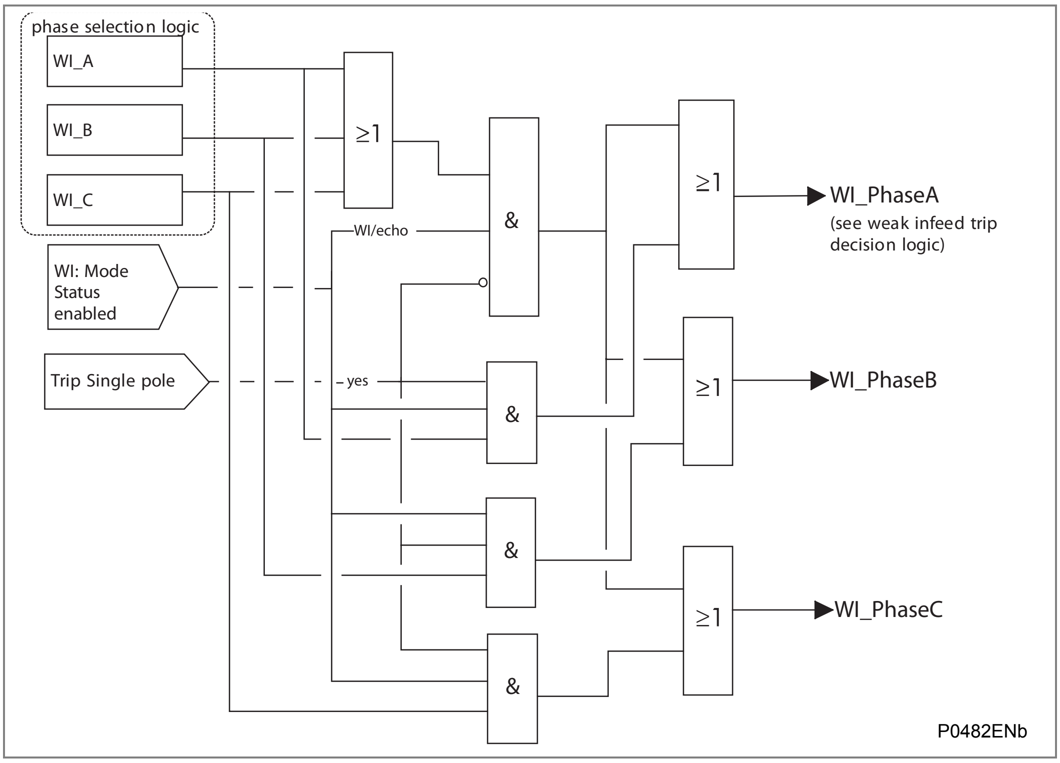


Figure 51 – Weak infeed trip decision logic

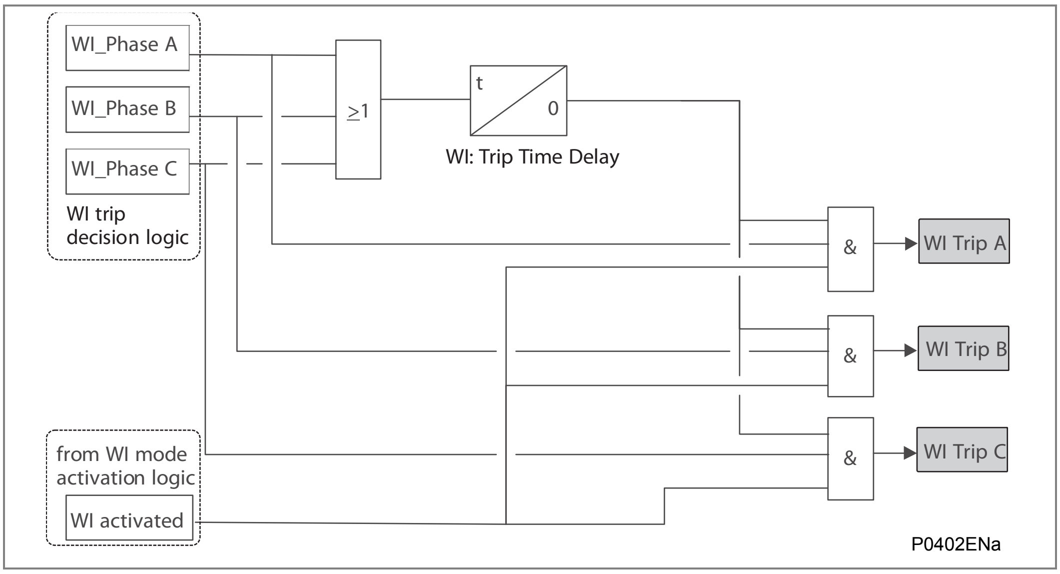


Figure 52 - Weak Infeed Trip Logic

3.2.10 Loss of Load (LoL)

3.2.11 Loss of Load (LoL) Accelerated Tripping

The Loss of Load (LoL) logic provides fast fault clearance for faults over the whole of a double end fed protected circuit for all types of fault, except three phases. The scheme has the advantage of not requiring a signalling channel. Alternatively, the logic can be chosen to be enabled when the channel associated with an aided scheme has failed. This failure is detected by permissive scheme unblocking logic, or a Channel Out of Service (COS) opto input.

Any fault located within the reach of Zone 1 will result in fast tripping of the local circuit breaker. For an end zone fault with remote infeed, the remote breaker will be tripped in Zone 1 by the remote relay and the local relay can recognise this by detecting the loss of load current in the healthy phases. This, coupled with operation of a Zone 2 comparator causes tripping of the local circuit breaker.

Before an accelerated trip can occur, load current must have been detected prior to the fault. The loss of load current opens a window during which time a trip will occur if a Zone 2 comparator operates. A typical setting for this window is 40ms as shown in the *Loss-of-Load Accelerated Trip Scheme* diagram, although this can be altered in the menu LoL: Window cell. The accelerated trip is delayed by 18ms to prevent initiation of a loss of load trip due to circuit breaker pole discrepancy occurring for clearance of an external fault. The local fault clearance time can be deduced as follows:

t = Z1d + 2CB + LDr + 18ms

Where:
Z1d = maximum downstream zone 1 trip time
CB = Breaker operating time
LDr = Upstream level detector (LoL: I<) reset time

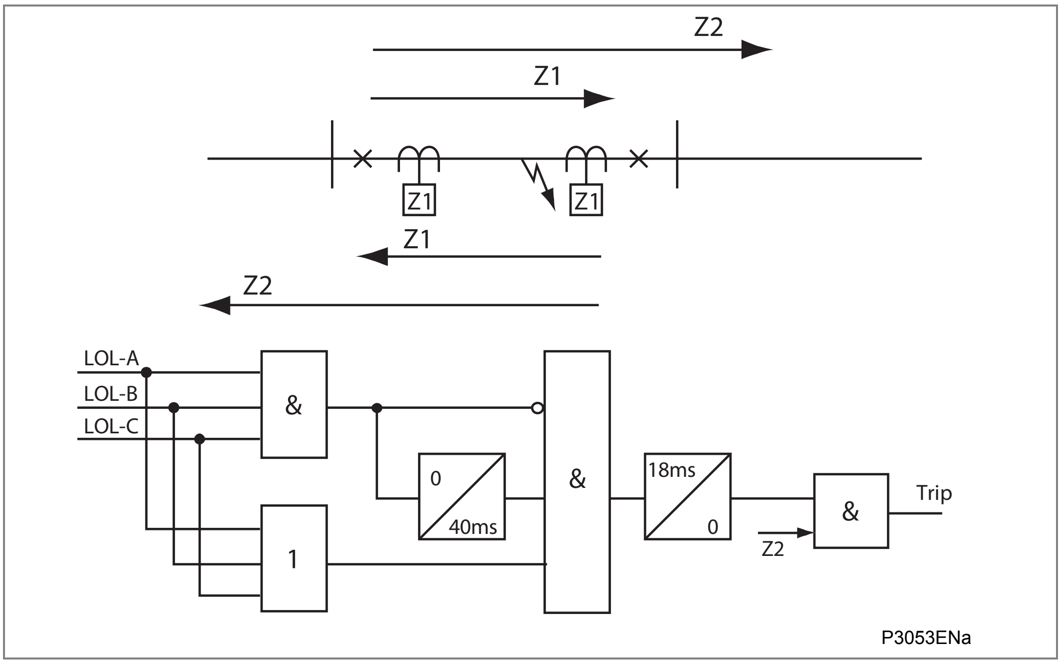


Figure 53 - Loss-of-Load Accelerated Trip Scheme

For circuits with load tapped off the protected line, care must be taken in setting the Loss of Load (LoL) feature to ensure that the I< level detector setting is above the tapped load current. When selected, the LoL feature operates in conjunction with the main distance scheme that is selected. In this way it provides high speed clearance for end zone faults when the Basic scheme is selected or, with permissive signal aided tripping schemes, it provides high speed back-up clearance for end zone faults if the channel fails.

Note	***Loss of load tripping is only available where 3 pole tripping is used.***

3.3 Power Swing

See the *Negative Sequence Overcurrent* section.

3.4 Other Protection Considerations - Settings Example

3.4.1 Distance Protection Setting Example

3.4.1.1 Objective

To protect the 100km double circuit line between the Green Valley and Blue River substations using relay protection in the POP Z2 Permissive Overreach mode and to set the relay at Green Valley substation, as shown in the *System Assumed for Worked Example* diagram.

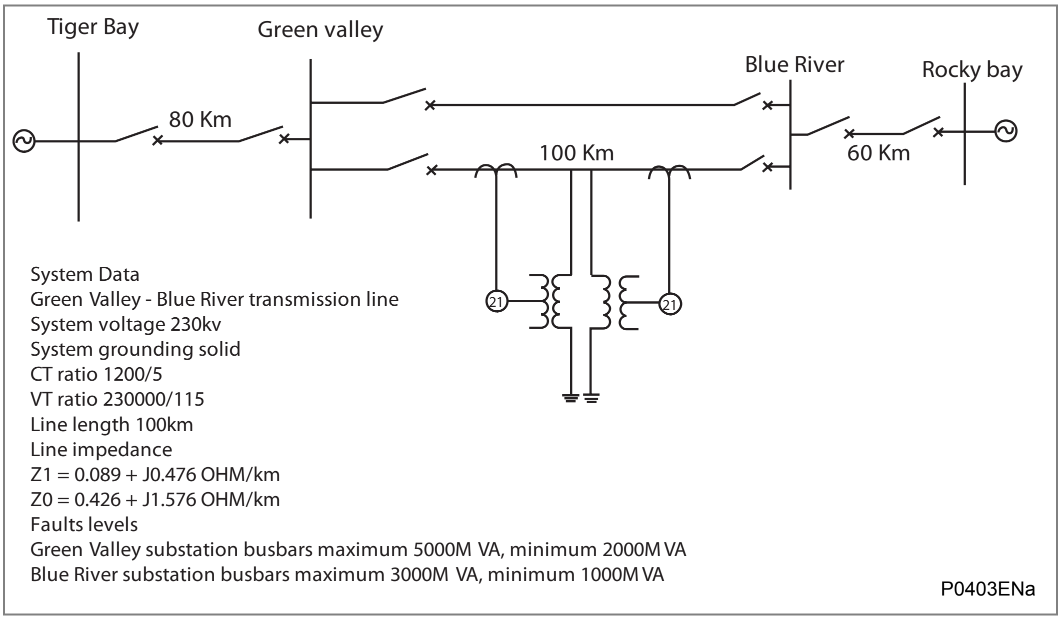


Figure 54 - System Assumed for Worked Example

3.4.1.2 System Data

Line length:	100 km		
Line impedances:	Z1	=	0.089 + j0.476 = 0.484 ∠79.4° Ω/km
	Z0	=	0.426 + j1.576 = 1.632 ∠74.8° Ω/km
	Z0/Z1	=	3.372 ∠-4.6°
CT ratio:	1 200/5		
VT ratio:	230 000/115		

3.4.1.3 Relay Settings

It is assumed that Zone 1 Extension is not used and that only three forward zones are required. Settings on the relay can be performed in primary or secondary quantities and impedances can be expressed as either polar or rectangular quantities (menu selectable). For the purposes of this example, secondary quantities are used.

3.4.1.4 Line Impedance

Ratio of secondary to primary impedance = $\frac{1200 / 5}{230000 / 115}$ = 0.12

Line impedance secondary = ratio CT/VT x line impedance primary.

Line Impedance = 100 x 0.484 $\angle$79.4° (primary) x 0.124

= 5.81 $\angle$79.4° Ω secondary.

Select Line Angle = 80° for convenience.

Therefore set Line Impedance and Line Angle: = 5.81 $\angle$80° Ω secondary.

3.4.1.5 Zone 1 Phase Reach Settings

Required Zone 1 reach is to be 80% of the line impedance between Green Valley and Blue River substations.

Required Zone 1 reach = 0.8 x 100 x 0.484 / $\underline{79.4°}$ x 0.12

Z1 = 4.64 / $\underline{79.4°}$ Ω secondary.

Z2 = 100 x 0.484 / $\underline{79.4°}$ + 50% x 60 x 0.484 / $\underline{79.4°}$

The Line Angle = 80°.

Therefore actual Zone 1 reach, Z1 = 4.64 / $\underline{80°}$ Ω secondary.

3.4.1.6 Zone 2 Phase Reach Settings

Required Zone 2 impedance = (Green Valley-Blue River) line impedance + 50% (Blue River-Rocky Bay) line impedance

Z2 = (100+30) x 0.484 $\angle$79.4° x 0.12 = 7.56 $\angle$79.4° Ω secondary.

The Line Angle = 80°

Actual Zone 2 reach setting = 7.56 $\angle$80° Ω secondary

Alternatively, in SIMPLE setting mode, this reach can be set as a percentage of the protected line. Typically a figure of at least 120% is used.

3.4.1.7 Zone 3 Phase Reach Settings

Required Zone 3 forward reach = (Green Valley-Blue River + Blue River-Rocky Bay) x 1.2

= (100+60) x 1.2 x 0.484 $\angle$79.4° x 0.12

Z3 = 11.15 $\angle$79.4° ohms secondary

Actual Zone 3 forward reach setting = 11.16 $\angle$80° ohms secondary

Alternatively, in SIMPLE setting mode, this reach can be set as a percentage of the protected line.

3.4.1.8 Zone 4 Reverse Settings with no Weak Infeed Logic Selected

Required Zone 4 reverse reach impedance = Typically 10% Zone 1 reach

= 0.1 x 4.64 / $\underline{79.4°}$

Z4 = 0.464 / $\underline{79.4°}$

Actual Zone 4 reverse reach setting = 0.46 / $\underline{80°}$ ohms secondary

3.4.1.9 Zone 4 Reverse Settings with Weak Infeed Logic Selected

Where zone 4 is used to provide reverse directional decisions for Blocking or Permissive Overreach schemes, zone 4 must reach further behind the relay than zone 2 for the remote relay. This can be achieved by setting: Z4 ≥ ((Remote zone 2 reach) x 120%) minus the protected line impedance:

Remote Zone 2 reach =

(Blue River-Green Valley) line impedance + 50% (Green Valley-Tiger Bay) line impedance

	=	(100+40) x 0.484 / $\underline{79.4°}$ x 0.12
	=	8.13 / $\underline{79.4°}$ Ω secondary.
Z4	≥	((8.13 / $\underline{79.4°}$) x 120%) - (5.81 / $\underline{79.4°}$)
	=	3.95 / $\underline{79.4°}$

Minimum zone 4 reverse reach setting = 3.96 / $\underline{80°}$ ohms secondary

3.4.1.10 Residual Compensation for Earth Fault Elements

The residual compensation factor can be applied independently to certain zones if required. This feature is useful where line impedance characteristics change between sections or where hybrid circuits are used. In this example, the line impedance characteristics do not change and as such a common KZN factor can be applied to each zone. This is set as a ratio **kZN Res. Comp**, and an angle **kZN Angle**:

kZN Res. Comp,	$\lvert kZN \rvert$	=	(Z0 - Z1) / 3Z1 i.e.: As a ratio	
kZN Angle,	∠kZN	=	∠ (Z0 - Z1) / 3Z1	Set in degrees
	ZL0 - ZL1	=	(0.426 + j1.576) - (0.089 + j0.476)	
		=	0.337 + j1.1	
		=	1.15 ∠72.9°	

$$kZN = \frac{1.15\angle 72.9°}{3 \times 0.484\angle 79.4°} = 0.79 \angle -6.5°$$

Therefore, select:

kZN Res. Comp	=	0.7
kZN Angle	=	- 6.5°

3.4.1.11 Resistive Reach Calculations

All distance elements must avoid the heaviest system loading. Taking the 5A CT secondary rating as a guide to the maximum load current, the minimum load impedance presented to the relay would be:

$Vn_{(phase-neutral)} / In$ = $(115 / \sqrt{3}) / 5$ = 13.3 Ω (secondary)

Typically, phase fault distance zones would avoid the minimum load impedance by a margin of ≥40% if possible (bearing in mind that the power swing characteristic surrounds the tripping zones), earth fault zones would use a ≥20% margin. This allows maximum resistive reaches of 7.9Ω, and 10.6Ω, respectively.

From the *Typical Arc Resistances Calculated using the van Warrington formula* table (see the *Zone Setting – Resistive Reach Calculation* section), taking a required primary resistive coverage of 14.5Ω for phase faults, and assuming a typical earth fault coverage of 40Ω, the minimum secondary reaches become:

RPh (min) = 14.5 x 0.12 = 1.74Ω (secondary);

RG (min) = 40 x 0.12 = 4.8Ω (secondary).

Resistive reaches could be chosen between the calculated values as shown in the following table. The zone 2 elements satisfy R2Ph ≤ (R3Ph x 80%), and R2G ≤ (R3G x 80%).

R3Ph/2 = R4Ph/2 should be set ≤ 80% Z minimum load – ΔR.

	Minimum	Maximum	Zone 1	Zone 2	Zones 3 & 4
Phase (RPh) Ω	1.74	7.9	R1Ph = 3	R1Ph = 4	R3Ph-4Ph = 8
Earth (RG) Ω	4.8	10.6	R1G = 5	R1G = 6	R3G-4G = 10

Table 7 - Selection of Resistive Reaches

3.4.1.12 Power Swing Band

Typically, the ΔR and ΔX band settings are both set between <u>10 - 30%</u> of R3Ph. This gives a secondary impedance between 0.6 and 1.8Ω. For convenience, <u>1.0Ω</u> could be set.

The width of the power swing band is calculated as follows:

$\Delta R = 1.3 \times \tan(\pi \times \Delta f \times \Delta t) \times R_{LOAD}$

Assuming that the load corresponds to 60° angles between sources and if the resistive reach is set so that $Rlim = R_{LOAD}/2$, the following is obtained:

$\Delta R = 0.032 \times \Delta f \times R_{LOAD}$

To ensure that a power swing frequency of 5Hz is detected, the following is obtained:

$\Delta R = 0.16 \times R_{LOAD}$

Where:

ΔR width of the power swing detection band

Δf power swing frequency ($f_A - f_B$)

Rlim resistive reach of the starting characteristic (=R3ph-R4ph)

Z network impedance corresponding to the sum of the reverse (Z4) and forward (Z3) impedances

R_{LOAD} load resistance

3.4.1.13 Current Reversal Guard

The current reversal guard timer available with POP schemes needs a non-zero setting when the reach of the zone 2 elements is greater than 1.5 times the impedance of the protected line. In this example, their reach is only 1.3 times the protected line impedance. Therefore, current reversal guard logic does not need to be used and the recommended settings for scheme time-delays are:

tREVERSAL GUARD = 0

'Aid Dist Delay' = 98ms (typical).

3.4.1.14 Instantaneous Overcurrent Protection

To provide parallel high-speed fault clearance to the distance protection, it is possible to use the I>3 element as an instantaneous highset. It must be ensured that the element will only respond to faults on the protected line. The worst case scenario for this is when only one of the parallel lines is in service.

Two cases must be considered. The first case is a fault at Blue River substation with the relay seeing fault current contribution via Green Valley. The second case is a fault at Green Valley with the relay seeing fault current contribution via Blue River.

Case 1:

Source Impedance	=	230^2 / 5000	=	10.58Ω
Line Impedance	=	48.4Ω		
Fault current seen by relay	=	(230000 / √3) / (10.58 + 48.4)		
	=	2251A		

Case 2:

Source Impedance	=	230^2 / 3000	=	17.63Ω
Line Impedance	=	48.4Ω		
Fault current seen by relay	=	(230000 / √3) / (17.63 + 48.4)		
	=	2011A		

The overcurrent setting must be in excess of 2251A. To provide an adequate safety margin a setting ≥120% the minimum calculated should be chosen, say 2800A.

3.4.2 Teed Feeder Protection

The application of distance relays to three terminal lines is fairly common. However, several problems arise when applying distance protection to three terminal lines.

3.4.2.1 Apparent Impedance

The following illustration shows a typical three terminal line arrangement. For a fault at the busbars of terminal B the impedance seen by a relay at terminal A will be equal to:

Za = Zat + Zbt + [Zbt.(Ic/Ia)]

Relay A will underreach for faults beyond the tee-point with infeed from terminal C. When terminal C is a relatively strong source, the underreaching effect can be substantial. For a zone 2 element set to 120% of the protected line, this effect may result in non-operation of the element for internal faults. This not only effects time delayed zone 2 tripping but also channel-aided schemes. Where infeed is present, it will be necessary for Zone 2 elements at all line terminals to overreach both remote terminals with allowance for the effect of tee-point infeed. Zone 1 elements must be set to underreach the true impedance to the nearest terminal without infeed. Both these requirements can be met through use of the alternative setting groups.

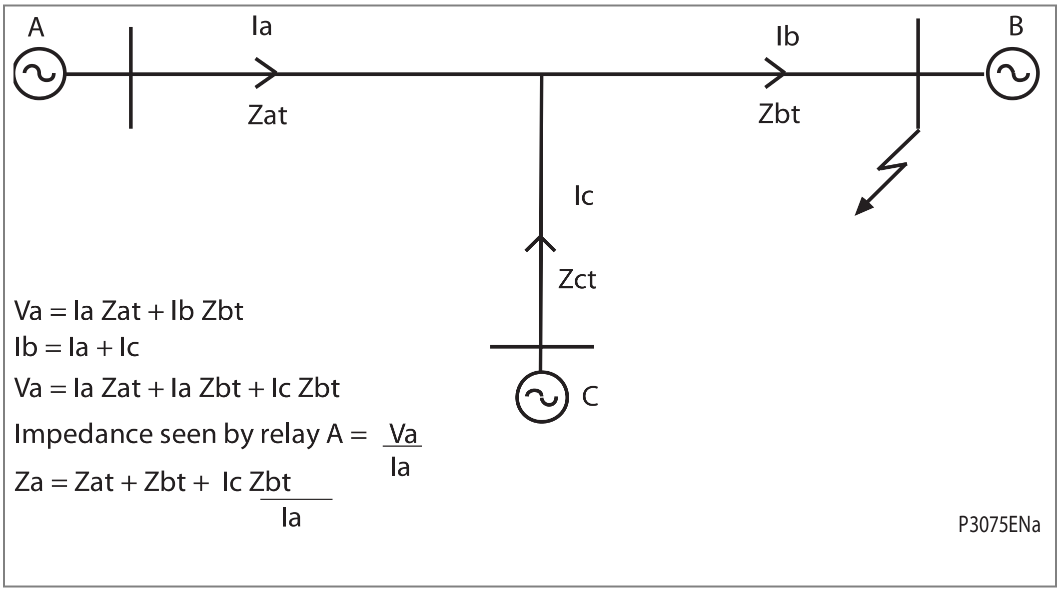


Figure 55 - Teed feeder application - apparent impedances seen by relay

3.4.2.2 Permissive Overreach Schemes

To ensure operation for internal faults in a POR scheme, the relays at the three terminals should be able to see a fault at any point within the protected feeder. This may demand very large zone 2 reach settings to deal with the apparent impedances seen by the relays.

A POR scheme requires the use of two signaling channels. A permissive trip can only be issued upon operation of zone 2 and receipt of a signal from both remote line ends. The requirement for an 'AND' function of received signals must be realized through use of contact logic external to the relay, or the internal Programmable Scheme Logic (PSL). Although a POR scheme can be applied to a three terminal line, the signaling requirements make its use unattractive.

3.4.2.3 Permissive Underreach Schemes

For a PUR scheme, the signaling channel is only keyed for internal faults. Permissive tripping is allowed for operation of zone 2 plus receipt of a signal from either remote line end. This makes the signaling channel requirements for a PUR scheme less demanding than for a POR scheme. A common Power Line Carrier (PLC) signaling channel or a triangulated signaling arrangement can be used. This makes the use of a PUR scheme for a teed feeder a more attractive alternative than use of a POR scheme.

The channel is keyed from operation of zone 1 tripping elements. Provided at least one zone 1 element can see an internal fault then aided tripping will occur at the other terminals if the overreaching zone 2 setting requirement has been met. There are however two cases where this is not possible:

The following figure is divided into three parts: (i), (ii) and (ii).

- Part (i) shows the case where a short tee is connected close to another terminal. In this case, zone 1 elements set to 80% of the shortest relative feeder length do not overlap. This leaves a section not covered by any zone 1 element. Any fault in this section would result in zone 2 time delayed tripping.
- Part (ii) shows an example where terminal 'C' has no infeed. Faults close to this terminal will not operate the relay at 'C' and hence the fault will be cleared by the zone 2 time-delayed elements of the relays at 'A' and 'B'.
- Part (iii) illustrates a further difficulty for a PUR scheme. In this example current is outfed from terminal 'C' for an internal fault. The relay at 'C' will therefore see the fault as reverse and not operate until the breaker at 'B' has opened; i.e. sequential tripping will occur.

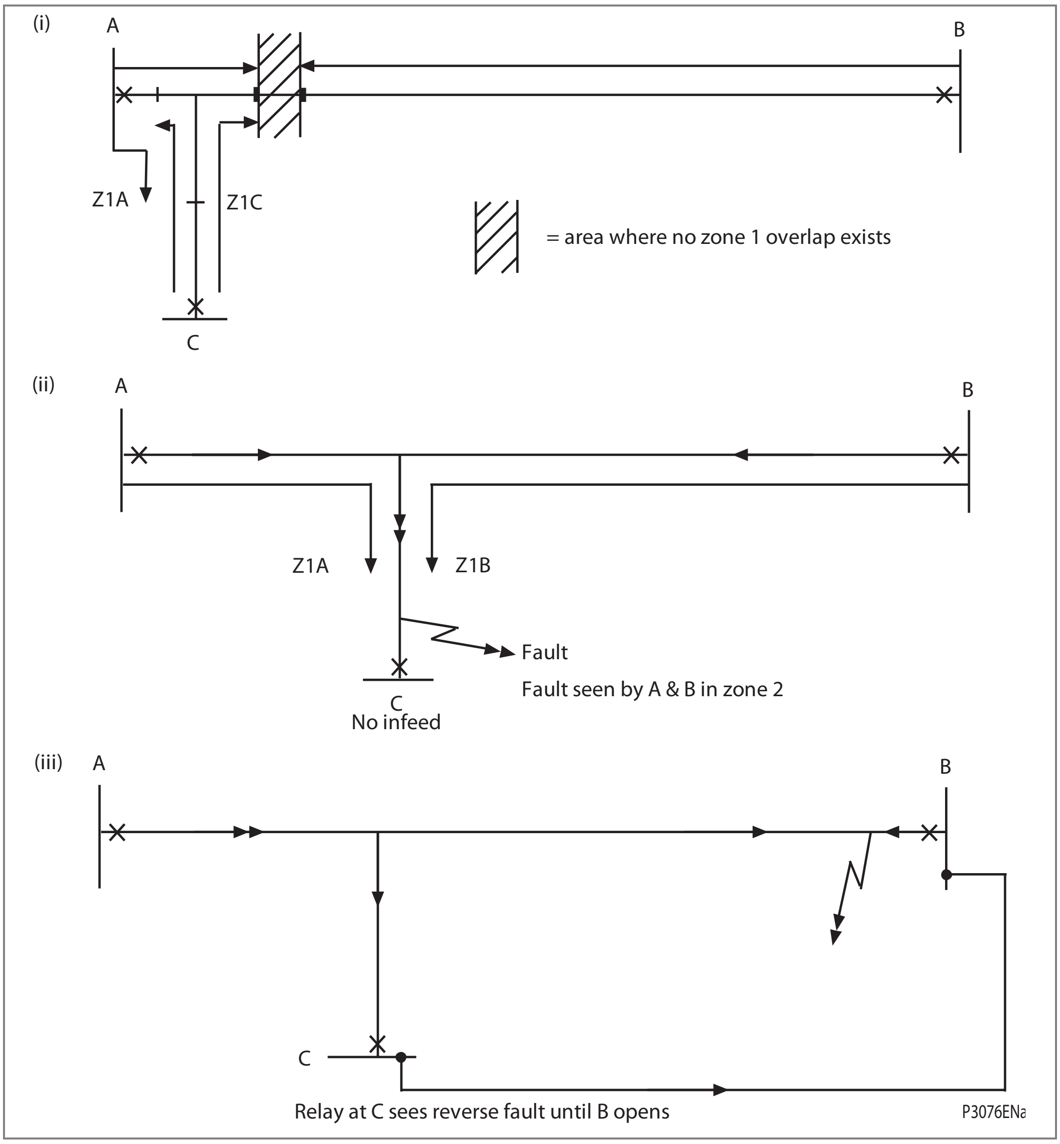


Figure 56 - Teed Feeder Applications

3.4.2.4 Blocking Schemes

Blocking schemes are particularly suited to the protection of teed feeders, since high speed operation can be achieved where there is no current infeed from one or more terminals. The scheme also has the advantage that only a common simplex channel or a triangulated simplex channel is required.

The major disadvantage of blocking schemes is highlighted in section (iii) of the previous figure where fault current is outfed from a terminal for an internal fault condition. Relay 'C' sees a reverse fault condition. This results in a blocking signal being sent to the two remote line ends, preventing tripping until the normal zone 2 time delay has expired.

3.5 Distance Protection Logic

The following diagram gives the logic of the distance protection:

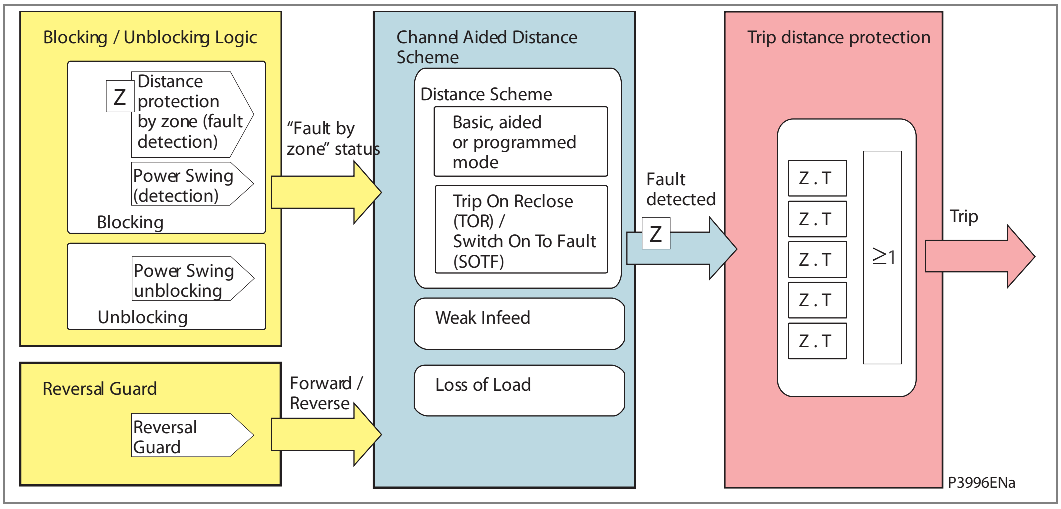


Figure 57 - Mimic diagram

3.5.1 Blocking / Unblocking Logic

The zones unblocking/blocking logic with power swing are managed as explained in the *Channel Aided Distance Schemes* section.

3.5.1.1 Distance Protection by Zones and Unblocking / Blocking Logic with Power Swing

The logic of the distance protection by zones (including Power Swing Basic Unblocking / Blocking logic) is illustrated (within the following diagram:

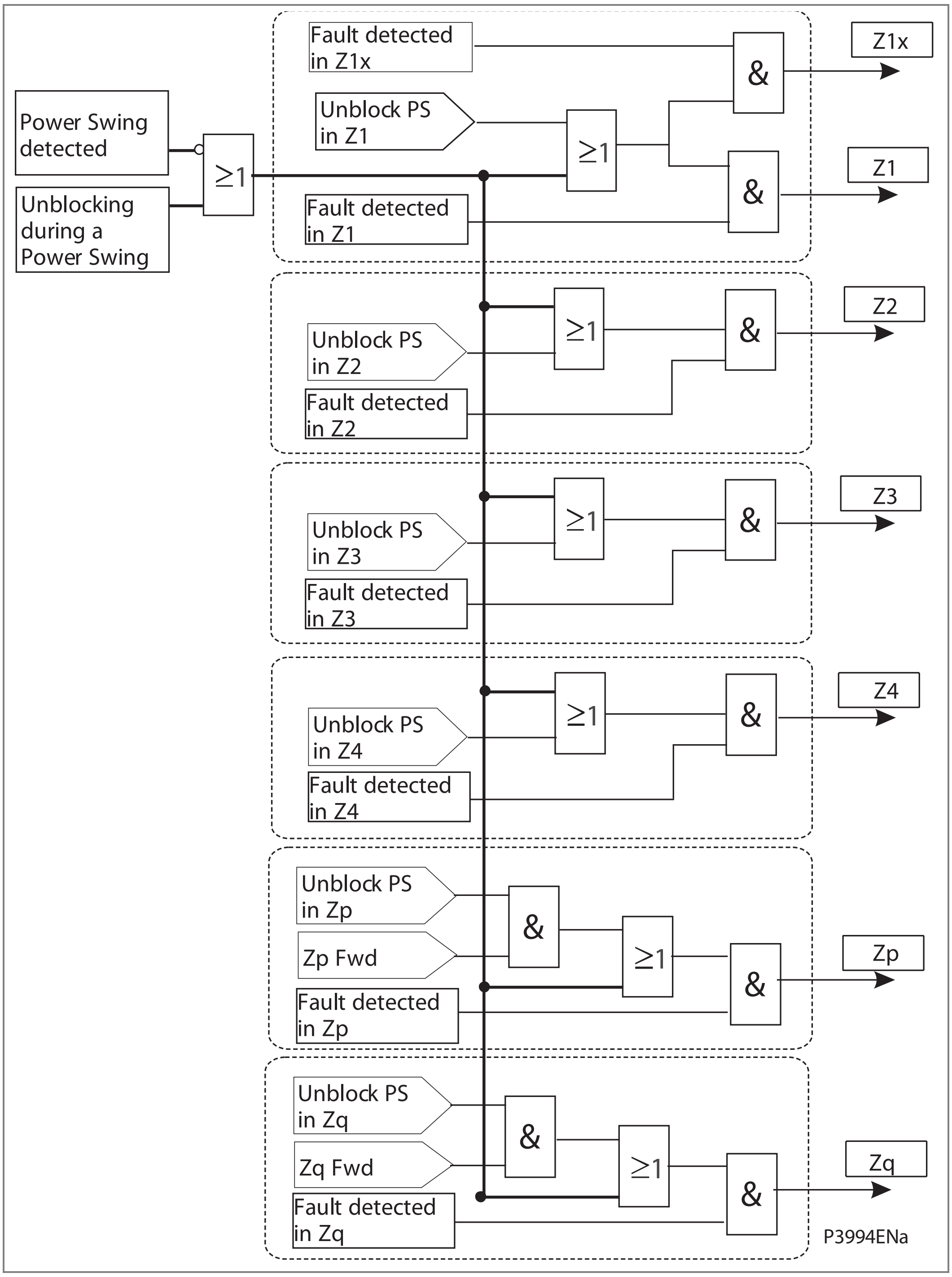


Figure 58 – Logic of the distance protection by zones

Where:

Unblock PS Z1, Z2, Z3, Z4, Zp or Zq:	Unblocking of Zone 1 (Z1), Z2, Z3, Z4, Zp or Zq during a power swing (‘Power swing / Blocking zone’ menu) 0 => Zx blocked during power swing 1 => Zx unblocked during power swing
DDB: Z1,Z1x, Z2, Z3, Z4, Zp, Zq:	Fault detected in zone 1, Z1x, 2, 3, 4, p or q and filtered by blocking/unblocking Power Swing

The fault detection is modified when the following conditions are met:

- Power swing detection (in this case, power swing detected or unblocking during a power swing),
- Blocking logic settings during power swing,
- Type of teleprotection scheme.

When zones are blocked during the power swing, those can be unblocked by:

- Start of unblocking logic,

Unblocking logic enabled for the concerned zone or all zones (setting).

3.5.1.2 Unblocking / Blocking Logic with Power Swing or Reversal Guard

For double circuit lines, the fault current direction can change in one circuit when circuit breakers open sequentially to clear the fault on the parallel circuit. The change in current direction causes the overreaching distance elements to see the fault in the opposite direction to the direction in which the fault was initially detected. (settings of these elements exceed 150% of the line impedance at each terminal). The race between operation and resetting of the overreaching distance elements at each line terminal can cause the Permissive Overreach, and Blocking schemes to trip the healthy line. A system configuration that could result in current reversals is shown in the *Current Reversal in Double Circuit Lines* diagram. For a specific fault (see distance scheme for details) on line L1 close to circuit breaker B, as circuit breaker B trips it causes the direction of current flow in line L2 to reverse.

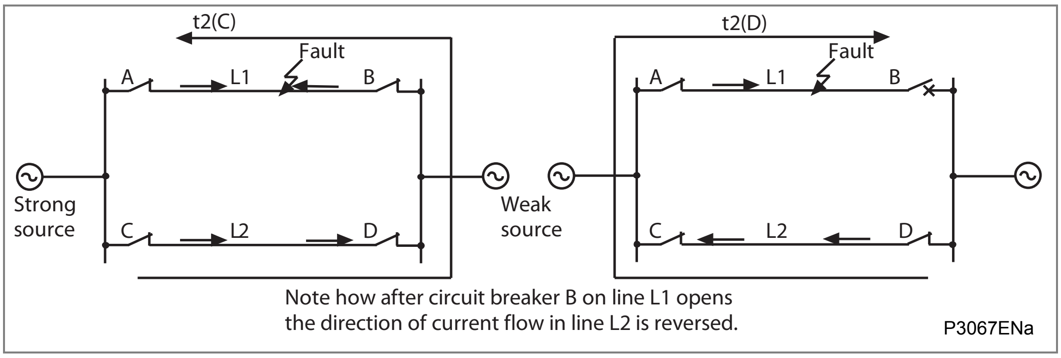


Figure 59 - Current Reversal in Double Circuit Lines

In this case, zones & directionality are modified when the following conditions are met (basic unblocking / blocking logic in the *Current Reversal in Double Circuit Lines* diagram):

- Power swing detection (in this case, power swing detected or unblocking during a power swing),
- Blocking logic settings during power swing,
- Reversal Guard time-delay (DDB: '**Reversal Guard**'),
- Type of teleprotection scheme.

When zones are blocked during the power swing, those can be unblocked by:

- Start of unblocking logic,
- Unblocking logic enabled for the concerned zone or all zones (setting).

In the next figure, the following acronyms are used

Unblock PS Z1, Z2, Z3, Z4, Zp or Zq:	Unblocking of Zone 1 (Z1), Z2, Z3, Z4, Zp or Zq during a power swing ('Power swing / Blocking zone' menu) 0 => Zx blocked during power swing 1 => Zx unblocked during power swing
DDB: Z1,Z1x, Z2, Z3, Z4, Zp, Zq:	Fault detected in zone 1, Z1x, 2, 3, 4, p or q and filtered by blocking/unblocking Power Swing
Z1<ZL	Setting: internal configuration that determines that Z1 is smaller than the length of the line ZL.

During the reversal guard logic (in the case of parallel lines with overreaching teleprotection scheme - Z1x>ZL), the reverse direction decision is latched (until that timer is elapsed) from the change from reverse to forward fault direction.

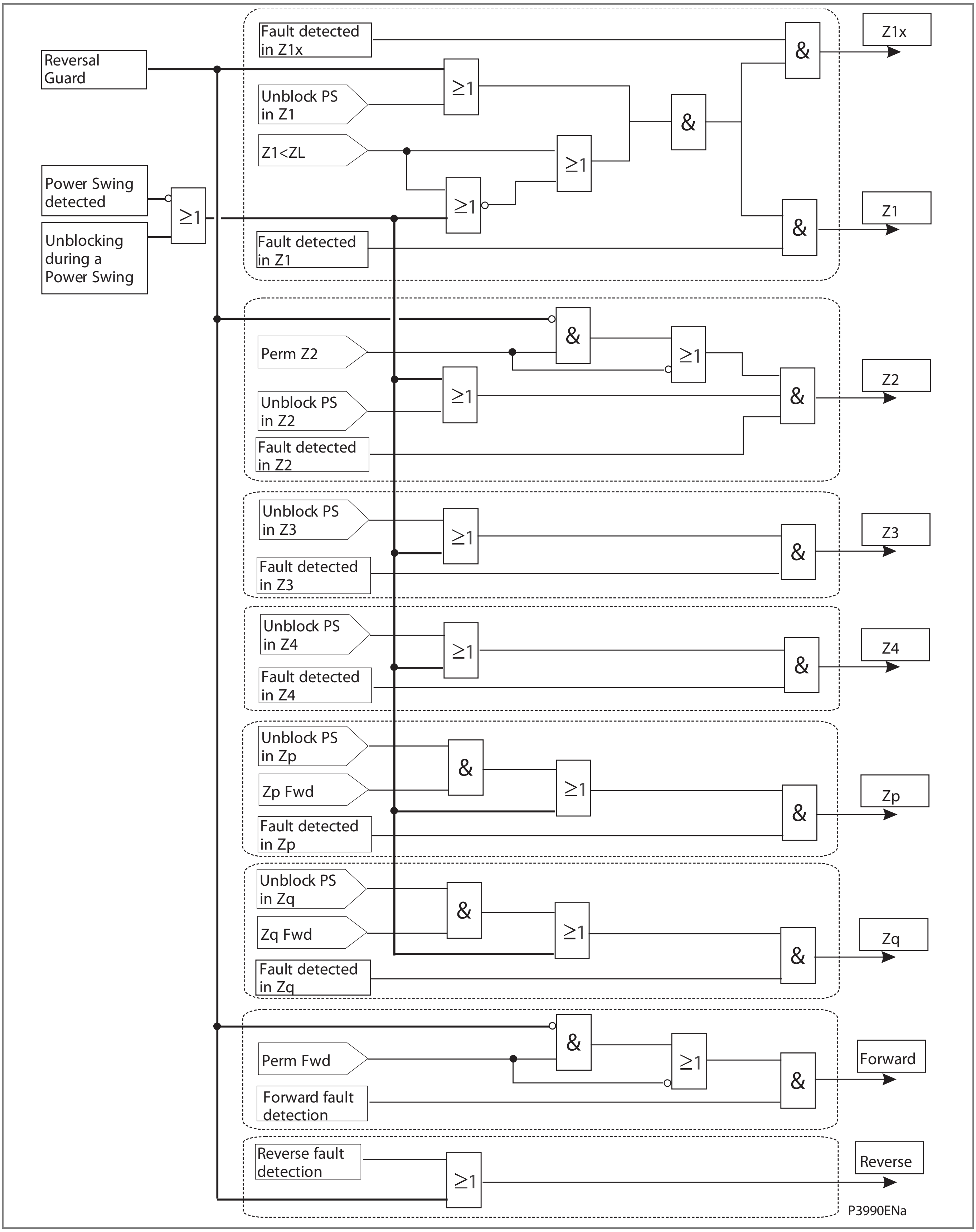


Figure 60 - Current Reversal in Double Circuit Lines Zones Blocking / Unblocking with power swing or reversal guard

3.5.1.3 Zone 1 Extended

The following trip logic represents the zone 1 extended logic:

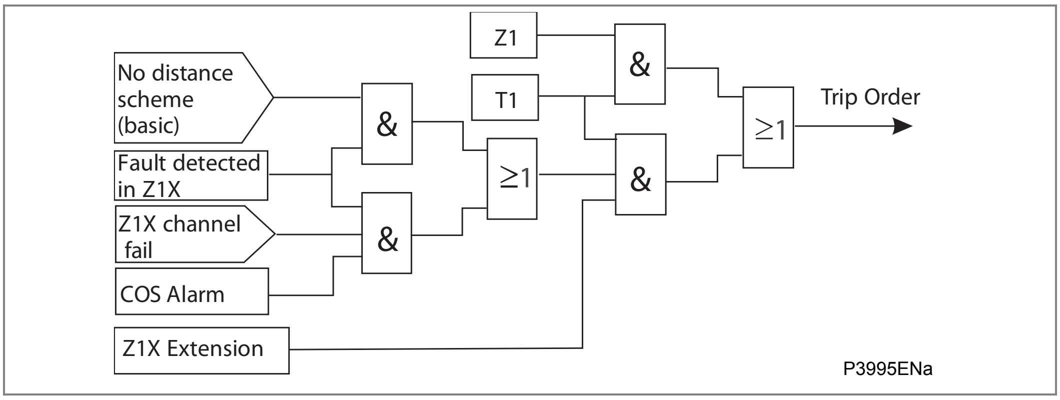


Figure 61 – Zone 1 Extended (Z1X) Trip logic

Z1X can be used as well as the default scheme logic in case of UNB _Alarm-carrier out of service (as described in the *Unblocking Logic (Permissive Scheme)* section).

Where:

	Description
‘COS alarm’	Alarm channel (main and DEF)
Z1x, Z1	Z1X, Z1 Decision (lock out by Power Swing)
T1	distance timer 1, 2, 3, 4, p or q elapsed

3.5.2 Channel Aided Distance Scheme Logic

3.5.2.1 Loss of Load

The next figure illustrates the loss of load trip logic:

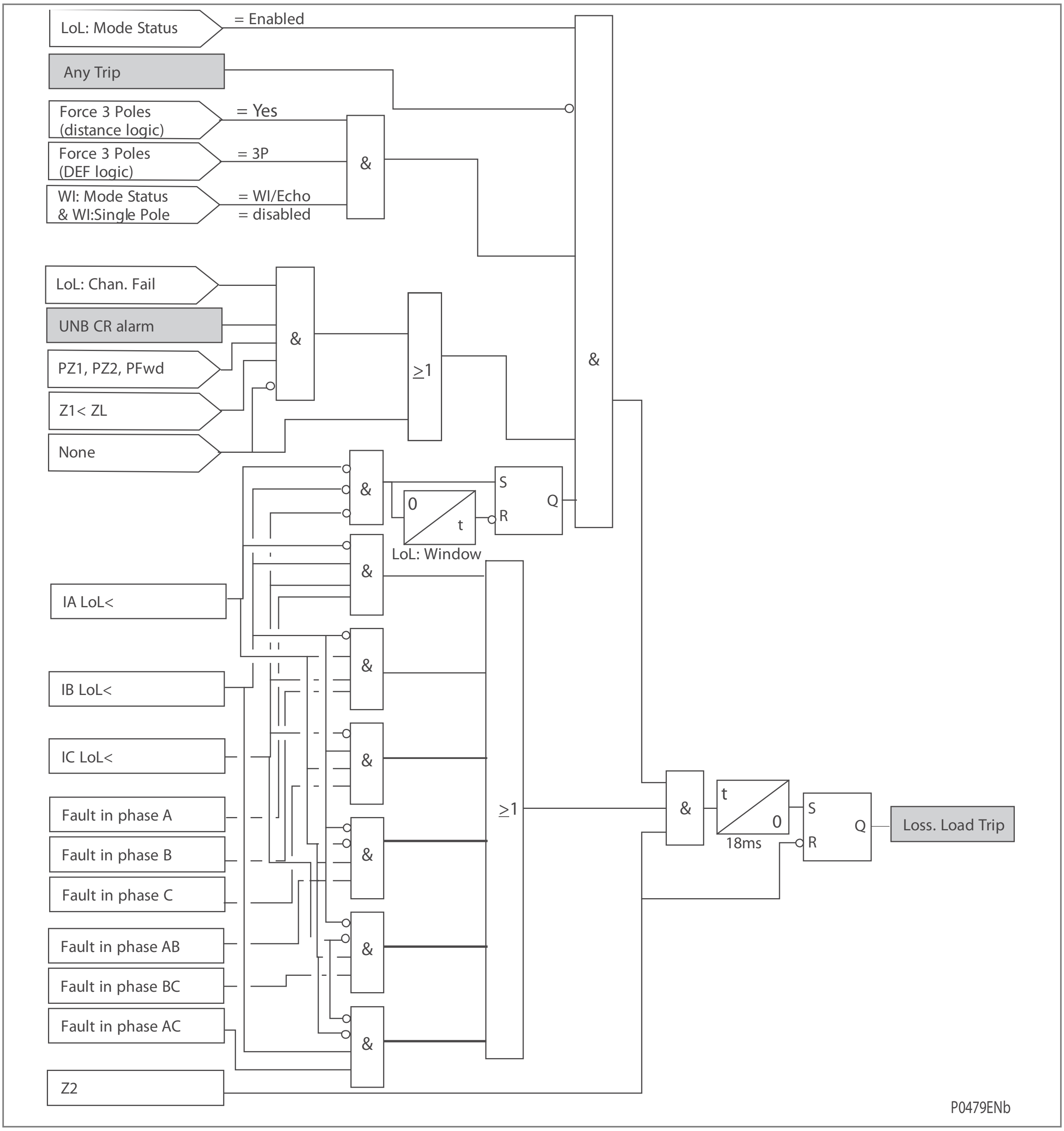


Figure 62 – Loss of load trip logic

Where:

	Description
PZ1, PZ2, PFwd, None	Underreach scheme: Z1 < ZL: Permissive underreach Z1, Z2 or forward None: no distance scheme (basic scheme)
Z1<ZL	Underreach scheme in Z1
Z2'	Fault in Z2 (lockout by Power swing or Reversal Guard)

3.5.3 Trip Logic and Zone 1 Extension Logic

The following trip logic completes the distance protection by zone:

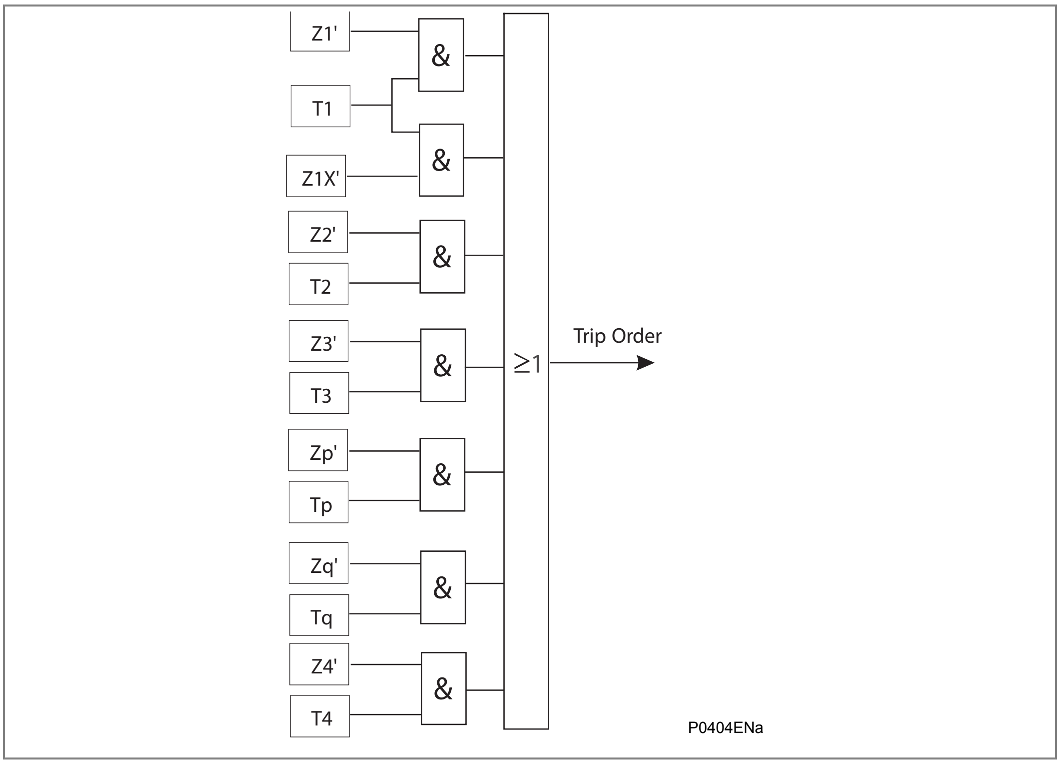


Figure 63 – trip and Z1X Trip logic

Z1X can be used as well as the default scheme logic in case of UNB _Alarm-carrier out of service (See the *Unblocking Logic (Permissive Scheme)* section).

3.5.4 Distance Trip Equation

The following equation summarizes the distance trip equation (previously illustrated in logic diagrams):

Distance Trip logic (*) =

Z1 . T1 . $\overline{\text{BZ1}}$. $\overline{\text{PZ1}}$

\+ Z1x' . (None + Z1xChannel_Fail . ‘COS alarm’).(T1 . INP_Z1EXT)

\+ ‘DIST. UNB CR’ . T1 . [PZ1 . Z1' + PZ2 . Z2' + PFwd . Aval’]

\+ $\overline{\text{UNB\_CR}}$. T1 . ‘Aid Dist Delay’ + ‘DIST. COS’) . [Z1' . BZ1 + (Z2' . BZ2 . $\overline{\text{INP\_COS}}$)]

\+ T2 [Z2' + PZ1 . Z1' + BZ1 . Z1']

\+ Z3' . T3

\+ Zp' . TZp

\+ Zq' . TZq

\+ Z4'. T4

Note 1	*In case of Carrier Out of Service (COS), the logic swaps back to a basic scheme.*
Note 2	*The inputs Z1X must be polarised for activating Z1X the logic.*
Note 3	*For the 1P – 3P trip logic check in the Tripping Logic section.*

Acronyms used in the Previous Equation:

Inputs:	Description
T1 to, T2, T3, T4, TZp, TZq	Elapsed of Distance Timer 1 to 4 (T1 / T2 / T3 / TZp / TZq / T4)
'Aid Dist Delay'	Elapse of d transmission time in blocking scheme
Z1', Z2', Z3', ' to Z4' (*), Zp', Zq'	Detection of fault in zones 1 to 4 (lock out by PSWing or Rev Guard).
Forward'	Forward Fault Detection I (lockout by reversal guard)
UNB_CR	Carrier Received
INP_COS	Carrier Out of Service
None	Scheme without carrier
PZ1	Permissive scheme Z1
PZ2	Permissive scheme Z2
PFwd	Permissive Scheme with directional Fwd
BZ1	Blocking scheme Z1
BZ2	Blocking scheme Z2
INP_Z1EXT	Zone extension (digital input assigned to an opto input by dedicated PSL)
Z1xChannel Fail	Z1x logic enabled if channel fail detected (Carrier out of service = COS)
UNBAlarm	Carrier Out Of Service

Outputs:	Description
PDist_Dec	Distance protection Trip trip
CsZ1	Carrier send in case of zone 1 decision
CsZ2	Carrier send in case of zone 2 decision
CsZ4	Carrier send in case of zone 4 decision (Reverse)

4 APPLICATION OF INDIVIDUAL PROTECTION FUNCTIONS

4.1 Busbar Isolation Mode

The intention of busbar isolation mode (software version D6.x) is to open the coupling of a busbar when a fault is detected.

When Busbar isolation mode is enabled, fault directional decision is non-directional.

The objective of this feature is to embed in P44x a feature that can help to keep network stable as much as possible and avoid loss of voltages due to a too long fault clearance from the rest of the protection scheme.

The distance protection uses 6 loops, calculated by the distance algorithm:

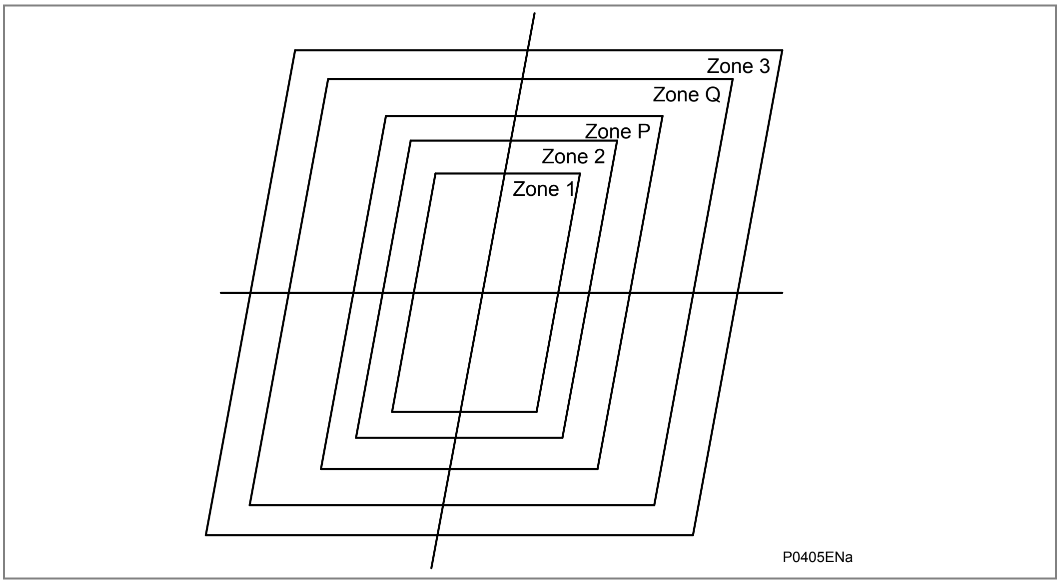


Figure 64 – Distance Protection Loops

Busbar isolation mode forces busbar isolation. In this case:

- all zones are symmetric (for example Zone 1 characteristics are valuable for both forward and reverse directions),
- tripping mode is only a 3-pole trip,
- no scheme logic is used.

Consequently, busbar isolation status enabled sets distance zone as follows:

- 'Z3' = 'Z4',
- 'Zone P – Direc' and 'Zone Q – Direc' = Directional Fwd,
- 'Program Mode' = Standard Scheme,
- 'Standard Mode' = Basic + Z1X,
- 'Trip Mode' = Force 3 Poles,
- 'Z1 Ext. on Chan. Fail' is disabled,
- Tilt angle is disabled,
- Reversal guard delay ('tReversal Guard') is not used.

4.2 Power Swing Detection and Blocking (PSB)

Power swings are caused by a lack of stability in the network with sudden load fluctuations. A power swing may cause the two sources connected by the protected line to go out of step (loss of synchronism) with each other.

The power swing detection element may be used to selectively prevent when the measured impedance point moves into the start-up characteristic from a power swing and still allows tripping for a fault (fault evolving during a power swing). The power swing detection element may also be used to selectively trip once an out-of-step condition has been declared.

Power swings are oscillations in power flow which can follow a power system disturbance. They can be caused by sudden removal of faults, loss of synchronism across a power system or changes in direction of power flow as a result of switching. Such disturbances can cause generators on the system to accelerate or decelerate to adapt to new power flow conditions, which in turn leads to power swinging. A power swing may cause the impedance presented to a distance relay to move away from the normal load area and into one or more of its tripping characteristics.

4.2.1 Power Swing Detection

A power swing is characterized by:

- A 3 successive impedance points in start-up zone of the biphase characteristic,
- A slow variation of current,
- A slow variation of voltage.

On the contrary a fault is characterized by a rapid (instantaneous) and “exaggerated” variation of current.

Power Swing detection uses a ΔR (resistive) and ΔX (reactive) impedance band which surrounds the entire biphase fault trip characteristic.

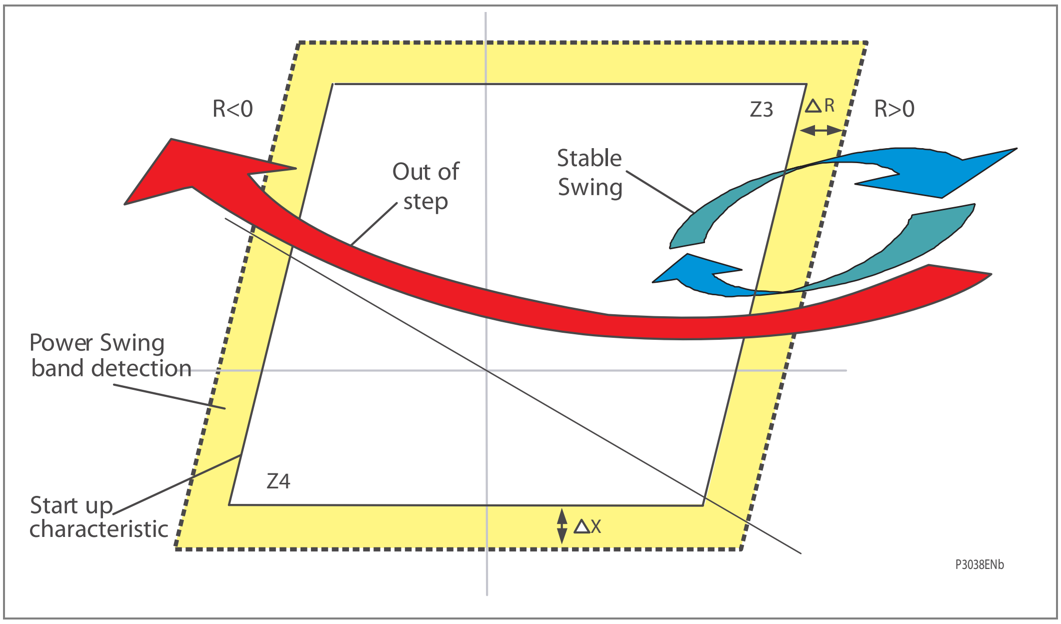


Figure 65 – Biphase Power swing characteristic

A power swing is detected when all 3 phase to phase impedances have remained within the ΔR for at least 3 acquisition samples (5ms at 50Hz) and have taken longer than 5ms to reach the trip characteristic.

More precisely, a power swing is detected and declared if:

- At least one phase-phase impedance is within the start-up zone after having crossed the power swing band in more than 5ms.
- The three impedance points have been in the power swing band for more than 5ms.
- At least two poles of the breaker are closed (impedance measurement possible on two phases).

Note	*During Power swing the residual compensation factors k0 are not applied in the detection of the characteristic.(the extended limit in R gives: R1=R2=R3=RpFwd)*

4.2.1.1 Line in One Pole Open Condition (during Single-Pole Trip)

In this case, the power swing occurs only on two phases. A power swing is detected if:

- At least one phase-phase impedance is within the start-up zone after having crossed the power swing band in more than 5ms.
- The two impedance points have been in the power swing band for more than 5 ms.

Note	*During an open-pole condition, the P44x monitors the power swing on the healthy phase-phase loop. No external information is needed if the voltage transformers are on the line side. If the voltage transformers are on the bus side, the "pole discrepancy" signal should be used. The "pole discrepancy" input represents a "one-circuit-breaker-pole-open" condition.*

4.2.1.2 Conditions for Isolating Lines

If there is a power swing, it may be necessary to disconnect the two out-of-step sources. There are various tripping and blocking options available that are used to select if the line has to be tripped for power swings or not.

The selective blocking of back up zones only allows the P44x to separate the network near the electrical zero by tripping zone 1 only. Therefore, in the example given in , the relay D trips out.

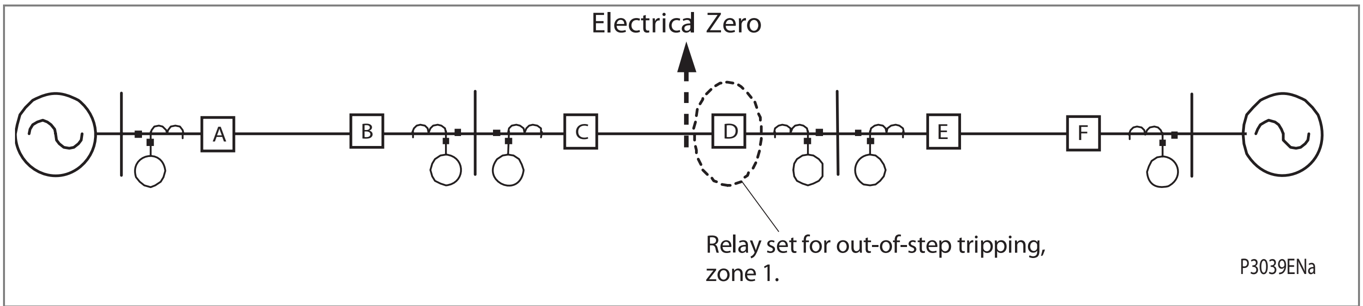


Figure 66 - Selective Protection Blocking

4.2.2 Stable Swing and Out Of Step

The relay is able to distinguish two types of Power Swing:

- Stable Swing
- Out Of Step (OOS)

In case of a "Stable Swing" the sigh of the resistance value at the instant the impedance enters the characteristic is the same as the sign of the resistance value at the instant the impedance goes out from the characteristic (see the *Biphase Power swing characteristic* diagram)

In case of an Out Of Step, the sign of the resistance value at the instant the impedance enters the characteristic is opposite to the sign of the resistance value at the instant the impedance goes out from the characteristic (see the *Biphase Power swing characteristic* diagram).

An out of Step is a loss of synchronism.

In both cases, the considered characteristic is the biphase loop characteristic. In other words the phase to phase impedance is considered to perform Power Swing detection.

The Protection relay is able to count how many Stable Swings and how many Out of step Occurs.

It is possible in MiCOM S1 Studio to set a number of out of step threshold above which a DDB (Out Of Step Conf DDB#352) is triggered.

4.2.3 Biphase Loop

To decide what loop (what phases) has to be monitored, 2 distinct algorithms are run:

- An exaggerated Delta current algorithm
- A Flat algorithm

4.2.4 Power Swing Blocking

As soon as a power swing is detected the protection relay is blocked ("Power swing blocking"). The Power Swing blocking algorithm prevents the protection relay from tripping due to a power swing.

Power Swing blocking can be enabled or disabled per zone through "Blocking Zones" setting.

If any or all of the distance zones are blocked, related trips are blocked including aided trip logic.

For non-blocked zones, the swing indication is provided without tripping.

It is possible to limit the time for which blocking of any distance protection zones is applied. In other words, unblocking timer is used to override any blocked zone. Thus, certain locations on the power system can be designed as split points, where circuit breakers will trip 3 phase in order to stabilize.

Power swing blocking is automatically removed after "unblocking delay".

This is used to separate the sources (open the breaker, 3-phase trip) in the event that a block was taking place, and the impedance remained in the blocked zone for a relatively long time. This would indicate a serious overcurrent condition as a result of too great a power transfer after a disturbance (a power swing that does not pass through or recover). If the impedance point moves out of the start-up characteristic again before the time delay expires, a trip is not issued and the adjustable time delay is reset.

Note	*Power Swing Blocking can be disabled (for distribution systems). Power Swings should not happen at Distribution voltage levels.*

4.2.5 Power Swing Unblocking (Unblocking of the Relay for Faults During Power Swing)

If a fault occurs while the power swing blocking algorithm is on going the Power Swing blocking algorithm is unblocked so that the protection relay can protect from the occurring fault (by tripping).

- The relay operates normally for any fault occurring during a power swing 4 fault detection criteria can unblock the “Power Swing blocking”:

Residual Current (IN> status setting) criterion:
This allows tripping for earth faults occurring during a power swing

0.1 In + (kr x Imax(t)) *

If Residual current condition is true for more than 40ms, then Power Blocking is unblocked.

Negative Sequence Current (I2> status setting) criterion:
This allows tripping for phase to phase faults occurring during a power swing.

0.1 In + (ki x Imax(t)) *

If Negative Sequence Current condition is true for more than 40ms, then Power Blocking is unblocked.

* Where:
kr = an adjustable coefficient for residual or zero sequence current (3I0),
ki: = an adjustable coefficient for negative sequence current (I2),
Imax(t): maximum instantaneous current detected on one phase (A, B or C),
In: nominal current

Phase current threshold (ImaxLine> status setting) criterion:
This allows tripping for 3 phase faults occurring during a power swing.

Delta I criterion (‘Delta I status’ setting)
This allows tripping for 3 phase faults occurring during a power swing even if the fault current is lower than ImaxLine>

- condition 1: There is an exaggerated Delta I
- condition 2: There is an absence of current variation on biphases loop.

If there is a delta exaggerated current (condition1 = true) and there is an absence of variation of current (condition 2 = true) for more than 100ms then Power Swing blocking is unblocked.

If there isn’t any delta exaggerated current (condition1 = false) and there is an absence of variation of current (condition 2) for more than 200ms then Power Swing blocking is unblocked.

4.2.6 What Loop is Faulty?

The delta quantity calculated by delta exaggerated algorithm is used to determine which loop will be chosen.

The identified faulty loop will lead to a trip in case of the power swing blocking is unblocked. This step is a way to accelerate the determination of the faulty loop an, thus, a trip.

Note	Even if Delta I status is disabled, exaggerated delta current is always internally calculated.

Regarding the presence of negative sequence current or residual current the exaggerated delta current detection are calculated on the phase to phase loop or phase to ground loop.

On what phase(s) is there the fault?

Input : I_AB, I_BC, I_CA (rms values)
I_AB = IB – IA

If I_AB > ($\sqrt{3}$ × 0.6 × In) then a ‘CN Fault is detected.

If I_BC > ($\sqrt{3}$ × 0.6 × In) then a ‘AN Fault is detected.

If I_CA > ($\sqrt{3}$ × 0.6 × In) then a ‘BN Fault is detected.

Caution	**During a Power Swing, all Directional elements are disabled (it is not possible to determine fault direction during a Power Swing).**

4.2.6.1 Power Swing Detection and Blocking Logic

The next figure summarizes power swing logic (detection and blocking):

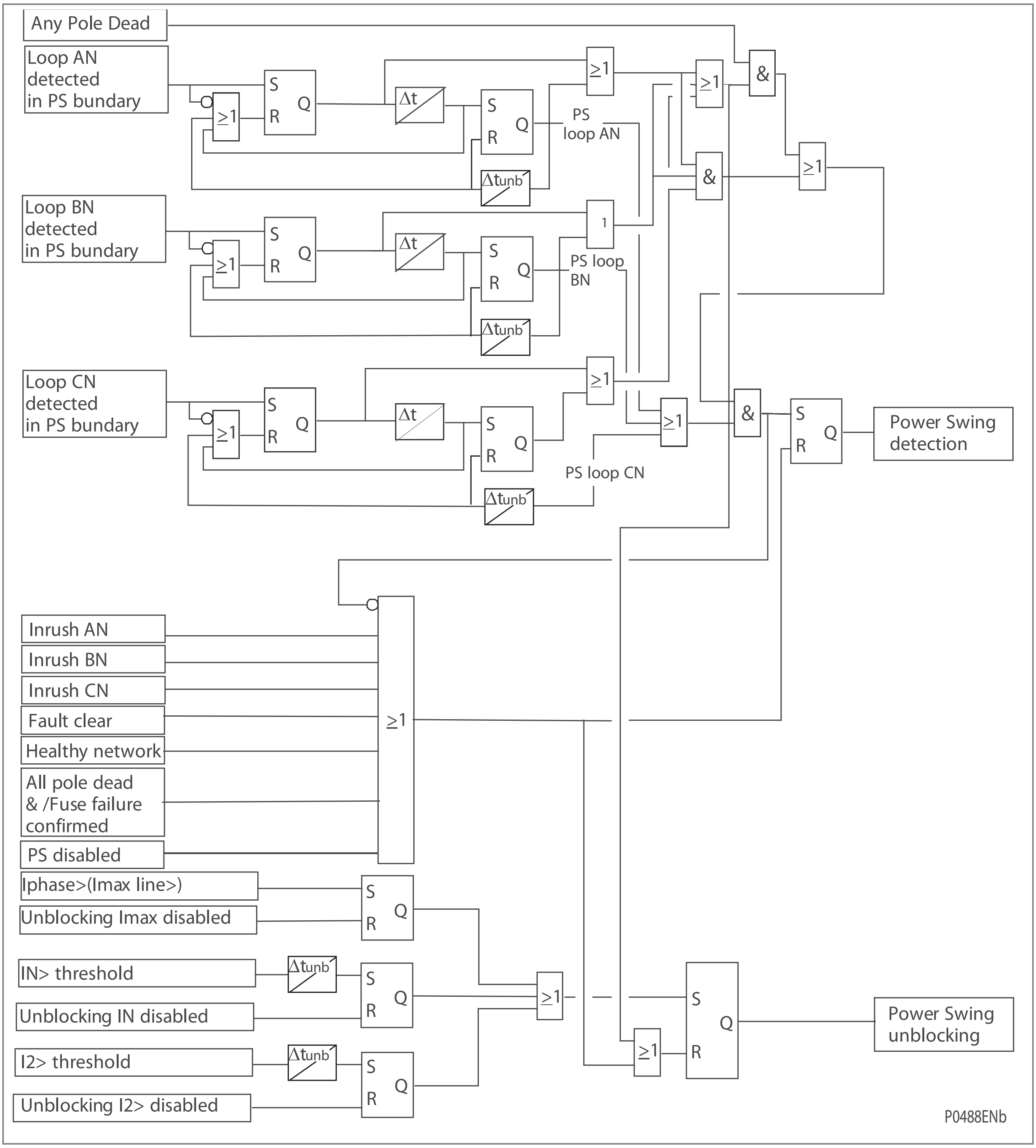


Figure 67 – Power swing detection & Unblocking logic

4.3 Directional and Non-Directional Overcurrent Protection

4.3.1 Inverse Time Characteristics

The inverse time-delay characteristics comply with this formula:

$$t = \frac{TD}{7} x \left[\frac{K}{(I / Is)^{\alpha} - 1} + L \right]$$

Where:

t	=	Operation time
K	=	Constant
I	=	Measured current
Is	=	Current threshold setting
α	=	Constant
L	=	ANSI/IEEE constant (zero for IEC curves)
TD	=	Time Multiplier Setting for IEEE/US Curves

IDMT Curve description	Standard	K 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
Moderately Inverse	IEEE	0.0515	0.02	0.0114
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	0.02394	0.02	0.1694

Note that the IEEE and US curves are set differently to the IEC/UK curves, with regard to the time setting. A time multiplier setting (TMS) is used to adjust the operating time of the IEC curves, whereas a time dial setting is employed for the IEEE/US curves. Both the TMS and Time Dial settings act as multipliers on the basic characteristics but the scaling of the time dial is 10 times that of the TMS, as shown in the previous menu. The menu is arranged such that if an IEC/UK curve is selected, the **I> Time Dial** cell is not visible and vice versa for the **TMS** setting.

4.3.2 Application of Timer Hold Facility

The first two stages of overcurrent protection in the P442 and P444 relays are provided with a timer hold facility, which may either be set to zero or to a definite time value (Note that if an IEEE/US operate curve is selected, the reset characteristic may be set to either definite or inverse time in cell **I>1 Reset Char**; otherwise this setting cell is not visible in the menu). Setting of the timer to zero means that 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. This may be useful in certain applications, for example when grading with upstream electromechanical overcurrent relays that have inherent reset time delays.

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 may not 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.

Note that the timer hold facility should not be used where high speed autoreclose with short dead times are set.

The timer hold facility can be found for the first and second overcurrent stages as settings **I>1 tRESET** and **I>2 tRESET**. Note that these cells are not visible if an inverse time reset characteristic has been selected, as the reset time is then determined by the programmed time dial setting.

4.3.3 Directional Overcurrent Protection

If fault current can flow in both directions through a relay location, it is necessary to add directional control to the overcurrent relays in order to obtain correct discrimination. Typical systems that require such protection are parallel feeders and ring main systems. Where I>1 or I>2 stages are directionalised, no characteristic angle needs to be set as the relay uses the same directionalising technique as for the distance zones (fixed superimposed power technique).

4.3.4 Time Delay Voltage Transformer Supervision (VTS)

Should the Voltage Transformer Supervision (VTS) function detect an ac voltage input failure to the relay, such as due to a VT fuse blow, this will affect operation of voltage dependent protection elements. Distance protection will not be able to make a forward or reverse decision, and so will be blocked. As the I>1 and I>2 overcurrent elements in the relay use the same directionalising technique as for the distance zones, any directional zones would be unable to trip.

To maintain protection during periods of VTS detected failure, the relay allows an **I> Time Delay VTS** to be applied to the I>1 and I>2 elements. On VTS pickup, both elements are forced to have non-directional operation, and are subject to their revised definite time delay.

4.3.5 Setting Guidelines

4.3.5.1 I>1 and I>2 Overcurrent Protection

When applying the overcurrent or directional overcurrent protection provided in the P442 and P444 relays, standard principles should be applied in calculating the necessary current and time settings for co-ordination. In general, where overcurrent elements are set, these should also be set to time discriminate with downstream and reverse distance protection. The I>1 and I>2 elements are continuously active. However tripping is blocked if the distance protection function starts. An example is shown in below.

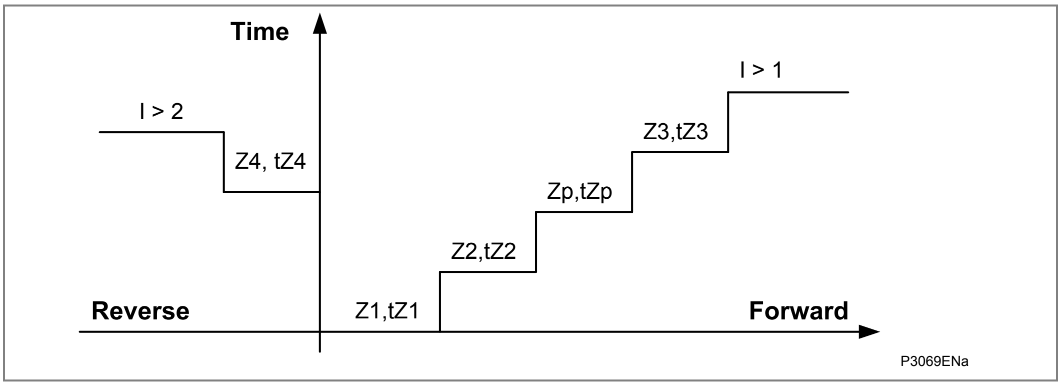


Figure 68 - Time Grading Overcurrent Protection with Distance Protection (DT Example)

4.3.5.2 I>1 and I>2 Time Delay VTS

The I>1 and I>2 overcurrent elements should be set to mimic operation of distance protection during VTS pickup. This requires I>1 and I>2 current settings to be calculated to approximate to distance zone reaches, although operating non-directional. If fast protection is the main priority then a time delay of zero or equal to tZ2 could be used. If parallel current-based main protection is used alongside the relay, and protection discrimination remains the priority, then a DT setting greater than that for the distance zones should be used. An example is shown in below.

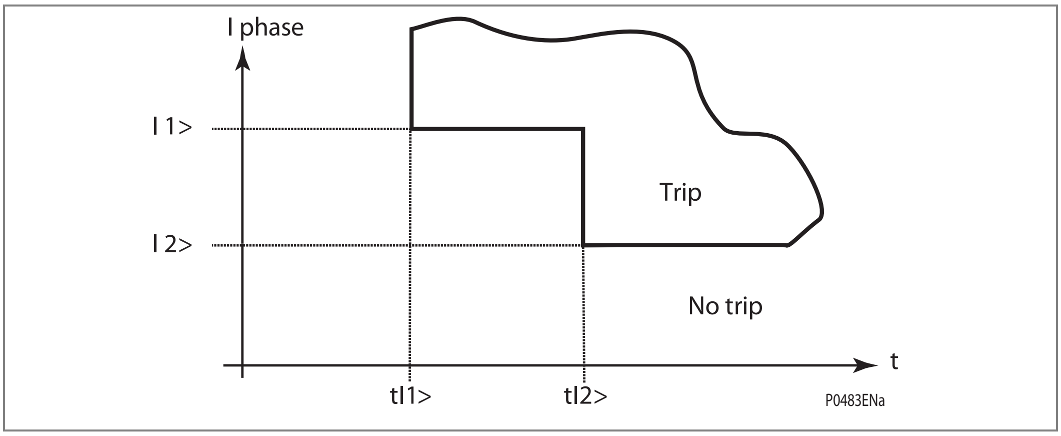


Figure 69 - Tripping logic for phase overcurrent protection

4.3.5.3 I>3 Highset Overcurrent and Switch on to Fault Protection (SOTF)

The I>3 overcurrent element of the P442 and P444 relays can be Enabled as an instantaneous highset just during the TOR/SOTF period. After this period has ended, the element remains in service with a trip time delay setting **I>3 Time Delay**. This element would trip for close-up high current faults, such as those where maintenance earth clamps are inadvertently left in position on line energisation.

The I>3 current setting applied should be above load current, and > 35% of peak magnetising inrush current for any connected transformers as this element has no second harmonic blocking. If a high current setting is chosen, such that the I>3 element will not overreach the protected line, then the I>3 Time Delay can be set to zero. The remote source should not not be sufficiently strong to cause element pickup for a close-up reverse fault.

If a low current setting is chosen, I>3 will need to discriminate with local and remote distance protection. This principle is shown in below.

I>3 Current Setting	Instantaneous TOR/SOTF Function	Function After TOR/SOTF Period	Time Delay Required
Above load and inrush current but LOW	Yes - sensitive.	Time delayed backup protection.	Longer than tZ3 to grade with distance protection.
HIGH, ≥ 120% of max. fault current for a fault at the remote line terminal and max. reverse fault current	Yes - may detect high current close-up faults.	Instantaneous highset to detect close-up faults.	I>3 Time Delay = 0. (Note #.)

Table 8 - Current and Time Delay Settings for the I>3 Element

Key:	*As the instantaneous highset trips three pole it is recommended that the I>3 Time Delay is set ≥ tZ2 in single pole tripping schemes, to allow operation of the correct single pole autoreclose cycle.*

4.3.5.4 I>4 Stub Bus Protection

When the protected line is switched from a breaker and a half arrangement it is possible to use the I>4 overcurrent element to provide stub bus protection. When stub bus protection is selected in the relay menu, the element is only enabled when the opto input Stub Bus Isolator Open (**Stub Bus Enable**) is energised. Thus, a set of 52b auxiliary contacts (closed when the isolator is open) is required.

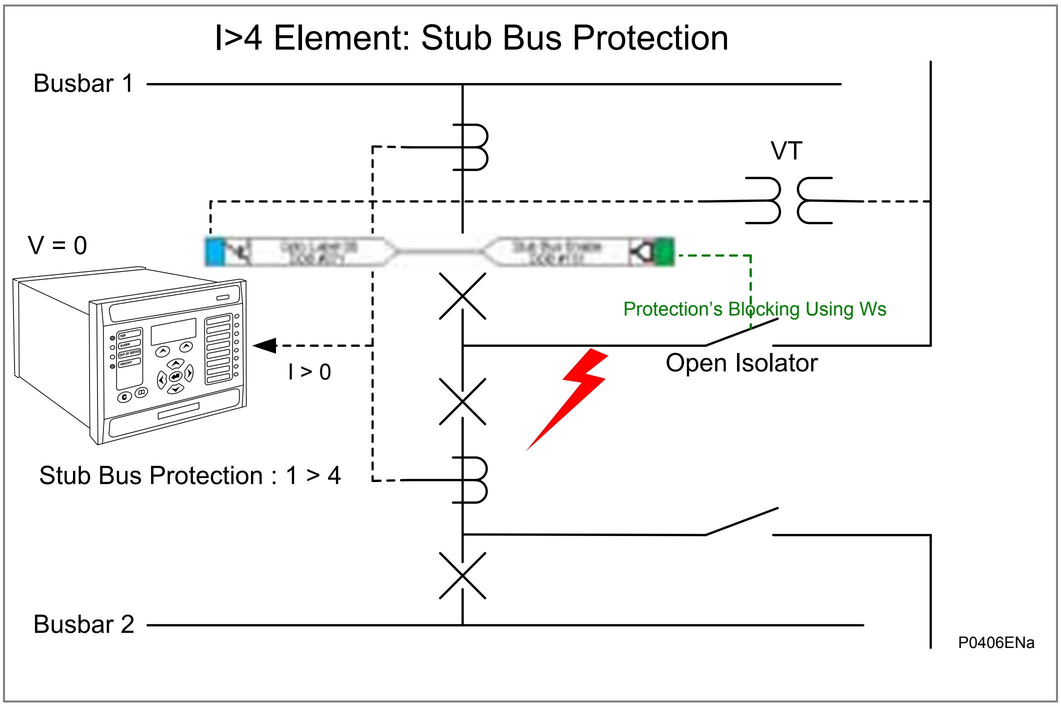


Figure 70 - I>4 stub bus protection

Although this element would not need to discriminate with load current, it is still common practice to apply a high current setting. This avoids maloperation for heavy through fault currents, where mismatched CT saturation could present a spill current to the relay. The I>4 element would normally be set instantaneous, t>4 = 0s.

4.4 Negative Sequence Overcurrent Protection

4.4.1 Setting Guidelines

The MiCOM P44x negative sequence overcurrent protection elements include four thresholds. The first and the second thresholds can be set as DT or IDMT trip delay time. The curves are the same as for the directional and non directional overcurrent protection.

The current pick-up threshold must be set higher than the negative phase sequence 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 negative phase sequence current, and setting at least 20% above this figure.

Where the negative phase sequence 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 negative phase sequence fault current contribution to a specific remote fault condition.

Note that in practice, if the required fault study information is not available, the setting must adhere to the minimum threshold previously outlined, employing a suitable time delay for co-ordination with downstream devices. This is vital to prevent unnecessary interruption of the supply resulting from inadvertent operation of this element.

A correct setting of the time delay 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, such as:

- Phase overcurrent elements
- Earth fault elements
- Broken conductor elements
- Negative phase sequence influenced thermal elements

4.4.2 Directionalising the Negative Phase Sequence Overcurrent Element

Directionality is achieved by comparison of the angle between the negative phase sequence voltage and the negative phase sequence current. It 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 ($-V_2$), in order to be at the centre 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°

4.5 Maximum of Residual Power Protection – Zero Sequence Power Protection ("Zero Seq Power" menu)

The aim of this protection is to provide the system with selective and autonomous protection against resistive phase to ground faults. High resistive faults such as vegetation fires cannot be detected by distance protection.

When a phase to ground fault occurs, the fault can be considered as a zero-sequence power generator. Zero-sequence voltage is at maximum value at the fault point. Zero-sequence power is, therefore, also at maximum value at the same point. Supposing that zero-sequence current is constant, zero-sequence power will decrease along the lines until null value at the source's neutral points (see below).

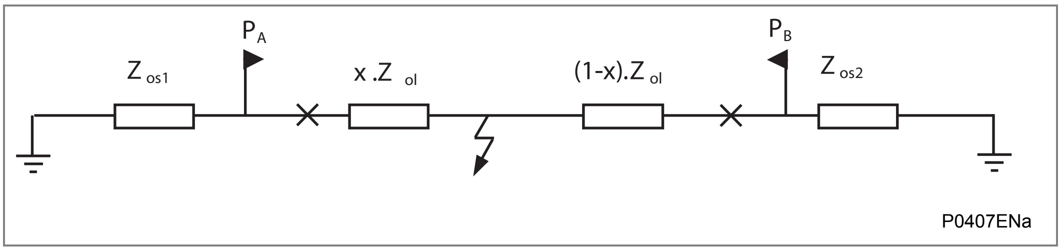


Figure 71 - Zero sequence

Where:

Zos1:	=	Zero-sequence source side 1 impedance
Zol	=	Zero-sequence line impedance
Zos2	=	Zero-sequence source side 2 impedance
x	=	Distance to the fault from P_A.

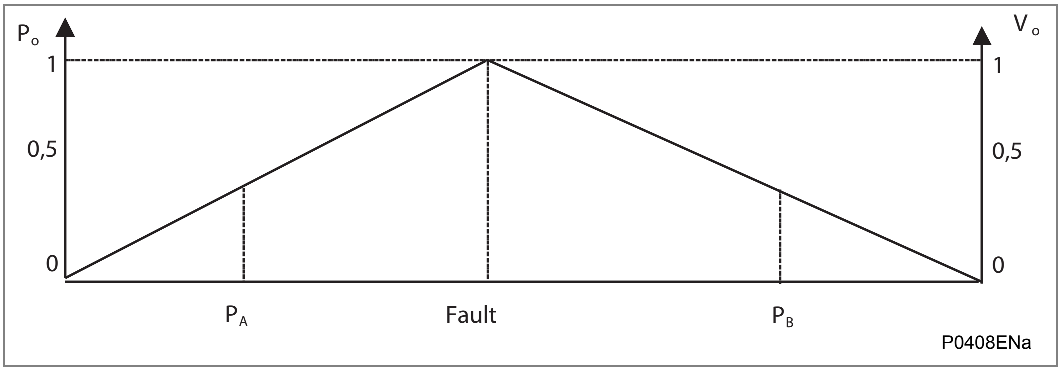


Figure 72 - Zero sequence decreasing along the line

Selective fault clearance of the protection for forward faults is provided by the power measurement combined with a time-delay inversely proportional to the measured power.

Caution	**This protection function does not issue any trip command for reverse faults**

In compliance with sign conventions (the zero-sequence power flows from the fault towards the sources) and with a mean characteristic angle of the zero-sequence source impedances of the equal to 75°, the measured power is determined by the formula:

$Sr = Vr_{r.m.s} \times Ir_{r.m.s} \times \cos(\varphi - \varphi_0)$

Where:

φ	=	Phase shift between Vr and Ir
φ_0	=	255° or – 75°
$Vr_{r.m.s}$, $Ir_{r.m.s}$	=	R.M.S values of the residual voltage and current

The Vr and Ir values are filtered in order to eliminate the effect of the 3rd and 5th harmonics.

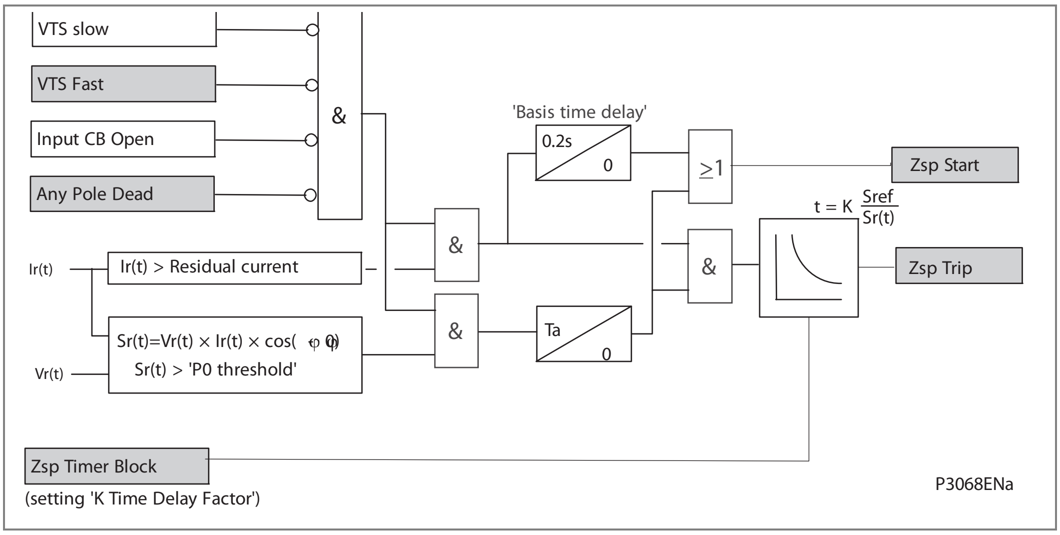


Figure 73 – Zero sequence power logic

3-pole trip is sent out when the residual power threshold “Residual Power" is overshot, after a time-delay (‘**Basis Time Delay**’) and an IDMT time-delay adjusted by the “K” time delay factor.

The basis time-delay is set at a value greater than the second stage time of the distance protection of the concerned feeder if the 3-pole trip is active, or at a value greater than the single-phase cycle time if single-pole autorecloser shots are active.

Ta time-delay is fixed (200ms) and starts with residual current.

The IDMT time-delay is determined by the formula:

$t = K \times (S_{ref}/S_r)$

Where:

K	=	Adjustable time constant from 0 to 2sec (‘**K Time Delay Factor**’ setting)
S_{ref}	=	Reference residual power, depending on the CT: 10 VA for In = 1A 50 VA for In = 5A
S_r	=	Residual power generated by the fault

4.6 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.

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 following table shows the relay menu for the Broken Conductor protection, including the available setting ranges and factory defaults:

4.6.1 Setting Guidelines

In the case of 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 impedances in each sequence network), the ratio I2/I1 will be 50%.

It is possible to calculate the ratio of I2/I1 that will occur for varying system impedances, by referring to the following equations:

$$I_{1F} = \frac{E_g (Z_2+Z_0)}{Z_1Z_2 + Z_1Z_0 + Z_2Z_0}$$

$$I_{2F} = \frac{-E_g Z_0}{Z_1Z_2 + Z_1Z_0 + Z_2Z_0}$$

Where:

E_g = System Voltage
Z_0 = Zero sequence impedance
Z_1 = Positive sequence impedance
Z_2 = Negative sequence impedance

Therefore:

$$\frac{I_{2F}}{I_{1F}} = \frac{Z_0}{Z_0 + Z_2}$$

It follows that, for an open circuit in a particular part of the system, I2/I1 can be determined from the ratio of zero sequence to negative sequence impedance. It must be noted however, that this ratio may vary depending upon the fault location. It is desirable therefore to apply as sensitive a setting as possible. In practice, this minimum setting is governed by the levels of standing negative phase sequence current present on the system. 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 that a minimum value of 8% negative phase sequence current is required for successful relay operation.

Since 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 autoreclose cycle). Hence, a long time-delay is necessary to ensure co-ordination with other protective devices. A 60 second time-delay setting may be typical.

4.6.2 Setting Example

The following information was recorded by the relay during commissioning:

$I_{full\ load}$ = 1000A

I_2 = 100A

therefore the quiescent I2/I1 ratio is given by:

- I_2/I_1 = 100/1000 = 0.1

To allow for tolerances and load variations a setting of 200% of this value may be typical: Therefore set **I2/I1** = 0.2

Set **I2/I1 Time Delay** = 60 s to allow adequate time for short circuit fault clearance by time delayed protections.

4.7 Directional and Non-Directional Earth Fault Protection

4.7.1 Setting Guidelines

The MiCOM P44x earth fault protection elements include four thresholds. The first and the second thresholds can be set as DT or IDMT trip delay time. The curves are the same as for the directional and non directional overcurrent protection.

Note that the elements are set in terms of residual current, which is three times the magnitude of the zero sequence current (Ires = $3I_0$). The IDMT time-delay characteristics available for the IN>1 and IN>2 elements, and the grading principles used will be as per the phase fault overcurrent elements.

To maintain protection during periods of VTS detected failure, the relay allows an **IN> Time Delay VTS** to be applied to the IN>1 to IN>4 elements. On VTS pickup, both elements are forced to have non-directional operation, and are subject to their revised definite time-delay.

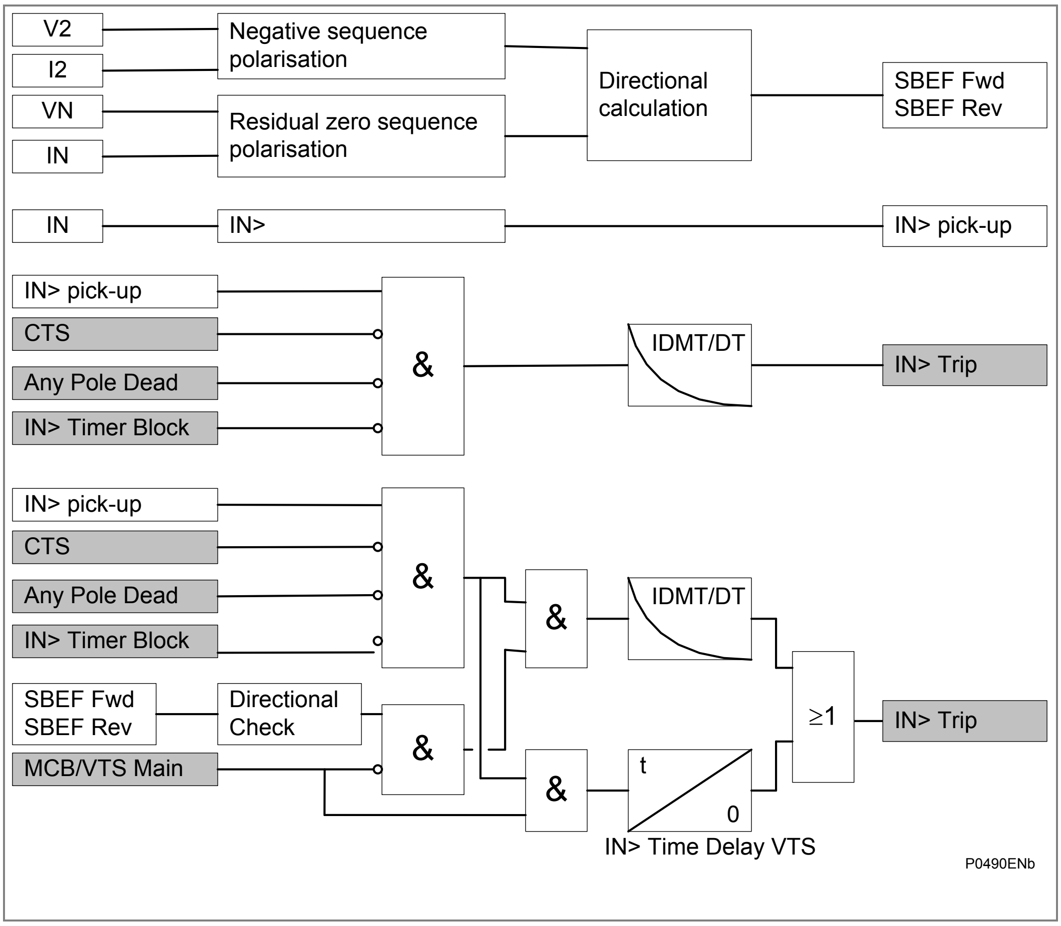


Figure 74 - SBEF Calculation & logic

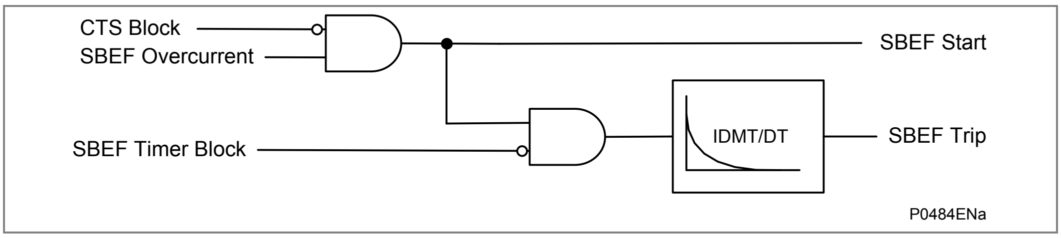


Figure 75 - Logic without directionality

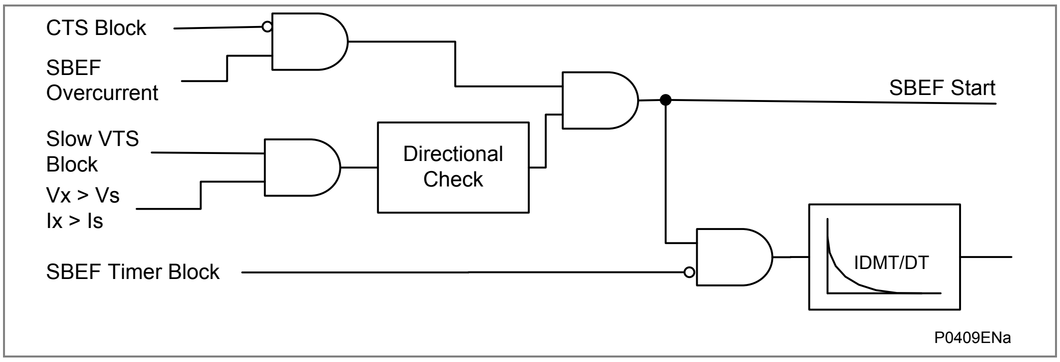


Figure 76 - Logic with directionality

4.7.1.1 Directionalising the IN> Element

Where earth fault overcurrent may flow in either direction through a relay location, such as parallel lines or ring main systems, directional control of the element should be employed.

Directionality is achieved by comparison of the angle between the earth fault voltage and the earth fault current. It may be selected to operate in either the forward or reverse direction.

A suitable relay characteristic angle setting (**IN> Char Angle**) is chosen to provide optimum performance. This setting should be set equal to the phase angle of the earth fault current with respect to the inverted earth fault voltage ($-V_N$), in order to be at the centre of the directional characteristic.

The angle that occurs between VN and IN under fault conditions is directly dependent upon the earth fault 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°.

“Earth fault” is set by default (‘**Polarisation**’ cell set to “Zero sequence”). When VN is too low, it is possible to set negative sequence characteristic angle with the “**Polarisation**” cell.

4.7.1.2 IN> Blocking Pole Dead Detection (Versions C7.x and D6.x)

On railway cases, only 2 phases are used. For this reason, the relay always detects any pole dead: IN> function is blocked.

‘**IN> Block Pole dead**’ allows IN> function blocking by any pole dead (or all pole dead). By default, ‘**IN> Block Pole dead**’ setting is “enabled” to block the “IN> function” on any pole dead.

4.7.2 Directional Earth Fault Protection (DEF)

The method of directional polarising selected is common to all directional earth fault elements, including the channel-aided element. There are two options available in the relay menu:

- Zero sequence polarising - The relay performs a directional decision by comparing the phase angle of the residual current with respect to the inverted residual voltage: (–Vres = –(Va + Vb + Vc)) derived by the relay. The application of zero sequence polarising is detailed in the following *Application of Zero Sequence Polarising* section.
- Negative sequence polarising - The relay performs a directional decision by comparing the phase angle of the derived negative sequence current with respect to the derived negative sequence voltage. The application of negative sequence polarising is detailed in the *Application of Negative Sequence Polarising* section.

Note	*Even though the directional decision is based on the phase relationship of I_2 with respect to V_2, the operating current quantity for DEF elements remains the derived residual current.*

4.7.2.1 Application of Zero Sequence Polarising

This is the conventional option, applied where there is not significant mutual coupling with a parallel line, and where the power system is not solidly earthed close to the relay location. As residual voltage is generated during earth fault conditions, this quantity is commonly used to polarise DEF elements. The relay internally derives this voltage from the 3 phase voltage input which must be supplied from either a 5-limb or three single phase VT's. 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 incompatible with the use of zero sequence polarising.

The required characteristic angle (RCA) settings for DEF will differ depending on the application. Typical characteristic angle settings are as follows:

- Resistance earthed systems generally use a 0° RCA setting. This means that for a forward earth fault, the residual current is expected to be approximately in phase with the inverted residual voltage (-Vres).
- When protecting solidly-earthed distribution systems or cable feeders, a -45° RCA setting should be set.
- When protecting solidly-earthed transmission systems, a -60° RCA setting should be set.

4.7.2.2 Application of Negative Sequence Polarising

In certain applications, the use of residual voltage polarisation 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 were 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 sequence quantities for polarisation. This method determines the fault direction by comparison of negative sequence voltage with negative sequence current. The operate quantity, however, is still residual current.

When negative sequence polarising is used, the relay requires that the Characteristic Angle is set. The Application Notes section for the Negative Sequence Overcurrent Protection better describes how the angle is calculated - typically set at - 45° (I_2 lags ($-V_2$)).

4.8 Aided Directional Earth Fault (DEF)

4.8.1 DEF Protection Against High Resistance Earth Faults

Protection against high-resistance earth faults, also called DEF (Directional Earth Fault), is used to protect the network against highly resistive faults. High resistance faults may not be detected by distance protection. DEF Protection can be applied in one of the two following modes: faults using the following:

- The main operating mode, directional comparison protection uses the signalling channel and is a communication-aided scheme.
- In backup-operating mode SBEF (Stand-By Earth Fault), an inverse/definite time earth overcurrent element with 4 stages is selectable.

Both the main and backup mode can use different methods for fault detection and directional determination (negative or zero sequence polarisation, RCA angle settable for backup SBEF protection, etc).

The use of Aided-Trip logic in conjunction with the DEF element allows faster trip times, and can facilitate single-phase tripping if single-phase tripping is applied to the breaker.

The DEF directional comparison protection may be applied on the same signal channel as the distance protection, or it may be applied on an independent channel (ability to use two different aided-trip logics for the distance and DEF elements).
When used on the same signalling channel (shared scheme selected by MiCOM S1 Studio) as the distance protection, if the distance protection picks up, it has priority (the output from the DEF element is blocked from asserting the Carrier Send common output).

The use of directional comparison protection with an independent signalling channel allows the distance functions and DEF function to operate in parallel. Each function is routed to its own Carrier Send output. If an earth fault is present where both the distance and DEF elements pick up, the faster of the two functions will perform the trip.

4.8.1.1 High Resistance Earth Fault Detection

A high resistance fault is detected when residual or zero sequence voltage (3V0) and current thresholds are exceeded or using the high speed algorithms:

- $\Delta I \geq 0.05$ In
- $\Delta V \geq 0.1$ Vn (Ph-N)

A fault is confirmed if these thresholds are exceeded for more than 1 ½ cycles.

4.8.1.2 Directional Determination

The fault direction is determined by measuring the angle between the residual voltage and the residual current derivative. The fault is forward if the angle is between -14° and $+166^\circ$. A negative or zero-sequence polarisation is selectable in order to determinate the earth fault direction.

4.8.1.3 Phase Selection

The phase is selected in the same way as for distance protection except that the current threshold is reduced ($\Delta I \geq 0.05$ x In and $\Delta V \geq 0.1$ x Vn).

Note	*If the phase has not been selected within one cycle, a three-phase selection is made automatically.*

4.8.2 Tripping Logic

Legend For Tripping Logic Diagrams (DEF)

Abbreviation	Definition
Vr>	Threshold of residual or zero sequence voltage (3V0)
IRev	Threshold of residual current (Setting, 0,6IN)
Forward	Forward directional with zero/negative sequence polarisation
Reverse	Reverse directional with zero/negative sequence polarisation
DEF blocking	Blocking of DEF element
Carrier Receive DEF	Carrier received for the principal line protected (same channel as distance protection)
Iev	Threshold of residual current (0.6 x Ied)
Tripping mode	Single or three-phase tripping (selectable)
Z< starting	Convergence of at least 1 of the 6 loops within the tripping characteristic (internal starting of the distance element)
t_cycle	Additional time delay (150ms) of 1 pole AR cycle
t_delay	Tripping time delay
t_trans	Carrier Send delay

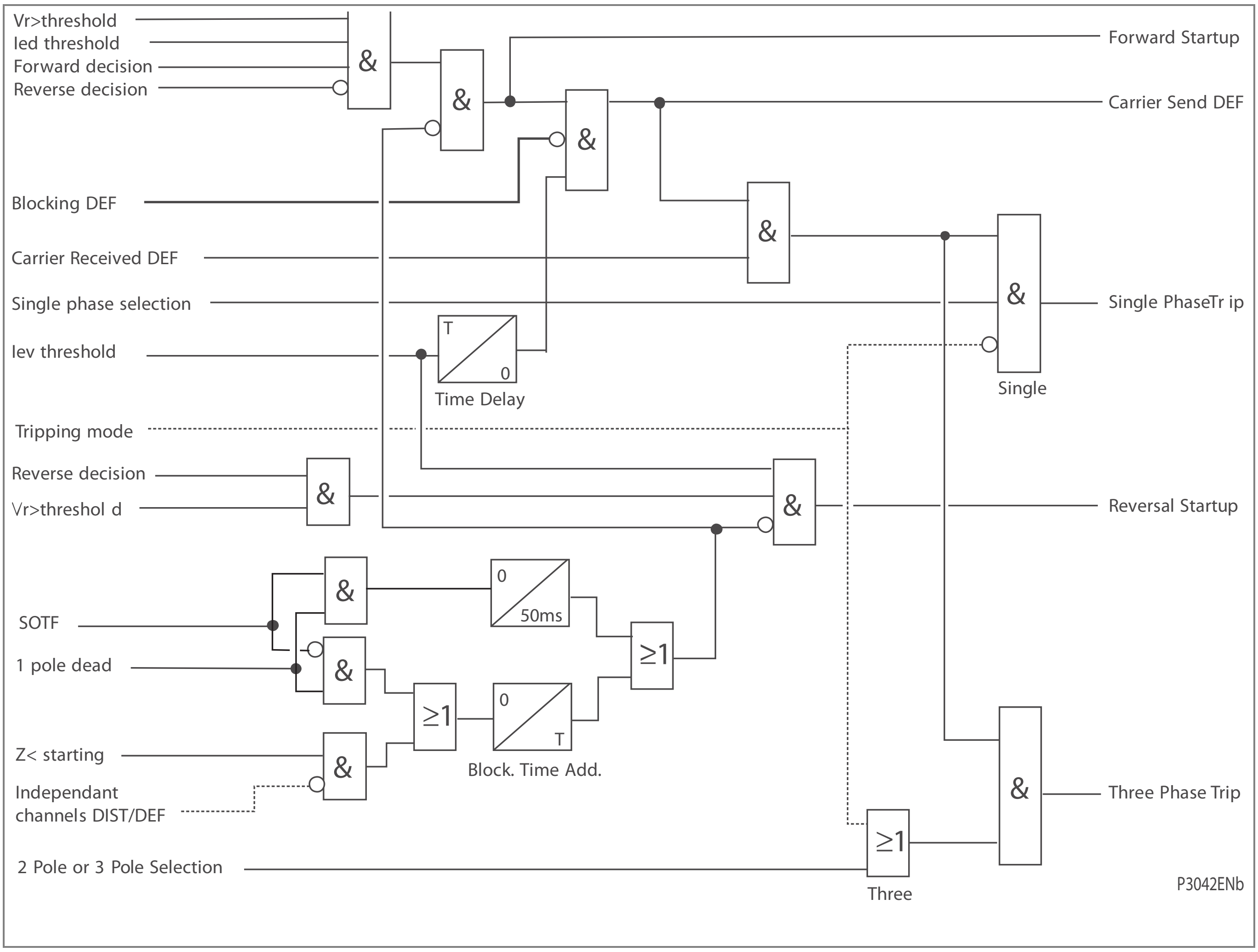


Figure 77 - Directional Comparison Protection Permissive Scheme

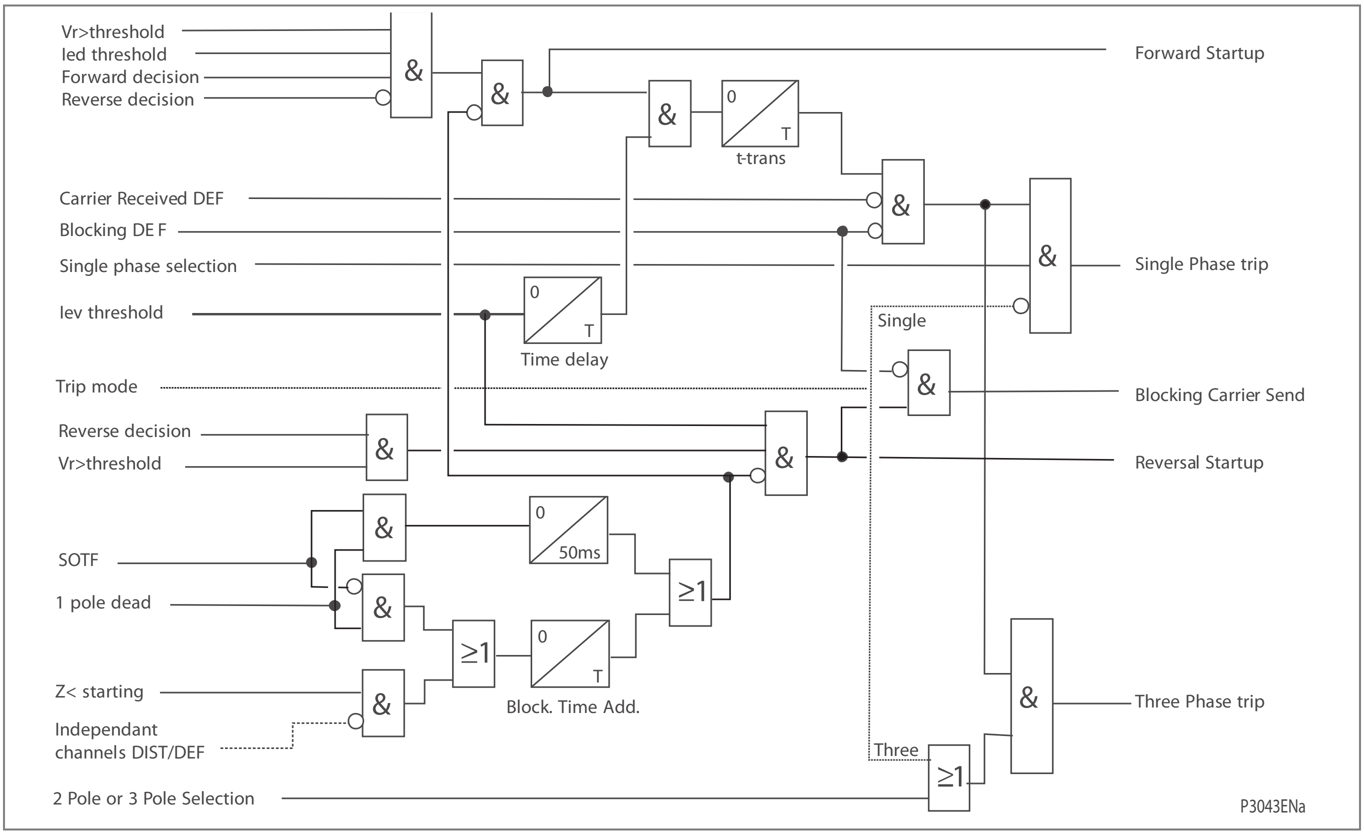


Figure 78 - Directional comparison protection blocking scheme

If the DEF directional comparison transmission is selected on the same channel that is used to transmit distance aided-trip messages, the DEF will have the same tripping logic as the main protection (permissive or blocking).

4.8.2.1 SBEF – Stand-By Earth Fault (not Communication-Aided)

This protection trips the local breaker directly, without an aided-trip signal, if a high resistance fault remains after a time delay. The time delay varies inversely with the value of the fault current. The selectable inverse time curves comply with the ANSI and IEC standards (see Appendix A).

This protection three-pole trips and can block autoreclosing.

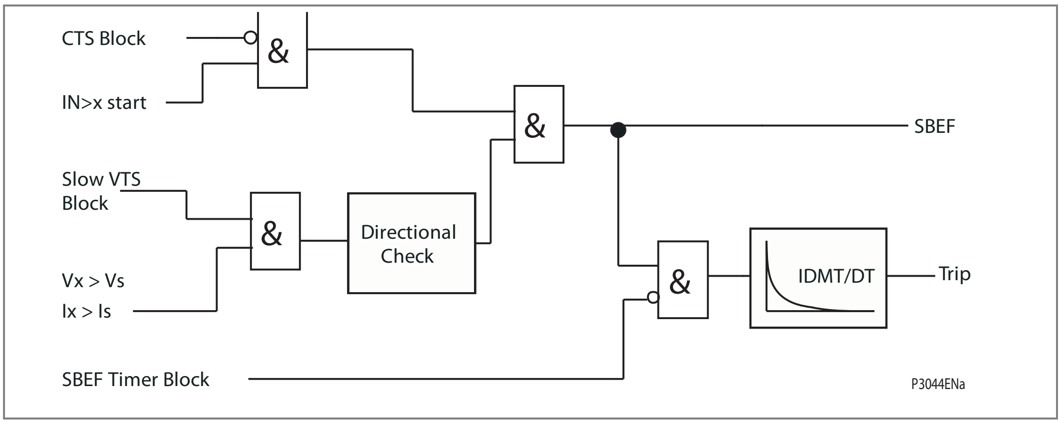


Figure 79 - SBEF – Stand-By earth fault

4.8.3 Aided Directional Earth Fault (DEF) Protection Schemes

The option of using separate channels for Directional Earth Fault (DEF) aided tripping, and distance protection schemes, is offered in the P442 and P444 relays.

When a separate channel for DEF is used, the DEF scheme is independently selectable. When a common signalling channel is employed, the distance and DEF must **share** a common scheme. In this case a permissive overreach or blocking distance scheme must be used. The aided tripping schemes can perform single pole tripping.

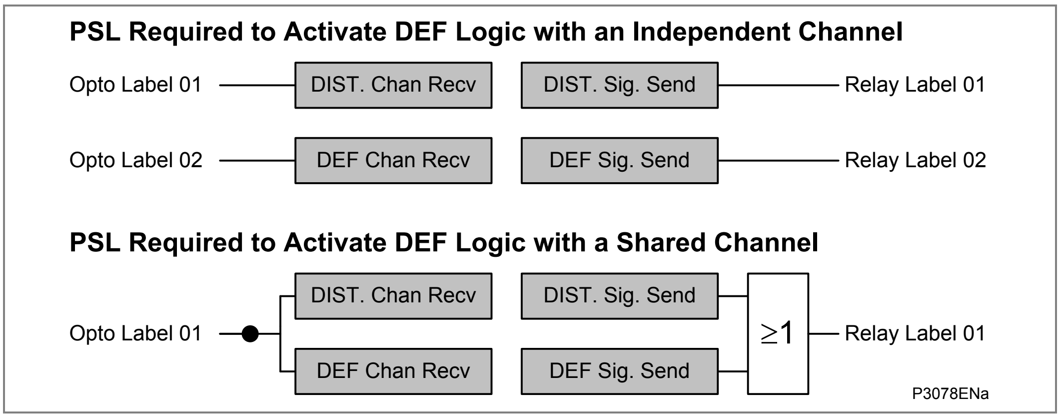


Figure 80 - PSL required to activate DEF logic with an independant or shared channel

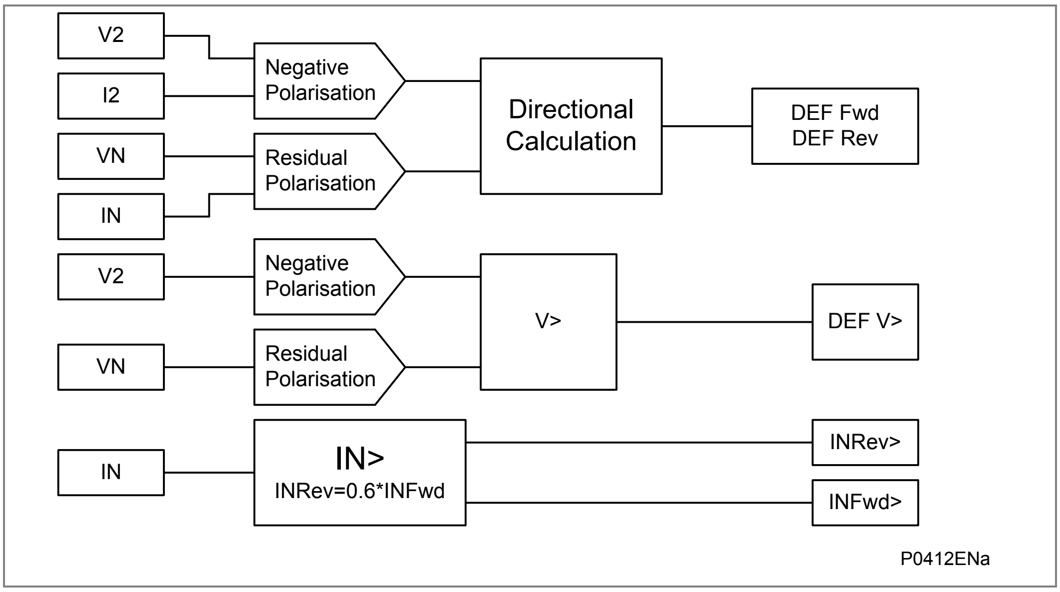


Figure 81 - DEF calculation

Note	*The DEF is blocked in case of VTS or CTS.*

4.8.3.1 Polarising the Directional Decision

The relative advantages of zero sequence and negative sequence polarising are outlined in the *Directionalising the IN> Element* section. Note how the polarising chosen for aided DEF is independent of that chosen for backup earth fault elements.

The V> threshold is set above the standing residual voltage on the protected system, to avoid operation for typical power system imbalance and voltage transformer errors. In practice, the typical zero sequence voltage on a healthy system can be as high as 1% (ie: 3% residual), and the VT error could be 1% per phase. This could equate to an overall error of up to 5% of phase-neutral voltage, although a setting between 2% and 4% is typical. On high resistance earthed and insulated neutral systems the settings might need to be as high as 10% or 30% of phase-neutral voltage, respectively.

When negative sequence polarising is set, the V> threshold becomes a V2> negative sequence voltage detector.

The Characteristic Angle for Aided DEF Protection (as shown below) is fixed at **–14°**, suitable for protecting all solidly earthed and resistance earthed systems.

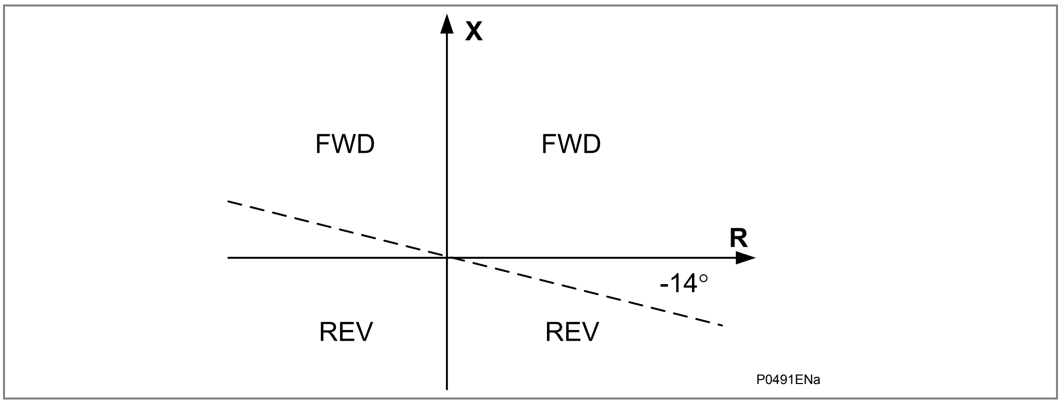


Figure 82 – Characteristic angle for aided DEF protection

4.8.3.2 Aided DEF Schemes

4.8.3.2.1 Aided DEF Permissive Overreach Scheme

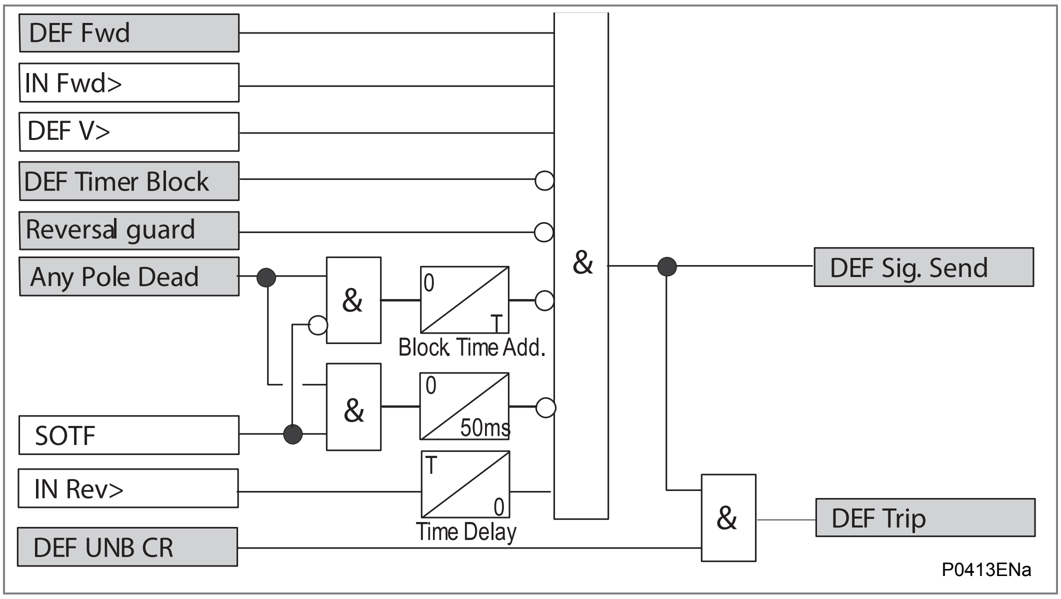


Figure 83 - IndependEnt Channel – permissive scheme

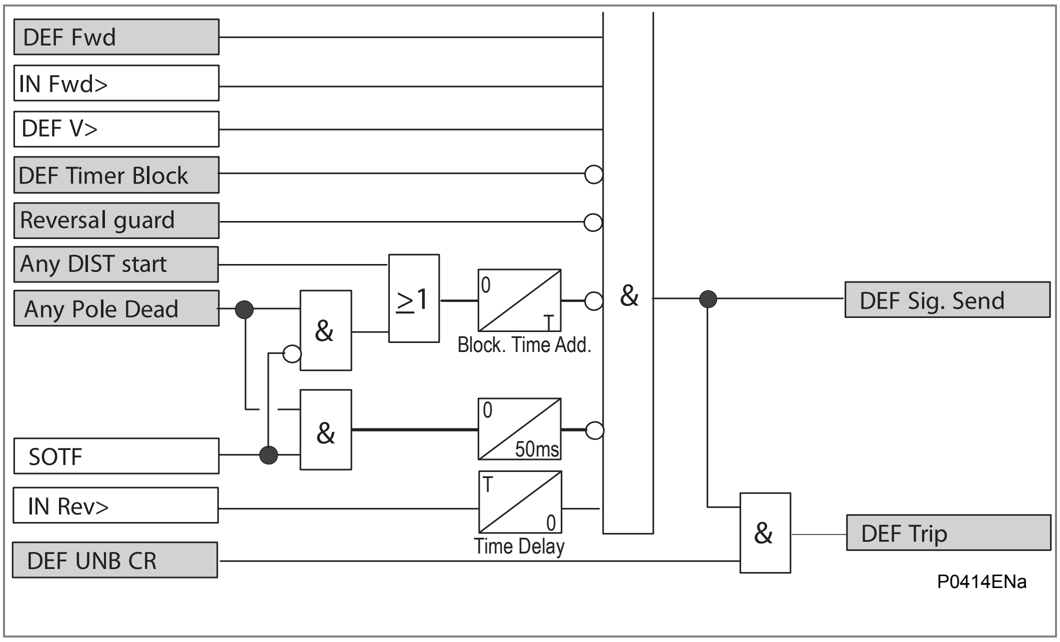


Figure 84 - Shared Channel – permissive scheme

The *DEF Permissive Scheme* diagram shows the element reaches.

The signalling channel is keyed from operation of the forward IN> DEF element of the relay. If the remote relay has also detected a forward fault, then it will operate with no additional delay upon receipt of this signal.

Send logic: IN> Forward pickup

Permissive trip logic: IN> Forward plus Channel Received.

The scheme has the same features/requirements as the corresponding distance scheme and provides sensitive protection for high resistance earth faults.

Where “t” is shown in the diagram this signifies the time delay associated with an element, noting that the time-delay for a permissive scheme aided trip would normally be set to zero.

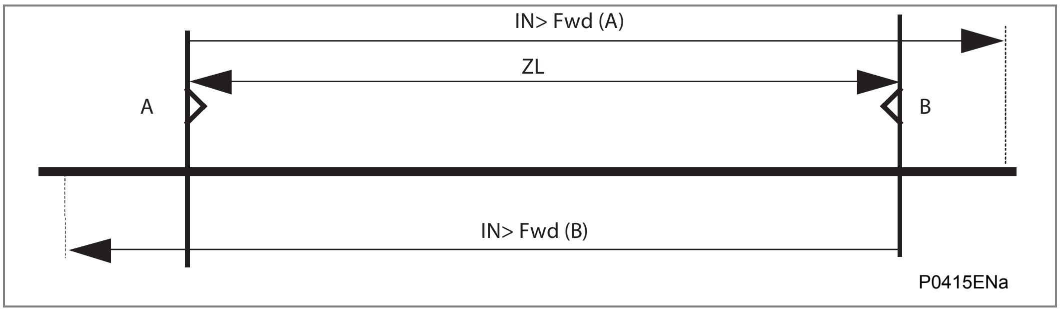


Figure 85 - The DEF Permissive Scheme

4.8.3.2.2 Aided DEF Blocking Scheme

The *Independent channel – blocking scheme* diagram shows the element reaches

The *Shared channel – blocking scheme* diagram shows the simplified scheme logic.

The signalling channel is keyed from operation of the reverse DEF element of the relay. If the remote relay forward IN> element has picked up, then it will operate after the set time delay if no block is received.

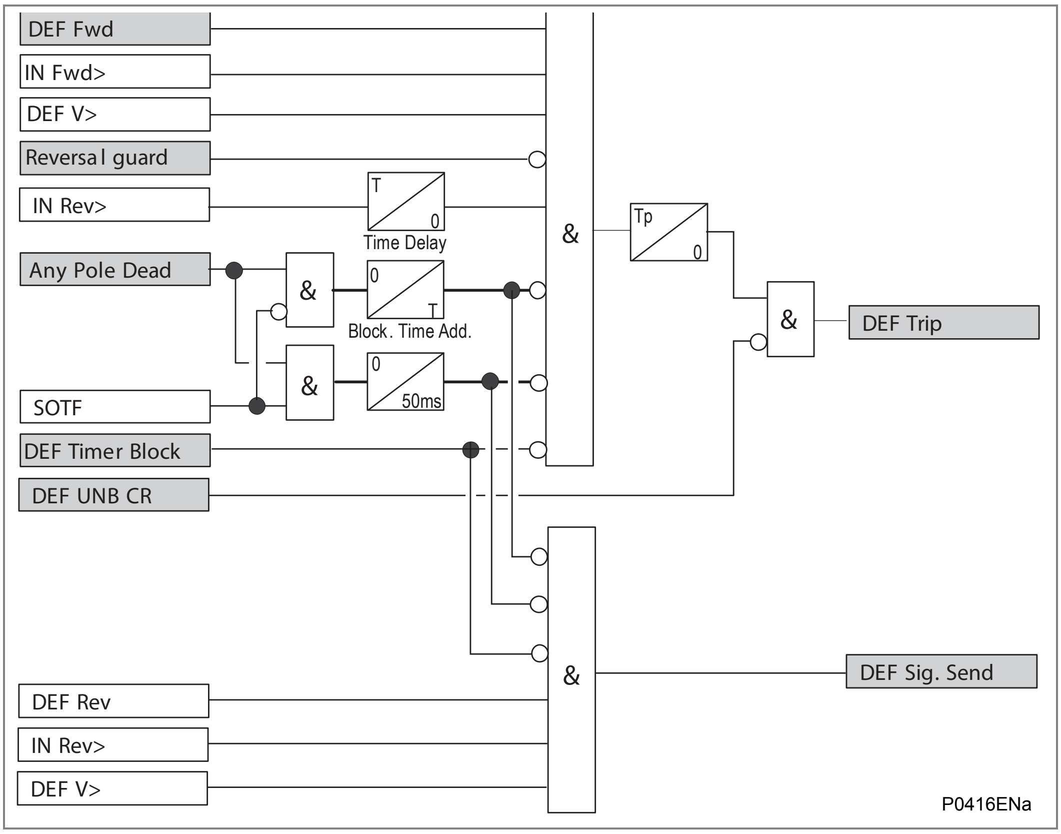


Figure 86 - Independent channel – blocking scheme

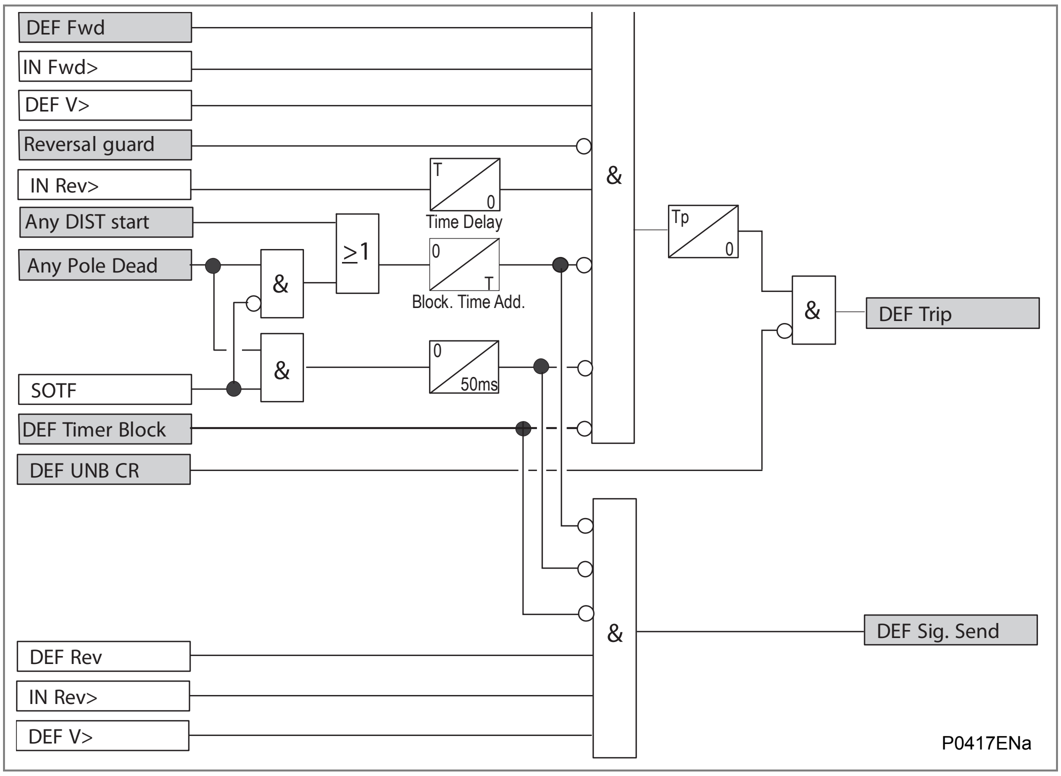


Figure 87 - Shared channel – blocking scheme

Send logic: DEF Reverse

Trip logic: IN> Forward, plus Channel NOT Received, with small set delay.

The scheme has the same features/requirements as the corresponding distance scheme and provides sensitive protection for high resistance earth faults.

Where “t” is shown in the diagram this signifies the time delay associated with an element. To allow time for a blocking signal to arrive, a short time delay on aided tripping must be used. The recommended Time Delay setting = max. signalling channel operating time + 14ms.

Figure 88 - The DEF Blocking Scheme

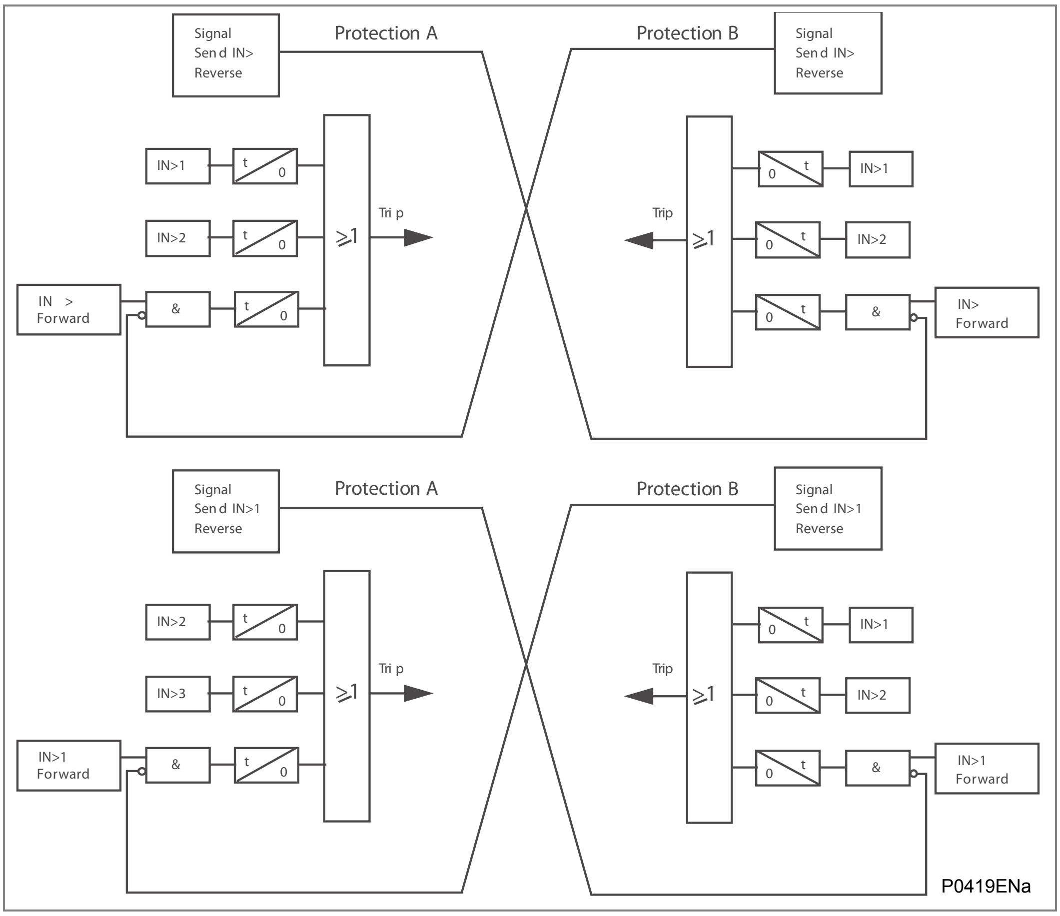


Figure 89 - Logic Diagram for the DEF Blocking Scheme

4.9 Thermal Overload

Thermal overload protection can be used to prevent electrical plant from operating at temperatures in excess of 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.

Transformer overheating can be caused due to failures of the cooling system, external faults that are not clear promptly, overload and abnormal system conditions. These abnormal conditions include low frequency, high voltage, non-sinusoidal load current, or phase-voltage unbalance.

The thermal protection also provides an indication of the thermal state in the measurement column of the relay. The thermal state canbe reset by either an opto input (if assigned to this function using the programmable scheme logic) or the relay menu, for example to reset after injection testing. The reset function in the menu is found in the measurement column with the thermal state.

4.9.1 Time Constant Characteristic

4.9.1.1 Single Time Constant Characteristic

This characteristic is the recommended typical setting for line and cable protection. The thermal time characteristic is given by:

$$\exp(-t/\tau) = (I^2 - (k.I_{FLC})^2) / (I^2 - I_P^2)$$

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 current setting is calculated as:

Thermal Trip = Permissible continuous loading of the plant item/CT ratio.

Typical time constant values are given in the following table. The relay setting, '**Time Constant 1**', is in minutes.

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.

	Time constant τ (minutes)	Limits
Air-core reactors	40	
Capacitor banks	10	
Overhead lines	10	Cross section $\geq$ 100 mm^2 Cu or 150 mm^2 Al
Cables	60 - 90	Typical, at 66 kV and above
Busbars	60	

Table 9 – Typical protected plant thermal time constants

4.9.1.2 Dual Time Constant Characteristic (Typically Not Applied for P443)

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 time constants must be set. The thermal curve is defined as:

$$0.4 \exp(-t/\tau 1) + 0.6 \exp(-t/\tau 2) = (I^2 - (k.I_{FLC})^2) / (I^2 - I_P^2)$$

Where:

$\tau 1$ = Heating and cooling time constant of the transformer windings;

$\tau 2$ = Heating and cooling time constant for the insulating oil.

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 minimise gas production by overheated oil. Note, however, that the thermal model does not compensate for the effects of ambient temperature change.

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.*

	$\tau 1$ (minutes)	$\tau 2$ (minutes)	Limits
Oil-filled transformer	5	120	Rating 400 - 1600 kVA

4.10 Residual Overvoltage 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 (ground) fault occurs on the primary system this balance is upset and a '**residual**' voltage is produced.

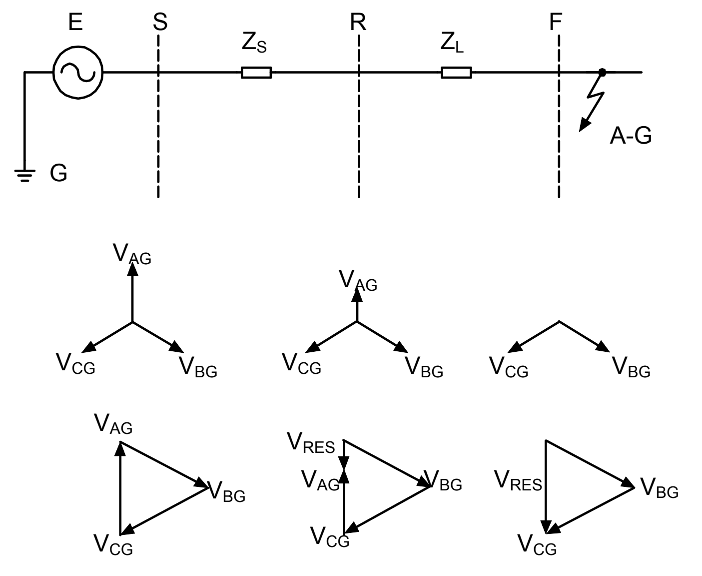
Note	*This condition causes a rise in the neutral voltage with respect to earth which is commonly referred to as **neutral voltage displacement** or NVD.*

The voltage setting applied to the elements is dependent upon the magnitude of residual voltage that is expected to occur during the earth fault condition. This in turn is dependent upon the method of system earthing employed and may be calculated by using the formulae's previously given in the above figures. It must also be ensured that the relay is set above any standing level of residual voltage that is present on the healthy system.

Note	*IDMT characteristics are selectable on the first stage of NVD and a time delay setting is available on the second stage of NVD in order that elements located at various points on the system may be time graded with one another.*

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.

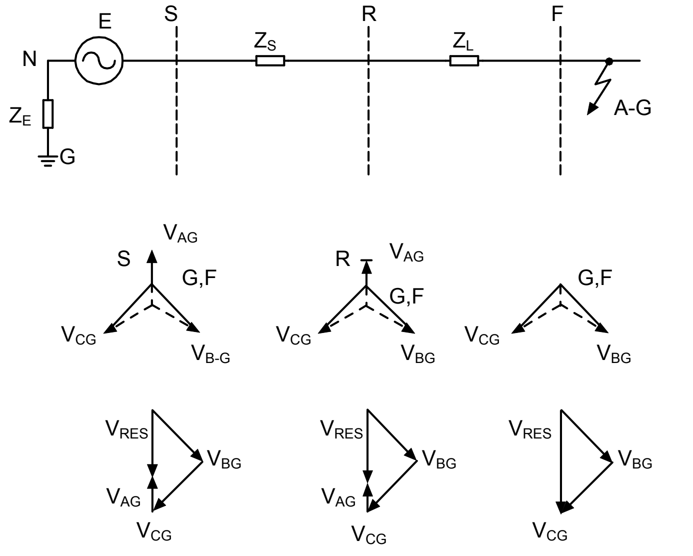
$$VRES = \frac{Z_{S0}}{2Z_{S1} + Z_{S0} + 2Z_{L1} + Z_{L0}} \times 3E$$

P0117ENb

Figure 90 – 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.



$$V_{RES} = \frac{Z_{S0} + 3Z_E}{2Z_{S1} + Z_{S0} + 2Z_{L1} + Z_{L0} + 3Z_E} \times 3E$$

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Figure 91 – 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 zero sequence current. This may be particularly advantageous at a tee terminal where the infeed is from a delta winding of a transformer (and the delta acts as a zero sequence current trap).

Note	*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/ground fault protection.*

4.11 Undercurrent Protection

The undercurrent protection is activated when the current lower than a threshold. It uses definite delay time undercurrent protection.

The undercurrent protection included within the P442 and P444 relays consists of two independent stages. These stages may be selected or disabled within the “I<1 Status” and “I<2 Status” cells.

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 current dip.

4.12 Voltage Protection

Voltage protection contains undervoltage and overvoltage protection. Both the under and overvoltage Protection functions can be found in the relay menu "Volt Protection".

4.12.1 Undervoltage

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 its 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 its 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.

This function will be blocked with Voltage Transformer Supervision (VTS) logic or could be disabled if CB open.

As can be seen from the "Volt Protection" menu, the undervoltage protection included within the MiCOM P442 and P444 relays consists of four 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 either IDMT, DT or disabled, within the V<1 Function cell. Stages 2, 3 and 4 are DT only and are enabled/disabled in the V<2, V<3 and V<4 Status cells.

Four 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.

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)

4.12.1.1 Setting Guidelines

In the majority of 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 with regard to 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.

4.12.2 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. Therefore 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.

As previously stated, both the over and undervoltage protection functions can be found in the relay menu “Volt Protection”.

As can be seen, the setting cells for the overvoltage protection are identical to those previously described for the undervoltage protection. 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)

4.12.2.1 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 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, the four 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 stages 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.

4.13 Frequency Protection

The frequency protection menu contains underfrequency and overfrequency protections, individually activated when the corresponding status is activated.

4.13.1 Underfrequency Protection

Frequency variations on a power system are an indication that the power balance between generation and load has been lost. In particular, underfrequency 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 underfrequency 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.

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, 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.

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 should be supplemented by rate of change of frequency protection elements.

4.13.2 Overfrequency Protection

Overfrequency 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.

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 overfrequency 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 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.

4.14 Circuit Breaker Fail 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.

4.14.1 Typical Settings

4.14.1.1 Breaker Fail Timer Settings

Typical timer settings to use are as follows:

CB fail reset mechanism	tBF time delay	Typical delay for 2 cycle circuit breaker
Initiating element reset	CB interrupting time + element reset time (max.) + error in tBF timer + safety margin	50 + 50 + 10 + 50 = 160 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 operating time	50 + 25 + 50 = 125 ms

Note that 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 that where auxiliary tripping relays are used, an additional 10-15ms must be added to allow for trip relay operation.

4.14.1.2 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, with 5% In common for generator circuit breaker CBF.

4.14.2 Breaker Failure Protection Configurations

Resetting of the CBF is possible from a breaker open indication (from the relay's pole dead logic) or from a protection reset. In these cases resetting is only allowed provided the undercurrent elements have also been reset. The resetting options are summarised in the following table.

Initiation (Menu selectable)	CB fail timer reset mechanism
Current based protection - (eg. 50/51/46/21/87..)	The resetting mechanism is fixed. [IA< operates] AND [IB< operates] AND [IC< operates] AND [IN< operates]
Non-current based protection (eg. 27/59/81/32L..)	Three options are available. You can select from these 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]
External protection	Three options are available. You can select any or all of these 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]

The phase selection must be performed by creating a dedicated PSL.

The circuit breaker failure protection incorporates two time-delays, '**CB Fail 1 Timer**' and '**CB Fail 2 Timer**', allowing configuration for the following scenarios:

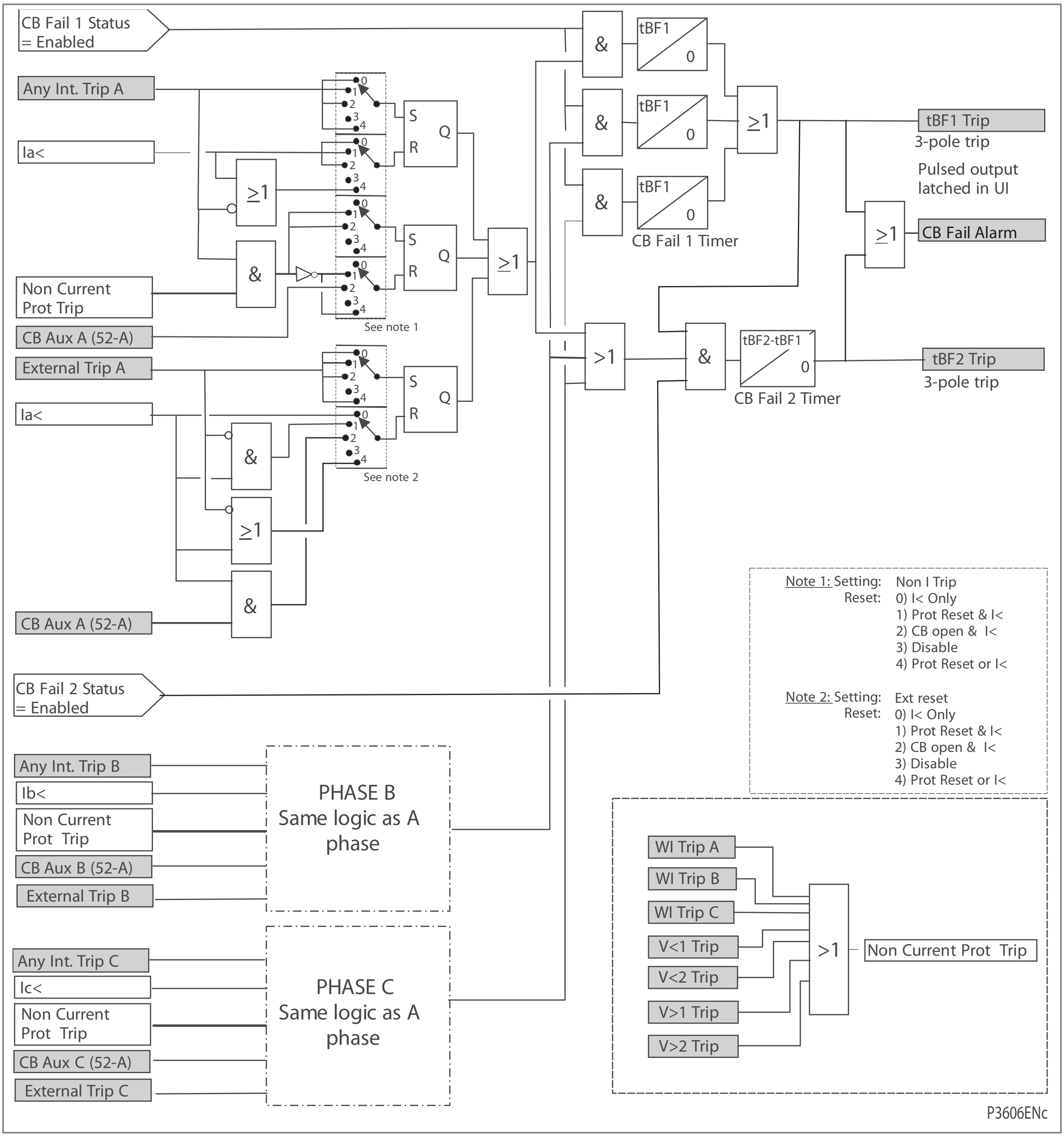


Figure 92 - CB Fail general logic

- 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 (PSL)). This contact is used to backtrip upstream switchgear, generally tripping all infeeds connected to the same busbar section.
- A re-tripping scheme, plus delayed back-tripping. 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 back-trip may be issued following an additional time delay. The back-trip uses ‘CB Fail 2 Timer’, which is also started at the instant of the initial protection element trip.

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 PSL.

4.14.3 Reset Mechanisms for Breaker Fail Time-Delays

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.

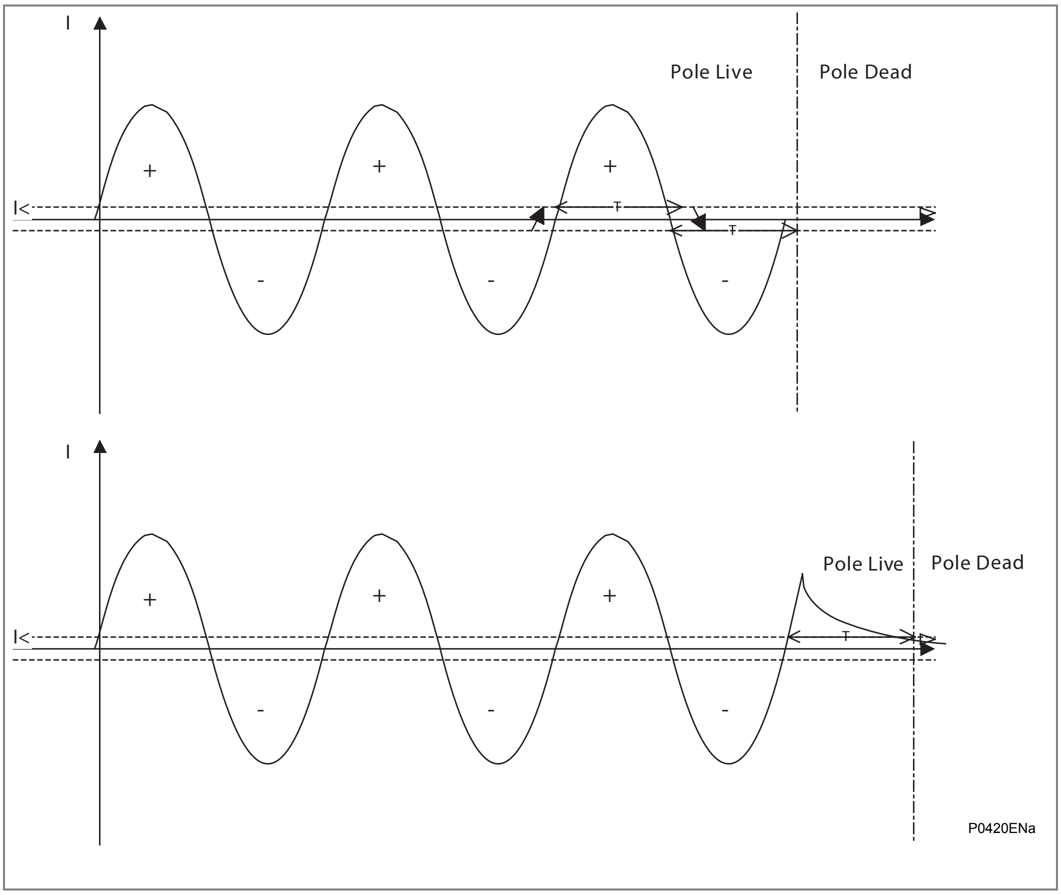


Figure 93 - Algorithm for pole dead detection

Description of the Open Pole Detection Algorithm:

Each half cycle after the current crosses zero, the algorithm detects whether the current is higher than the I< threshold. If it is, then the detection timer is restarted, if it is lower than the set value then nothing is done.

At the end of the detection timer, open pole decision is given by the algorithm.

Time delay value given by: (Number of Samples/2 + 2) * ((1/Freq)/Number of Samples)

Where:
T = 13,3ms (50Hz)
or
T = 11,1ms (60Hz)

The current used is the unfiltered current (only the analog low pass filter is used)

Example:

In the first example, the line current is broken by the opening of the circuit breaker.

The detection is confirmed 3ms after the pole is opened.

In the second example, some residual current remains due to the CT. The detection is confirmed 12 / 15ms after the pole is opened.

5 NON-PROTECTION FUNCTIONS

5.1 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.

5.1.1 Circuit Breaker Condition Monitoring Features

For each circuit breaker trip and autoreclose operation the relay, records statistics. The '**CB condition'** and '**CB monitor setup**' menu cells are counter values only. The Min/Max values show the range of the counter values. These cells can be disabled.

The 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. The number of operation is displayed phase by phase.

These operating values are compared to two thresholds (setting with '**CB Monitor Setup**' menu): Maintenance Alarm or LockOut Alarm can be generated. Counters can be re-initiated with the command Reset all values.

When 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 DDB signal that is mapped to the opto is called '**External TripA** or **B** or **C**'.

Note	*When the relay is in Commissioning test mode, the CB condition monitoring counters will not be updated.*

5.1.2 CB Condition Monitoring

5.1.2.1 Setting the Σ I^ Thresholds Guidelines

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 Σ $\mathbf{I}^2$t, 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 (I^2 or "**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.

5.1.2.2 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 preventive maintenance is due. Should maintenance not be carried out, the relay can be set to lockout the autoreclose 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 carbonising of the oil, degrading its dielectric properties. The maintenance alarm threshold ('**N° 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 ('**N° CB Ops Lock**') may be set to disable autoreclosure when repeated further fault interruptions could not be guaranteed. This minimises the risk of oil fires or explosion.

5.1.2.3 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**' and '**CB Time Lockout**') are provided and are settable in the range of 5 to 500ms. This time is set in relation to the specified interrupting time of the circuit breaker.

5.1.2.4 Setting the Excessive Fault Frequency Thresholds

A circuit breaker may be rated to break fault current a set number of times before maintenance is required. However, successive circuit breaker operations in a short period of time may result in the need for increased maintenance. 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.

5.1.2.5 Lockout Reset

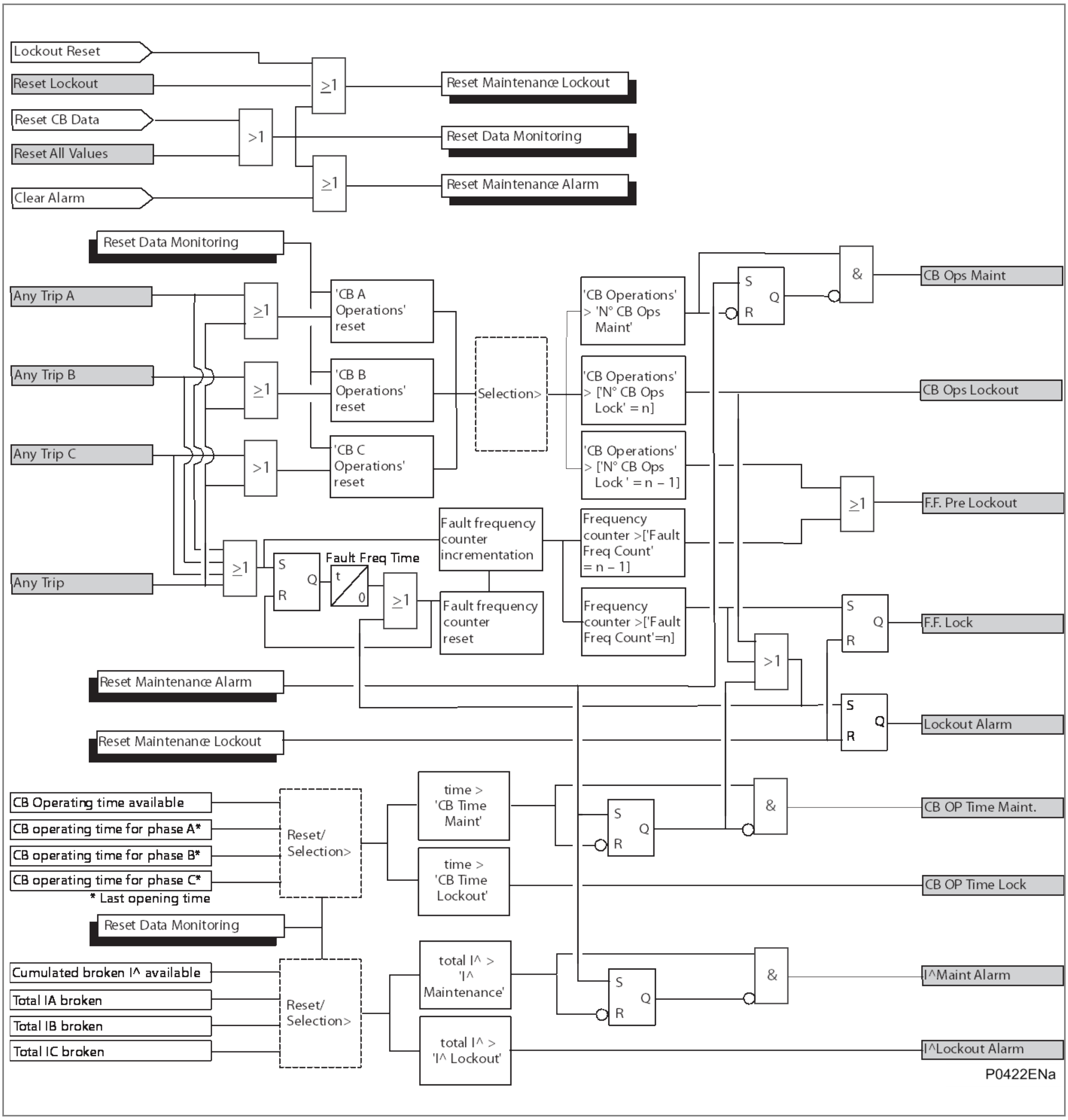
The '**Lockout Reset**' and '**Reset Lockout by**' setting cells in the menu are applicable to CB Lockouts associated with manual circuit breaker closure, CB Condition monitoring (Number of circuit breaker operations, for example) and auto-reclose lockouts.

5.1.2.6 Inputs/Outputs for CB Monitoring Logic

The following DDB are available for CB monitoring (see the Programmable Logic chapter):

- Inputs
  - Reset Lockout
  - Reset All Values
- Outputs
  - I^Maint Alarm
  - I^Lock Out Alarm
  - CB Ops Maint
  - CB Ops Lockout
  - CB Op Time Maint
  - CB Op Time Lock
  - F.F. Pre Lockout
  - F.F. Lock
  - Lockout Alarm

5.1.2.7 Logic Diagram



5.2 Circuit Breaker Control

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

- Local tripping and closing, via the relay menu
- 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. Where this feature is not required the same output contact(s) can be used for both protection and remote tripping.

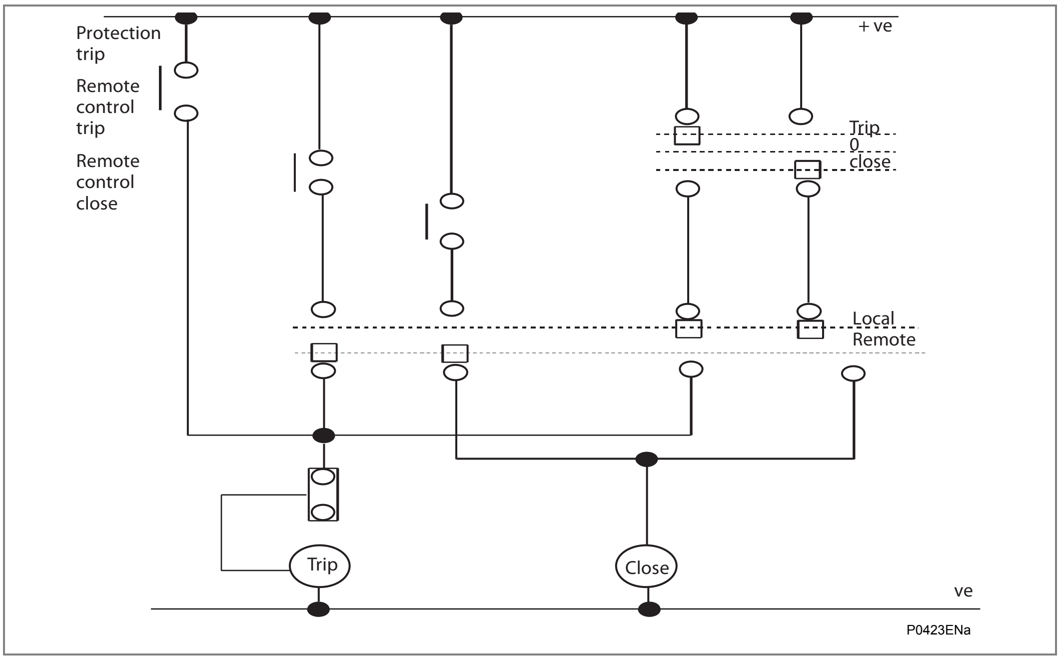


Figure 94 - Remote Control of Circuit Breaker

A manual trip will be possible if the circuit breaker is closed. Likewise, a close command can only be issued if the CB is initially open.

Therefore, it will be necessary to use the breaker positions 52a and/or 52b contacts via PSL. If no CB auxiliary contacts are available, no CB control (manual or auto) will be possible (see the different solutions proposed in the *CBAux logic* section).

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 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	*CB close command is in the ‘**System Data**’ column (‘**CB Trip/Close**’ cell).*

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.

When the check synchronisation function (‘**System check**’ menu) is enabled, it can be used to control manual circuit breaker close commands. When the check synchronism criteria are satisfied, ‘**CBC Close**’ pulse is emitted. The ‘**C/S Window**’ time delay is used to set manual closure according to system check logic. If the system check criteria are not satisfied before that time-delay elapses, the relay will lockout and issue alarm.

In addition, a CB Healthy information (from the CB), connected to one of the relay’s opto-isolators, will indicate the circuit breaker condition for closing availability. When “CB Healthy input” (DDB: '**CB Healthy**') is used, the ‘**Healthy Window**’ time-delay can be set to adjust the manual close of the CB. If the CB does not indicate a healthy condition during this time-delay period, the relay will lockout and issue an alarm.

Where auto-reclose is used it may be desirable to block its operation when performing a manual close. In general, the majority of faults following a manual closure will be permanent faults and it will be undesirable to auto-reclose. The "man close" input without CB Control selected OR the "CBClose in progress" with CB control enabled: will initiate the SOTF logic for which auto-reclose will be disabled following a manual closure of the breaker during 500msec (see SOTF logic in section P44x/EN AP).

If the CB fails to respond to the control command (indicated by no change in the state of CB Status inputs) a ‘**CB Fail Trip Control**’ or ‘**CB Fail Close Control**’ alarm will be generated (see the *CB Fail to Trip or to close* diagram) after the relevant trip (1) or close (2) command has 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).

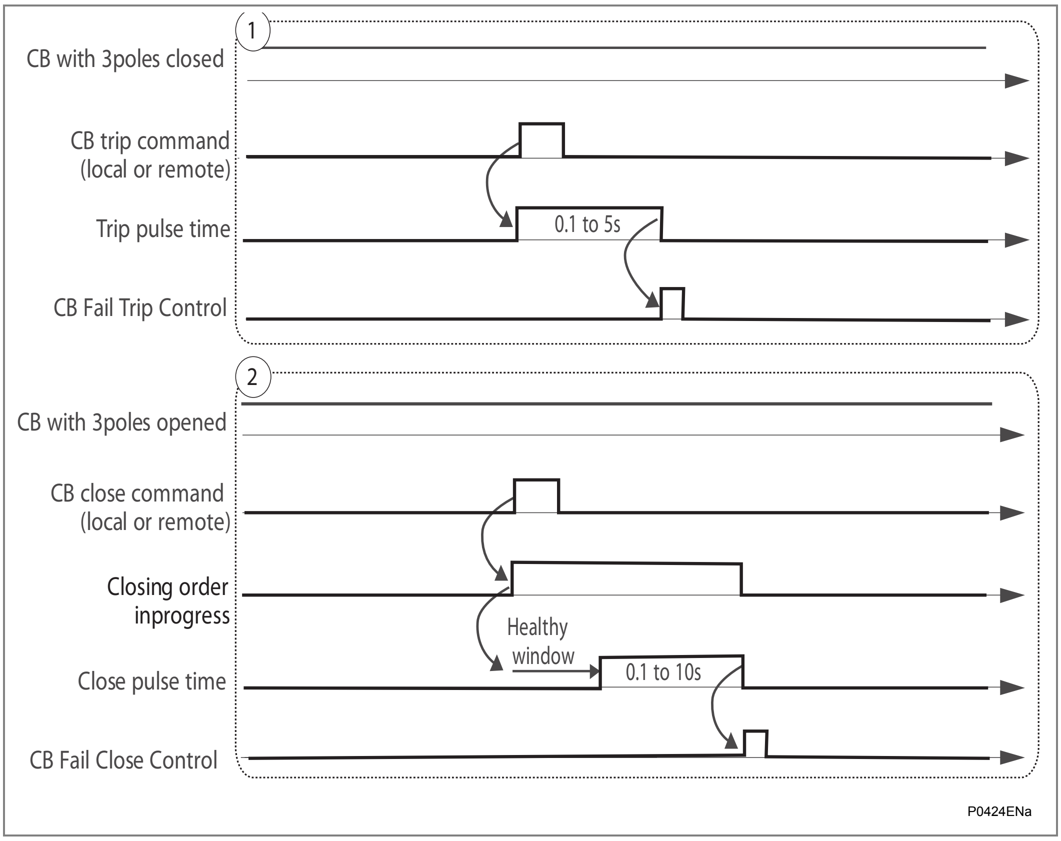


Figure 95 - CB Fail to Trip or to close

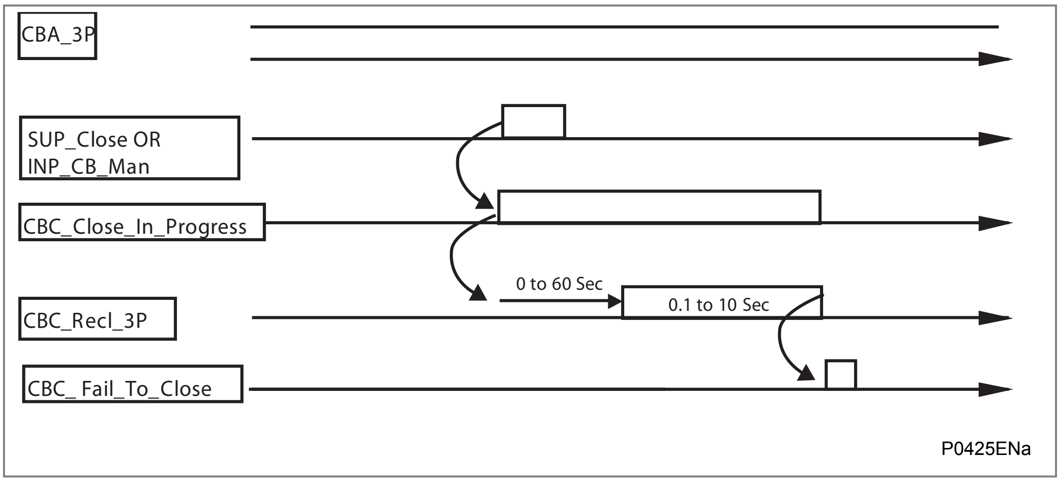


Figure 96 - Status of CB is incorrect CBA3P (3Poles are opened) stays – an alarm is generated "CB Fail to Close"

Important	**The 'Healthy Window' and 'C/S Window' time-delay settings are applicable <u>to manual circuit breaker operations only</u>. These are duplicated in the Auto-reclose menu for Auto-reclose applications.**

5.2.1 Logic Inputs/Outputs used by the CB Control Logic

The following DDB are available for CB Control logic (see the Programmable Logic chapter):

- Inputs:
  - Man. Trip CB
  - Man.Close CB
  - All pole dead
  - CB Status alarm,
  - A/R 1P In prog
  - A/R 3P In prog
  - A/R Close
  - CB Healthy
  - Check Synck OK
  - Any Trip
  - Any pole Dead
  - CB Discrepancy
- Outputs:
  - Control close
  - Control No C/S
  - Control Trip
  - Ctrl Cls In Prog
  - Man CB Cls Fail
  - Man CB trip Fail

5.2.1.1 General CB Control Logic

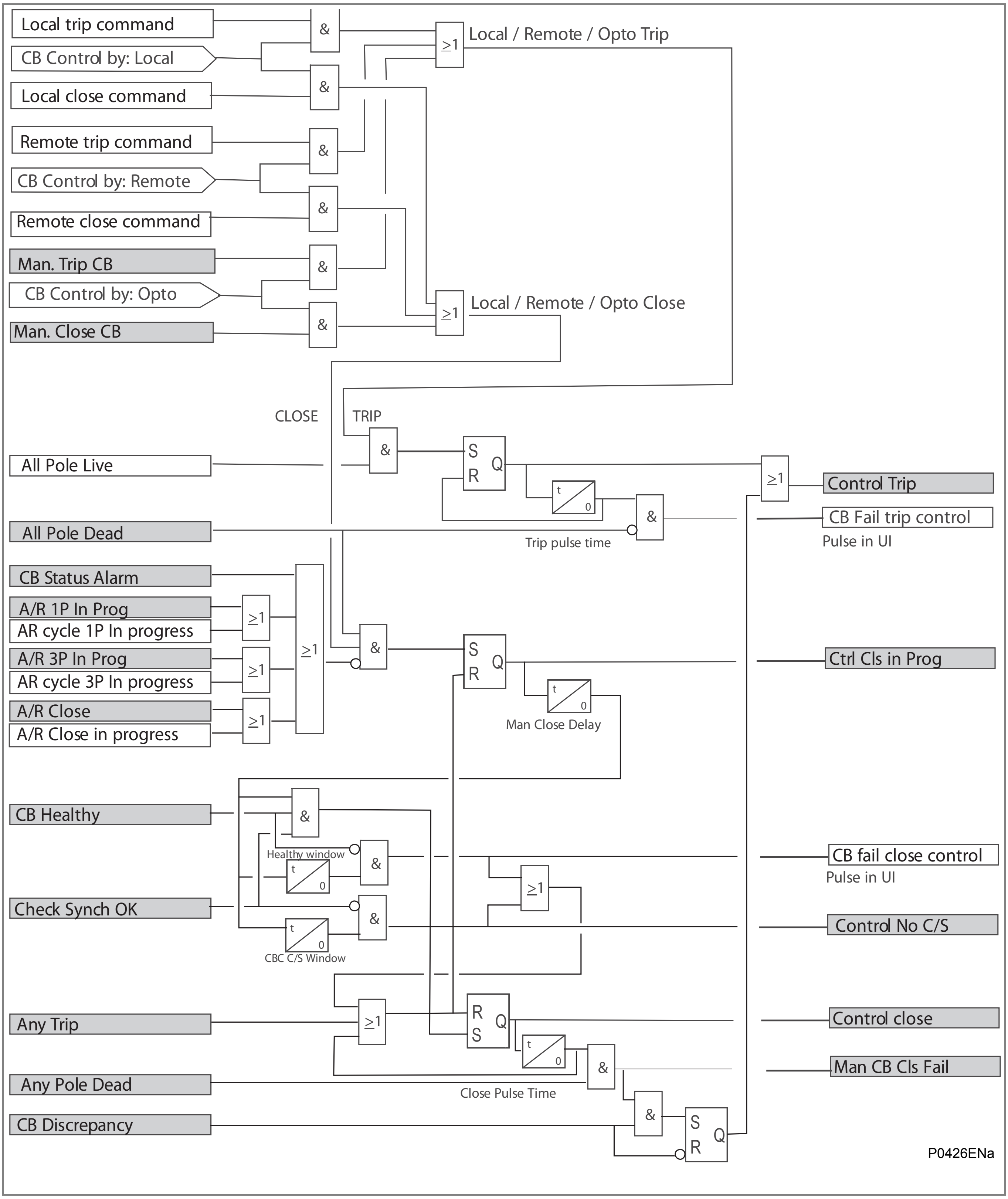


Figure 97 - General circuit breaker control logic

5.3 CT and VT Ratio

For each Terminal (connected to the secondary of a High voltage CT), the following values have to be known.

5.3.1 CT Ratios

Only **3 values** have to be known and entered:

1. Phase CT Primary current (from 1 to 30000 A) given by the manufacturer.
2. Phase CT secondary current (1 or 5 A) given by the manufacturer.
3. Polarity (Standard (towards the bar) or Inverted (opposite the bar)

> *NOTE For the busbar protection reference **2 values** have to be entered:*
> *Phase reference CT Primary current (from 1 to 30000 A).*
> *Phase reference CT secondary current (1 or 5 A).*

5.3.2 VT Ratios

Only **2 values** have to be known and entered:

1. Phase VT Primary current (from 100 to 100 kV) given by the manufacturer.
2. Phase VT secondary current (80 or 140 V) given by the manufacturer.

5.4 Opto Inputs Configuration

This series of relays have universal opto-isolated logic inputs that can be programmed for the nominal battery voltage of the circuit of which they are a part. This allows different voltages for different circuits such as signaling and tripping. They can also be programmed as Standard 60% - 80% or 50% - 70% to satisfy different operating constraints.
Threshold levels are shown in this table:

Nominal battery voltage (Vdc)	Standard 60% - 80%		50% - 70%	
	No operation (Logic 0) Vdc	Operation (Logic 1) Vdc	No operation (Logic 0) Vdc	Operation (Logic 1) Vdc
24/27	<16.2	>19.2	<12.0	>16.8
30/34	<20.4	>24.0	<15.0	>21.0
48/54	<32.4	>38.4	<24.0	>33.6
110/125	<75.0	>88.0	<55.0	>77.0
220/250	<150.0	>176.0	<110	>154

Table 10 – Opto-config threshold levels

This lower value eliminates fleeting pick-ups 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 selectable filtering. This allows a pre-set ½ cycle filter to be used to prevent induced noise on the wiring. However, although the ½ cycle filter is secure it can be slow, particularly for intertripping. If the ½ cycle filter is switched off to improve speed, double pole switching or screened twisted cable may be needed on the input to reduce ac noise.

5.5 Hotkeys / Control Inputs

5.5.1 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:

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.

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.

The two hotkeys in the front panel can perform a direct command if a dedicated PSL has been previously created using DDB: '**CONTROL INPUT**' cells (see the *Programmable Logic* chapter). The MiCOM P44x offers 32 control inputs which can be activated by the Hotkey manually or by the IEC 103 remote communication.

5.5.2 Control I/P Configuration

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.

5.5.3 Control I/P Labels

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	*With the exception of pulsed operation, the status of the control inputs is stored in battery backed memory. In the event that the auxiliary supply is interrupted the status of all the inputs will be recorded. Following the restoration of the auxiliary supply the status of the control inputs, prior to supply failure, will be reinstated. If the battery is missing or flat the control inputs will set to logic 0 once the auxiliary supply is restored.*

5.6 InterMiCOM Teleprotection

InterMiCOM is a protection signalling system that is an optional feature of MiCOM Px40 relays and provides a cost-effective alternative to discrete carrier equipment. InterMiCOM sends eight signals between the two relays in the scheme, with each signal having a selectable operation mode to provide an optimal combination of speed, security and dependability in accordance with the application. Once the information is received, it may be assigned in the Programmable Scheme Logic to any function as specified by the user's application.

5.6.1 Protection Signalling

In order to achieve fast fault clearance and correct discrimination for faults anywhere within a high voltage power network, it is necessary to signal between the points at which protection relays are connected. Two distinct types of protection signalling can be identified:

5.6.1.1 Unit Protection Schemes

In these schemes the signalling channel is used to convey analog data concerning the power system between relays, typically current magnitude and/or phase. These unit protection schemes are not covered by InterMiCOM, with the MiCOM Px4x range of current differential and phase comparison relays available.

5.6.1.2 Teleprotection – Channel Aided Schemes

In these schemes the signalling channel is used to convey simple ON/OFF data (from a local protection device) thereby providing some additional information to a remote device which can be used to accelerate in-zone fault clearance and/or prevent out-of-zone tripping. This kind of protection signalling has been discussed earlier in this chapter, and InterMiCOM provides the ideal means to configure the schemes in the P443 relay.

The decision to send a command is made by a local protective relay operation, and three generic types of InterMiCOM signal are available:

Intertripping — 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.

Permissive — 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.

Blocking — 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.

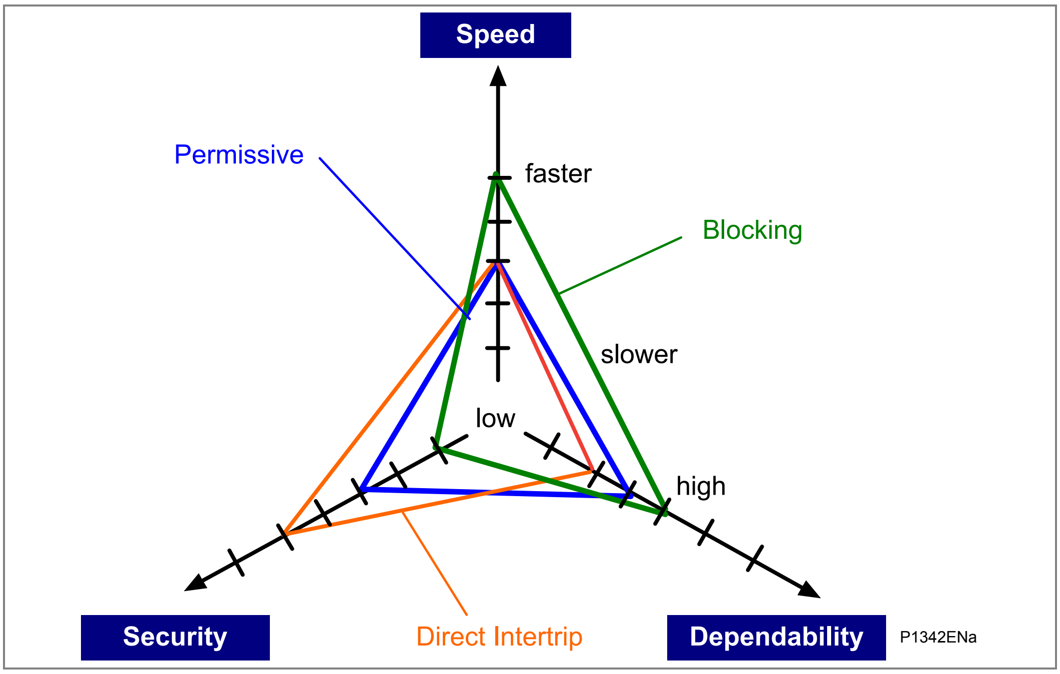


Figure 98 - Pictorial Comparison of Operating Modes

5.6.1.3 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).

Note	*The MiCOM P442/P444 relays only use electrical connections (EIA(RS)232, port SK5).*

5.6.1.4 General Features & 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.

5.6.1.5 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	-

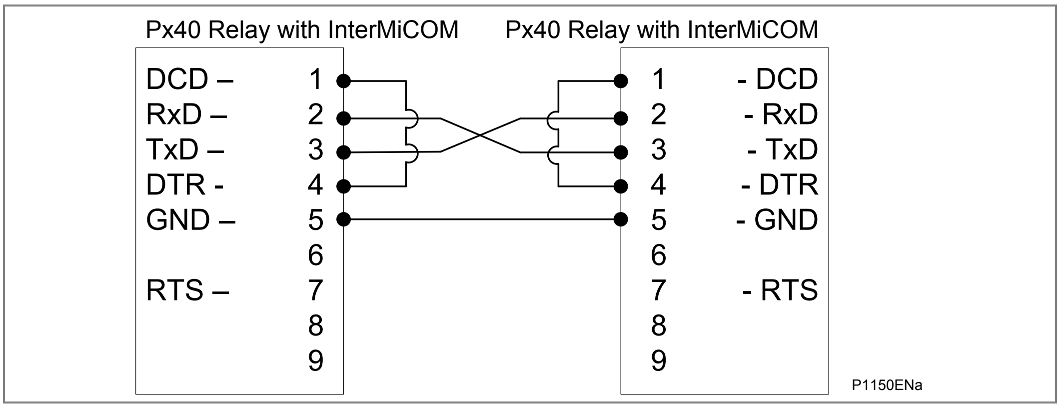
Table 11 - InterMICOM D9 port pin-out connections

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.

5.6.1.6 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.

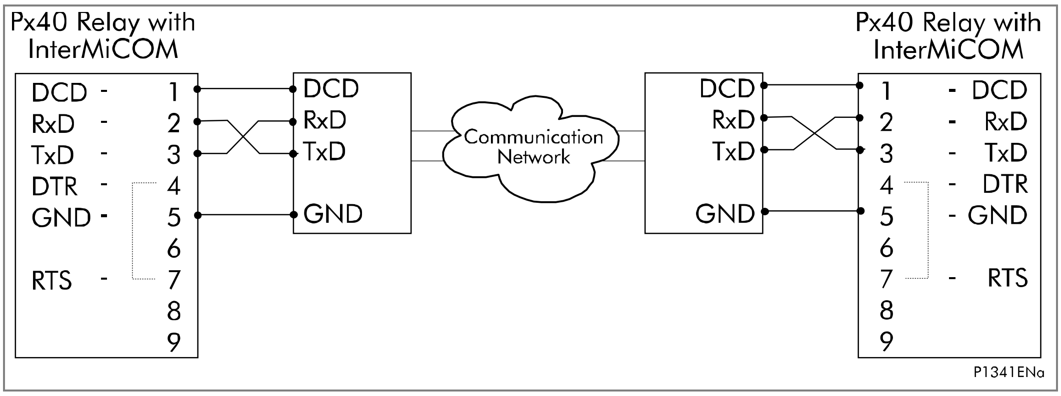


Direct connection within the local substation

5.6.1.7 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.



InterMICOM teleprotection via a MODEM link

5.6.2 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 Studio for “Integral tripping In” and “Integral tripping out” which can be used to assign the 8 intertripping commands.

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.

5.6.3 InterMiCOM Settings

The settings necessary for the implementation of InterMiCOM are contained within two columns of the relay 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 following tables show the relay menus including the available setting ranges and factory defaults.

Once the relay operation has been confirmed using the loopback test facilities, it will be necessary to ensure that the communications between the two relays in the scheme are reliable. To facilitate this, a list of channel statistics and diagnostics are available in the InterMiCOM COMMS column:

5.6.3.1 Setting Guidelines

The settings required for the InterMiCOM signalling are largely dependant upon 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 (using CILI204) based and hence can be set to have the highest signalling speed of 19200b/s. Due to this high signalling rate, the difference in operating speed between the direct, permissive and blocking type signals is so small that the most secure signalling (direct intertrip) can be selected without any significant loss of speed. In turn, since the direct intertrip signalling 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 10msecs. 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 should be applied will become more application and communication media dependent. As for the direct connections, it may be appealing to 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 9600b/s. It should be noted that as the baud rate decreases, the communications become more robust with fewer interruptions, but that overall signalling times will increase.

Since it is likely that slower baud rates will be selected, the choice of signalling mode becomes significant. However, once the signalling 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”.

If “Direct Intertrip” 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.

If “Permissive” 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 signalling modes and baud rates:

Baud Rate	Minimum Recommended “IM# FrameSyncTim” Setting		Minimum Setting	Maximum Setting
	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

Table 12 - Recommended Frame Synchronism Time settings

Note	*No recommended setting is given for the Permissive mode since it is anticipated that "Latched" operation will be selected. However, 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.*

5.6.3.2 InterMiCOM Statistics & 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.

5.6.4 Testing InterMiCOM Teleprotection

5.6.4.1 InterMiCOM Loopback Testing & Diagnostics

A number of features are included within the InterMiCOM function to assist a user in commissioning and diagnosing any problems that may exist in the communications link.

"Loopback" test facilities, located within the INTERMICOM COMMS column of the relay menu, provide a user with the ability to check the software and hardware of the InterMiCOM signalling.

By selecting "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. In the latter case, it is necessary to connect the transmit and receive pins together (pins 2 and 3) and ensure that the DCD signal is held high (connect pin 1 and pin 4 together). When the relay is switched into "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. The loopback mode will be indicated on the relay frontplate by the amber Alarm LED being illuminated and a LCD alarm message, "IM Loopback".

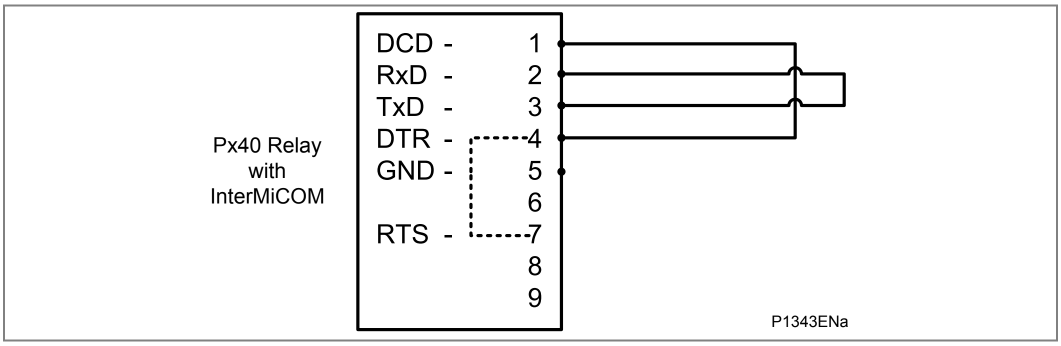


Figure 99 - Connections for External Loopback mode

Once the relay is switched into either of the Loopback modes, a test pattern can be entered in the "Test Pattern" cell which is then transmitted through the software and/or hardware. Providing all connections are correct and the software is working correctly, the "Loopback Status" cell will display "OK". An unsuccessful test would be indicated by "FAIL", whereas a hardware error will be indicated by "UNAVAILABLE". Whilst the relay is in loopback test mode, the "IM Output Status" cell will only show the "Test Pattern" settings, whilst the "IM Input Status" cell will indicate that all inputs to the PSL have been forced to zero.

Care should be taken to ensure that once the loopback testing is complete, the "Loopback Mode" is set to "Disabled" thereby switching the InterMiCOM channel back in to service. With the loopback mode disabled, the "IM Output Status" cell will show the InterMiCOM messages being sent from the local relay, whilst the "IM Input Status" cell will show the received InterMiCOM messages (received from the remote end relay) being used by the PSL.

Once the relay operation has been confirmed using the loopback test facilities, it will be necessary to ensure that the communications between the two relays in the scheme are reliable. To facilitate this, a list of channel statistics and diagnostics are available in the InterMiCOM COMMS column – see section 10.2. 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.

Another indication of the amount of noise on the channel is provided by the communications failure alarm. Within a fixed 1.6 second time period the relay calculates the percentage of invalid messages received compared to the total number of messages that should have been received based upon the "Baud Rate" setting. If this percentage falls below the threshold set in the "IM Msg Alarm Lvl" cell, a "Message Fail" alarm will be raised.

5.7 Programmable Function Keys and Tricolour LEDs

The relay offers users 10 function keys for programming any operator control functionality via PSL. Each function key has an associated programmable tri-colour 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 the Settings chapter). 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, 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.

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.*

DDB: 'Function Key' (see the Programmable Logic chapter)

The activation of the function key will drive an associated DDB signal. 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.

DDB: 'FnKey LED 1 Red'

Ten programmable tri-colour LEDs associated with each function key are used to indicate the status of the associated pushbutton's function. Each LED can be programmed to indicate red, yellow or green as required. The green LED is configured by driving the green DDB input. The red LED is configured by driving the red DDB input. The yellow LED is configured by driving the red and green DDB inputs simultaneously. When the LED is activated the associated DDB signal will be asserted. For example, if FnKey Led 1 Red is activated, DDB will be asserted.

DDB 'FnKey LED 1 Grn'

The same explanation as for Fnkey 1 Red applies.

DDB 'LED 1 Red'

Eight programmable tri-colour LEDs that can be programmed to indicate red, yellow or green as required. The green LED is configured by driving the green DDB input. The red LED is configured by driving the red DDB input. The yellow LED is configured by driving the red and green DDB inputs simultaneously. When the LED is activated the associated DDB signal will be asserted. For example, if Led 1 Red is activated, DDB #640 will be asserted.

DDB 'LED 1 Grn'

The same explanation as for LED 1 Red applies.

5.8 Supervision

The “Supervision” menu contains three sections:

- Voltage Transformer Supervision (VTS) for analog ac voltage inputs failures supervision
- Current Transformer Supervision (CTS) for ac phase current inputs failures supervision

Capacitive Voltage Transformer Supervision (CVT) for voltage dividers capacitors supervision.

5.8.1 Voltage Transformer Supervision (VTS) – Main VT for minZ Measurement

5.8.1.1 VTS Description

The Voltage Transformer Supervision (VTS) feature is used to detect failure of the analog 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 maloperation of the distance element.

The VTS logic in the relay is designed to detect the voltage failure (with internal thresholds or external opto input), and automatically adjust the configuration of protection elements (the distance element is blocked but may be unblocked by I1, I2 or I0 conditions in the event of a fault during VTS conditions) whose stability would otherwise be compromised (Distance, DEF, Weak infeed, Directionnal phase current & all directional elements used in the internal logic).

A settable time-delayed (VTS Time Delay) alarm output is also available (min 1s to max 20s). This alarm is instantaneous if an opto inputs is energised by an external fuse blowing signal (for instance from a micro circuit breaker contact). This external information is secure, and will instantaneously block the distance function and the functions using directional elements.

In the absence of load, the time-delay covers the duration of the Dead time-delay 1 of the autoreclose cycle which could be detected as a 1-pole VT failure.

Where a Miniature Circuit Breaker (MCB) is used to protect the voltage transformer ac output circuits, it is common to use MCB auxiliary contacts to indicate a three phase output disconnection. As described previously, it is possible for the VTS logic to operate correctly without this input. However, this facility has been provided for compatibility with the current practices of various utilities. Energising an opto-isolated input assigned to “MCB Open” on the relay will therefore provide the necessary block.

Fuse failure conditions are confirmed instantaneously if the opto input receiving the fuse blowing signal is energised and assigned in the PSL, or after elapse of the VTS Time delay in case of 1-, 2- or 3-phase Fuse Failure.

Confirmed Fuse Failure blocks all protection functions which use the voltage measurement (Distance, Weak infeed, Directional overcurrent,etc.). The directional overcurrent element may be blocked or set to become non-directional with a dedicated time-delay ('I>1 Time Delay VTS' or 'IN>1 Time Delay VTS' setting).

An unconfirmed Fuse Failure will be a detection of an internal fuse failure before the time-delay has expired. In that case a fault can be detected by the I2>,I0>,I1>, ΔI> criteria and will force the unblocking functions:

- Distance Protection
- DEF Protection
- Weak-infeed Protection
- I> Directional
- U>, U<

5.8.1.2 Loss of One, Two or Three Voltages (‘VTS I2 & I0 Inh’ and ‘Detect 3P’)

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

Loss of One or Two Phase Voltages

The VTS feature within the relay operates on detection of residual voltage without the presence of zero and negative phase sequence current, and earth fault current (ΣIph). 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 I0 and/or I2 current. Also, VTS operation is blocked (and distance element unblocked) when any phase current exceeds 2.5 × In.

Zero Sequence VTS Element:

The thresholds used by the element are:

- Fixed operate threshold: $V_N \geq 0.75$ x Vn;
- Blocking current thresholds, I0 = I2 = 0 to 1 x In; settable (default 0.05In), and Iph = 2.5 x In.

Loss of All Three Phase Voltages Under Load Conditions

Under the loss of all three phase voltages to the relay, there will be no zero 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), then a VTS condition will be raised. In practice, the relay detects the presence of superimposed current signals (delta I), which are changes in the current applied to the relay. These signals are generated by comparison of the present value of the current with the value one cycle before. 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.

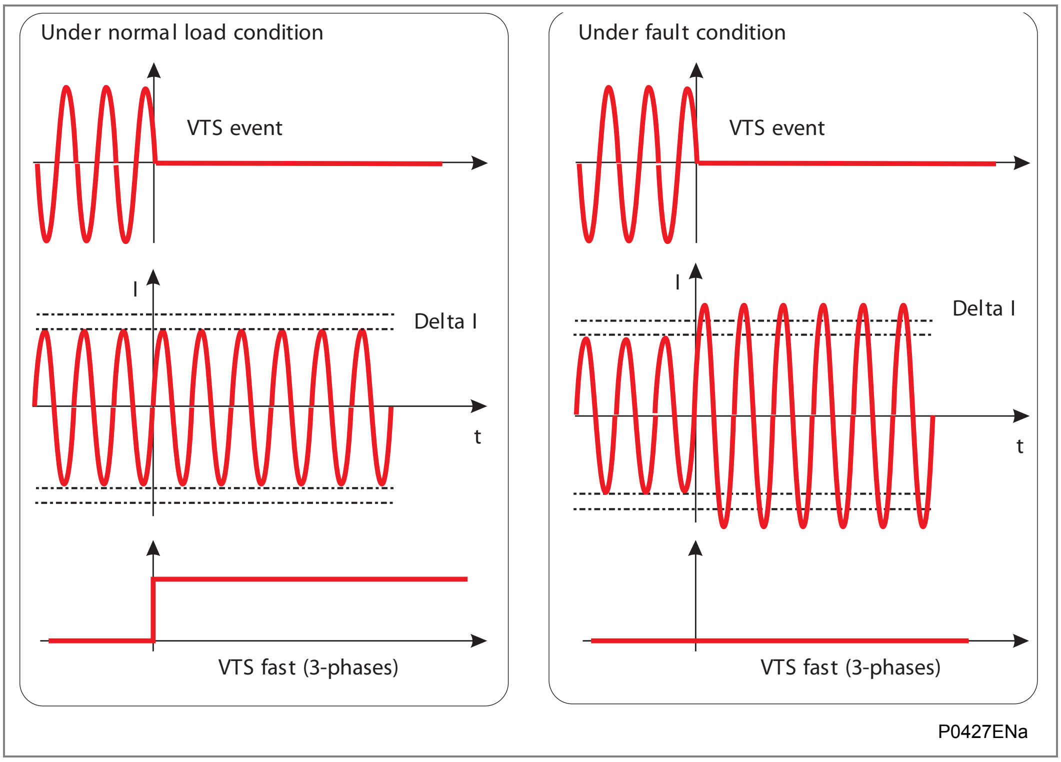


Figure 100 – Line energisation – Superimposed current under fault condition (VT non isolated)

If a VT were inadvertently left isolated prior to line energisation, on line energisation will change in current. If the phase currents do not exceed nominal current (superimposed current – delta – is null), VTS condition will be raised. If a fault condition is detected, superimposed current signal is generated and prevents operation of the VTS:

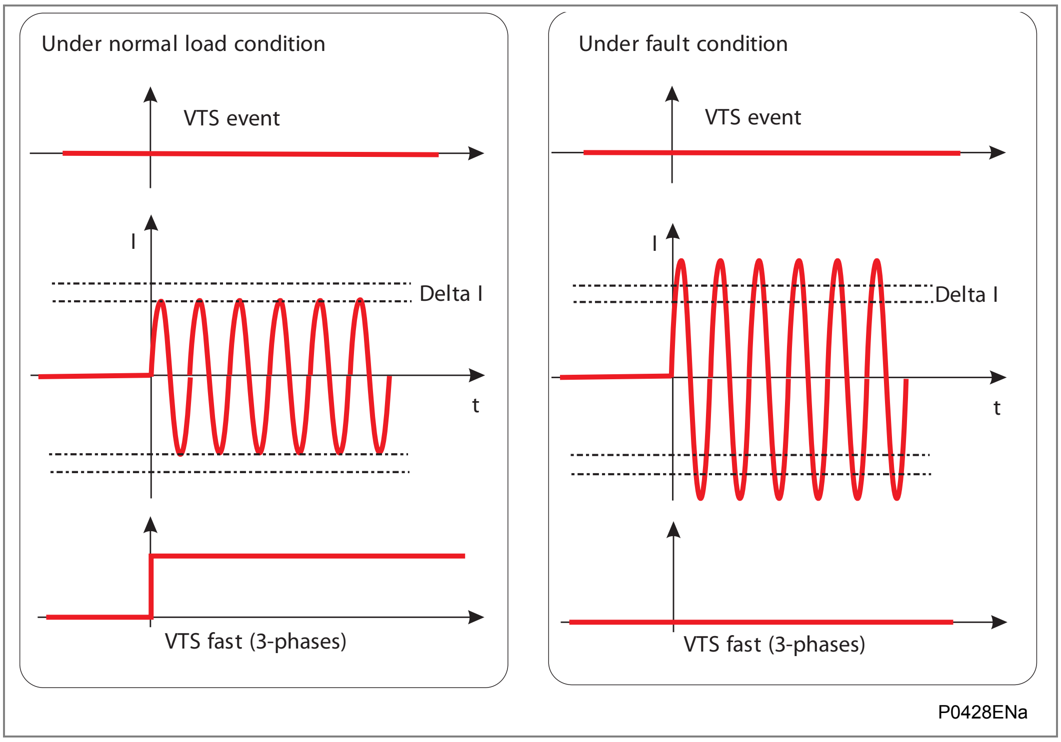


Figure 101 - Line energisation – Superimposed current under fault condition (VT isolated)

The phase voltage level detector is settable ('**Threshold 3P**' setting)).

The sensitivity of the superimposed current – '**delta I>**'– elements is settable and default value is set to 0.1In.

Caution	**If line is energised at nominal current, delta I> has to be set at In + 20% for instance.**

Absence of Three Phase Voltages Upon Line Energisation

If a VT were inadvertently left isolated prior to line energisation, incorrect operation of voltage dependent elements could result. The previous VTS element detected three phase VT failure by absence of all 3-phase voltages with no corresponding change in current. On line energisation 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 energisation: in that case the SOTF logic is applied.

Absence of Three Phase Voltages with Line Energized

Note	*For the P44x, this function relates to Software Version D6.x*

The absence of voltage measurements on all three phases with line energized can result of two conditions:

- A 3 phase VT failure
- 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 Imax> Inh") 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.

The "VTS Imax> inh" setting covers the event of a phase fault occurring, where three voltages are lost and the line is energized.

5.8.1.3 Internal Logic of the VT Failure Detection

The VT failure (fuse blowing or fuse failure detection) alarm is given when the following conditions are met:

- VT Failure is internally detected and the VTS time-delay is elapsed (VT failure & VTS_Time_delay)
- Or the opto input dedicated to the function receives a fuse blowing signal (VTS opto input energised).

The equation (as shown in the *VTS Logic* diagram) of the VT failure is:

Fuse Failure (confirmation of the fuse blowing) =
("Fuse Failure detected" AND "VTS Time-Delay")
OR "opto input energized"

The VT protection fuse blowing is detected when the following conditions are met:

- VN>: The residual voltage is higher than a fixed threshold:= 0,75Vn
- NOT I0>: The zero-sequence current is higher than I0> threshold:
- NOT I2>: The negative sequence current is higher than a I2> threshold (identical to the I0 threshold).
- NOT I>: The direct current is higher than a fixed threshold equal to 2,5In.
- V<: All the voltages are lower than a V< threshold.
- NOT ΔI>: The line currents' variation are higher than "Delta I" value.
- Detect 3P: setting that which allows the FFU three pole detection.
- Any pole dead: Cycle in progress.
  - The I0 criterion (zero sequence current threshold) makes it possible to UNBLOCK the distance protection in the event of phase-to-ground fault (if the fuse failure has not yet been confirmed).
  - The I2 criterion (negative sequence current threshold) makes it possible to UNBLOCK the distance protection in the event of insulated phase to phase fault (if the fuse failure has not been yet confirmed).
  - The (V< AND /ΔI) criterion makes it possible to detect the 3-pole Fuse Failure (no phase voltage and no current variation) (no specific line energisation logic).

As soon as 'a start occurs and for the following 20 ms' AND 'during the trip': I< threshold for dead pole is equal to 5% In or to CB 'I< Current set' if "CB Fail" is enabled.

The rest of the time I< Threshold for dead pole is equal to 10% of In.

Fuse Failure detected =
(VN> AND "NOT I0>" AND "NOT I2>" AND "NOT I>")
OR
("Detect 3P" AND "NOT Any pole dead" AND "V<" AND "NOT ΔI")

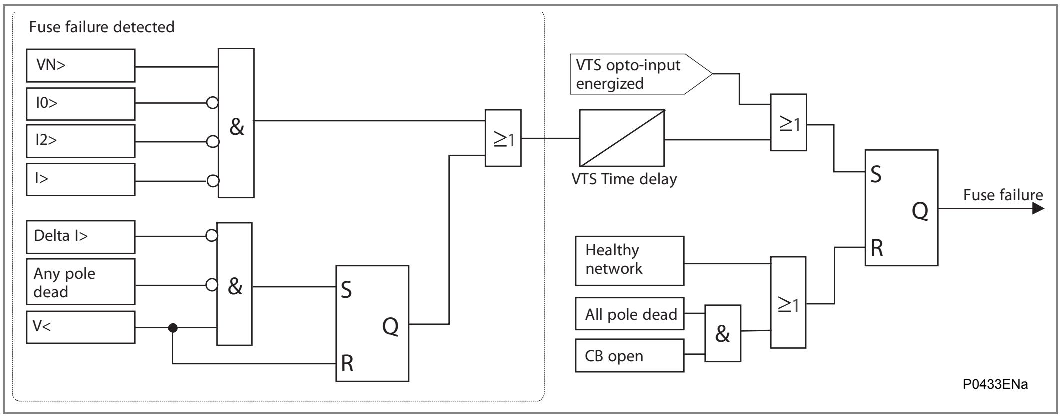


Figure 102 - VTS Logic

5.8.1.4 Fuse Failure Alarm reset

In the event of of a confirmed Fuse Failure, the condition which manages the reset is given by (as shown in the *VTS Logic* diagram):

Fuse Failure (reset) =
"No Fuse Failure detected"
AND "NO opto input energized"
AND ["Healthy netwotk"
OR ["All Pole dead" AND "CB Open"]

Where:

- "All Pole dead" means "All circuit breaker poles dead (breaker open 3 phase)":
  All Pole Dead =
  "No current" AND "no voltage"
  OR CB Opened ((52a) if assigned in PSL)
- Healthy Network =
  "Rated Line voltage"
  AND "No V0" AND "No I0"
  AND "No start element" ∗
  AND "No Power Swing"
- = no CVMR (no General Start Convergency).

  Healthy Network = U_N AND $\overline{V_0}$ AND $\overline{I_0}$ AND $\overline{\text{CVMR}}$ AND $\overline{\text{PSWING}}$

5.8.1.5 Input / Output DDBs used in the PSL:

The following DDBs are associated to VTS in the PSL (see the Programmable Logic chapter):

Inputs:

- MCB/VTS Main
- MCB/VTS Synchro

Outputs:

- VTS Fast
- VT Fail Alarm
- Any Pole Dead
- All Pole Dead

5.8.2 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.

5.8.2.1 CT Supervision Feature

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. In this case, distance protection is blocked.

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 (DDB '**CT Fail Alarm**' will be high), with an instantaneous block for inhibition of protection elements. Protection elements operating from derived quantities (Broken Conductor, Earth Fault, Neg Seq O/C) are always blocked on operation of the CT supervision element.

5.8.2.2 Setting the CT Supervision Element

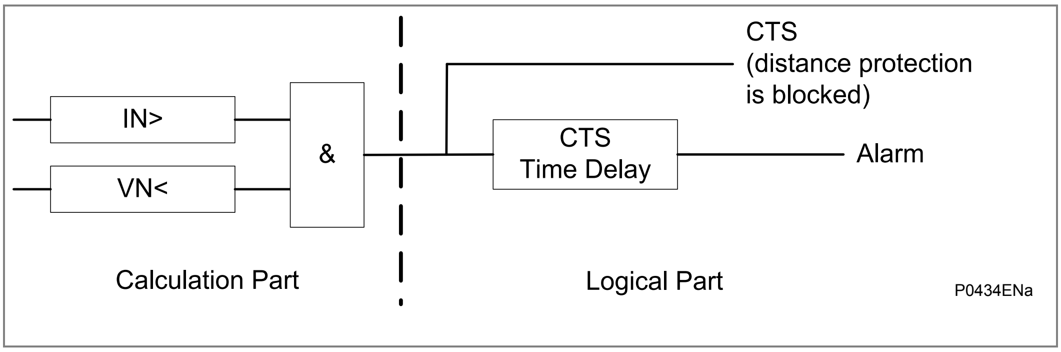


Figure 103 - Basic CT supervision diagram

A “CTS fault” signal is sent out, after a settable time-delay if the conditions are as follows:

- The residual voltage is smaller than the setting threshold during a delay greater then time delay
- The residual current is greater than the setting threshold.

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 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 an earth fault is unpredictable, the element must be disabled to prevent a protection elements being blocked during fault conditions.

The DDB: ’**CT Fail Alarm**’ output is associated to CTS in the PSL (see the *Programmable Logic* chapter).

5.8.3 Capacitive Voltage Transformers Supervision (CVTS)

5.8.3.1 Function Description

This Capacitive Voltage Transformers (CVT) Supervision will detect the degradation of one or several capacitors of voltage dividers. It is based on permanent detection of residual voltage.

A “CVT fault” signal is sent out, after a settable time-delay if the conditions are as follows:

- The residual voltage is greater than the setting threshold during a delay greater than time-delay,
- The 3 phase-phase voltages have a value greater than 0.4 Un,

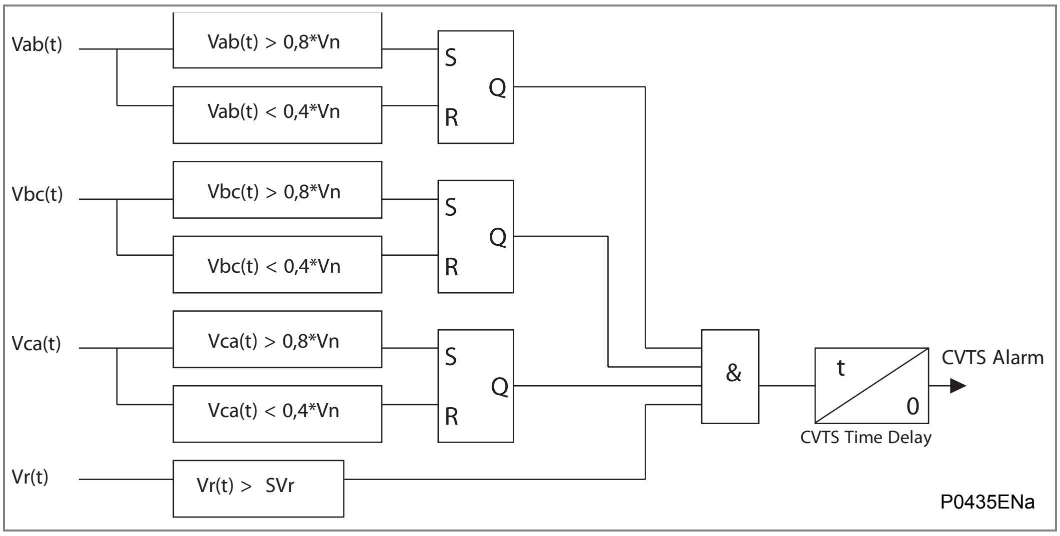


Figure 104 - Basic CVT supervision diagram

5.8.3.2 Output DDB used in the PSL

The DDB: '**CVT ALARM**' is associated to CVTS in the PSL (see the Programmable Logic chapter).

5.9 Check Synchronisation

The check synchronism option is used to qualify reclosure of the circuit breaker so that it can only occur when the network conditions on the busbar and line side of the open circuit breaker are acceptable. If a circuit breaker were closed when the two system voltages were out of synchronism with one another, ie. a difference in voltage magnitudes or phase angles existed, the system would be subjected to an unacceptable ‘shock’, resulting in loss of stability and possible damage to connected machines.

Check synchronism therefore involves monitoring the voltage on both sides of a circuit breaker and, if both sides are ‘live’, the relative synchronism between the two supplies. Such checking may be required to be applied for both automatic and manual reclosing of the circuit breaker and the system conditions which are acceptable may be different in each case. For this reason, separate check synchronism settings are included within the relay for both manual and automatic reclosure of the circuit breaker. With manual closure, the CB close signal is applied into the logic as a pulse to ensure that an operator cannot simply keep the close signal applied and wait for the system to come into synchronism. This is often referred to as guard logic and requires the close signal to be released and then re-applied if the closure is unsuccessful.

The check synchronism element provides two ‘output’ signals which feed into the manual CB control and the auto reclose logic respectively. These signals allow reclosure provided that the relevant check synchronism criteria are met.

Note that if check-synchronisim is disabled, the DDB: '**Check synch. OK**' signal is automatically asserted and becomes invariant (logical state always forced to 1).

For an interconnected power system, tripping of one line should not cause a significant shift in the phase relationship of the busbar and line side voltages. Parallel interconnections will ensure that the two sides remain in synchronism, and that autoreclosure can proceed safely. However, if the parallel interconnection(s) is/are lost, the frequencies of the two sections of the split system will begin to slip with respect to each other during the time that the systems are disconnected. Hence, a live busbar / live line synchronism check prior to reclosing the breaker ensures that the resulting phase angle displacement, slip frequency and voltage difference between the busbar and line voltages are all within acceptable limits for the system. If they are not, closure of the breaker can be inhibited.

The SYSTEM CHECKS menu contains all of the check synchronism settings for auto (“A/R”) and manual (“Man”) reclosure.

- **If SOTF is disabled in S1, a dedicated PSL must be created using Deb B (live line or live bus/dead line) – live/live cannot be managed – in that case.**

Note that the combination of the Diff Phase and Bus-Line Delay settings can also be equated to a differential frequency, as shown below:

- Diff Phase angle set to +/-20°, Bus-Line Delay set to 0.2s.
- The phase angle ‘window’ is therefore 40°, which corresponds to 40/360ths of a cycle = 0.111 cycle. This equates to a differential frequency of:

  0.111 / 0.2 = 0.55Hz

Thus it is essential that the time delay chosen before an “in synchronism” output can be given is not too long, otherwise the synchronising conditions will appear more restrictive than the actual Diff Frequency setting.

The Live Line and Dead Line settings define the thresholds which dictate whether or not the line or bus is determined as being live or dead by the relay logic. Under conditions where either the line or bus is dead, check synchronism is not applicable and closure of the breaker may or may not be acceptable. Hence, setting options are provided which allow for both manual and auto-reclosure under a variety of live/dead conditions. The following paragraphs describe where these may be used.

Warning **Voltage Setting is always calculated in phase to ground – even if phase/phase ref has been selected.**

If the live line threshold has been set too high, the relay will never detect a healthy network (as the line voltage is always measured below the voltage threshold). Without the live line condition, the distance protection cannot use the delta algorithms as no pre-fault detection has been previously made.

5.9.1 Live Busbar and Dead Line

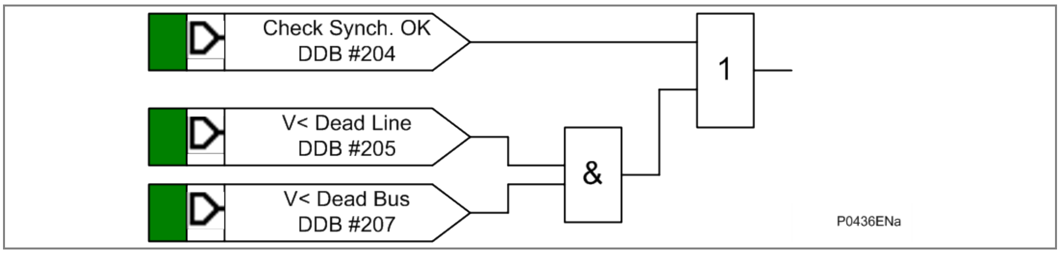
Where a radial feeder is protected, tripping the circuit breaker will isolate the infeed, and the feeder will be dead. Provided that there is no local generation which can backfeed to energise the feeder, reclosure for live busbar / dead line conditions is acceptable. This setting might also be used to allow re-energisation of a faulted feeder in an interconnected power system, which had been isolated at both line ends. Live busbar / dead line reclosing allows energising from one end first, which can then be followed by live line / live busbar reclosure with voltages in synchronism at the remote end.

5.9.2 Dead Busbar and Live Line

If there is a circuit breaker and busbar at the remote end of the radial feeder mentioned above, the remote breaker might be reclosed for a dead busbar / live line condition.

5.9.3 Dead Busbar and Dead Line

This mode is not integrated in the internal logic, however it can be created using a dedicated PSL:



This setting may also be used to allow manual close with specific test conditions on the CB.

5.9.4 Check Synchronism Settings

The main three phase VT location (busbar or line is set in the '**CT & VT RATIOS / Main VT Location**' setting to allow the previously described logic to operate correctly. (see DDB description below)

Note that the check synchronism VT input may be driven from either a phase to phase or phase-to-neutral voltage '**CT & VT Ratios / C/S Input**' cell.

If the VTS feature internal to the relay operates, the check synchronism element is inhibited from giving an 'Allow Reclosure' output. This avoids allowing reclosure in instances where voltage checks are selected and a VT fuse failure has made voltage checks unreliable.

Measurements of the magnitude angle and delta frequency (slip frequency) – system rated frequency is displayed by default in the event of problems with the delta f calculation: No line voltage or no bus voltage or neither of the check synchronism voltages are displayed in the '*MEASUREMENTS 1*' column.

Individual System Check logic features can be enabled or disabled by means of the **C/S Check Scheme** function links. Setting the relevant bit to 1 will enable the logic, setting bits to 0 will disable that part of the logic. Voltage, frequency, angle and time-delay thresholds are shared for both manual and autoreclosure, it is the live/dead line/bus logic which can differ.

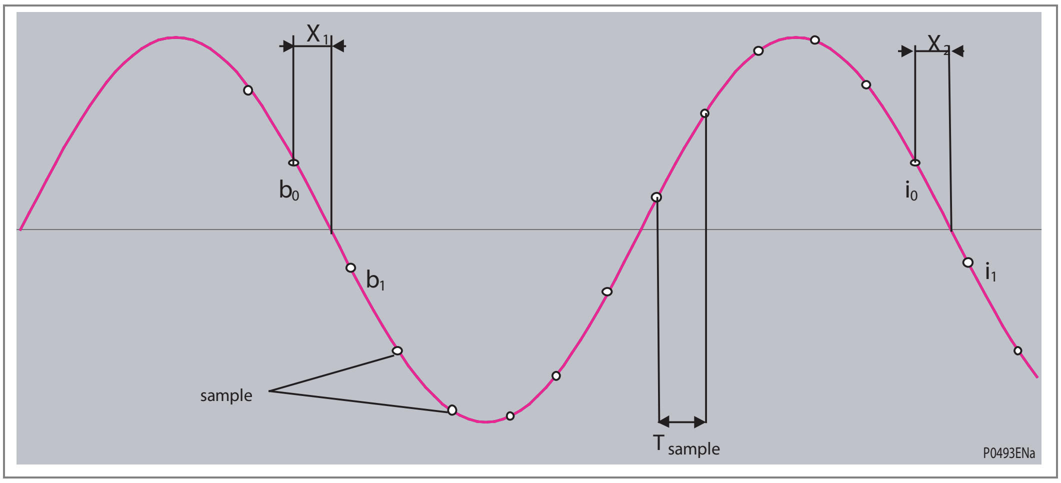


Figure 105 –Frequency calculation

Frequency tracking is calculated by: freq=1/((X_2-X_1+ $Nb_{samples}$)* $T_{samples}$)

With $X_1 = b_0 /(b_0 – b_1)$ et $X_2 = I_0 /(I_0 – I_1)$.

$T_{samples}$ is the sampling period.

$Nb_{samples}$ is the number of samples per period (between b1 and i1 (b1 being excluded))

The Line & Bus frequencies are calculated with the same principle (described here after).

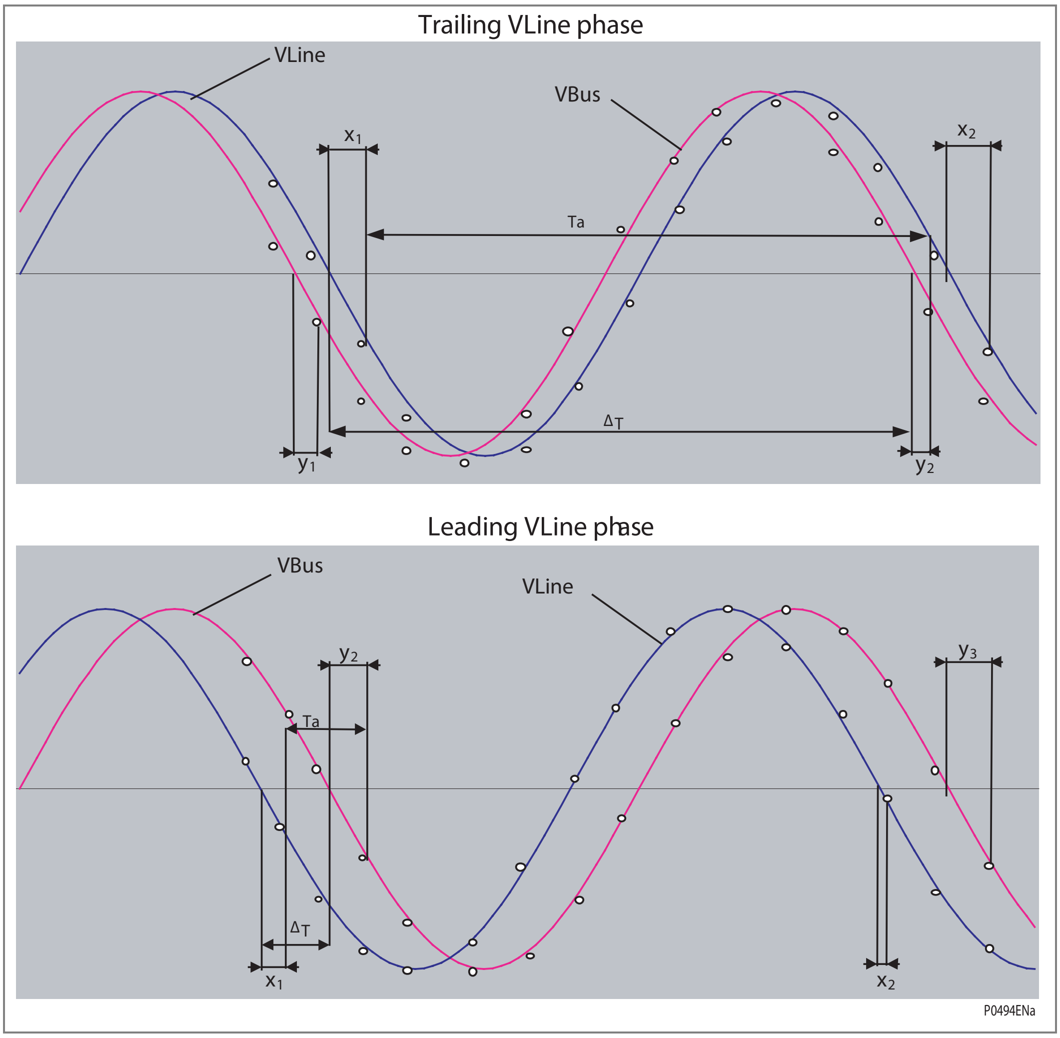


Figure 106 - Calculation of Diff. phase

Phase shift = (ΔT/ T) *360

ΔT = Ta + (x1-y2)

A phase shift calculation requires a change of sign of both signals.

All the angles will be between 0° and 180°. For a phase shift of 245°, (360 –245) = 115° will be displayed

5.9.5 DDBs from Check Synchronism Function used in the PSL

The following DDBs are associated with the the check synchronization logic in the PSL (see the *Programmable Logic* chapter).

Logic inputs used by the check synchronism logic include:

- MCB/VTS Synchro,
- MCB/VTS Main,

These are managed dynamically (regarding where the main VT are located:bus side or line side – then the Csync ref is assigned to the other VT which is managed as the Csync ref).

Logic DDB outputs issued by the check sync logic

- Check Sync OK [Used with AR close in the relevant PSL – "AND" gate: [(AR Close) & (CheckSync OK)]
- A/R Force Sync,
- V<Dead Line
- V>Live Line
- V<Dead Bus
- V>Live Bus
- Control No C/S
- Ext Chk Synch OK

Warning **To ensure that the Autoreclose command is controlled by the check synchronism conditions, the above PSL should be set.**

(Different schemes can be created with internal AR & external CSync or internal Csync & external AR)

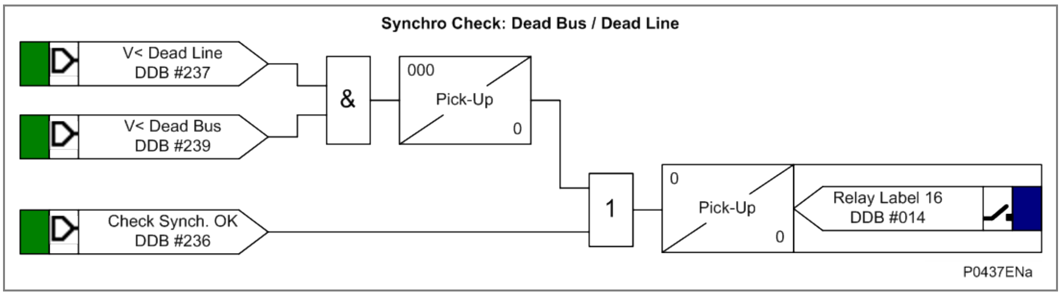


Figure 107 – Check sync PSL logic

5.9.5.1 Logic Diagram

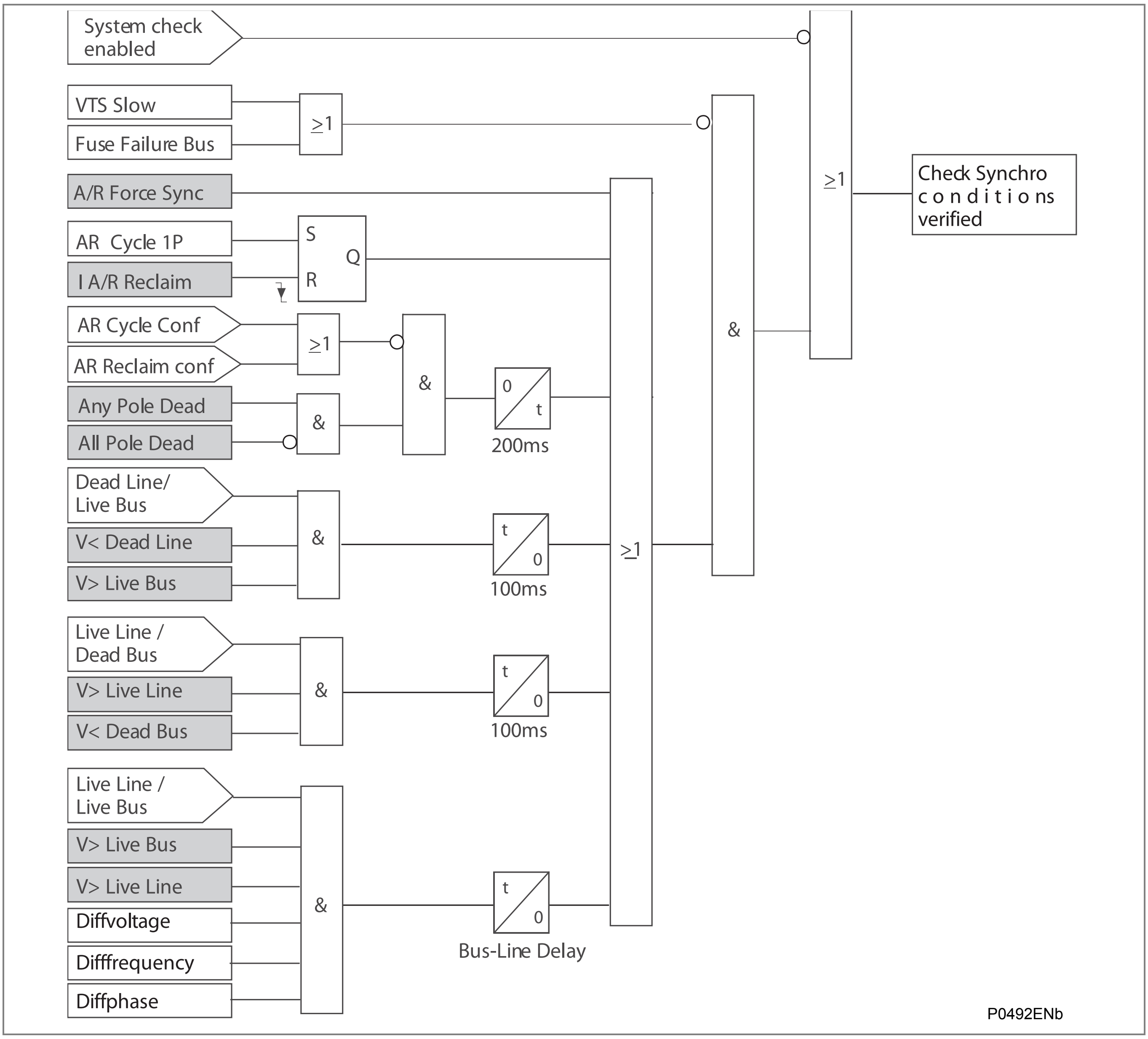


Figure 108 – Check sync logic description

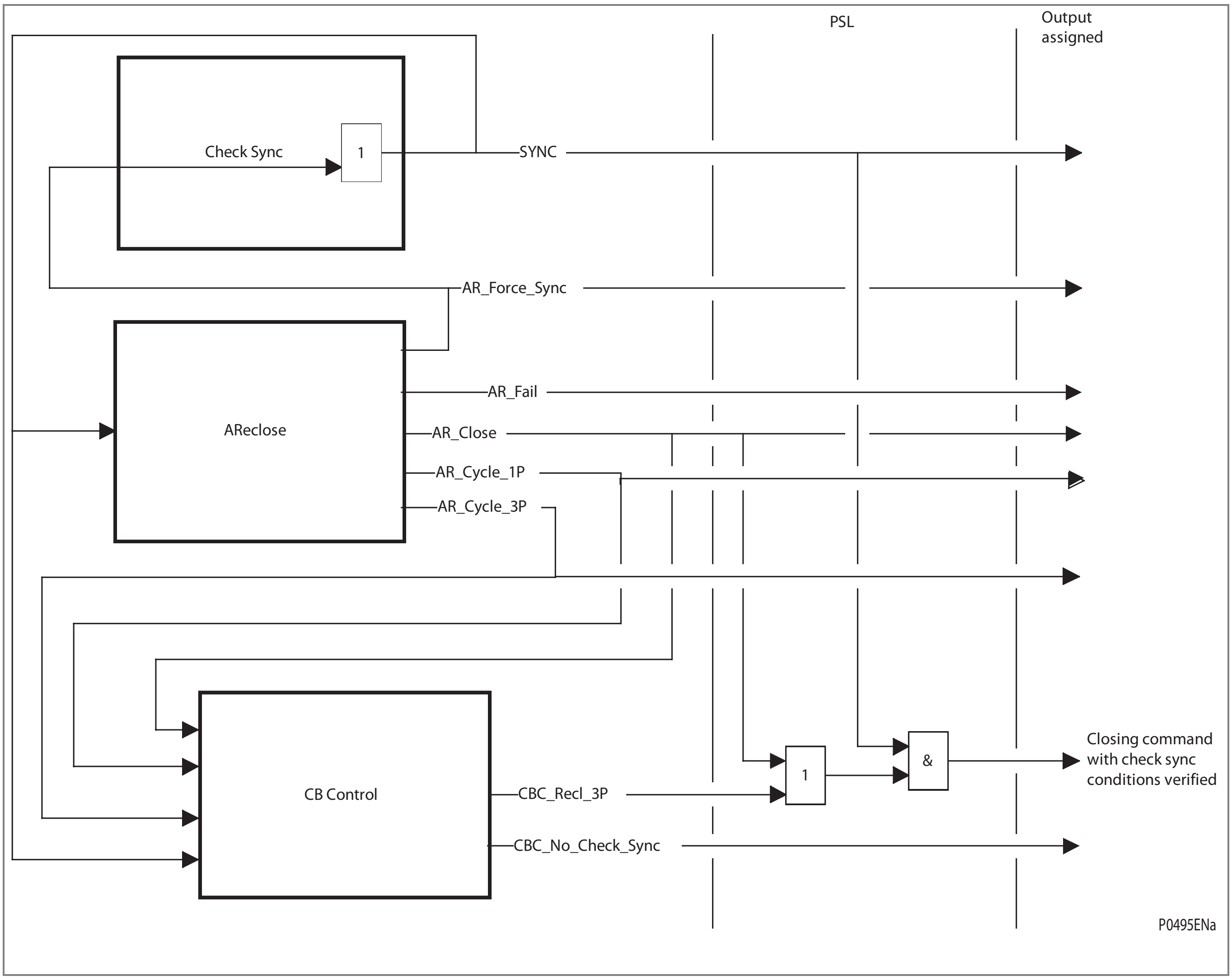


Figure 109 – Internal check synchronism and internal autoreclose logic

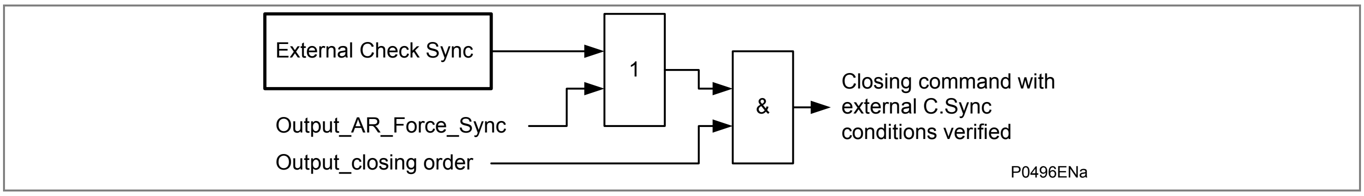


Figure 110 - Logic with external synchronisation check

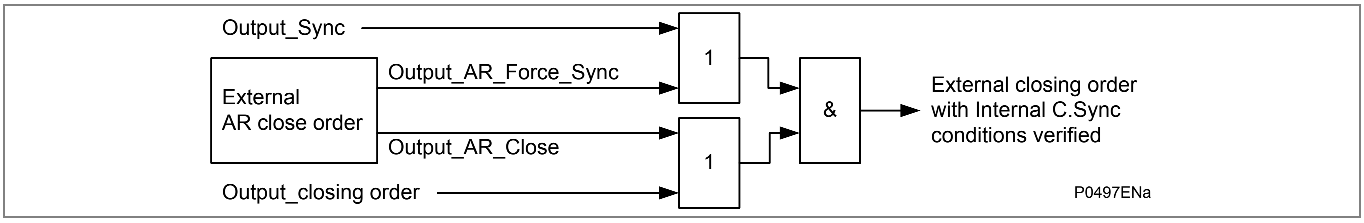


Figure 111 - Logic with external autoreclose

5.10 Autorecloser

The relay autorecloser provides selectable multishot reclosure of the line circuit breaker. The standard scheme logic is configured to permit control of one circuit breaker. Autoreclosure of two circuit breakers in a 1½ circuit breaker or mesh corner scheme is not supported by the standard logic (Dedicated PSL must be created & tested by user). The autorecloser can be adjusted to perform a single shot, two shot, three shot or four shot cycle. Dead times for all shots (reclose attempts) are independently adjustable (using setting).

Where the relay is configured for single and three pole tripping, the recloser can perform a high speed single pole reclose shot, for a single phase to earth fault. This single pole shot may be followed by up to three delayed autoreclose shots, each with three phase tripping and reclosure. For a three pole trip, up to four reclose shots are available in the same scheme. Where the relay is configured for three pole tripping only, up to four reclose shots are available, each performing three phase reclosure.

An analysis of faults on any overhead line network has shown that 80-90% are transient in nature.

Lightning is the most common cause, other possibilities being clashing conductors and wind blown debris. Such faults can be cleared by the immediate tripping of one or more circuit breakers to isolate the fault, followed by a reclose cycle for the circuit breakers. As the faults are generally self clearing ‘non-damage’ faults, a healthy restoration of supply will result.

The remaining 10 - 20% of faults are either semi-permanent or permanent. A semi-permanent fault could be caused by a small tree branch falling on the line. The cause of the fault may not be removed by the immediate tripping of the circuit, but could be burnt away/thrown clear after several further reclose attempts or “shots”. Thus several time delayed shots may be required in forest areas.

Permanent faults could be broken conductors, transformer faults or cable faults which 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-ionise, reclosure of the circuit breakers will result in the line being successfully re-energised, with obvious benefits. The main advantages to be derived from using autoreclose can be summarised as follows:

- Minimises interruptions in supply to the consumer;
- A high speed trip and reclose cycle clears the fault without threatening system stability.

When considering feeders which 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 reclosing on to a faulty cable is likely to aggravate the damage.

At subtransmission and transmission voltages, utilities often employ single pole tripping for earth faults, leaving circuit breaker poles on the two unfaulted phases closed. High speed single phase autoreclosure then follows. The advantages and disadvantages of such single pole trip/reclose cycles are:

- Synchronising power flows on the unfaulted phases, using the line to maintain synchronism between remote regions of a relatively weakly interconnected system.

However, the capacitive current induced from the healthy phases can increase the time taken to de-ionise fault arcs.

5.10.1 Functional Description

The following diagram summarizes the autoreclose process:

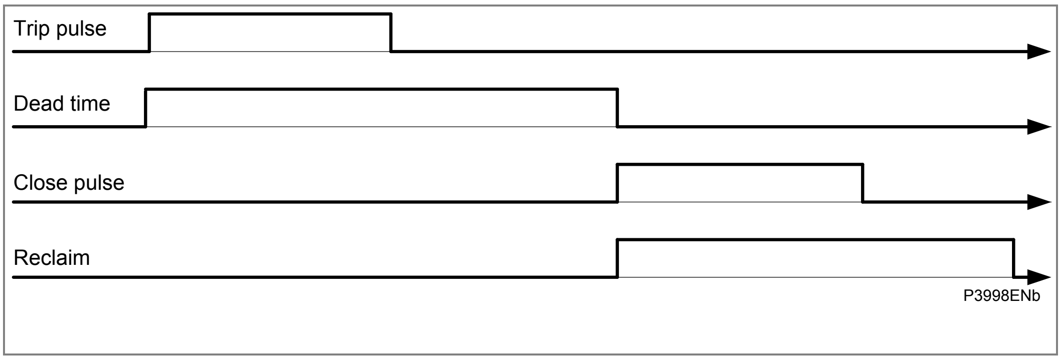


Figure 112 – Autoreclose timing diagram

Should autoreclosure not be required, the function may be Disabled in the relay **Configuration** menu. Disabling the autorecloser does not prevent the use of the internal check synchronism element to supervise manual circuit breaker closing.

An autoreclose cycle is internally initiated by operation of a protective element (could be started by an internal trip or external trip), provided the circuit breaker is closed at the instant of protection operation. The appropriate dead time-delay for the shot is started (**Dead Time 1, 2, 3 or 4;** noting that separate dead times are provided for the first high speed shot of single pole (1P), and three pole (3P), reclosure). At the end of the dead time, a CB close pulse command of **'Close Pulse Time**' duration (see the *Circuit Breaker Condition Monitoring* section: '**CB Control**" menu) is given, provided system conditions are suitable.

The reclaim time (**Reclaim Time**) starts with the CB Close pulse. If the circuit breaker has not been retripped, the autoreclose logic is reset at the end of the reclaim time. The autorecloser is ready again to start a new cycle again from the first shot a new cycle again (for future faults). If the protection retrips during the reclaim time, the relay either advances to the next shot in the programmed autoreclose cycle, or, if all programmed reclose attempts have been made, goes to lockout.

The following timing diagram illustrates the P44x autoreclose cycle (1P / 3P trip) in normal condition:

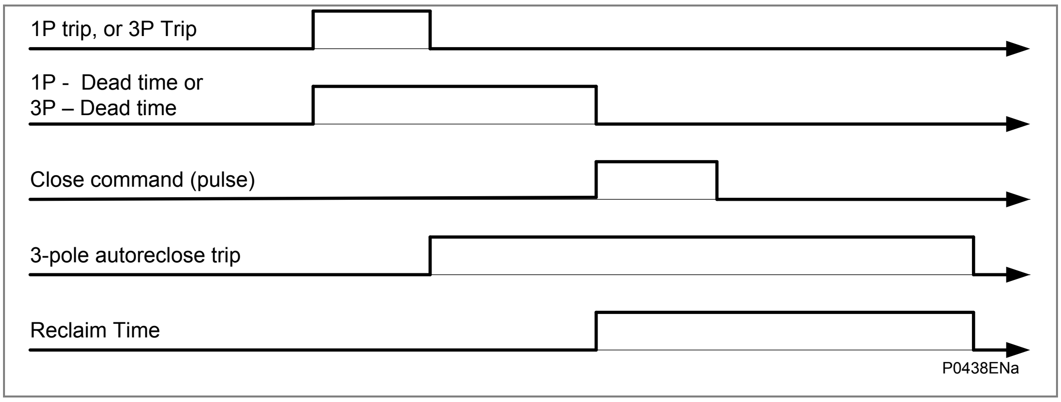


Figure 113 - Autoreclose cycle – general description

The conditions to be met for closing are that the system voltages satisfy the internal check synchronism criteria (see Check synchronisation section), and that the circuit breaker closing spring, or other energy source, is fully charged. The following diagram illustrates a second trip command before the end of reclaim time:

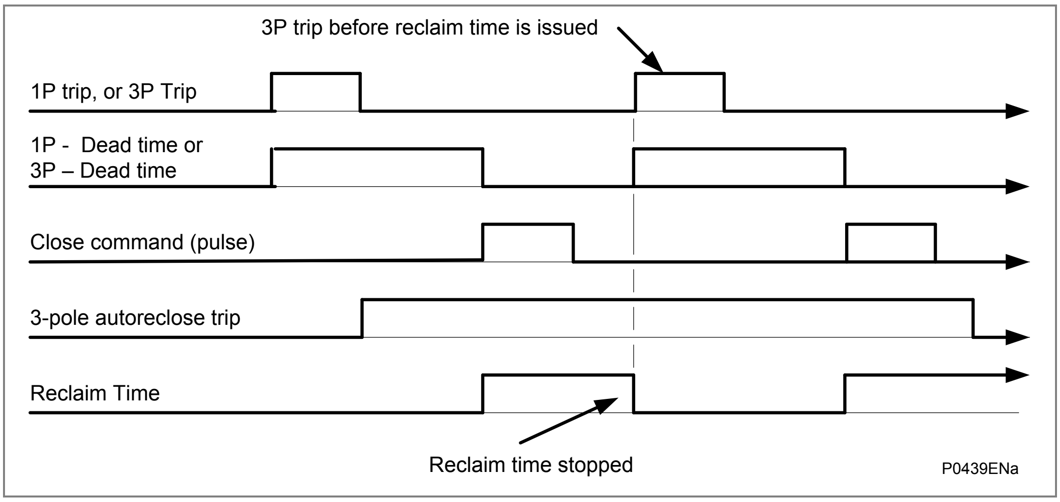


Figure 114 - Successive autoreclose cycles

If protection operates during the reclaim time, after the final reclose attempt, the relay will be driven to lockout and the autoreclose function will be disabled until the lockout condition is reset. This will produce an alarm, **AR Lockout**. Then, the DDB: '**BAR**' input will block the autorecloser and cause a lockout if a reclose cycle is in progress. Lockout will also occur if the CB energy is low and that the CB fails to close. Once the autorecloser is locked out, it will not function until a Reset Lockout or CB Manual Close command is received (depending on the Reset Lockout method chosen in **CB Monitor Setup**).

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 and CB failed to close, manual close no check synchronism and CB unhealthy.*

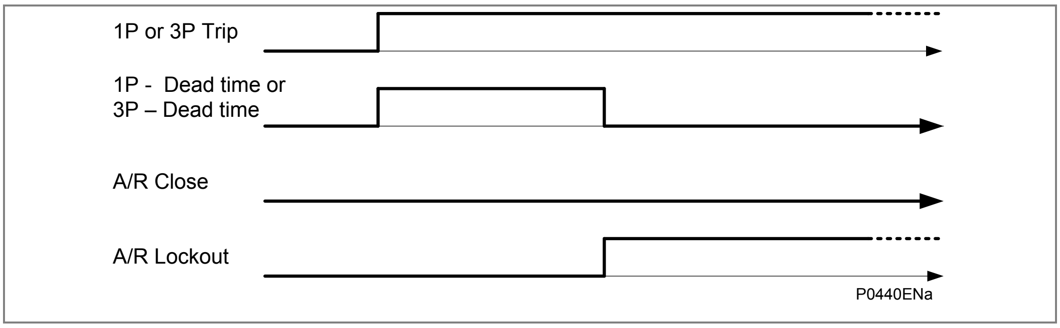


Figure 115 - Trip Signal still present when Dead time elapses will force AR Lockout

5.10.1.1 Number of Shot (Trip Mode Cells) Setting

There are no clear-cut rules for defining the number of shots for any particular application. 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.
- The fact that 80 - 90% of faults are transient highlights the advantage of single shot schemes. If statistical information for the power system shows that a moderate percentage of faults are semi-permanent, further time-delayed autoreclose shots may be used provided that system stability is not threatened.

The relay allows up to four reclose shots, ie. one high speed single pole autoreclose shot, plus up to three time-delayed shots. All time-delayed shots have three-pole operation. The scheme is selected in the relay menu as follows:

“1P Trip Mode”	first shot	second shot	3rd shot	4th shot
1	1P	--	--	--
1 / 3	1P	3P	--	--
1 / 3 / 3	1P	3P	3P	--
1 / 3 / 3 / 3	1P	3P	3P	3P

“3P Trip Mode”	first shot	second shot	3rd shot	4th shot
1	3P	--	--	--
1 / 3	3P	3P	--	--
1 / 3 / 3	3P	3P	3P	--
1 / 3 / 3 / 3	3P	3P	3P	3P

Notes *“1P”: Single Pole autoreclose shot*
“3P”: Three Pole autoreclose shot
“--”: No shot.

Table 13 - Reclosing Scheme for Single Phase Trips

If single pole and three pole autoreclose are enabled, then:

- If the first fault is a single phase fault, a single pole autoreclose sequence will start,
- If the first fault is a multi phase fault, the first autoreclose sequence a three pole autoreclose sequence will start.

5.10.1.2 Dead-Time Setting

At the end of the relevant dead time, the autoreclose single phase or three phase in progress signal is reset and 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 synchronism element and that the circuit breaker closing spring, or other energy source, is fully charged indicated from the DDB: '**CB Healthy**' input. The CB close signal is cut-off when the circuit breaker closes. For single pole autoreclose no voltage or synchronism check is required as synchronising power is flowing in the two healthy phases. Check synchronism for the first three phase cycle is controlled by a setting.

High speed autoreclose may be required to maintain stability on a network with two or more power sources. For high speed autoreclose, the system disturbance time should be minimised by using fast protection, <50 ms, such as distance or feeder differential protection and fast circuit breakers <100 ms. For stability between two sources a system dead time of <300 ms may typically be required. The minimum system dead time considering just the CB is the trip mechanism reset time plus the CB closing time.

Minimum relay dead time settings are governed primarily by two factors:

- Time taken for de-ionization of the fault path
- Circuit breaker characteristics

Also it is essential that the protection fully resets during the dead time, so that correct time discrimination will be maintained after reclosure onto a fault. For high speed auto-reclose instantaneous reset of protection is required.

For highly interconnected systems synchronism is unlikely to be lost by the tripping out of a single line. Here the best policy may be to adopt longer dead times, to allow time for power swings on the system resulting from the fault to settle.

Should a single phase fault evolve to affect other phases during the single pole dead time, the recloser will then move to the appropriate three phase cycle.

5.10.1.2.1 De-Ionising Time

The de-ionization time of a fault arc depends on circuit voltage, conductor spacing, fault current and duration, wind speed and capacitive coupling from adjacent conductors. As circuit voltage is generally the most significant, minimum de-ionizing times can be specified as in the table below.

> *Note* *For single pole high-speed auto-reclose, the capacitive current induced from the healthy phases can increase the time taken to de-ionize fault arcs.*

Line voltage (kV)	Minimum de-energization time (s)
66	0.1
110	0.15
132	0.17
220	0.28
275	0.3
400	0.5

Table 14 - Minimum Fault Arc De-Ionising Time (Three Pole Tripping)

Example Minimum Dead Time Calculation

The following circuit breaker and system characteristics are to be used:

CB Operating time (Trip coil energized → Arc interruption): 50 ms (a);

CB Opening + Reset time (Trip coil energized → Trip mechanism reset): 200 ms (b);

Protection reset time: < 80 ms (c);

CB Closing time (Close command → Contacts make): 85 ms (d).

De-ionizing time for 220 kV line:

280 ms (e) for a three phase trip. (560 ms for a single pole trip).

The minimum relay dead time setting is the greater of:

(a) + (c) = 50 + 80 = 130 ms, to allow protection reset;

(a) + (e) - (d) = 50 + 280 - 85 = 245 ms, to allow de-ionizing (three pole);

= 50 + 560 - 85 = 525 ms, to allow de-ionizing (single pole).

In practice a few additional cycles would be added to allow for tolerances, so **3P - Dead Time 1** could be chosen as ≥ 300 ms, and **1P - Dead Time** could be chosen as ≥ 600 ms. The overall system dead time is found by adding (d) to the chosen settings, and then subtracting (a). (This gives 335 ms and 635 ms respectively here).

5.10.1.3 Reclaim Time

When the CB has closed, the reclaim time (“Reclaim Time”) starts. If the circuit breaker does not trip again, the autoreclose 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 autoreclose cycle, or, if all programmed reclose attempts have been made, goes to lockout. The reclaim time is reset on expiry of the reclaim time-delay (setting) or if a new 1P or 3P trip command is issued (see logic diagram).

A number of factors influence the choice of the reclaim timer, such as;

- Fault incidence/Past experience - Small reclaim times may be required where there is a high incidence of recurrent 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. A minimum reclaim time of >5 s 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. For delayed auto-reclose there is no need as the dead time can be extended by an extra CB healthy check AR Inhibit Time window time if there is insufficient energy in the CB
- Switchgear Maintenance - Excessive operation resulting from short reclaim times can mean shorter maintenance intervals
- The Reclaim Time setting is generally set greater than the tZ2 distance zone delay

5.10.1.4 Discrimination Time Setting

When a single pole trip is issued by the relay, a 1-pole autoreclose cycle is initiated. The Dead time1 and Discrimination timer are started.

If the autoreclose logic detects a single pole or three-pole trip (internal or external) during the discrimination time-delay, the 1P high speed autoreclose cycle is disabled and replaced by a 3P high speed autoreclose cycle (if 3P trip mode is enabled, otherwise, the relay trips 3-poles and the autorecloser is blocked):

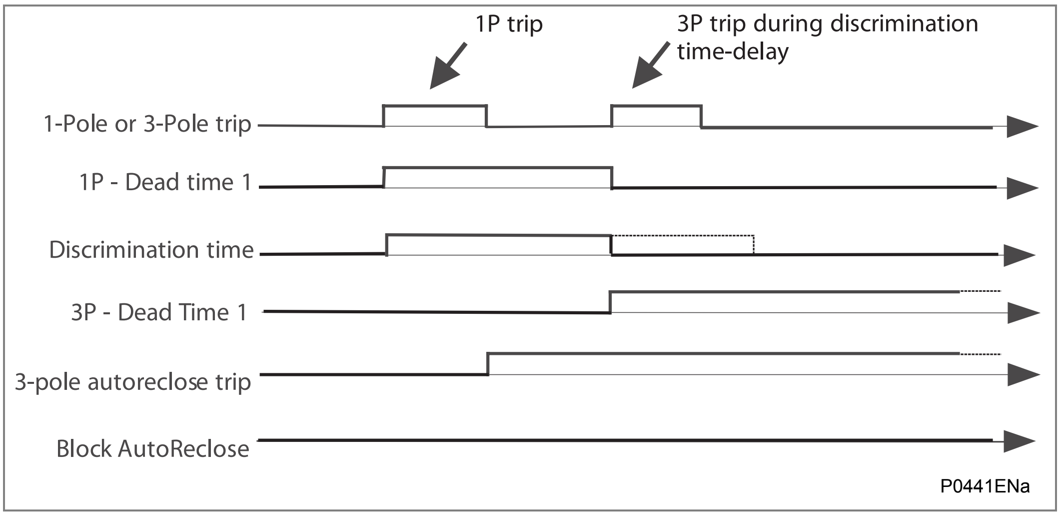


Figure 116 - Fault during an autoreclose cycle during (Discrimination Time-delay has not expired)

If the autoreclose logic detects a 3-pole trip (internal or external) on expiry of the discrimination time-delay, and during the 1P dead time; the single pole autoreclose cycle is stopped and the relay trips 3-pole and blocks the autorecloser (see the *Fault during an autoreclose cycle during (Discrimination Time-delay has not expired* diagram).

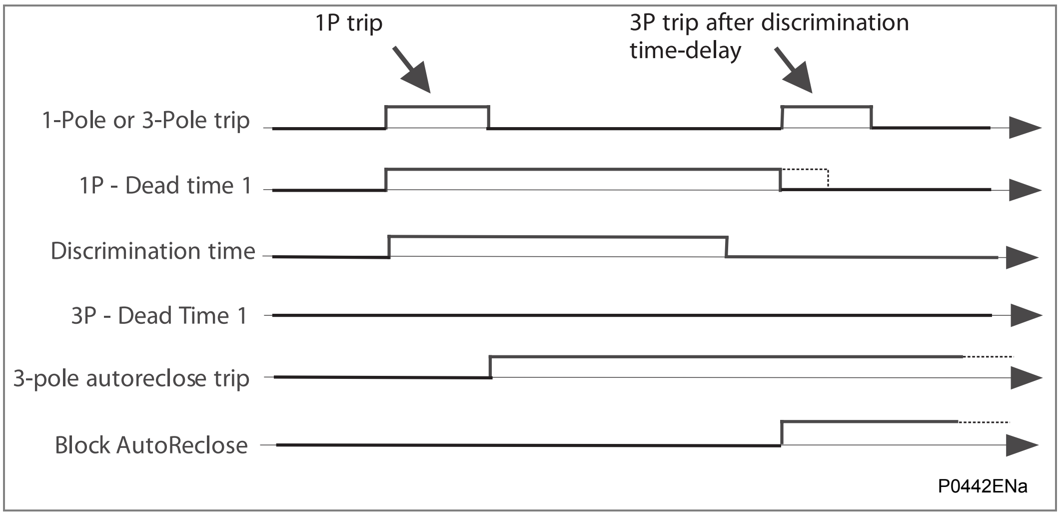


Figure 117 - Fault during an autoreclose 1P cycle (discrimination time-delay has expired)

5.10.1.5 Autoreclose Inhibit Window

Most circuit breakers are only capable of providing one trip-close-trip cycle. It is necessary to re-establish sufficient energy in the circuit breaker before the CB can be reclosed. The CB healthy information from the CB (DDB: '**CB Healthy**') 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 (1), the relay does not detect sufficient energy within a period given by the autoreclose inhibition window (3) – ('**A/R Inhibit Wind**' setting), lockout will result (4) and the CB will remain open (Blocking Autoreclose, DDB: '**BAR**').

If the CB energy becomes healthy again within the time window (2), autoreclosure will occur.

This check can be disabled by not allocating it any opto input. In this case, the DDB cell '**CB Healthy**' is considered invariant in the relay's logic. This means that the signal is always high within the relay when the logic requires a high level and at 0 if low level is required. It is an invariant state for the firmware (same logic is applied for every optional opto input – if not linked in the PSL these cells are managed as invariant data by the internal logic).

The inhibit time-delay is started at the end of dead time if CB healthy is absent.

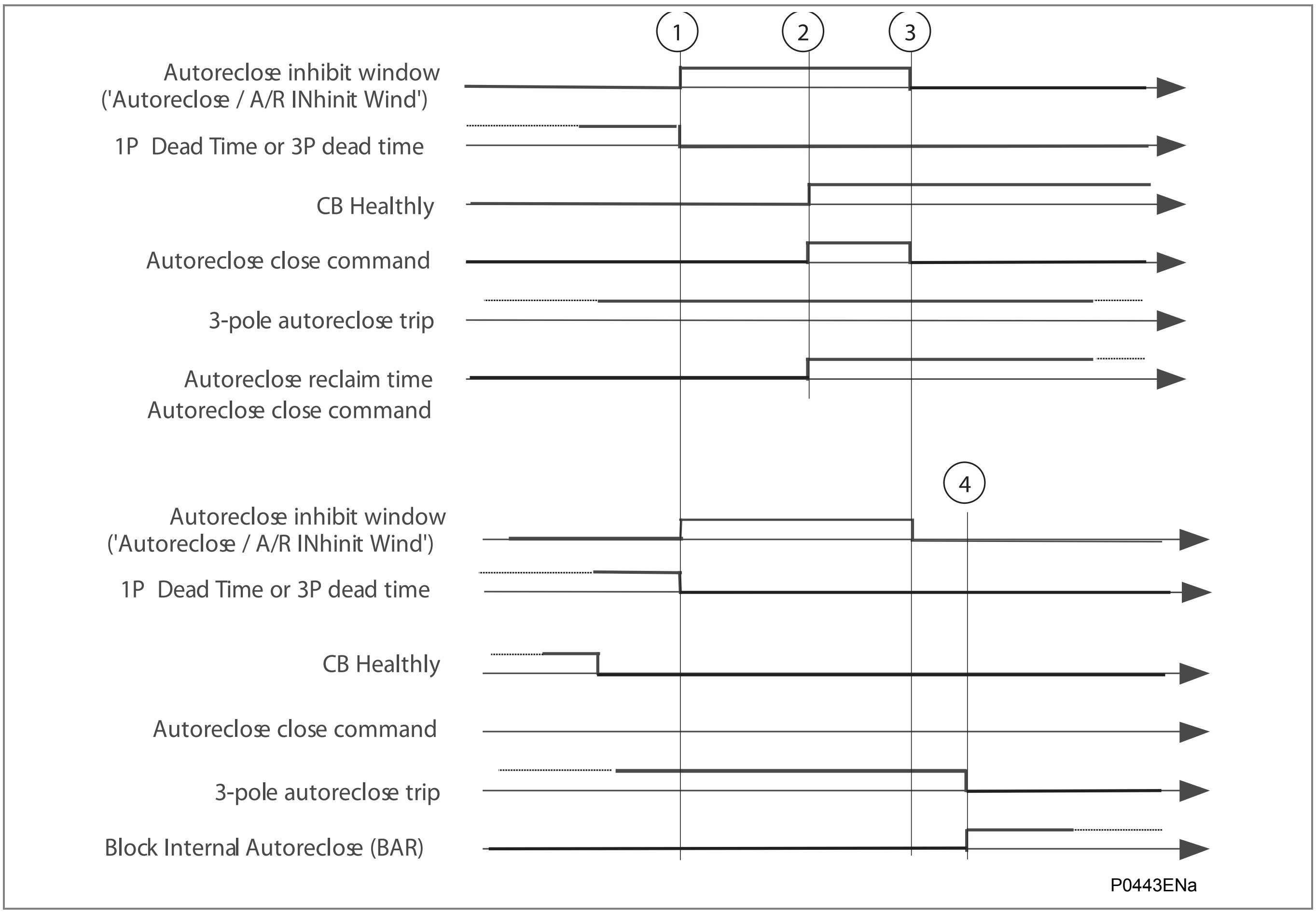


Figure 118 - Autoreclose inhibit window

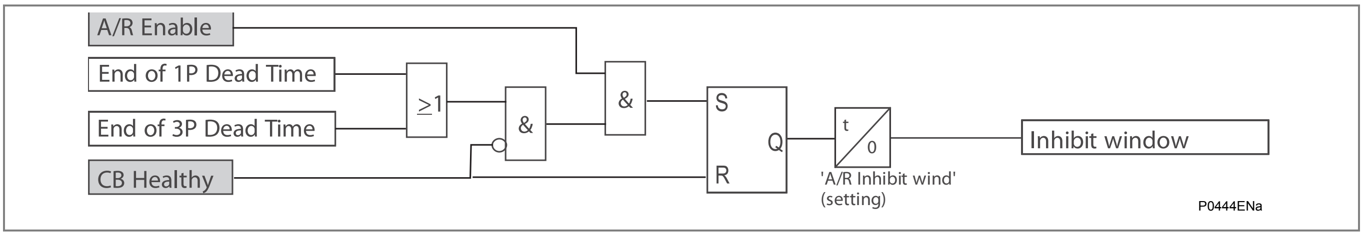


Figure 119 - Autoreclose inhibit window logic

5.10.1.6 Check Synchronism on 3-Pole Reclosure

The Check synchronism on 3-pole reclosure (‘**C/S on 3P Rcl DT1**’) setting is used to “Enable/Disable” system checks for the first reclose after a 3 pole trip in an autoreclose cycle. When the “SysChk on Shot 1” is set to “Disabled”, no system checks are required for the first reclose which may be preferred when high speed autoreclose is applied to avoid the extra time for a system check. Subsequent reclose attempts in a multi-shot cycle will still require a system check.

5.10.1.7 Block Autoreclose

When enabled (the relevant bit is set to 1), the detected fault will block the autoreclose, and cause a lockout if autoreclose is in progress. If a single-pole is in progress, a three-pole trip will be issued and the autorecloser will lock-out.

It can be set when protection operation is required without autoreclose. A typical example is for a transformer feeder, where autoreclosing may be initiated by the feeder’s protection relay but blocked by the transformer’s protection relay. Similarly, where a circuit breaker low gas pressure or loss of vacuum alarm occurs during the dead time, autoreclosure should be blocked – and ‘**Block A/R**’ can be used to perform this blocking logic.

Autoreclose logic is partly fixed, so that autoreclosure is always blocked for any Switch on to Fault, Stub Bus Protection, Broken Conductor or Zone 4 trip. Autoreclosure is also blocked when relay Supervision functions detect a Circuit Breaker Failure or Voltage Transformer/Fuse Failure. All other protection trips initiate autoreclosure (when blocking bit is set to 0).

When autoreclosure is not required for multiphase faults, DDB signals '**2Ph Fault**' and '**3Ph Fault**' can be mapped via the PSL in a logic OR combination onto input DDB: '**BAR**' (in the Block internal AutoReclose section). When blocking is only required for a three phase fault, the DDB signal '**3Ph Fault**' is mapped to '**BAR**' alone. Three phase faults are more likely to be persistent, so many utilities may not wish to initiate autoreclose in such instances.

The next diagram illustrates the block autoreclose logic.

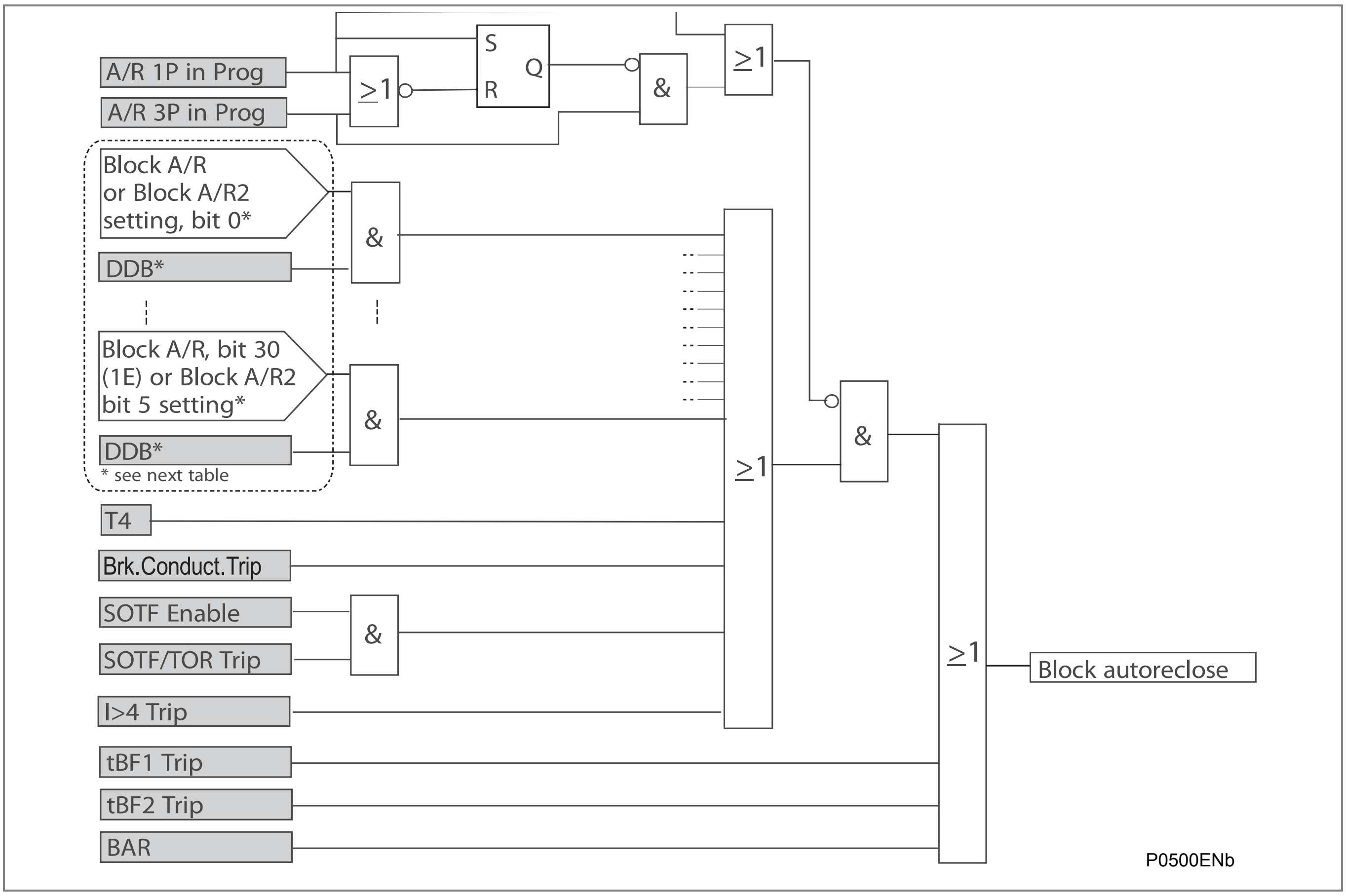


Figure 120 – Block autoreclose logic

Bit	Setting	DDB
Autoreclose lockout / Block A/R		
00	At T2	T2
01	At T3	T3
02	At Tzp	tZp
03	LoL Trip	Loss. Load Trip
04	I>1 Trip	I>1 Trip
05	I>2 Trip	I>2 Trip
06	V<1 Trip	V<1 Trip
07	V<2 Trip	V<2 Trip
08	V>1 Trip	V>1 Trip
09	V>2 trip	V>2 Trip
0A	IN>1 Trip	IN>1 Trip
0B	IN>2 Trip	IN>2 Trip
0C	Aided D.E.F Trip	DEF Trip A C
		OR DEF Trip B
		OR DEF Trip C
0D	Zero. Seq.	ZSP Trip
	Power Trip	
0E	IN>3 Trip	IN>3 Trip
0F	IN>4 Trip	IN>4 Trip

Bit	Setting	DDB
Autoreclose lockout / Block A/R		
10	PAP Trip	PAP Trip A
		OR PAP Trip B
		OR PAP Trip C
11	Thermal Trip	Trip Thermal
12	I2>1 Trip	I2> Trip
13	I2>2 Trip	I2>2 Trip
14	I2>3 Trip	I2>3 Trip
15	I2>4 Trip	I2>4 Trip
16	VN>1 Trip	VN>1 Trip
17	VN>2 Trip	VN>2 Trip
18	At Tzq	tZq
19	V<3 Trip	V<3 Trip
1A	V<4 Trip	V<4 Trip
1B	V>3 Trip	V>3 Trip
1C	V>4 trip	V>4 trip
1D	I<1 Trip	I<1 Block
1E	I<2 Trip	I<2 Block

Bit	Setting	DDB
Autoreclose lockout / Block A/R 2		
00	F<1 Trip	F<1 Trip
01	F<2 Trip	F<2 Trip
02	F<3 Trip	F<3 Trip
03	F<4 Trip	F<4 Trip
05	F>2 Trip	F>2 Trip

Caution	**When "autoreclose Lockout / Block A/R" is enabled, the autoreclose does not initiate any additional A/R cycle. If the autorecloser locks out during a cycle, 'A/R close' is blocked.**

Caution	**A dedicated PSL can be created for performing an autoreclose lockout in case of confirmed Fuse Failure.**

5.10.1.8 Autoreclose Force Sync

The DDB: '**A/R Force Sync**' forces synchronism check to be made.

It simulates the check synchronisation control and forces the logical DDB output '**CheckSync OK**' at 1 during a 1 pole or 3 poles high speed AR cycle.

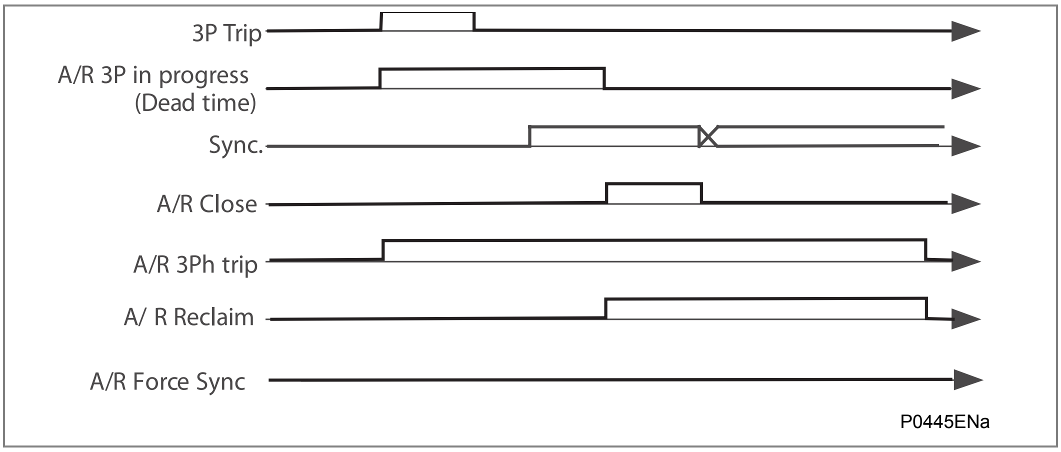


Figure 121 – No pick-up at the end of the Dead time

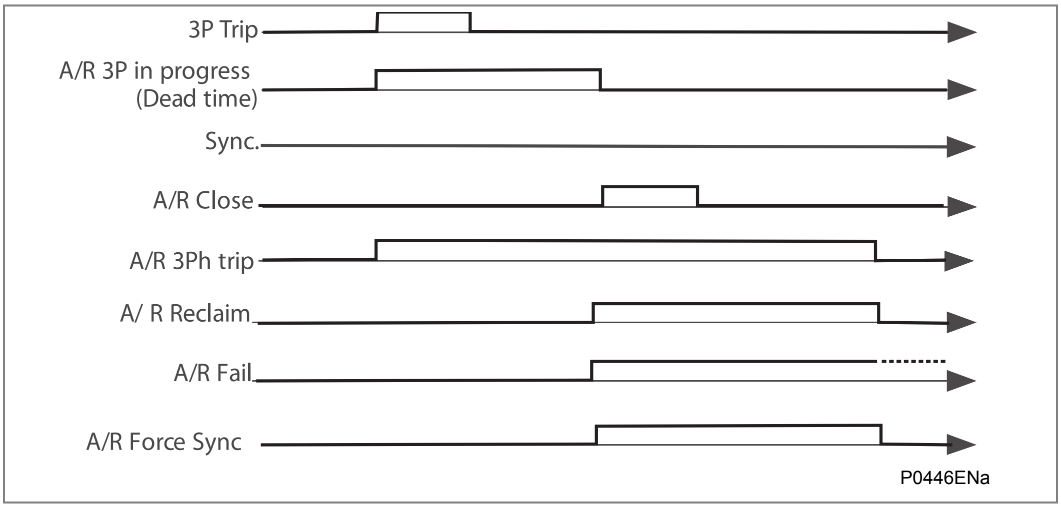


Figure 122 – Check Sync signal will be forced at the end of dead time

5.10.1.9 CB Discrepancy

The DDB: '**CB Discrepancy**' signal informs the protection of a pole discrepancy status (one pole opened and the other two poles closed). It must be set to high logical level before Dead time 1 has elapsed – it can also be generated internally (see Cbaux logic).

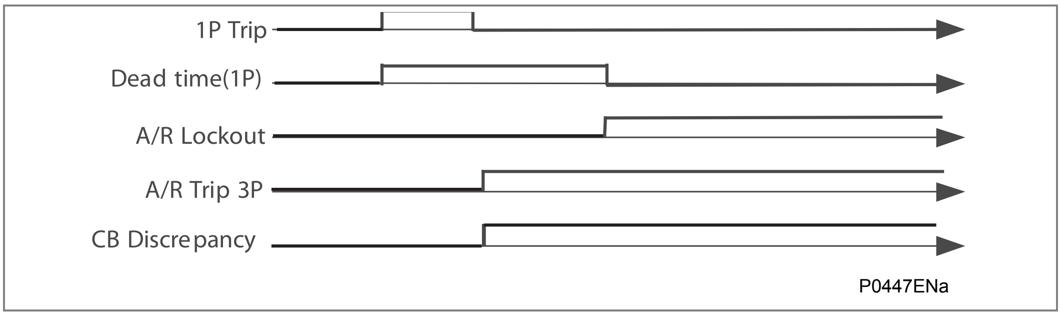


Figure 123 - Pole discrepancy (CBA-Disc)

5.10.2 Logic Inputs / Outputs used by the Autoreclose Logic

5.10.2.1 Logic Inputs used by the Autoreclose Logic

Contacts from external equipment (External protection or external Check Synchronism or external Autoreclose) may be used to influence the autorecloser via opto-isolated inputs. Such functions can be allocated to any of the opto-isolated inputs on the relay via the programmable scheme logic (Ensure that *optos1&2 are not set for setting group change*-Otherwise, these opto inputs cannot be mapped to functions in the PSL. The inputs can be selected to accept either a normally open or a normally closed contact, programmable via the PSL editor (see the Programmable Logic chapter for a complete description).

- A/R SPAR Enable (the opto input must be be energised for over 1.2s),
- A/R TPAR Enable (the opto input must be energised for over 1.2s),

Note	*After a new PSL has been downloaded to the relay (including the "TPAR" or "SPAR" cells); the settings configuration must be uploaded back (from PC to relay) to update the data in the RAM and the EEPROM (otherwise discrepancies could appear in the "A/R enable" logic state).*

- A/R Internal
- I A/R 1p In Prog (internal autoreclose single-pole in progress)
- I A/R 3p In Pr. (internal autoreclose three-pole in progress)
- I A/R Close (Circuit Breaker closing order from external autoreclose)
- I A/R Reclaim (Autoreclose in reclaim)
- BAR (Block internal Autoreclose)
- Ext Chk Synch OK (external check synchronisation OK),
- Force 3P trip
- Man. Close CB (circuit breaker manual close)
- Man. Trip CB (circuit breaker manual trip),
- CB Discrepancy
- External Trip A, External Trip B and External Trip C

5.10.2.2 Logic Outputs Generated by the Autoreclose Logic

The following DDB signals can be masked to a relay contact in the PSL or assigned to a Monitor Bit in **Commissioning Tests**, to provide information about the autoreclose cycle status. They are described below, and identified by their DDB signal label (see the Programmable Logic chapter for a complete description).

- A/R 1P In Prog.,
- A/R 234 in Prog.,
- A/R Close,
- A/R Enable,
- A/R Fail,
- A/R first in Prog.,
- A/R Force Sync,
- A/R Lockout,
- A/R Reclaim,
- A/R SPAR Enable,
- A/R TPAR Enable,
- A/R Trip 3 P,
- AR 3P In Prog.,
- AR Discrim,
- AR Lockout Shot>,
- Check Sync;OK
- Control Close
- Control Trip
- Ctrl Cls In Prog
- Ext Chk Synch OK,
- V<Dead Bus
- V<Dead Line
- V>Live Bus
- V>Live Line

5.10.2.3 Logic Diagrams

Autoreclose activation:

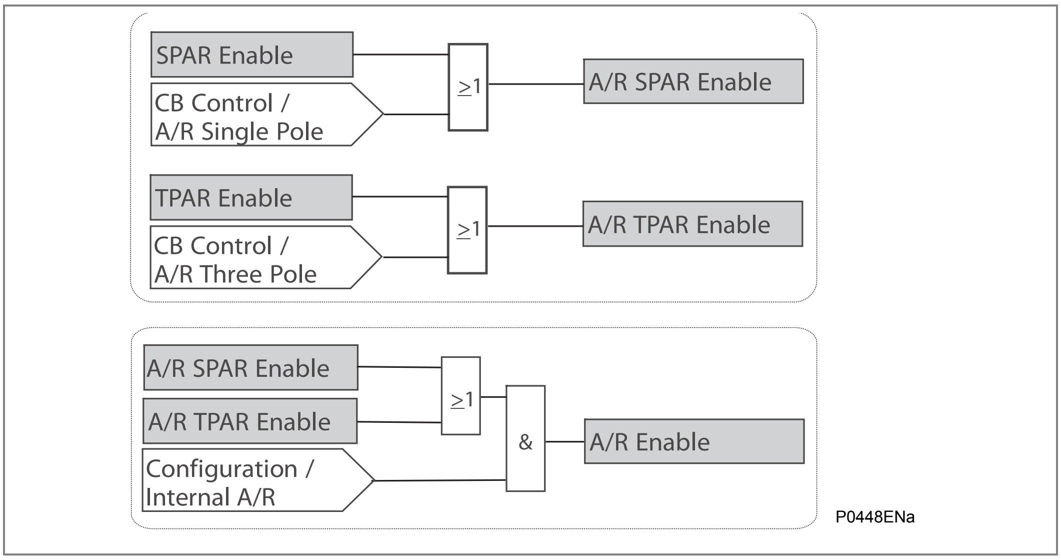


Figure 124 – SPAR, TPAR and AR activation

The next diagram illustrates the logic for **A/R close**, **A/R fail** and **A/R Force Sync**. Note that A/R fail is reset with 3 poles closed:

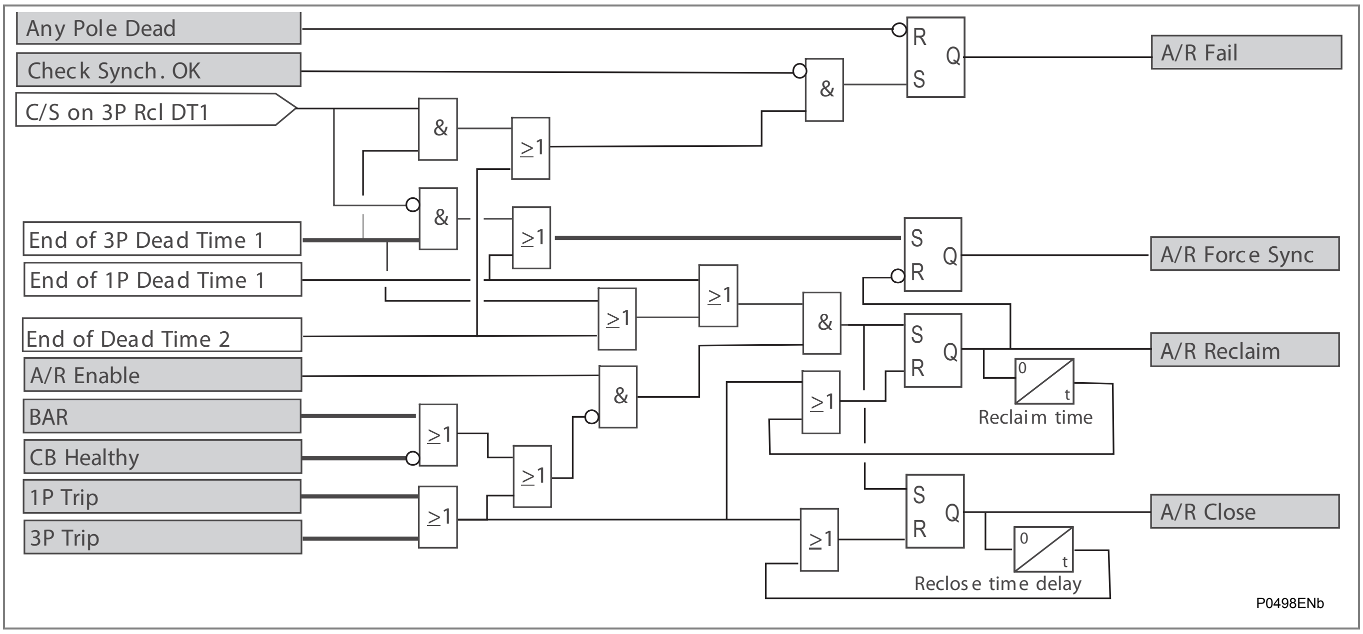


Figure 125 - Logic for reclaim time / A/R Close / A/R fail and A/R Force Sync

Forces the Check Sync conditions to the high logic level – used for SPAR or TPAR with SYNC AR3 fast (Enabled using setting) – The signal is reset with AR reclaim

In the next diagram, **A/R lockout** logic picks up by

- block autoreclose logic (**BAR**)
- or **A/R lockout Shots>**
- or Inhibit window logic
- or no pole discrepancy detected at the end of dead time1
- or trip command still present at the end of Dead time
- or Trip3P issued during 1P cycle after Discrimination Timer
- or Trip3P issued during 1P cycle with no 3PAR enabled.

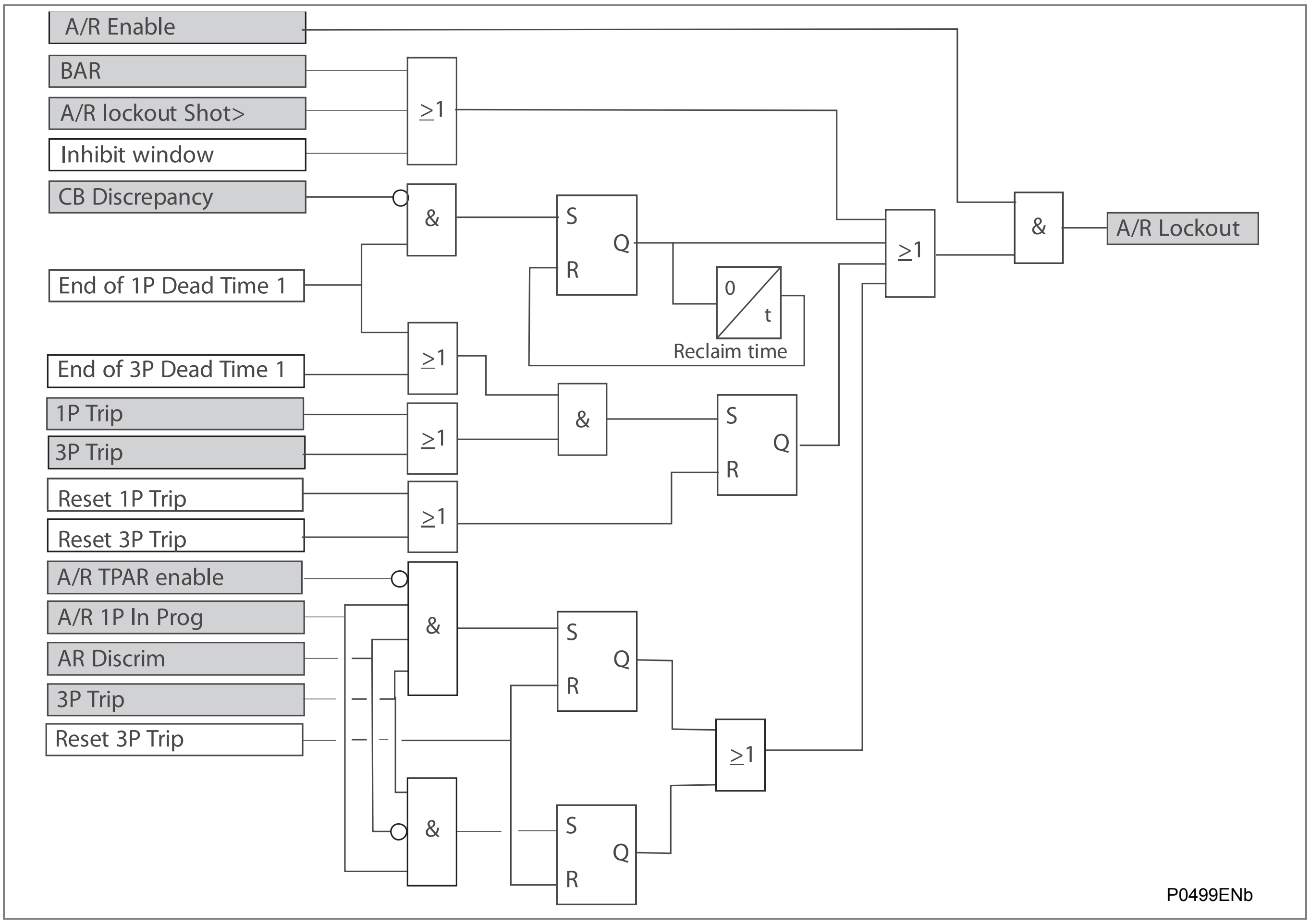


Figure 126 - Internal logic of AR lockout

The next diagram illustrates AR Lockout Shots> logic:

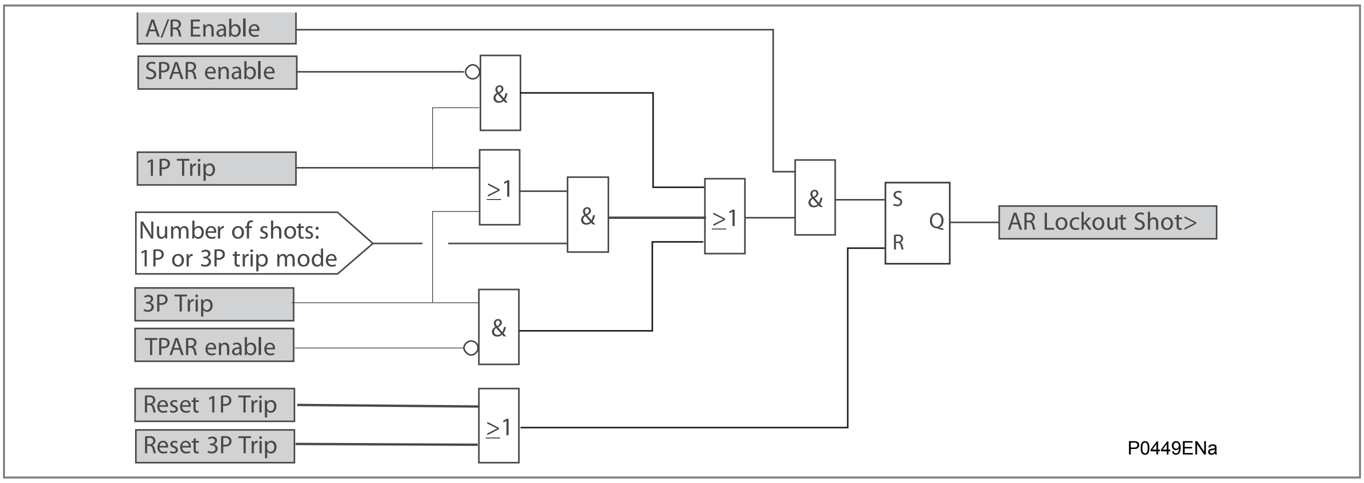


Figure 127 - AR lockout by number of shots

The CB healthy logic is used as a negative logic (due to an inverter in the scheme – see the *Autoreclose inhibit window* diagram) but the DDB considers CB healthy as a positive logic [1=opto input energised during inhwind (setting) =AR close pulse]

One-pole autoreclose cycle in progress (**A/R 1P in Prog**) and **AR discrimination** (discrimination time-delay window in progress, starts with the trip command) logic:

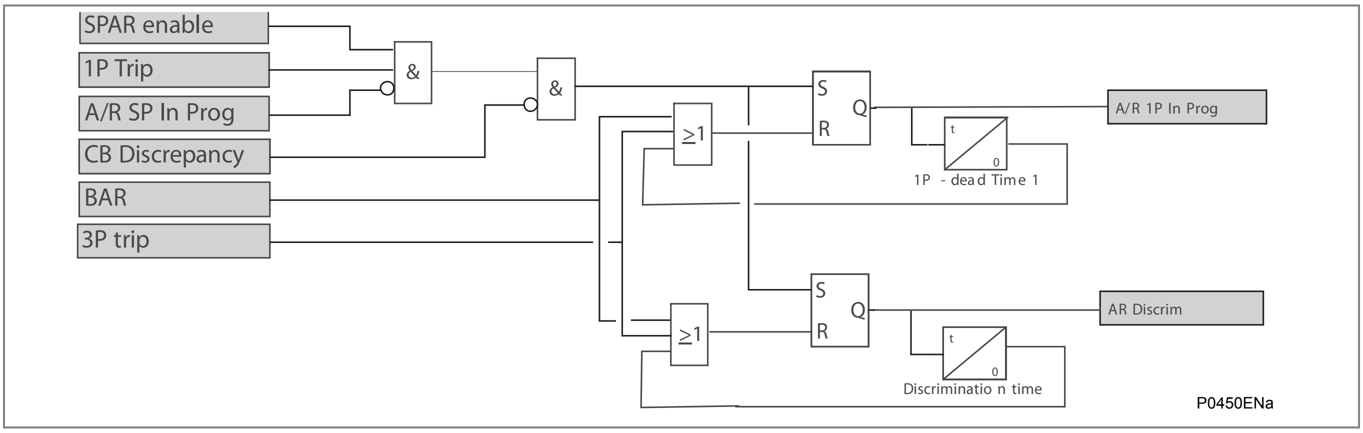


Figure 128 – A/R 1 pole in progress and A/R discrim logic

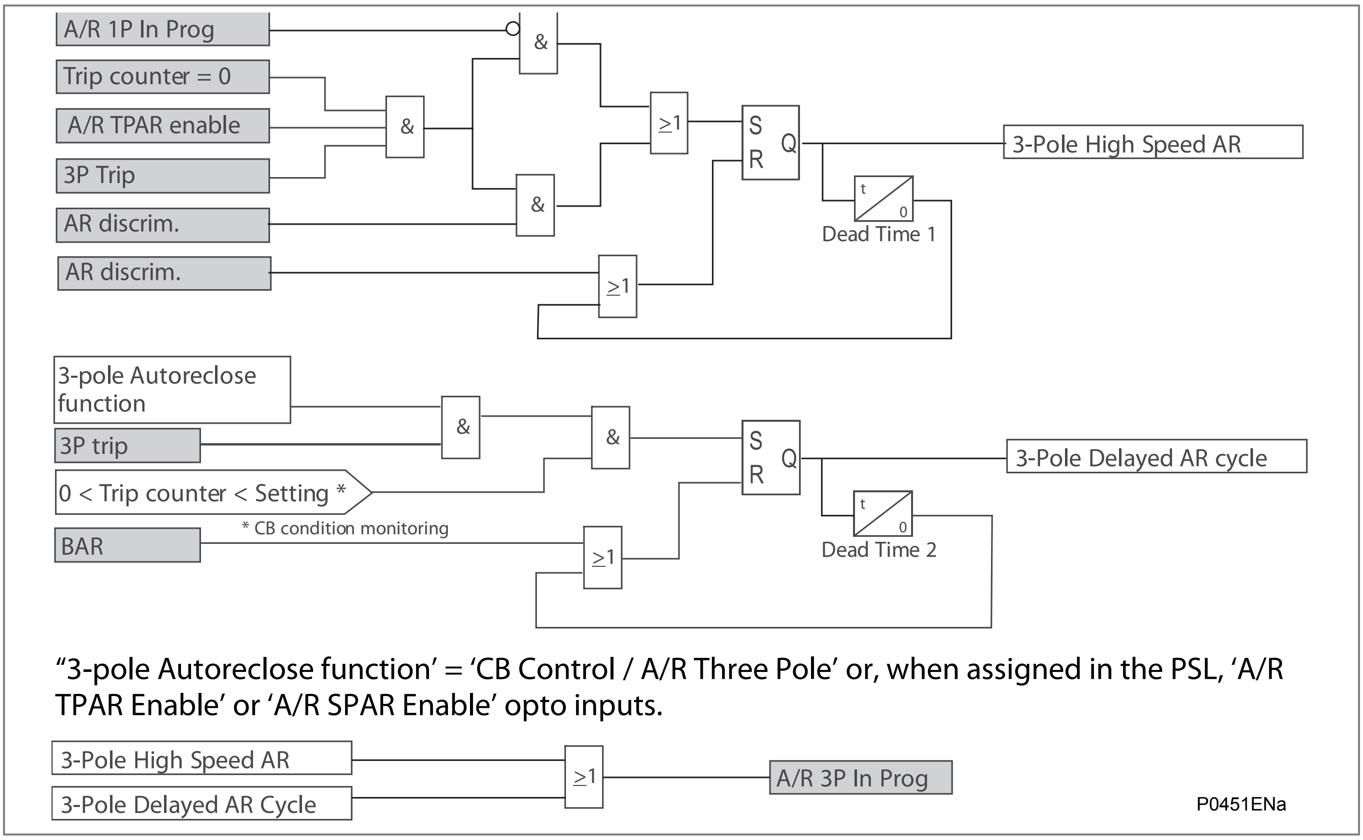


Figure 129 - 3-Pole AR in progress

Where single-pole tripping is enabled, a fixed logic converts single-phase trips for faults on autoreclosure to three-pole trips:

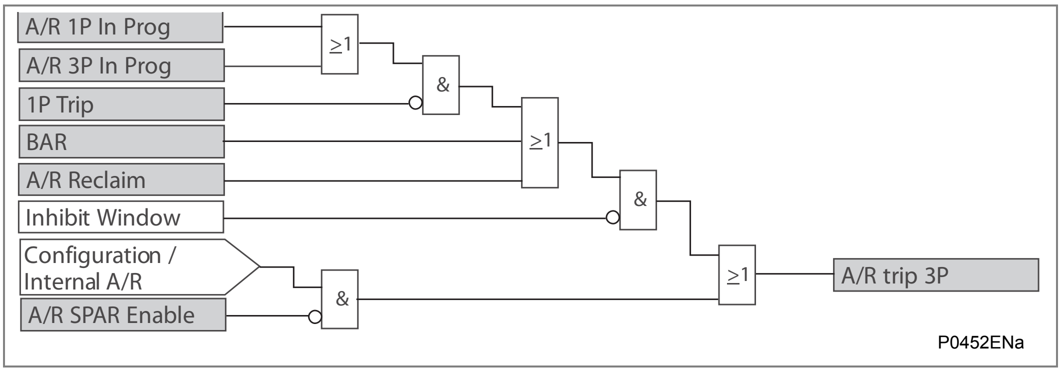


Figure 130 - AR logic for 3p trip decision

Further autoreclose cycles (cycles 2, 3 and 4) in progress (**AR 234 In Prog**) logic:

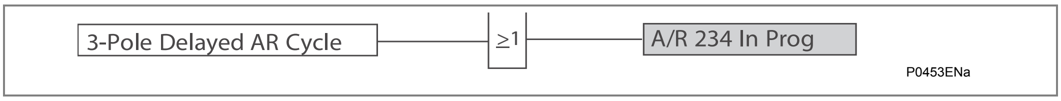


Figure 131 - Output Delayed Autoreclose (for dead time 2, 3, 4)

If it is assigned to an opto input in the PSL and energised, The DDB: '**Force 3P Trip**' signal will force the internal single-phase protection to trip three-poles. (external order from Main1 to Main2 (P44x)) – the next trip will be three-pole.

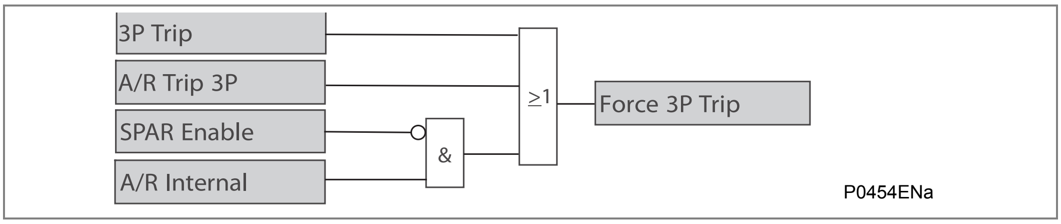


Figure 132 – Force 3P Trip Logic

5.11 Circuit Breaker State Monitoring

An operator at a remote location requires a reliable indication of the state of the switchgear. Without an indication that each circuit breaker is either open or closed, the operator has insufficient information to decide on switching operations. 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.

The Circuit Breaker state can be locally displayed in the "**System data / Plant status**" menu.

5.11.1 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 these 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 PSL, CB AUX can be used or not, according to the four options below:

- None
- 52A (1 or 3 opto inputs for a single pole logic)
- 52B (1 or 3 opto inputs)
- Both 52A and 52B (2 opto inputs or 6 opto inputs)

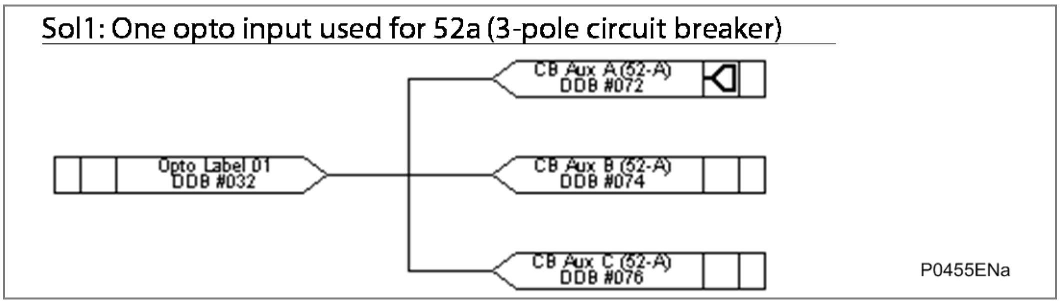


Figure 133 – Sol1 : One opto input used for 52a (3-pole circuit breaker) (CB Aux schemes)

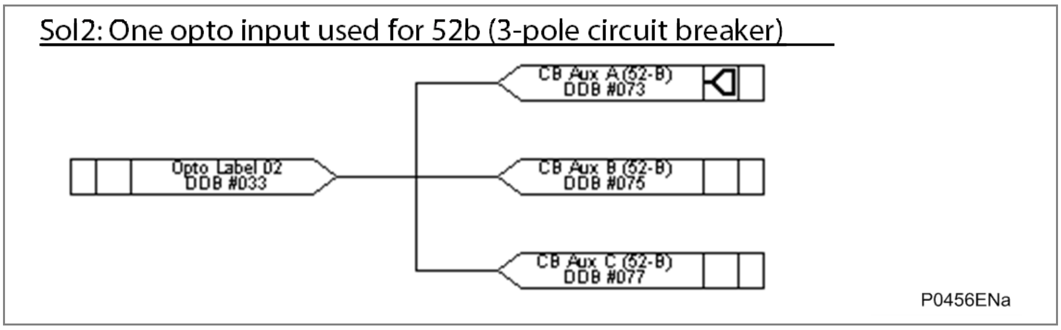


Figure 134 – Sol2 : One opto input used for 52b (3-pole circuit breaker) (CB Aux schemes)

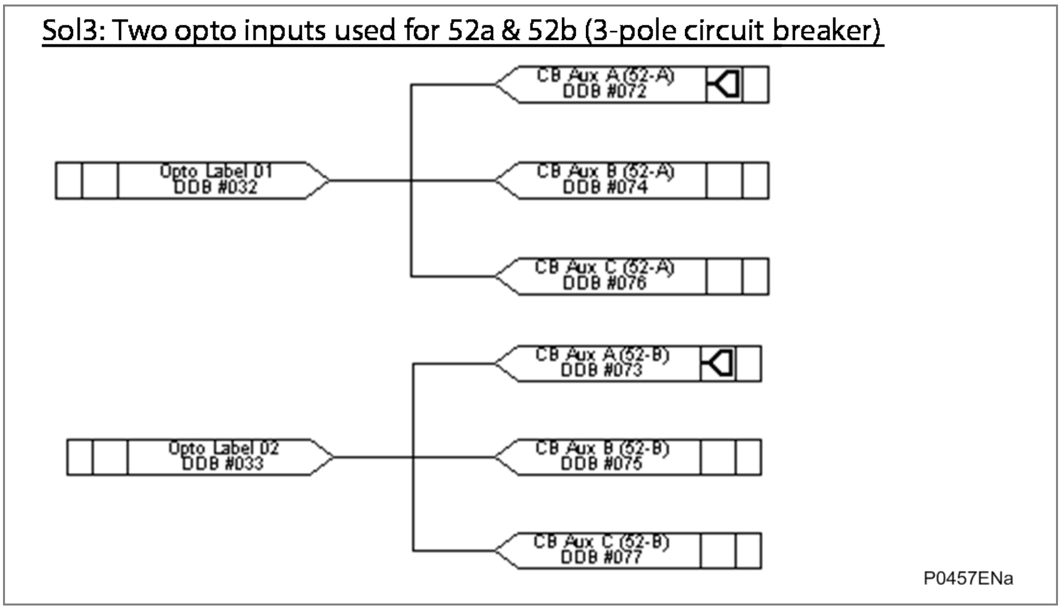


Figure 135 – Sol3 : Two opto inputs used for 52a and 52b (3-pole circuit breaker) (CB Aux schemes)

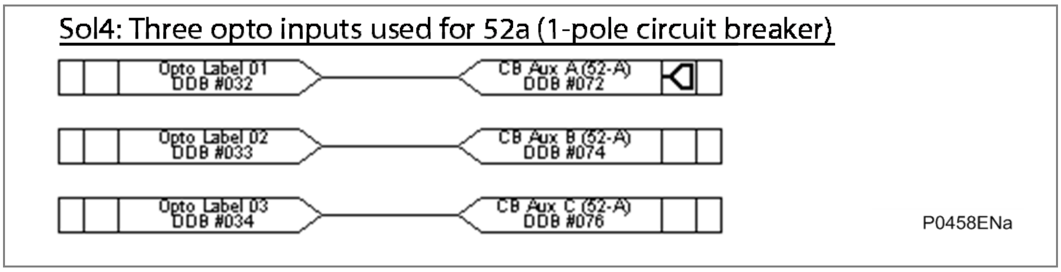


Figure 136 – Sol4 : Three opto inputs used for 52a (1-pole circuit breaker) (CB Aux schemes)

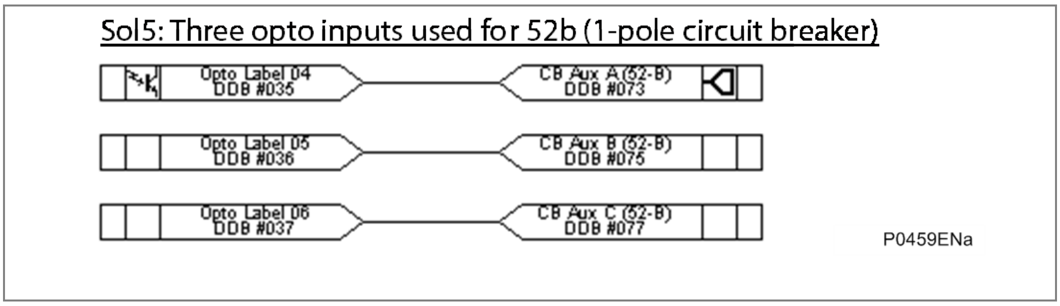


Figure 137 – Sol5 : Three opto inputs used for 52b (1-pole circuit breaker) (CB Aux schemes)

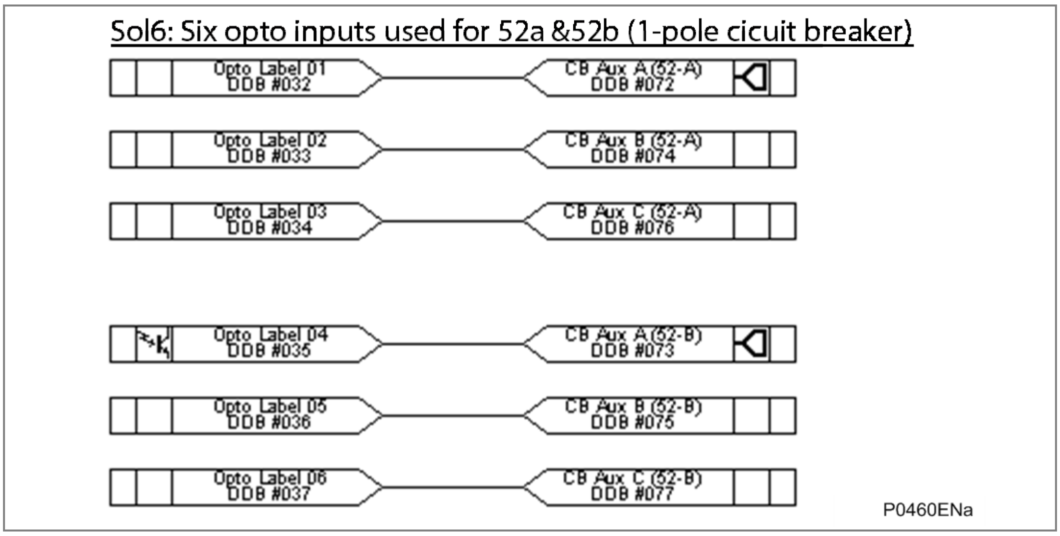


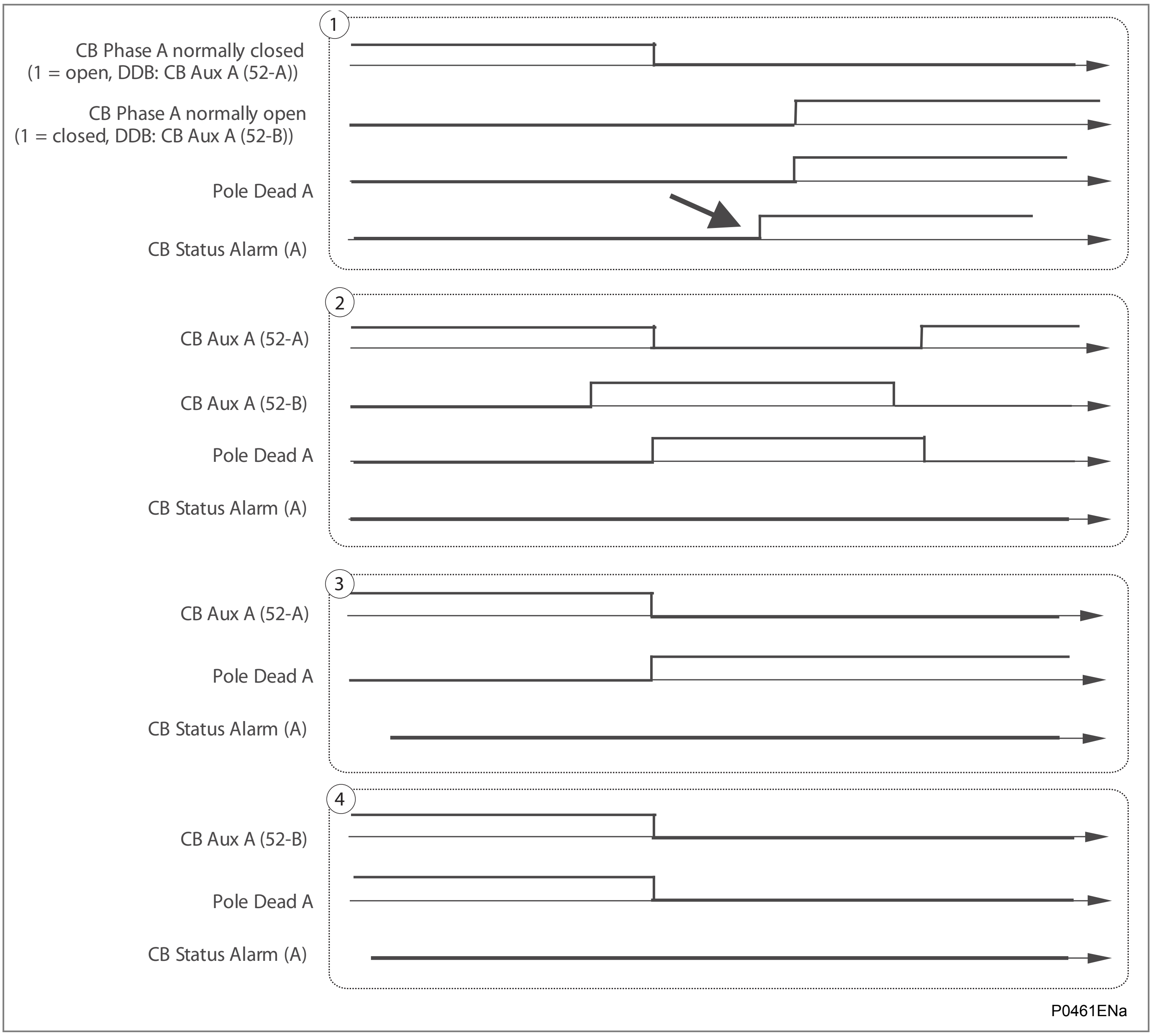
Figure 137 – Sol6 : Six opto inputs used for 52a & 52b (1-pole circuit breaker) (CB Aux schemes)

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.

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

Where single pole tripping is used (available on P442 and P444) then an open breaker condition will only be given if all three phases indicate and open condition. Similarly for a closed breaker condition indication that all three phases are closed must be given. For single pole tripping applications 52a-A, 52a-B and 52a-C and/or 52b-A, 52b-B and 52b-C inputs should be used.

With 52a and 52b both present, the relay stores in memory the last valid state of the 2 inputs (52a=/52b). If no valid state is present (52a=52b) on expiry of the Alarm time-delay (value=150ms), the CB Status Alarm is issued.



Notes	*1 – Coherence of 52-A/52-B long enough to raise the alarm* *2 – Discrepancy of 52-A/52-B too brief to raise the alarm* *3 – Pole dead logic With one opto input 52A* *3 – Pole dead logic With one opto input 52A*

Figure 138 - Circuit Breaker State Monitoring

5.11.2 DDB Inputs / Outputs for CB logic

5.11.2.1 Inputs

- External TripA
- External TripB
- External TripC

From External Protection Devices (via opto inputs) – see the *General trip logic* diagram.

If these optos inputs are assigned to **External Trip A**, **External Trip B** and **External Trip C** – their change of state will update the CB Operation counter (External trip is integrated in the DDB: '**Any Trip**'. As for an internal trip, no Dwell timer is associated.

- CB aux A(52a)
- CB aux B(52a)
- CB aux C(52a)
- CB aux A(52b)
- CB aux B(52b)
- CB aux C(52b)

If it is assigned to an opto input in the PSL and energised, the DDB: '**CB Aux**' signal will be used for Any pole dead & All pole dead internal logic & Discrepancy logic.

- CB Discrepancy: Used for internal CBA Disc issued by external (opto input) or internal detection (CB Aux)

5.11.2.2 Outputs

CB Status Alarm

Picks up when CB Discrepancy status is detected after CBA timer issued externally by opto or internally by CB Aux

- CB aux A
- CB aux B
- CB aux C

Pole A+B+C detected Dead pole by the internal logic or CB status

Any Pole Dead

If it is assigned in the PSL, the DDB: '**Any Pole Dead**' signal indicates that one or more poles are open.

All Pole Dead

If it is assigned in the PSL, The DDB: '**All Pole Dead**' signal indicates that all poles are dead (all 3 poles are open).

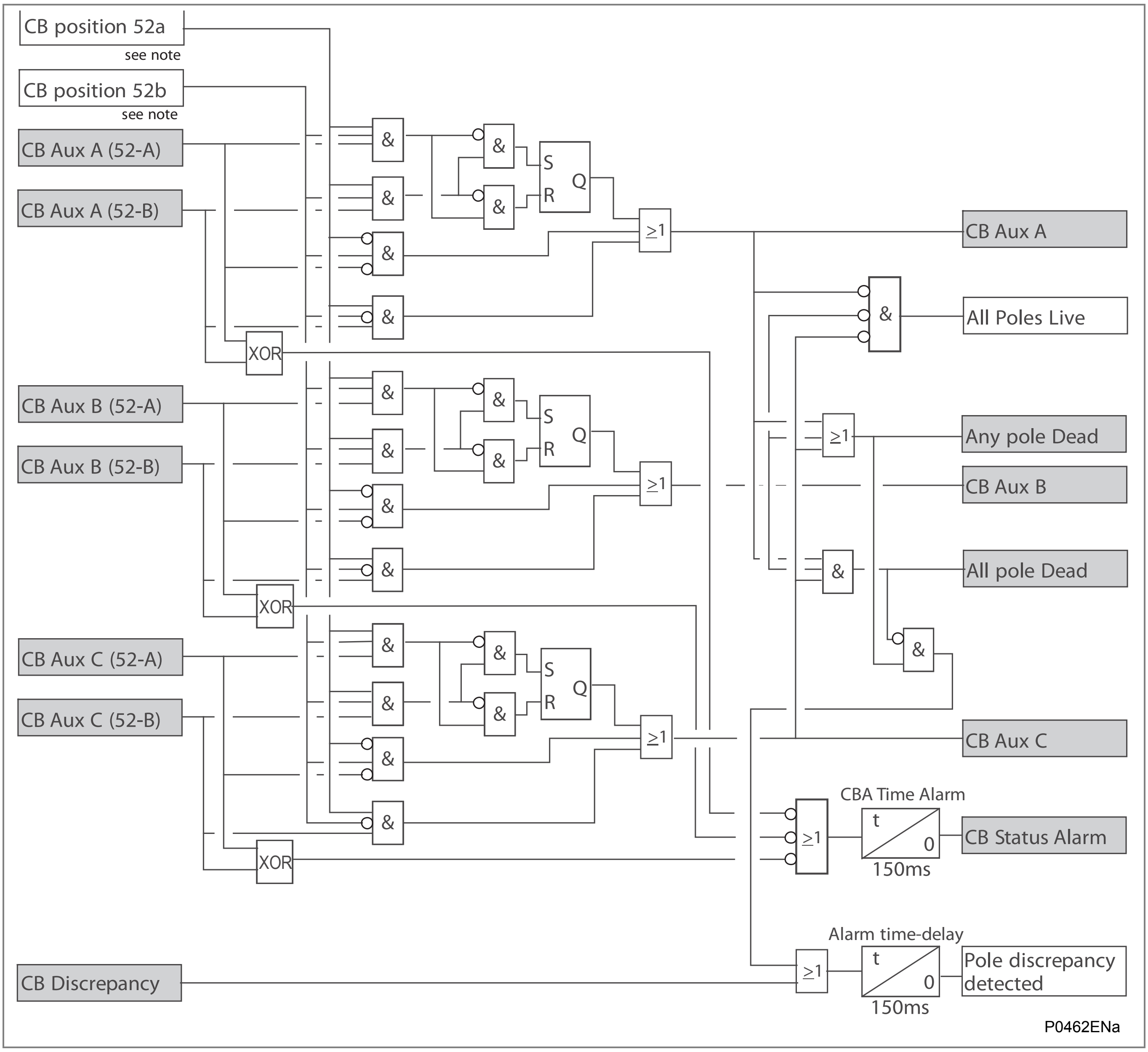


Figure 139 - Logic CBAUX scheme

CBA time disc=150msec fixed value

Dead Pole Logic:

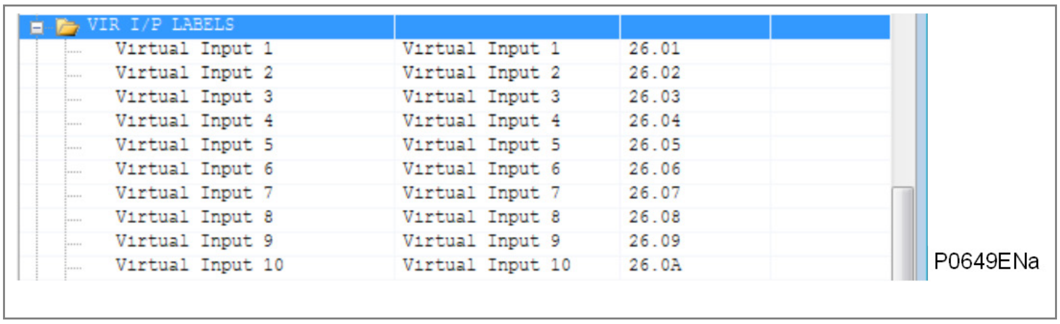
- CBA_A = Pole A Dead
- CBA_3P = All pole Dead
- CBA_3P_C = All poles Live
- 'Any Pole Dead'= Minimum 1 Pole dead

The total number of autoreclosures is shown in the "CB Condition" LCD menu under **Total Reclosures.** Separate counters for single pole and three pole reclosures are available (See HMI description document P44x/EN HI). The counters can be reset to zero with the **Reset Total A/R** command (HMI).

5.12 Virtual Input Label Operation

The Virtual 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 default labels are available in the "VIR I/P LABELS" (or "VIRT I/P LABELS") folder in the settings file as shown below:



VIR I/P LABELS		
Virtual Input 1	Virtual Input 1	26.01
Virtual Input 2	Virtual Input 2	26.02
Virtual Input 3	Virtual Input 3	26.03
Virtual Input 4	Virtual Input 4	26.04
Virtual Input 5	Virtual Input 5	26.05
Virtual Input 6	Virtual Input 6	26.06
Virtual Input 7	Virtual Input 7	26.07
Virtual Input 8	Virtual Input 8	26.08
Virtual Input 9	Virtual Input 9	26.09
Virtual Input 10	Virtual Input 10	26.0A

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Figure 140 - MiCOM S1 Studio VIR I/P Labels Tree

The default "Virtual Input" labels can be changed to suit the customer requirements. For example, to change default text from "Virtual Input 1" to "Customer Func 1" open the ***Virtual Input 1*** dialog box, and change "Virtual Input 1" in the ***New Text:*** text box to be "Customer Func 1", as follows:

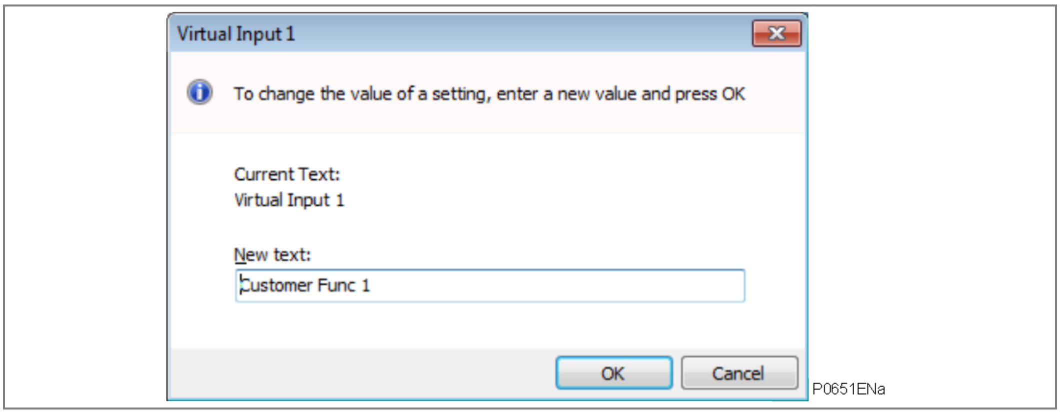
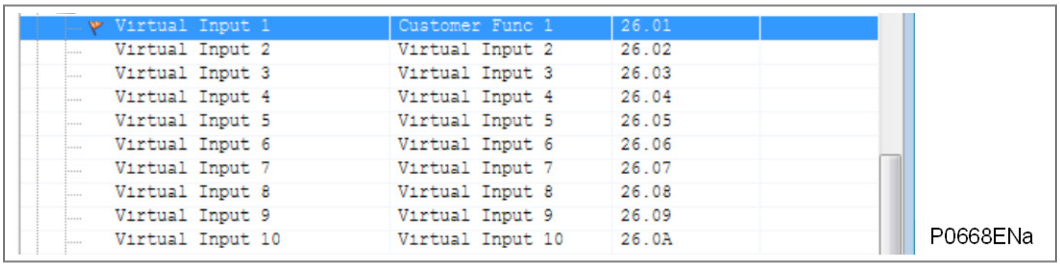


Figure 141 - Virtual Input 1 dialog box

Pressing OK will save the setting and return to the settings page as follows:



Virtual Input 1	Customer Func 1	26.01
Virtual Input 2	Virtual Input 2	26.02
Virtual Input 3	Virtual Input 3	26.03
Virtual Input 4	Virtual Input 4	26.04
Virtual Input 5	Virtual Input 5	26.05
Virtual Input 6	Virtual Input 6	26.06
Virtual Input 7	Virtual Input 7	26.07
Virtual Input 8	Virtual Input 8	26.08
Virtual Input 9	Virtual Input 9	26.09
Virtual Input 10	Virtual Input 10	26.0A

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Figure 142 - Easergy Studio (MiCOM S1 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.

5.13 Virtual Output Label Operation

The Virtual Output 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 virtual Output labels are available in the “VIR O/P LABELS” ” (or “VIRT O/P LABELS”) folder in the settings file as shown below:

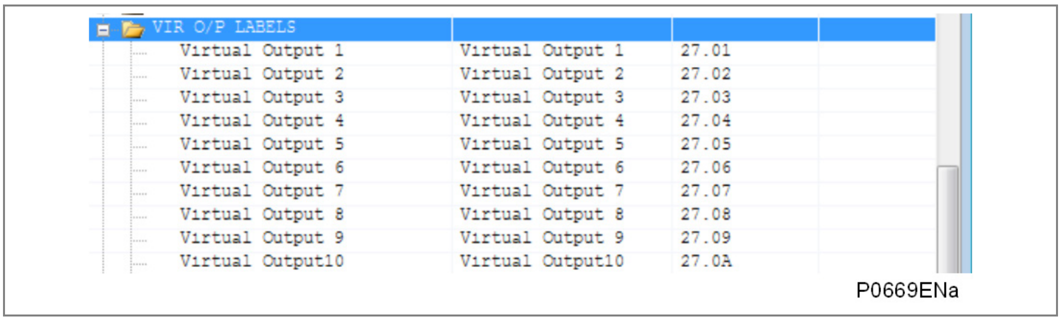

Figure 143 - Easergy Studio (MiCOM S1 Studio) VIR O/P Labels Tree

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.

5.14 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 (MiCOM S1 Studio). This example is using S1 Studio Version 5.0.0.

The default labels are available in the “USR ALARM LABELS” folder in the settings file as shown below:

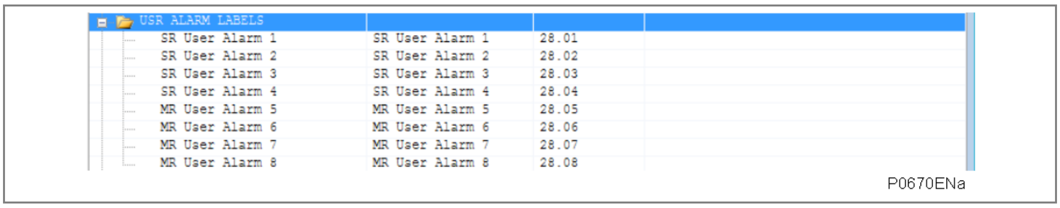

Figure 144 - Easergy Studio (MiCOM S1 Studio) USR Labels Tree

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”.

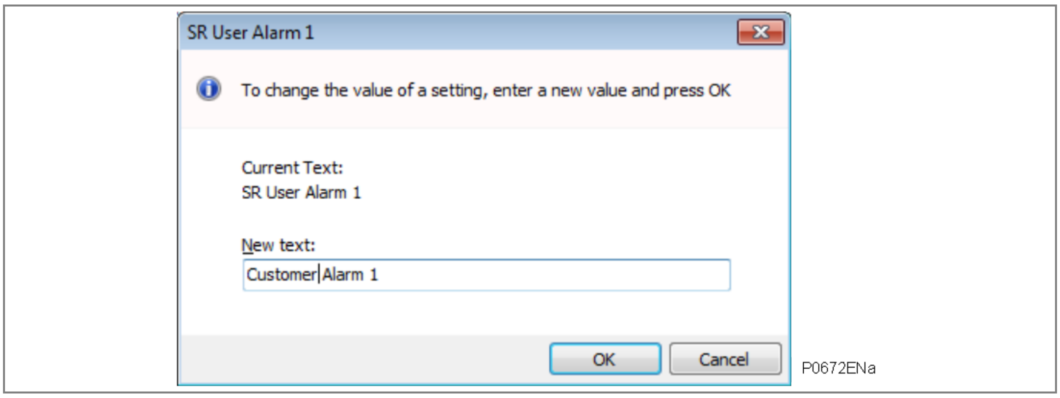

Figure 145 - Virtual Input 1 dialog box

Pressing OK will save the setting and return to the settings page as follows:

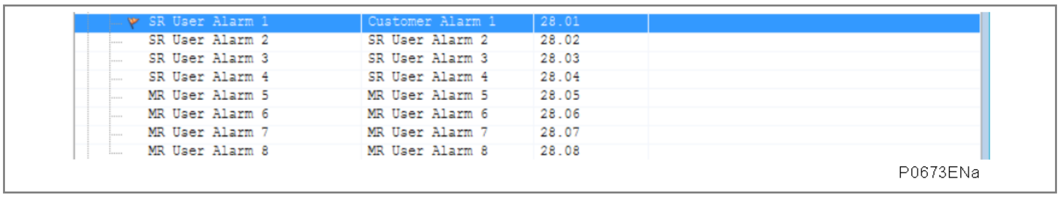

Figure 146 - Virtual Input 1 settings

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.

USING THE PSL EDITOR

CHAPTER 6

Date:	12/2016	
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: 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: 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)

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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 MiCOM S1 Studio.

Note	*MiCOM S1 Studio has been renamed as Easergy Studio.*

2 EASERGY STUDIO (MICOM S1 STUDIO) PSL EDITOR

Note	*MiCOM S1 Studio has been renamed as Easergy Studio.*

The PSL Editor can be used inside Easergy Studio (MiCOM S1 Studio) or directly.

This chapter assumes that you are using the PSL Editor from within Easergy Studio (MiCOM S1 Studio).

If you use it from Easergy Studio (MiCOM S1 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 (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).**

2.1 How to Obtain Easergy Studio (MiCOM S1 Studio) Software

Easergy Studio (MiCOM S1 Studio) is available from the Schneider Electric website:

- www.schneider-electric.com

2.2 To Start Easergy Studio (MiCOM S1 Studio)

To Start the Easergy Studio (MiCOM S1 Studio) software, click the **Start** > **Programs** > **Schneider Electric** > **MiCOM S1 Studio** > **MiCOM S1 Studio** menu option.

2.3 To Open a Pre-Existing System

Within Easergy Studio (MiCOM S1 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 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 MiCOM S1 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.

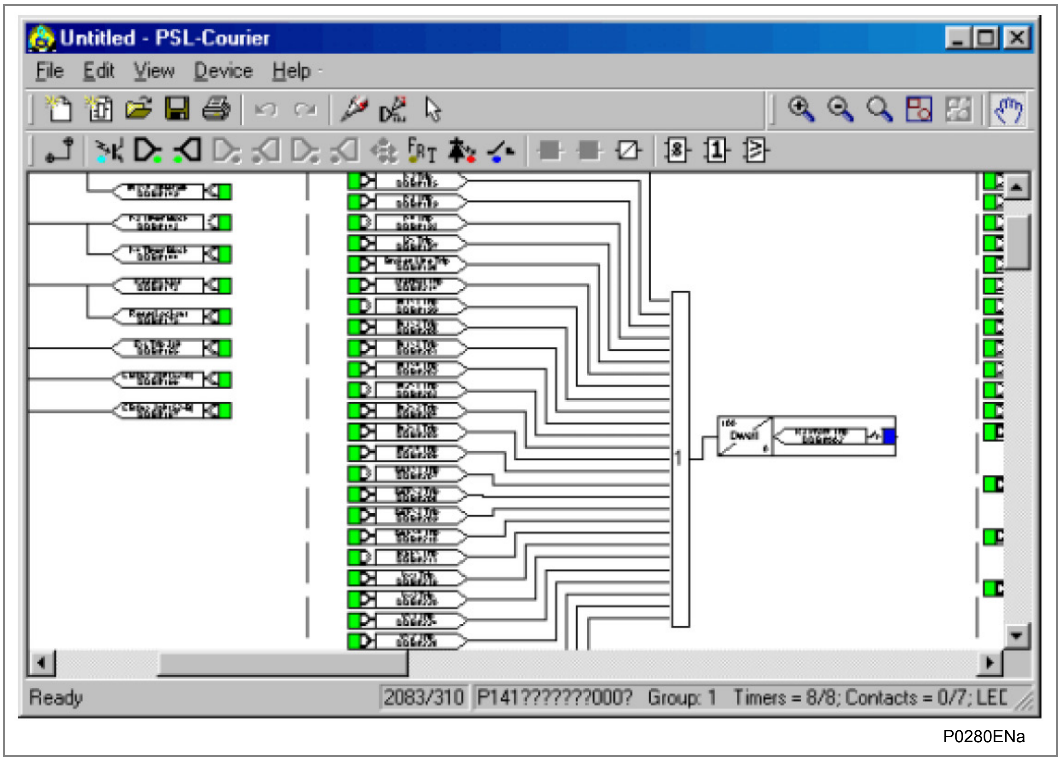


Figure 1 - Example of a PSL editor module

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 (MiCOM S1 Studio) User Manual.

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:

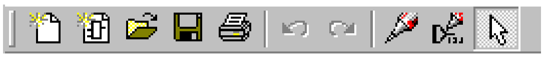
- One or more gates, LED signals, contact signals, and/or timers have their outputs linked directly back to their inputs. An erroneous link of this sort could lock up the relay, or cause other more subtle problems to arise.
- Inputs to Trigger (ITT) exceeds the number of inputs. If a programmable gate 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.

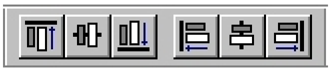


	Blank Scheme	Create a blank scheme based on a relay model.
	Default Configuration	Create a default scheme based on a relay model.
	Open	Open an existing diagram.
	Save	Save the active diagram.
	Print	Display the Windows Print dialog, enabling you to print the current diagram.
	Undo	Undo the last action.
	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.

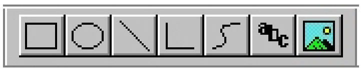
 **Align Left** Align all selected components so the leftmost point of each is level with the others.

 **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.

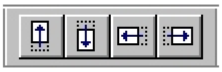
 **Curve** When selected, move the mouse pointer to where you want the polycurve to start and click the left mouse button. Each time you click the button after this a line will be drawn, each line bisects its associated curve. Double click to end. The straight lines will disappear leaving the polycurve.
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.



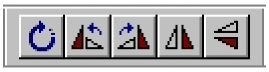
The nudge tool buttons enable you to shift a selected component a single unit in the selected direction, or five pixels if the SHIFT key is held down.

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

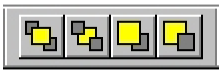
To spin, mirror and flip.

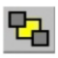


	Free Rotate	Enable the rotation function. While rotation is active components may be rotated as required. Press the ESC key or click on the diagram to disable the function.
	Rotate Left	Rotate the selected component 90 degrees to the left.
	Rotate Right	Rotate the selected component 90 degrees to the right.
	Flip Horizontal	Flip the component horizontally.
	Flip Vertical	Flip the component vertically.

3.6 Structure Tools

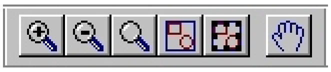
To change the stacking order of logic components.



	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.

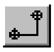


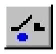
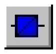
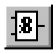
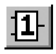
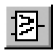
	Zoom In	Increases the Zoom magnification by 25%.
	Zoom Out	Decreases the Zoom magnification by 25%.
	Zoom	Enable the zoom function. While this button is active, the mouse pointer is displayed as a magnifying glass. Right-clicking will zoom out and left-clicking will zoom in. Press the ESC key to return 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.

P2718ENa

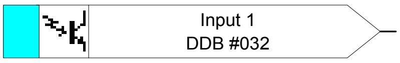
Link Create a link between two logic symbols.	
Opto Signal Create an opto signal.	
Input Signal Create an input signal.	
Output Signal Create an output signal.	
GOOSE In Create an input signal to logic to receive a UCA2.0 or IEC 61850 GOOSE message transmitted from another IED.	
GOOSE Out Create an output 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.

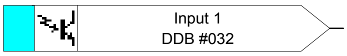
  Right-click the link and select Highlight to find the other signal. Click anywhere on the diagram to disable the highlight.

- 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.

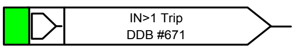


DDB Nos	*"Input 1 DDB #064" applies to: P24x, P64x.* *"Opto Label DDB #064" applies to: P44x.*

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.

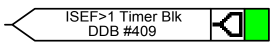
For example, DDB 671 is asserted in the PSL for the P44y, P547 & P841 product if the active earth fault 1, stage 1 protection operate/trip.



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.

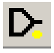


4.6 GOOSE Input Signal Properties

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.

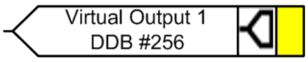
For example DDB 224 will be asserted in PSL for the P44y, P54x, P547 & P841 product should virtual input 1 operate.




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.

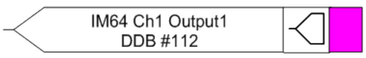
4.8 Control In Signal Properties

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.

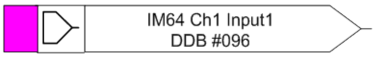

4.9 InterMiCOM Output Commands Properties

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.

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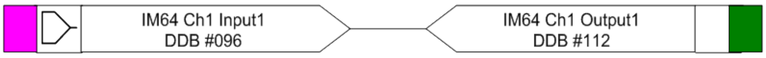

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4.11 Function Key Properties

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

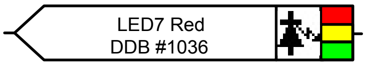
The fault recording facility can be activated by driving the fault recorder trigger DDB signal.

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.

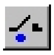
For example DDB 1036 will be asserted when LED 7 is activated for the P44y, P54x, P547 or P841 product.



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.

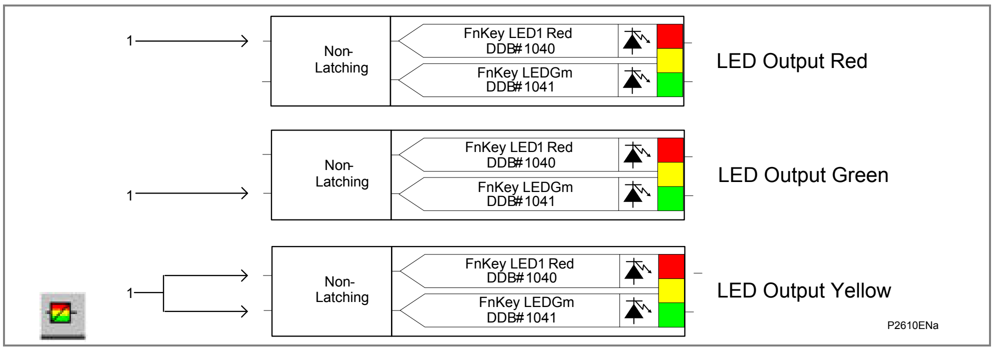


Figure 3 - Red, green and yellow LED outputs

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.

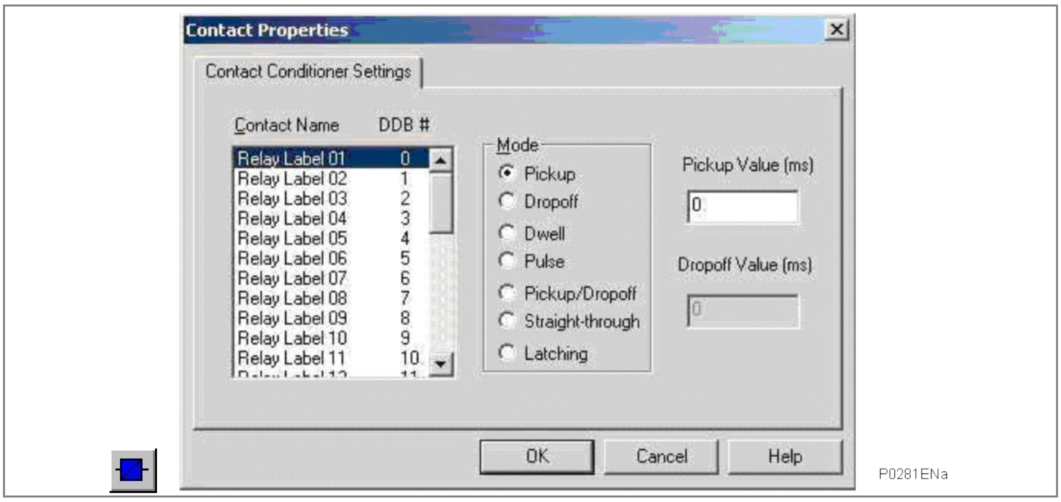


Figure 4 - Contact conditioner settings

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.

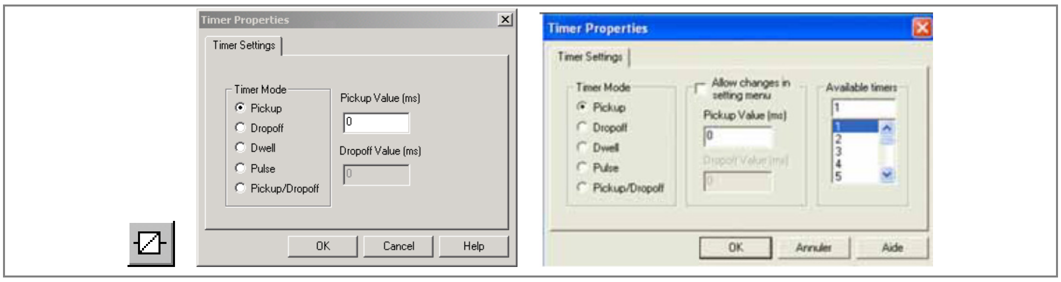


Figure 5 - Timer settings

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.

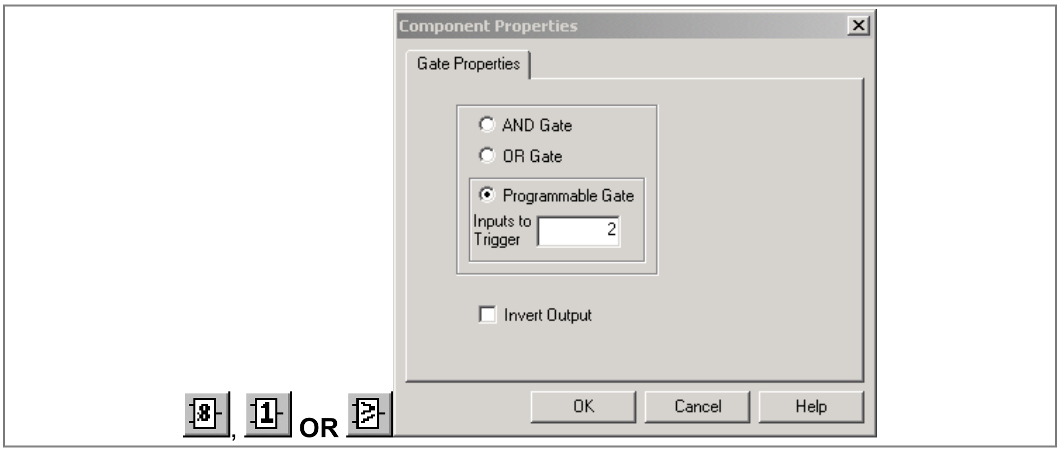


Figure 6 - Gate properties

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

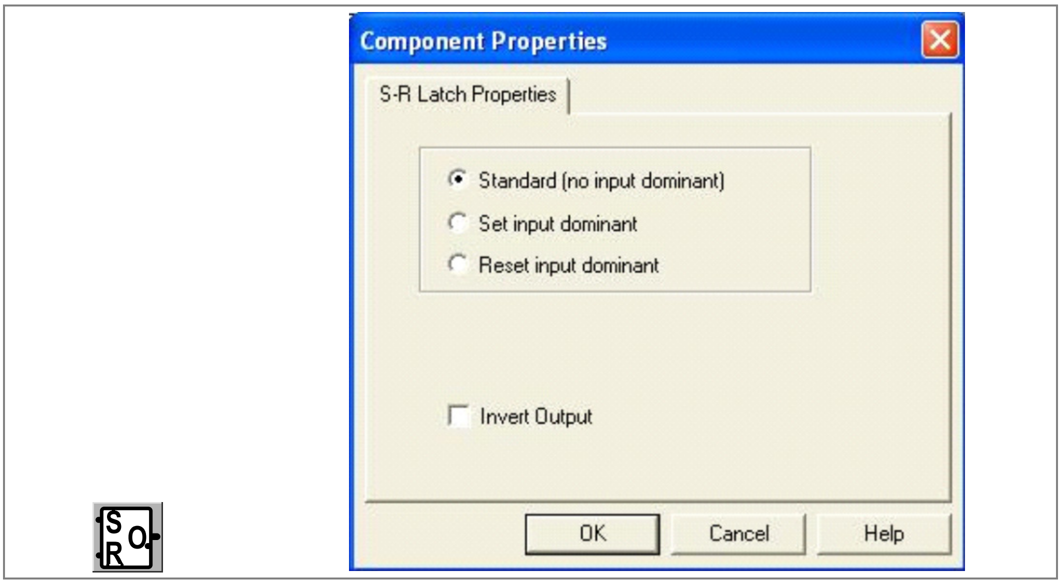


Figure 7 - SR latch component properties

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:

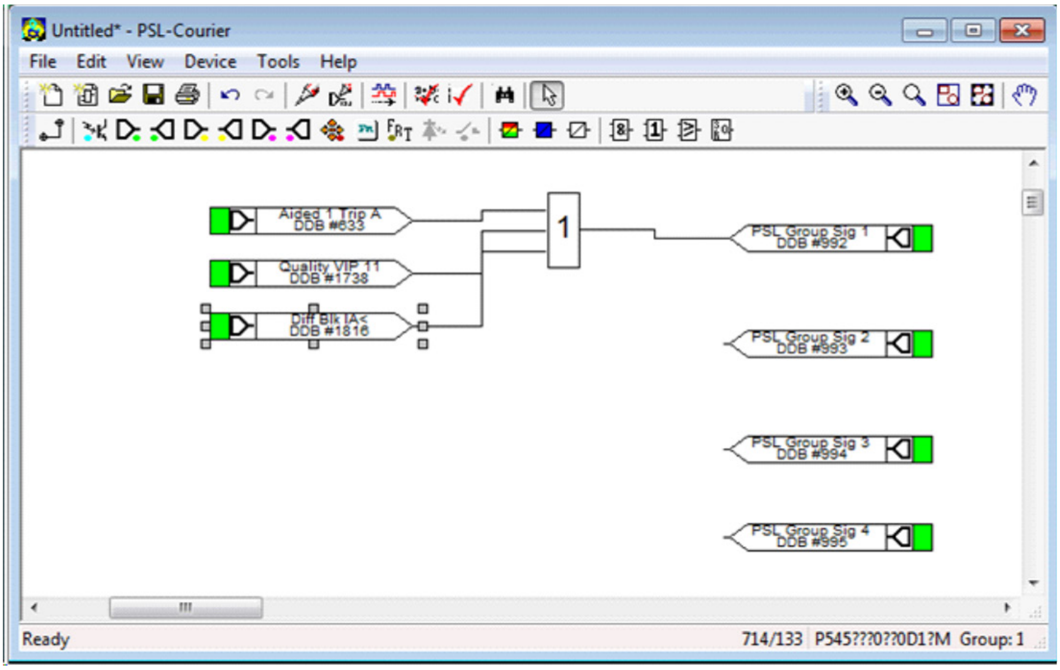


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Figure 8 - PSL diagram

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)

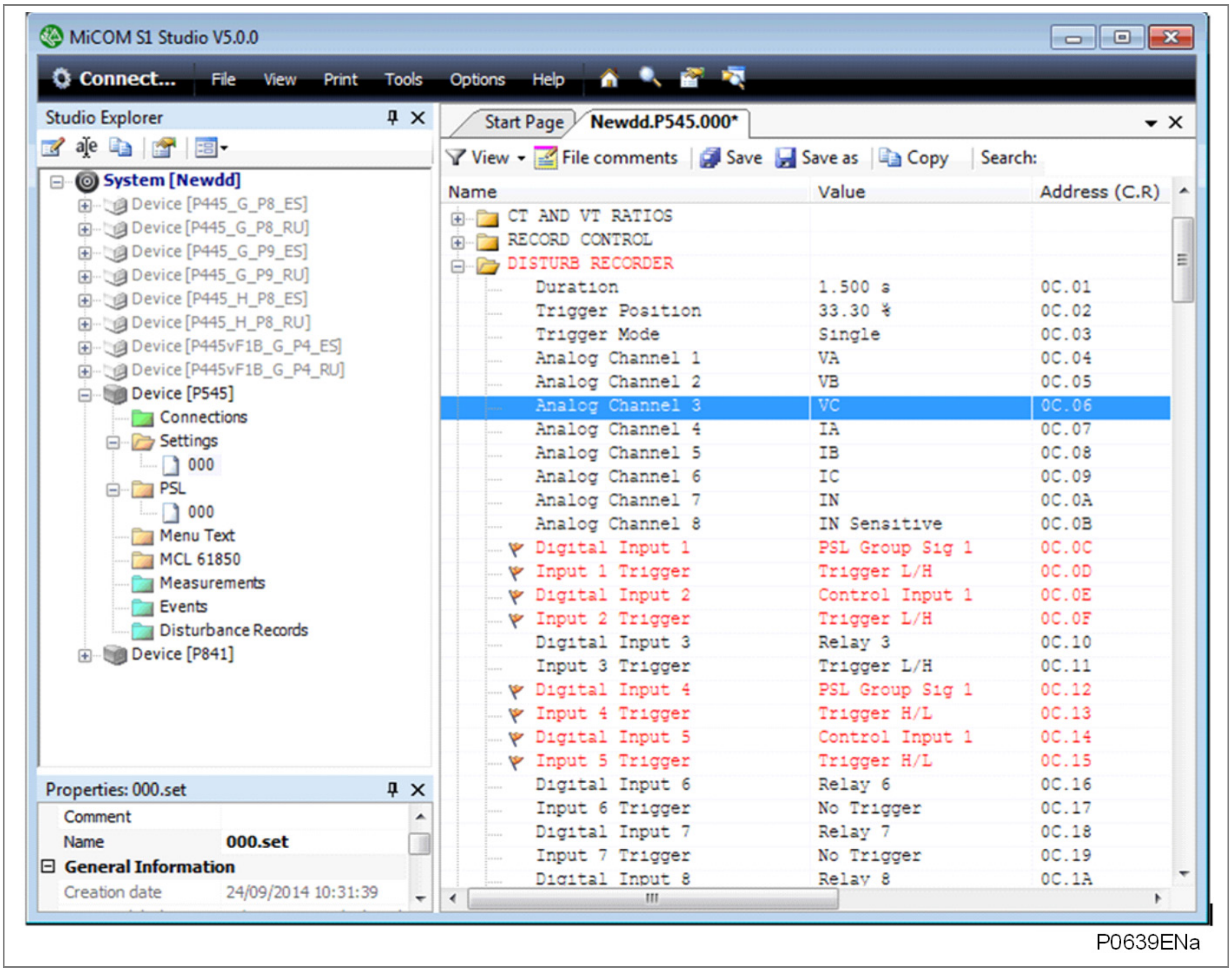


Figure 9 – Easergy Studio (MiCOM S1 Studio) Disturb Recorder table diagram

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 Digital Input Label Operation (not included in P44x)

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:

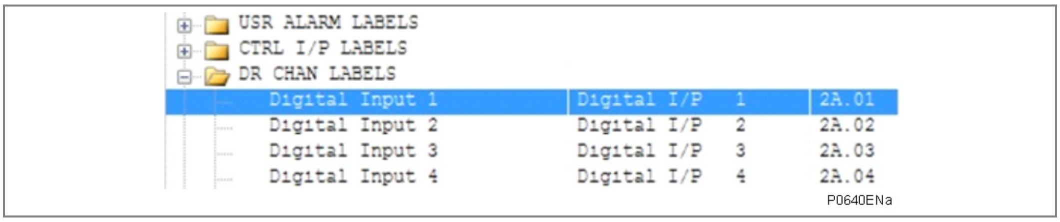


Figure 10 - DR Chan Labels tree

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.

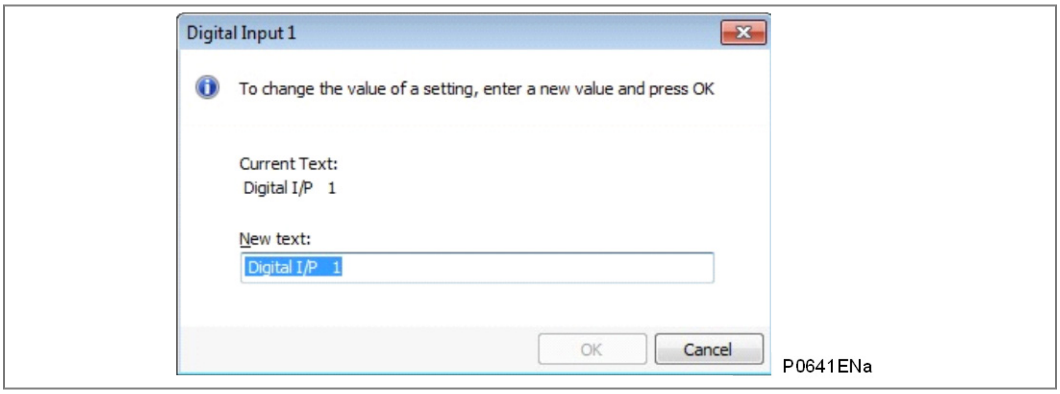


Figure 11 - Digital Input 1 dialog box

Pressing OK will save the setting and return to the settings page as follows:

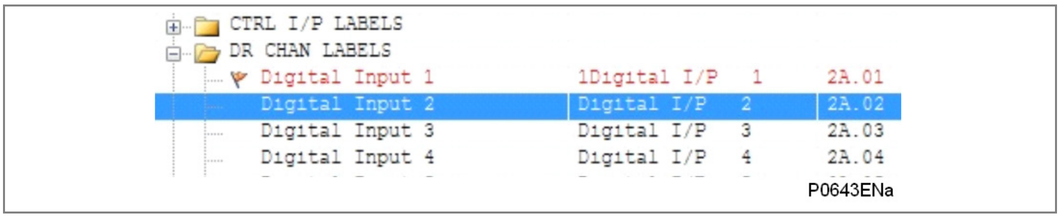


Figure 12 - DR Chan Labels tree

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 (MiCOM S1 Studio). The following example is using S1 Studio Version 5.0.0.

The default labels are available in the "VIR I/P LABELS" (or "VIRT I/P LABELS") folder in the settings file as shown below:

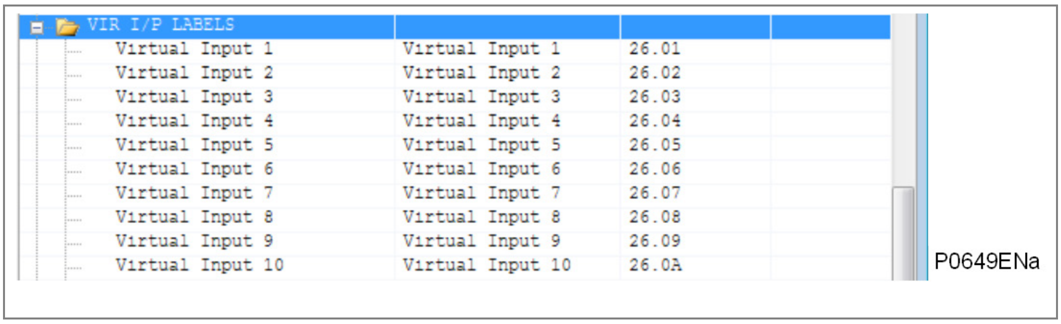


Figure 13 - MiCOM S1 Studio VIR I/P Labels Tree

The default "Virtual Input" labels can be changed to suit the customer requirements. For example, to change default text from "Virtual Input 1" to "Customer Func 1" open the ***Virtual Input 1*** dialog box, and change "Virtual Input 1" in the ***New Text:*** text box to be "Customer Func 1", as follows:

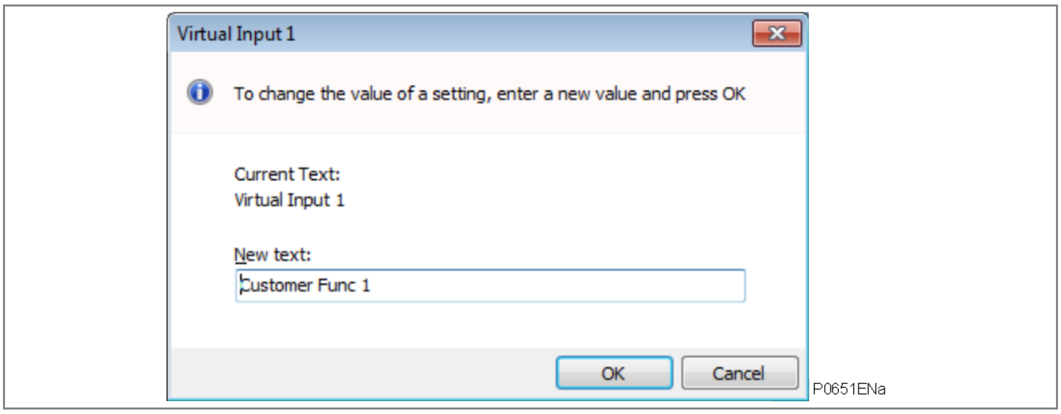


Figure 14 - Virtual Input 1 dialog box

Pressing OK will save the setting and return to the settings page as follows:

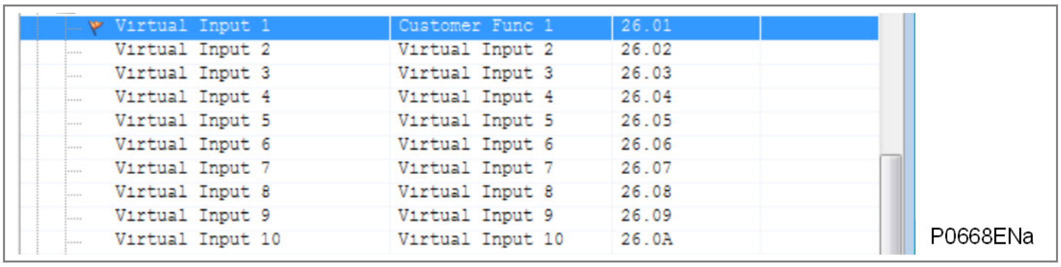


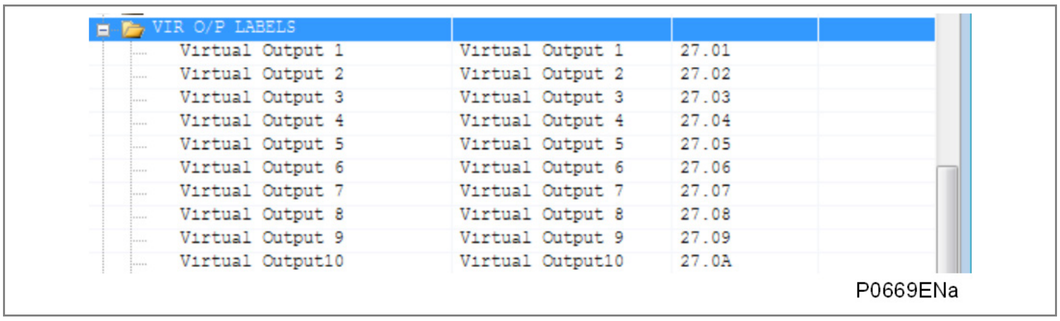
Figure 15 - Easergy Studio (MiCOM S1 Studio) VIR I/P Labels Tree

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 MiCOM Px40 user interface or Easergy Studio (MiCOM S1 Studio). The following example is using S1 Studio Version 5.0.0.

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:



VIR O/P LABELS		
Virtual Output 1	Virtual Output 1	27.01
Virtual Output 2	Virtual Output 2	27.02
Virtual Output 3	Virtual Output 3	27.03
Virtual Output 4	Virtual Output 4	27.04
Virtual Output 5	Virtual Output 5	27.05
Virtual Output 6	Virtual Output 6	27.06
Virtual Output 7	Virtual Output 7	27.07
Virtual Output 8	Virtual Output 8	27.08
Virtual Output 9	Virtual Output 9	27.09
Virtual Output10	Virtual Output10	27.0A

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Figure 16 - Easergy Studio (MiCOM S1 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 (MiCOM S1 Studio). This example is using S1 Studio Version 5.0.0.

The default labels are available in the “USR ALARM LABELS” folder in the settings file as shown below:

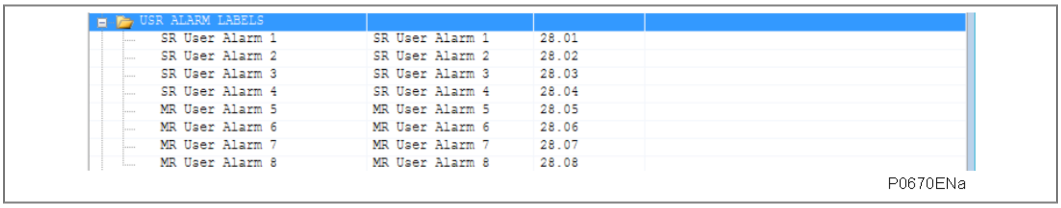

Figure 17 - Easergy Studio (MiCOM S1 Studio) USR Labels Tree

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”.

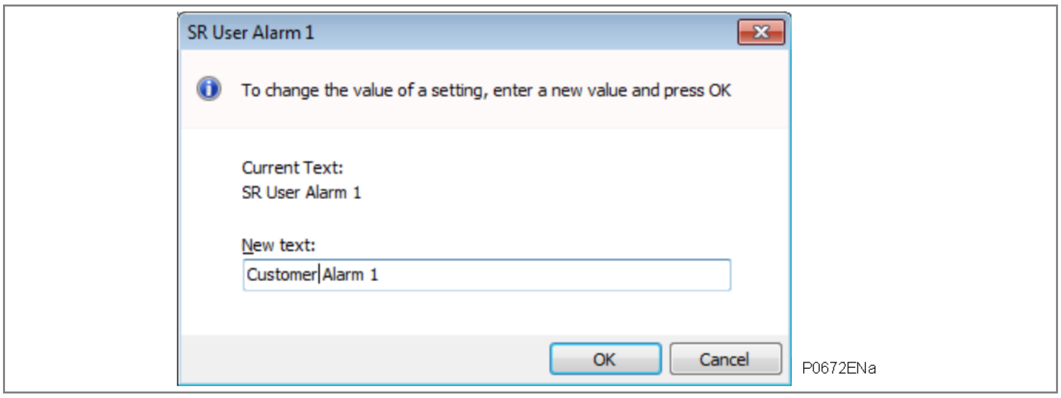

Figure 18 - Virtual Input 1 dialog box

Pressing OK will save the setting and return to the settings page as follows:

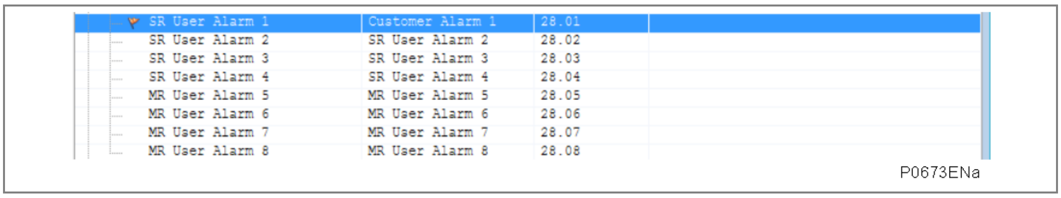

Figure 19 - Virtual Input 1 settings

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 (not included in P44x)

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.

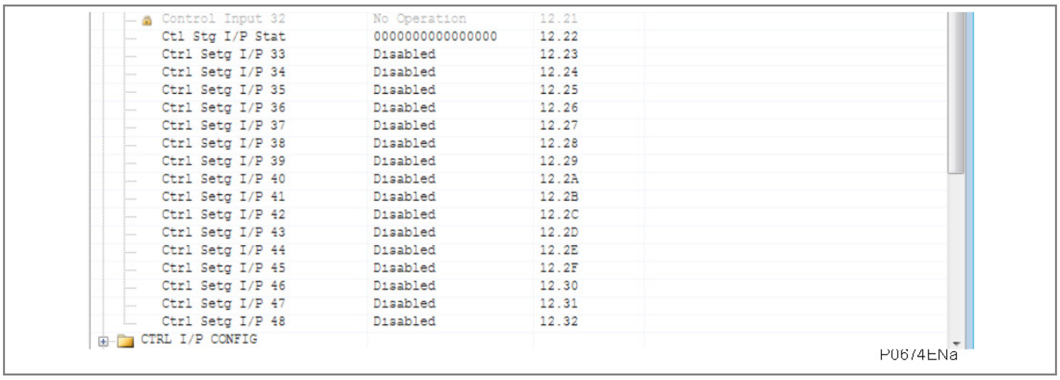

Figure 20 - Easergy Studio (MiCOM S1 Studio) Control Inputs tree

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:

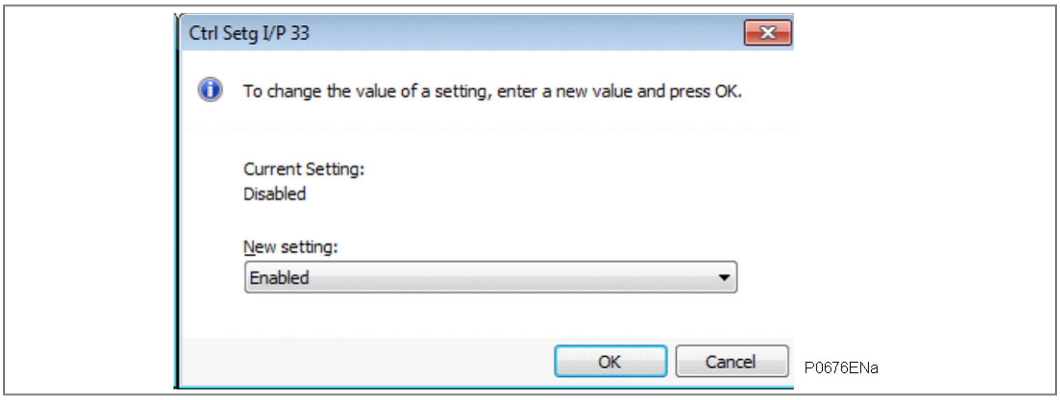

Figure 21 – Ctrl Setg I/P 33 dialog box

Pressing OK will save the setting and return to the settings page as follows:

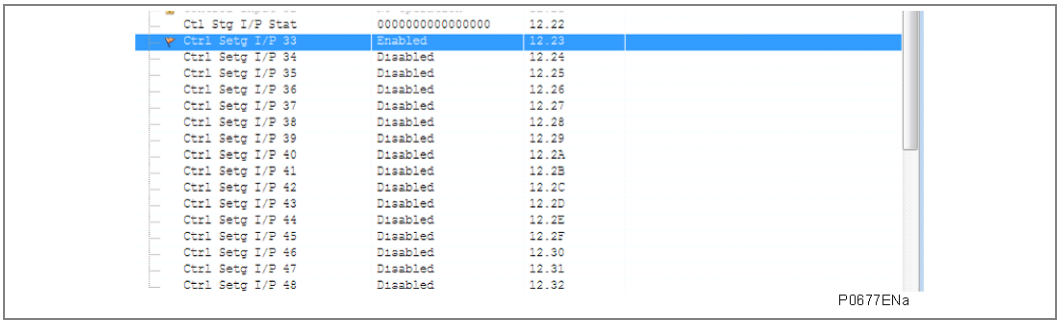

Figure 22 - Easergy Studio (MiCOM S1 Studio) Control Inputs (Ctl Setg I/P 33) tree

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 (MiCOM S1 Studio) files.

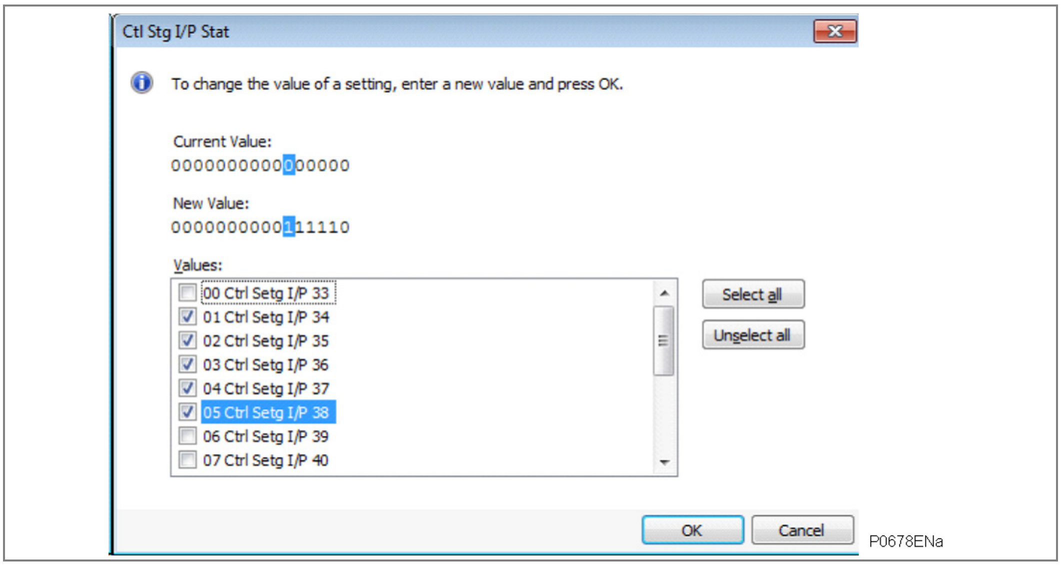

Figure 23 – Ctrl Stg I/P Stat dialog box

5.6 Settable Control Setg I/P Label Operation (P14x, P44y, P54x, P445 & P841 only) (not included in P44x)

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:

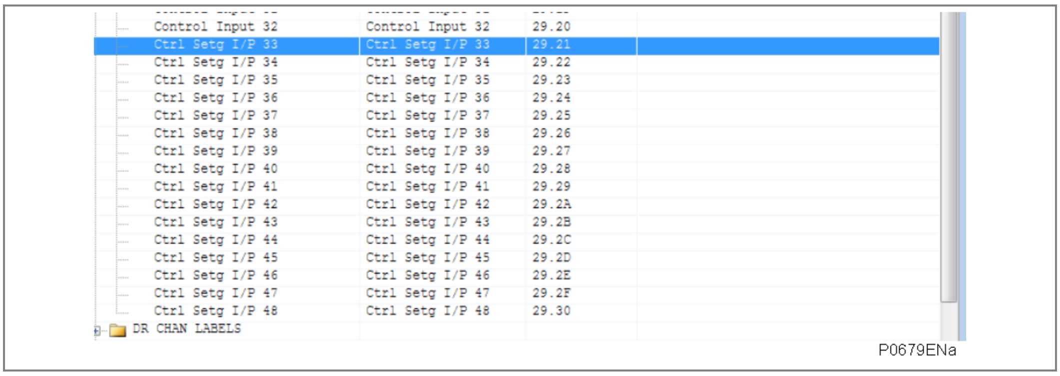

Figure 24 - Easergy Studio (MiCOM S1 Studio) Control I/P Labels (Ctl Setg I/P 33) tree

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”.

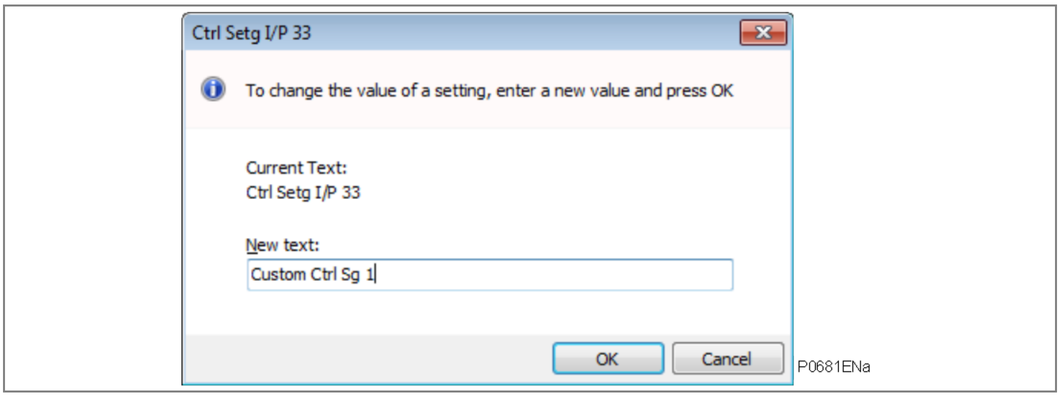

Figure 25 – Ctrl Setg I/P 33 dialog box

Pressing OK will save the setting and return to the settings page as follows:

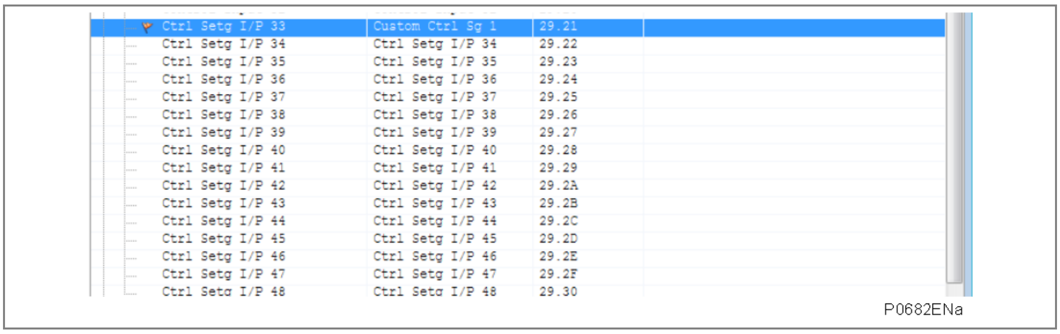

Figure 26 - Easergy Studio (MiCOM S1 Studio) Control I/P Labels (Ctl Setg I/P 33) tree

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 (MiCOM S1 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 (MiCOM S1 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 (MiCOM S1 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 (MiCOM S1 Studio) help.

A quick summary of the main steps is given here. In each case, you need to make sure that:

- Your computer includes the Easergy Studio (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).

6.2 Extract Settings from a MiCOM Px40 Device

Full details of how to do this is provided in the Easergy Studio (MiCOM S1 Studio) help.

As a quick guide, you need to do the following:

1. In Easergy Studio (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. 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 (MiCOM S1 Studio) help.

As a quick guide, you need to do the following:

1. In Easergy Studio (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. 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.

PROGRAMMABLE LOGIC

CHAPTER 7

Date:	01/2017
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:	M
Software version:	E1
Connection diagrams:	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)

CONTENTS

TABLES

FIGURES

Notes:

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 THE DIGITAL DATABASE (DDB)

The following table shows the available DDB Numbers, a Description of what they are and which product (or products) they apply to. If a DDB Number is not shown, it is not used in this range of products.

DDB No	Source	Description	Element Name
0	SW	Relay Label 01	DDB_OUTPUT_RELAY_1
1	SW	Relay Label 02	DDB_OUTPUT_RELAY_2
2	SW	Relay Label 03	DDB_OUTPUT_RELAY_3
3	SW	Relay Label 04	DDB_OUTPUT_RELAY_4
4	SW	Relay Label 05	DDB_OUTPUT_RELAY_5
5	SW	Relay Label 06	DDB_OUTPUT_RELAY_6
6	SW	Relay Label 07	DDB_OUTPUT_RELAY_7
7	SW	Relay Label 08	DDB_OUTPUT_RELAY_8
8	SW	Relay Label 09	DDB_OUTPUT_RELAY_9
9	SW	Relay Label 10	DDB_OUTPUT_RELAY_10
10	SW	Relay Label 11	DDB_OUTPUT_RELAY_11
11	SW	Relay Label 12	DDB_OUTPUT_RELAY_12
12	SW	Relay Label 13	DDB_OUTPUT_RELAY_13
13	SW	Relay Label 14	DDB_OUTPUT_RELAY_14
14	SW	Relay Label 15	DDB_OUTPUT_RELAY_15
15	SW	Relay Label 16	DDB_OUTPUT_RELAY_16
16	SW	Relay Label 17	DDB_OUTPUT_RELAY_17
17	SW	Relay Label 18	DDB_OUTPUT_RELAY_18
18	SW	Relay Label 19	DDB_OUTPUT_RELAY_19
19	SW	Relay Label 20	DDB_OUTPUT_RELAY_20
20	SW	Relay Label 21	DDB_OUTPUT_RELAY_21
21	SW	Relay Label 22	DDB_OUTPUT_RELAY_22
22	SW	Relay Label 23	DDB_OUTPUT_RELAY_23
23	SW	Relay Label 24	DDB_OUTPUT_RELAY_24
24	SW	Relay Label 25	DDB_OUTPUT_RELAY_25
25	SW	Relay Label 26	DDB_OUTPUT_RELAY_26
26	SW	Relay Label 27	DDB_OUTPUT_RELAY_27
27	SW	Relay Label 28	DDB_OUTPUT_RELAY_28
28	SW	Relay Label 29	DDB_OUTPUT_RELAY_29
29	SW	Relay Label 30	DDB_OUTPUT_RELAY_30
30	SW	Relay Label 31	DDB_OUTPUT_RELAY_31
31	SW	Relay Label 32	DDB_OUTPUT_RELAY_32
32	SW	Relay Label 33	DDB_OUTPUT_RELAY_33
33	SW	Relay Label 34	DDB_OUTPUT_RELAY_34
34	SW	Relay Label 35	DDB_OUTPUT_RELAY_35
35	SW	Relay Label 36	DDB_OUTPUT_RELAY_36
36	SW	Relay Label 37	DDB_OUTPUT_RELAY_37
37	SW	Relay Label 38	DDB_OUTPUT_RELAY_38
38	SW	Relay Label 39	DDB_OUTPUT_RELAY_39
39	SW	Relay Label 40	DDB_OUTPUT_RELAY_40

DDB No	Source	Description	Element Name
40	SW	Relay Label 41	DDB_OUTPUT_RELAY_41
41	SW	Relay Label 42	DDB_OUTPUT_RELAY_42
42	SW	Relay Label 43	DDB_OUTPUT_RELAY_43
43	SW	Relay Label 44	DDB_OUTPUT_RELAY_44
44	SW	Relay Label 45	DDB_OUTPUT_RELAY_45
45	SW	Relay Label 46	DDB_OUTPUT_RELAY_46
46	SW	Relay Label 47	DDB_OUTPUT_RELAY_47
47	SW	Relay Label 48	DDB_OUTPUT_RELAY_48
48	SW	Relay Label 49	DDB_OUTPUT_RELAY_49
49	SW	Relay Label 50	DDB_OUTPUT_RELAY_50
50	SW	Relay Label 51	DDB_OUTPUT_RELAY_51
51	SW	Relay Label 52	DDB_OUTPUT_RELAY_52
52	SW	Relay Label 53	DDB_OUTPUT_RELAY_53
53	SW	Relay Label 54	DDB_OUTPUT_RELAY_54
54	SW	Relay Label 55	DDB_OUTPUT_RELAY_55
55	SW	Relay Label 56	DDB_OUTPUT_RELAY_56
56	SW	Relay Label 57	DDB_OUTPUT_RELAY_57
57	SW	Relay Label 58	DDB_OUTPUT_RELAY_58
58	SW	Relay Label 59	DDB_OUTPUT_RELAY_59
59	SW	Relay Label 60	DDB_OUTPUT_RELAY_60
60	SW	Relay Label 61	DDB_OUTPUT_RELAY_61
61	SW	Relay Label 62	DDB_OUTPUT_RELAY_62
62	SW	Relay Label 63	DDB_OUTPUT_RELAY_63
63	SW	Relay Label 64	DDB_OUTPUT_RELAY_64
64	SW	Opto Label 01	DDB_OPTO_ISOLATOR_1
65	SW	Opto Label 02	DDB_OPTO_ISOLATOR_2
66	SW	Opto Label 03	DDB_OPTO_ISOLATOR_3
67	SW	Opto Label 04	DDB_OPTO_ISOLATOR_4
68	SW	Opto Label 05	DDB_OPTO_ISOLATOR_5
69	SW	Opto Label 06	DDB_OPTO_ISOLATOR_6
70	SW	Opto Label 07	DDB_OPTO_ISOLATOR_7
71	SW	Opto Label 08	DDB_OPTO_ISOLATOR_8
72	SW	Opto Label 09	DDB_OPTO_ISOLATOR_9
73	SW	Opto Label 10	DDB_OPTO_ISOLATOR_10
74	SW	Opto Label 11	DDB_OPTO_ISOLATOR_11
75	SW	Opto Label 12	DDB_OPTO_ISOLATOR_12
76	SW	Opto Label 13	DDB_OPTO_ISOLATOR_13
77	SW	Opto Label 14	DDB_OPTO_ISOLATOR_14
78	SW	Opto Label 15	DDB_OPTO_ISOLATOR_15
79	SW	Opto Label 16	DDB_OPTO_ISOLATOR_16
80	SW	Opto Label 17	DDB_OPTO_ISOLATOR_17
81	SW	Opto Label 18	DDB_OPTO_ISOLATOR_18
82	SW	Opto Label 19	DDB_OPTO_ISOLATOR_19
83	SW	Opto Label 20	DDB_OPTO_ISOLATOR_20

DDB No	Source	Description	Element Name
84	SW	Opto Label 21	DDB_OPTO_ISOLATOR_21
85	SW	Opto Label 22	DDB_OPTO_ISOLATOR_22
86	SW	Opto Label 23	DDB_OPTO_ISOLATOR_23
87	SW	Opto Label 24	DDB_OPTO_ISOLATOR_24
88	SW	Opto Label 25	DDB_OPTO_ISOLATOR_25
89	SW	Opto Label 26	DDB_OPTO_ISOLATOR_26
90	SW	Opto Label 27	DDB_OPTO_ISOLATOR_27
91	SW	Opto Label 28	DDB_OPTO_ISOLATOR_28
92	SW	Opto Label 29	DDB_OPTO_ISOLATOR_29
93	SW	Opto Label 30	DDB_OPTO_ISOLATOR_30
94	SW	Opto Label 31	DDB_OPTO_ISOLATOR_31
95	SW	Opto Label 32	DDB_OPTO_ISOLATOR_32
96	PSL	Unused	DDB_UNUSED96
97	PSL	Unused	DDB_UNUSED97
98	PSL	Unused	DDB_UNUSED98
99	PSL	Unused	DDB_UNUSED99
100	PSL	Unused	DDB_UNUSED100
101	PSL	Unused	DDB_UNUSED101
102	PSL	Unused	DDB_UNUSED102
103	PSL	Unused	DDB_UNUSED103
104	PSL	Unused	DDB_UNUSED104
105	PSL	Unused	DDB_UNUSED105
106	PSL	Unused	DDB_UNUSED106
107	PSL	Unused	DDB_UNUSED107
108	PSL	Unused	DDB_UNUSED108
109	PSL	Unused	DDB_UNUSED109
110	PSL	Unused	DDB_UNUSED110
111	PSL	Unused	DDB_UNUSED111
112	PSL	Unused	DDB_UNUSED112
113	PSL	Unused	DDB_UNUSED113
114	PSL	Unused	DDB_UNUSED114
115	PSL	Unused	DDB_UNUSED115
116	PSL	Unused	DDB_UNUSED116
117	PSL	Unused	DDB_UNUSED117
118	PSL	Unused	DDB_UNUSED118
119	PSL	Unused	DDB_UNUSED119
120	PSL	Unused	DDB_UNUSED120
121	PSL	Unused	DDB_UNUSED121
122	PSL	Unused	DDB_UNUSED122
123	PSL	Unused	DDB_UNUSED123
124	PSL	Unused	DDB_UNUSED124
125	PSL	Unused	DDB_UNUSED125
126	PSL	Unused	DDB_UNUSED126
127	PSL	Unused	DDB_UNUSED127

DDB No	Source	Description	Element Name
128	PSL	Unused	DDB_UNUSED128
129	PSL	Unused	DDB_UNUSED129
130	PSL	Unused	DDB_UNUSED130
131	PSL	Unused	DDB_UNUSED131
132	PSL	Unused	DDB_UNUSED132
133	PSL	Unused	DDB_UNUSED133
134	PSL	Unused	DDB_UNUSED134
135	PSL	Unused	DDB_UNUSED135
136	PSL	Unused	DDB_UNUSED136
137	PSL	Unused	DDB_UNUSED137
138	PSL	Unused	DDB_UNUSED138
139	PSL	Unused	DDB_UNUSED139
140	PSL	Unused	DDB_UNUSED140
141	PSL	Unused	DDB_UNUSED141
142	PSL	Unused	DDB_UNUSED142
143	PSL	Unused	DDB_UNUSED143
144	PSL	Unused	DDB_UNUSED144
145	PSL	Unused	DDB_UNUSED145
146	PSL	Unused	DDB_UNUSED146
147	PSL	Unused	DDB_UNUSED147
148	PSL	Unused	DDB_UNUSED148
149	PSL	Unused	DDB_UNUSED149
150	PSL	Unused	DDB_UNUSED150
151	PSL	Unused	DDB_UNUSED151
152	PSL	Unused	DDB_UNUSED152
153	PSL	Unused	DDB_UNUSED153
154	PSL	Unused	DDB_UNUSED154
155	PSL	Unused	DDB_UNUSED155
156	PSL	Unused	DDB_UNUSED156
157	PSL	Unused	DDB_UNUSED157
158	PSL	Unused	DDB_UNUSED158
159	PSL	Unused	DDB_UNUSED159
160	PSL	Unused	DDB_UNUSED160
161	PSL	Unused	DDB_UNUSED161
162	PSL	Unused	DDB_UNUSED162
163	PSL	Unused	DDB_UNUSED163
164	PSL	Unused	DDB_UNUSED164
165	PSL	Unused	DDB_UNUSED165
166	PSL	Unused	DDB_UNUSED166
167	PSL	Unused	DDB_UNUSED167
168	PSL	Unused	DDB_UNUSED168
169	PSL	Unused	DDB_UNUSED169
170	PSL	Unused	DDB_UNUSED170
171	PSL	Unused	DDB_UNUSED171

DDB No	Source	Description	Element Name
172	SW	Unused	DDB_UNUSED172
173	SW	Unused	DDB_ALARM_UNUSED0
174	SW	General Alarm	DDB_ALARM_GENERAL
175	SW	Prot'n Disabled	DDB_ALARM_PROT_DISABLED
176	SW	f out of Range	DDB_ALARM_F_OUT_OF_RANGE
177	SW	VT Fail Alarm	DDB_ALARM_VTS_SLOW
178	SW	CT Fail Alarm	DDB_ALARM_CTS
179	SW	CB Fail Alarm	DDB_ALARM_BREAKER_FAIL
180	SW	I^ Maint Alarm	DDB_ALARM_I_BROK_MAINT
181	SW	I^ Lockout Alarm	DDB_ALARM_I_BROK_LOCKOUT
182	SW	CB Ops Maint	DDB_ALARM_CB_OPS_MAINT
183	SW	CB Ops Lockout	DDB_ALARM_CB_OPS_LOCKOUT
184	SW	CB Op Time Maint	DDB_ALARM_CB_OP_TIME_MAINT
185	SW	CB Op Time Lock	DDB_ALARM_CB_OP_TIME_LOCKOUT
186	SW	F.F. Pre Lockout	DDB_ALARM_PRE_LOCKOUT
187	SW	F.F. Lock	DDB_ALARM_EFF_LOCKOUT
188	SW	Lockout Alarm	DDB_LOCKOUT_ALARM
189	SW	CB Status Alarm	DDB_ALARM_CB_STATUS
190	SW	Man CB Trip Fail	DDB_ALARM_CB_FAIL_TRIP
191	SW	Man CB Cls Fail	DDB_ALARM_CB_FAIL_CLOSE
192	SW	Man CB Unhealthy	DDB_ALARM_CB_CONTROL_UNHEALTHLY
193	SW	Control No C/S	DDB_ALARM_NO_CHECK_SYNC_CONTROL
194	SW	AR Lockout Shot>	DDB_ALARM_AR_LOCKOUT_MAX_SHOTS
195	SW	SG-opto Invalid	DDB_ALARM_SG_OPTO_INVALID
196	SW	A/R Fail	DDB_ALARM_CB_FAIL_AR
197	SW	V<1 Alarm	DDB_ALARM_UNDER_V_1
198	SW	V<2 Alarm	DDB_ALARM_UNDER_V_2
199	SW	V>1 Alarm	DDB_ALARM_OVER_V_1
200	SW	V>2 Alarm	DDB_ALARM_OVER_V_2
201	SW	COS Alarm	DDB_ALARM_COS
202	SW	Brok.Cond. Alarm	DDB_ALARM_BROKEN_COND
203	SW	CVT Alarm	DDB_ALARM_CVTS
204	SW	NCIT Alarm	DDB_ALARM_NCIT
205	SW	Unused	DDB_ALARM_UNUSED205
206	SW	Unused	DDB_ALARM_UNUSED206
207	SW	Unused	DDB_ALARM_UNUSED207
208	PSL	Unused	DDB_ALARM_UNUSED208
209	PSL	Unused	DDB_ALARM_UNUSED209
210	PSL	Unused	DDB_ALARM_UNUSED210
211	PSL	Unused	DDB_ALARM_UNUSED211
212	PSL	Unused	DDB_ALARM_UNUSED212
213	SW	V<3 Alarm	DDB_ALARM_UNDER_V_3
214	SW	V<4 Alarm	DDB_ALARM_UNDER_V_4

DDB No	Source	Description	Element Name
215	SW	V>3 Alarm	DDB_ALARM_OVER_V_3
216	SW	V>4 Alarm	DDB_ALARM_OVER_V_4
217	SW	On load Alarm	DDB_ALARM_DIST_ONLOAD
218	PSL	Unused	DDB_ALARM_UNUSED218
219	PSL	Unused	DDB_ALARM_UNUSED219
220	PSL	Unused	DDB_ALARM_UNUSED220
221	PSL	Unused	DDB_ALARM_UNUSED221
222	PSL	Unused	DDB_ALARM_UNUSED222
223	SW	A/R Close	DDB_PRT_AR_CLOSE
224	SW	A/R 1P In Prog	DDB_PRT_AR_1POLE_IN_PROG
225	SW	A/R 3P In Prog	DDB_PRT_AR_3POLE_IN_PROG
226	SW	A/R 1st In Prog	DDB_PRT_AR_1ST_CYCLE_IN_PROG
227	SW	A/R 234 In Prog	DDB_PRT_AR_234TH_CYCLE_IN_PROG
228	SW	A/R Trip 3P	DDB_PRT_AR_TRIP_3PH
229	SW	A/R Reclaim	DDB_PRT_AR_RECLAIM
230	SW	AR Discrim.	DDB_PRT_AR_DISCRIM
231	SW	A/R Enable	DDB_PRT_AR_ENABLE
232	SW	A/R SPAR Enable	DDB_PRT_AR_1PAR_ENABLE
233	SW	A/R TPAR Enable	DDB_PRT_AR_3PAR_ENABLE
234	SW	A/R Lockout	DDB_PRT_AR_LOCKOUT
235	SW	A/R Force Sync.	DDB_PRT_AR_FORCE_SYNC
236	SW	Check Synch. OK	DDB_PRT_SYNC
237	SW	V< Dead Line	DDB_PRT_DEAD_LINE
238	SW	V> Live Line	DDB_PRT_LIVE_LINE
239	SW	V< Dead Bus	DDB_PRT_DEAD_BUS
240	SW	V> Live Bus	DDB_PRT_LIVE_BUS
241	SW	Ctrl Cls In Prog	DDB_PRT_CONTROL_CLOSE_IN_PROG
242	SW	DIST Sig. Send	DDB_PRT_CARRIER_SEND
243	SW	DIST UNB CR	DDB_PRT_UNB_CR
244	SW	DIST Fwd	DDB_PRT_DIST_FWD
245	SW	DIST Rev	DDB_PRT_DIST_REV
246	SW	DIST Trip A	DDB_PRT_DIST_TRIP_A
247	SW	DIST Trip B	DDB_PRT_DIST_TRIP_B
248	SW	DIST Trip C	DDB_PRT_DIST_TRIP_C
249	SW	DIST Start A	DDB_PRT_DIST_START_A
250	SW	DIST Start B	DDB_PRT_DIST_START_B
251	SW	DIST Start C	DDB_PRT_DIST_START_C
252	SW	DIST Sch. Accel.	DDB_PRT_DIST_CR_ACC
253	SW	DIST Sch. Perm.	DDB_PRT_DIST_CR_PERM
254	SW	DIST Sch. Block.	DDB_PRT_DIST_CR_BLOCK
255	SW	Z1	DDB_PRT_Z1
256	SW	Z1X	DDB_PRT_Z1X
257	SW	Z2	DDB_PRT_Z2
258	SW	Z3	DDB_PRT_Z3

DDB No	Source	Description	Element Name
259	SW	Z4	DDB_PRT_Z4
260	SW	Zp	DDB_PRT_Zp
261	SW	T1	DDB_PRT_T1
262	SW	T2	DDB_PRT_T2
263	SW	T3	DDB_PRT_T3
264	SW	T4	DDB_PRT_T4
265	SW	Tzp	DDB_PRT_TZP
266	SW	WI Trip A	DDB_PRT_WI_TRIP_A
267	SW	WI Trip B	DDB_PRT_WI_TRIP_B
268	SW	WI Trip C	DDB_PRT_WI_TRIP_C
269	SW	Power Swing	DDB_PRT_POWER_SWING
270	SW	Reversal Guard	DDB_PRT_REVERSAL_GUARD
271	SW	DEF Sig. Send	DDB_PRT_DEF_CARRIER_SEND
272	SW	DEF UNB CR	DDB_PRT_UNB_CR_DEF
273	SW	DEF Rev	DDB_PRT_DEF_REV
274	SW	DEF Fwd	DDB_PRT_DEF_FWD
275	SW	DEF Start A	DDB_PRT_DEF_START_AN
276	SW	DEF Start B	DDB_PRT_DEF_START_BN
277	SW	DEF Start C	DDB_PRT_DEF_START_CN
278	SW	DEF Trip A	DDB_PRT_DEF_TRIP_A
279	SW	DEF Trip B	DDB_PRT_DEF_TRIP_B
280	SW	DEF Trip C	DDB_PRT_DEF_TRIP_C
281	SW	IN>1 Trip	DDB_PRT_IN_SUP_1_TRIP
282	SW	IN>2 Trip	DDB_PRT_IN_SUP_2_TRIP
283	SW	IN>1 Start	DDB_PRT_IN_SUP_1_PICK_UP
284	SW	IN>2 Start	DDB_PRT_IN_SUP_2_PICK_UP
285	SW	V< Start Any A	DDB_PRT_UNDER_V_ANY_PICK_UP_A
286	SW	V< Start Any B	DDB_PRT_UNDER_V_ANY_PICK_UP_B
287	SW	V< Start Any C	DDB_PRT_UNDER_V_ANY_PICK_UP_C
288	SW	V<1 Start	DDB_PRT_UNDER_V_1_PICK_UP
289	SW	V<2 Start	DDB_PRT_UNDER_V_2_PICK_UP
290	SW	V<1 Trip	DDB_PRT_UNDER_V_1_TRIP
291	SW	V<2 Trip	DDB_PRT_UNDER_V_2_TRIP
292	SW	V> Start Any A	DDB_PRT_OVER_V_ANY_PICK_UP_A
293	SW	V> Start Any B	DDB_PRT_OVER_V_ANY_PICK_UP_B
294	SW	V> Start Any C	DDB_PRT_OVER_V_ANY_PICK_UP_C
295	SW	V>1 Start	DDB_PRT_OVER_V_1_PICK_UP
296	SW	V>2 Start	DDB_PRT_OVER_V_2_PICK_UP
297	SW	V>1 Trip	DDB_PRT_OVER_V_1_TRIP
298	SW	V>2 Trip	DDB_PRT_OVER_V_2_TRIP
299	SW	I2>1 Start	DDB_PRT_I2_SUP_PICK_UP_1
300	SW	I2>1 Trip	DDB_PRT_I2_SUP_TRIP_1
301	SW	I> Start Any A	DDB_PRT_I_SUP_ANY_PICK_UP_A
302	SW	I> Start Any B	DDB_PRT_I_SUP_ANY_PICK_UP_B

DDB No	Source	Description	Element Name
303	SW	I> Start Any C	DDB_PRT_I_SUP_ANY_PICK_UP_C
304	SW	I>1 Start	DDB_PRT_I_SUP_1_PICK_UP
305	SW	I>2 Start	DDB_PRT_I_SUP_2_PICK_UP
306	SW	I>3 Start	DDB_PRT_I_SUP_3_PICK_UP
307	SW	I>4 Start	DDB_PRT_I_SUP_4_PICK_UP
308	SW	I>1 Trip	DDB_PRT_I_SUP_1_TRIP
309	SW	I>2 Trip	DDB_PRT_I_SUP_2_TRIP
310	SW	I>3 Trip	DDB_PRT_I_SUP_3_TRIP
311	SW	I>4 Trip	DDB_PRT_I_SUP_4_TRIP
312	SW	SOTF Enable	DDB_PRT_SOTF_ENABLE
313	SW	TOR Enable	DDB_PRT_I_TOR_ENABLE
314	SW	TOC Start A	DDB_PRT_TOC_START_A
315	SW	TOC Start B	DDB_PRT_TOC_START_B
316	SW	TOC Start C	DDB_PRT_TOC_START_C
317	SW	Any Start	DDB_PRT_ANY_START
318	SW	1ph Fault	DDB_PRT_1PH
319	SW	2ph Fault	DDB_PRT_2PH
320	SW	3ph Fault	DDB_PRT_3PH
321	SW	Any Trip	DDB_PRT_ANY_TRIP
322	SW	Any Int. Trip A	DDB_PRT_ANY_INTERNAL_TRIP_A
323	SW	Any Int. Trip B	DDB_PRT_ANY_INTERNAL_TRIP_B
324	SW	Any Int. Trip C	DDB_PRT_ANY_INTERNAL_TRIP_C
325	SW	Any Trip A	DDB_PRT_ANY_TRIP_A
326	SW	Any Trip B	DDB_PRT_ANY_TRIP_B
327	SW	Any Trip C	DDB_PRT_ANY_TRIP_C
328	SW	1P Trip	DDB_PRT_1P_TRIP
329	SW	3P Trip	DDB_PRT_3P_TRIP
330	SW	Brk.Conduct.Trip	DDB_PRT_BROKEN_CONDUCTOR_TRIP
331	SW	Loss. Load Trip	DDB_PRT_LOSS_OF_LOAD_TRIP
332	SW	SOTF/TOR Trip	DDB_PRT_SOTF_TOR_TRIP
333	SW	tBF1 Trip	DDB_PRT_TBF1_TRIP_3PH
334	SW	tBF2 Trip	DDB_PRT_TBF2_TRIP_3PH
335	SW	Control Trip	DDB_PRT_CONTROL_TRIP
336	SW	Control Close	DDB_PRT_CONTROL_CLOSE
337	SW	VTS Fast	DDB_PRT_VTS_FAST
338	SW	CB Aux A	DDB_PRT_CB_AUX_A
339	SW	CB Aux B	DDB_PRT_CB_AUX_B
340	SW	CB Aux C	DDB_PRT_CB_AUX_C
341	SW	Any Pole Dead	DDB_PRT_ANY_POLE_DEAD
342	SW	All Pole Dead	DDB_PRT_ALL_POLE_DEAD
343	SW	DIST Fwd No Filt	DDB_PRT_DIR_AV_WIT_FILT
344	SW	DIST Rev No Filt	DDB_PRT_DIR_AM_WIT_FILT
345	SW	DIST Convergency	DDB_PRT_CVMR
346	SW	Cross Count. Flt	DDB_PRT_CROSS_COUNTRY

DDB No	Source	Description	Element Name
347	SW	ZSP Start	DDB_PRT_ZSP_START
348	SW	ZSP Trip	DDB_PRT_ZSP_TRIP
349	SW	Z1 Not Filtered	DDB_PRT_Z1_WIT_FILT
350	SW	Out Of Step	DDB_PRT_OUT_OF_STEP
351	SW	S. Swing	DDB_PRT_STABLE_SWING
352	SW	Out Of Step Conf	DDB_PRT_OUT_OF_STEP_CONF
353	SW	S. Swing Conf	DDB_PRT_STABLE_SWING_CONF
354	SW	Dist Start N	DDB_PRT_DIST_START_N
355	SW	IN>3 Trip	DDB_PRT_IN_SUP_3_TRIP
356	SW	IN>4 Trip	DDB_PRT_IN_SUP_4_TRIP
357	SW	IN>3 Start	DDB_PRT_IN_SUP_3_PICK_UP
358	SW	IN>4 Start	DDB_PRT_IN_SUP_4_PICK_UP
359	SW	PAP Trip A	DDB_PRT_PAP_TRIP_A
360	SW	PAP Trip B	DDB_PRT_PAP_TRIP_B
361	SW	PAP Trip C	DDB_PRT_PAP_TRIP_C
362	SW	PAP Trip IN	DDB_PRT_PAP_TRIP_IN
363	SW	PAP Start A	DDB_PRT_PAP_START_A
364	SW	PAP Start B	DDB_PRT_PAP_START_B
365	SW	PAP Start C	DDB_PRT_PAP_START_C
366	SW	PAP Pres IN	DDB_PRT_PAP_PRES_IN
367	SW	PAP Pre Start	DDB_PRT_PAP_PRE_START
368	SW	Trace Trig OK	DDB_PRT_TRACE_TRIG_OK
369	SW	Thermal Alarm	DDB_PRT_THERMAL_OVERL_ALARM
370	SW	Trip Thermal	DDB_PRT_THERMAL_OVERL_TRIP
371	SW	V<1 Start A	DDB_PRT_UNDER_V1_PICK_UP_A
372	SW	V<1 Start B	DDB_PRT_UNDER_V1_PICK_UP_B
373	SW	V<1 Start C	DDB_PRT_UNDER_V1_PICK_UP_C
374	SW	V<2 Start A	DDB_PRT_UNDER_V2_PICK_UP_A
375	SW	V<2 Start B	DDB_PRT_UNDER_V2_PICK_UP_B
376	SW	V<2 Start C	DDB_PRT_UNDER_V2_PICK_UP_C
377	SW	V>1 Start A	DDB_PRT_OVER_V1_PICK_UP_A
378	SW	V>1 Start B	DDB_PRT_OVER_V1_PICK_UP_B
379	SW	V>1 Start C	DDB_PRT_OVER_V1_PICK_UP_C
380	SW	V>2 Start A	DDB_PRT_OVER_V2_PICK_UP_A
381	SW	V>2 Start B	DDB_PRT_OVER_V2_PICK_UP_B
382	SW	V>2 Start C	DDB_PRT_OVER_V2_PICK_UP_C
383	SW	I2>2 Start	DDB_PRT_I2_SUP_PICK_UP_2
384	SW	I2>3 Start	DDB_PRT_I2_SUP_PICK_UP_3
385	SW	I2>4 Start	DDB_PRT_I2_SUP_PICK_UP_4
386	SW	I2>2 Trip	DDB_PRT_I2_SUP_TRIP_2
387	SW	I2>3 Trip	DDB_PRT_I2_SUP_TRIP_3
388	SW	I2>4 Trip	DDB_PRT_I2_SUP_TRIP_4
389	SW	VN>1 Start	DDB_PRT_OVER_V0_1_PICK_UP
390	SW	VN>2 Start	DDB_PRT_OVER_V0_2_PICK_UP

DDB No	Source	Description	Element Name
391	SW	VN>1 Trip	DDB_PRT_OVER_V0_1_TRIP
392	SW	VN>2 Trip	DDB_PRT_OVER_V0_2_TRIP
393	SW	Any Int. Trip	DDB_PRT_ANY_INTERNAL_TRIP
394	SW	Zq	DDB_PRT_ZQ
395	SW	Tzq	DDB_PRT_TZQ
396	SW	V<3 Start	DDB_PRT_UNDER_V_3_PICK_UP
397	SW	V<4 Start	DDB_PRT_UNDER_V_4_PICK_UP
398	SW	V<3 Start A	DDB_PRT_UNDER_V3_PICK_UP_A
399	SW	V<3 Start B	DDB_PRT_UNDER_V3_PICK_UP_B
400	SW	V<3 Start C	DDB_PRT_UNDER_V3_PICK_UP_C
401	SW	V<4 Start A	DDB_PRT_UNDER_V4_PICK_UP_A
402	SW	V<4 Start B	DDB_PRT_UNDER_V4_PICK_UP_B
403	SW	V<4 Start C	DDB_PRT_UNDER_V4_PICK_UP_C
404	SW	V<3 Trip	DDB_PRT_UNDER_V_3_TRIP
405	SW	V<4 Trip	DDB_PRT_UNDER_V_4_TRIP
406	SW	V>3 Start	DDB_PRT_OVER_V_3_PICK_UP
407	SW	V>4 Start	DDB_PRT_OVER_V_4_PICK_UP
408	SW	V>3 Start A	DDB_PRT_OVER_V3_PICK_UP_A
409	SW	V>3 Start B	DDB_PRT_OVER_V3_PICK_UP_B
410	SW	V>3 Start C	DDB_PRT_OVER_V3_PICK_UP_C
411	SW	V>4 Start A	DDB_PRT_OVER_V4_PICK_UP_A
412	SW	V>4 Start B	DDB_PRT_OVER_V4_PICK_UP_B
413	SW	V>4 Start C	DDB_PRT_OVER_V4_PICK_UP_C
414	SW	V>3 Trip	DDB_PRT_OVER_V_3_TRIP
415	SW	V>4 Trip	DDB_PRT_OVER_V_4_TRIP
416	SW	F<1 Start	DDB_PRT_F_UNDER_1_PICK_UP
417	SW	F<2 Start	DDB_PRT_F_UNDER_2_PICK_UP
418	SW	F<3 Start	DDB_PRT_F_UNDER_3_PICK_UP
419	SW	F<4 Start	DDB_PRT_F_UNDER_4_PICK_UP
420	SW	F<1 Trip	DDB_PRT_F_UNDER_1_TRIP
421	SW	F<2 Trip	DDB_PRT_F_UNDER_2_TRIP
422	SW	F<3 Trip	DDB_PRT_F_UNDER_3_TRIP
423	SW	F<4 Trip	DDB_PRT_F_UNDER_4_TRIP
424	SW	F>1 Start	DDB_PRT_F_OVER_1_PICK_UP
425	SW	F>2 Start	DDB_PRT_F_OVER_2_PICK_UP
426	SW	F>1 Trip	DDB_PRT_F_OVER_1_TRIP
427	SW	F>2 Trip	DDB_PRT_F_OVER_2_TRIP
428	SW	F Inhibit	DDB_PRT_F_INHIB
429	SW	I<1 Start	DDB_PRT_I_INF_1_PICK_UP
430	SW	I<2 Start	DDB_PRT_I_INF_2_PICK_UP
431	SW	I<1 Trip	DDB_PRT_I_INF_1_TRIP
432	SW	I<2 Trip	DDB_PRT_I_INF_2_TRIP
433	SW	SBO Open Org 1	DDB_PRT_SBO_OPEN_ORG1
434	SW	SBO Open Org 2	DDB_PRT_SBO_OPEN_ORG2

DDB No	Source	Description	Element Name
435	SW	SBO Open Org 3	DDB_PRT_SBO_OPEN_ORG3
436	SW	SBO Open Org 4	DDB_PRT_SBO_OPEN_ORG4
437	SW	SBO Closed Org 1	DDB_PRT_SBO_CLOSE_ORG1
438	SW	SBO Closed Org 2	DDB_PRT_SBO_CLOSE_ORG2
439	SW	SBO Closed Org 3	DDB_PRT_SBO_CLOSE_ORG3
440	SW	SBO Closed Org 4	DDB_PRT_SBO_CLOSE_ORG4
441	SW	DST status	DDB_DST_STATUS
442	SW	IRIG-B Status Signal Valid	DDB_IRIGB_SIGNAL_VALID
443	SW	Logic 0 for use in PSL. This can be used to force a DDB, contact, LED, InterMiCOM or Virtual Output low (or high by using an inversion gate)	DDB_LOGIC_0
444	PSL	Unused	DDB_UNUSED_444
445	PSL	Unused	DDB_UNUSED_445
446	PSL	Unused	DDB_UNUSED_446
447	PSL	Unused	DDB_UNUSED_447
448	PSL	Unused	DDB_UNUSED_448
449	PSL	Unused	DDB_UNUSED_449
450	PSL	Unused	DDB_UNUSED_450
451	PSL	Unused	DDB_UNUSED_451
452	PSL	Unused	DDB_UNUSED_452
453	PSL	Unused	DDB_UNUSED_453
454	PSL	Unused	DDB_UNUSED_454
455	PSL	Unused	DDB_UNUSED_455
456	PSL	Unused	DDB_UNUSED_456
457	PSL	Unused	DDB_UNUSED_457
458	PSL	Unused	DDB_UNUSED_458
459	PSL	Unused	DDB_UNUSED_459
460	PSL	Unused	DDB_UNUSED_460
461	PSL	Unused	DDB_UNUSED_461
462	PSL	Unused	DDB_UNUSED_462
463	PSL	Unused	DDB_UNUSED_463
464	PSL	Unused	DDB_UNUSED_464
465	PSL	Unused	DDB_UNUSED_465
466	PSL	Unused	DDB_UNUSED_466
467	PSL	Unused	DDB_UNUSED_467
468	PSL	Fault_REC_TRIG	DDB_FAULT_RECORD_TRIG
469	SW	Battery Fail	DDB_PLAT_BATTERY_FAIL_ALARM
470	SW	Field Volt Fail	DDB_PLAT_FIELD_VOLT_FAIL_ALARM
471	SW	Comm2 H/W FAIL	DDB_REAR_COMMS_FAIL_ALARM_66
472	SW	GOOSE IED Absent	DDB_GOOSE_IED_MISSING_ALARM_67
473	SW	NIC Not Fitted	DDB_ECARD_NOT_FITTED_ALARM_68
474	SW	NIC No Response	DDB_NIC_NOT_RESPONDING_69
475	SW	NIC Fatal Error	DDB_NIC_FATAL_ERROR_70
476	SW	NIC Soft. Reload	DDB_NIC_SOFTWARE_RELOAD_71
477	SW	Bad TCP/IP Cfg.	DDB_INVALID_NIC_TCP_IP_CONFIG_72

DDB No	Source	Description	Element Name
478	SW	Bad OSI Config.	DDB_INVALID_NIC_OSI_CONFIG_73
479	SW	Unused	DDB_ALARM_UNUSED_479
480	SW	NIC SW Mis-Match	DDB_SW_MISMATCH_ALARM
481	SW	IP Addr Conflict	DDB_NIC_IP_ADDRESS_CONFLICT_76
482	SW	IM Loopback	DDB_INTERMICOM_LOOPBACK_ALARM_77
483	SW	IM Message Fail	DDB_INTERMICOM_MESSAGE_ALARM_78
484	SW	IM Data CD Fail	DDB_INTERMICOM_DCD_ALARM_79
485	SW	IM Channel Fail	DDB_INTERMICOM_CHANNEL_ALARM_80
486	SW	Backup Setting	DDB_BACKUP_SETTING_ALARM_81
487	SW	Bad DNP Settings	DDB_DNPEV_BAD_SETTINGS_ALARM_82
488	SW	Backup Usr Curve	DDB_USER_CURVE_BACKUP_ALARM_83
489	SW	Full DR Alarm	DDB_DR_RECORD_FULL_ALARM_84
490	SW	Invalid DNPoE IP Configuration Alarm	DDB_INVALID_DNPOE_IP_ALARM
491	SW	Invalid Config.	DDB_INVALID_CONFIG_ALARM
492	SW	Test Mode Activated Alarm	DDB_TEST_MODE_ALARM
493	SW	Contacts Blocked Alarm	DDB_CONT_BLK_ALARM
494	SW	NIC HW Mismatch	DDB_HW_MISMATCH_ALARM
495	SW	NIC APP Mismatch	DDB_IEC61850_VER_MISMATCH_ALARM
496	SW	Simul.GOOSE Alm	DDB_GS_ACEPT_SIMU_ALM
497	PSL	Unused	DDB_ALARM_UNUSED_497
498	PSL	Unused	DDB_ALARM_UNUSED_498
499	PSL	Unused	DDB_ALARM_UNUSED_499
500	PSL	Unused	DDB_ALARM_UNUSED_500
501	PSL	Unused	DDB_UNUSED_501
502	PSL	Unused	DDB_UNUSED_502
503	PSL	Unused	DDB_UNUSED_503
504	PSL	Unused	DDB_UNUSED_504
505	PSL	Unused	DDB_UNUSED_505
506	PSL	Unused	DDB_UNUSED_506
507	PSL	Unused	DDB_UNUSED_507
508	PSL	Unused	DDB_UNUSED_508
509	PSL	Unused	DDB_UNUSED_509
510	PSL	Unused	DDB_UNUSED_510
511	PSL	Unused	DDB_UNUSED_511
512	PSL	Virtual Output 1	DDB_GOOSEOUT_1
513	PSL	Virtual Output 2	DDB_GOOSEOUT_2
514	PSL	Virtual Output 3	DDB_GOOSEOUT_3
515	PSL	Virtual Output 4	DDB_GOOSEOUT_4
516	PSL	Virtual Output 5	DDB_GOOSEOUT_5
517	PSL	Virtual Output 6	DDB_GOOSEOUT_6
518	PSL	Virtual Output 7	DDB_GOOSEOUT_7
519	PSL	Virtual Output 8	DDB_GOOSEOUT_8
520	PSL	Virtual Output 9	DDB_GOOSEOUT_9
521	PSL	Virtual Output10	DDB_GOOSEOUT_10

DDB No	Source	Description	Element Name
522	PSL	Virtual Output11	DDB_GOOSEOUT_11
523	PSL	Virtual Output12	DDB_GOOSEOUT_12
524	PSL	Virtual Output13	DDB_GOOSEOUT_13
525	PSL	Virtual Output14	DDB_GOOSEOUT_14
526	PSL	Virtual Output15	DDB_GOOSEOUT_15
527	PSL	Virtual Output16	DDB_GOOSEOUT_16
528	PSL	Virtual Output17	DDB_GOOSEOUT_17
529	PSL	Virtual Output18	DDB_GOOSEOUT_18
530	PSL	Virtual Output19	DDB_GOOSEOUT_19
531	PSL	Virtual Output20	DDB_GOOSEOUT_20
532	PSL	Virtual Output21	DDB_GOOSEOUT_21
533	PSL	Virtual Output22	DDB_GOOSEOUT_22
534	PSL	Virtual Output23	DDB_GOOSEOUT_23
535	PSL	Virtual Output24	DDB_GOOSEOUT_24
536	PSL	Virtual Output25	DDB_GOOSEOUT_25
537	PSL	Virtual Output26	DDB_GOOSEOUT_26
538	PSL	Virtual Output27	DDB_GOOSEOUT_27
539	PSL	Virtual Output28	DDB_GOOSEOUT_28
540	PSL	Virtual Output29	DDB_GOOSEOUT_29
541	PSL	Virtual Output30	DDB_GOOSEOUT_30
542	PSL	Virtual Output31	DDB_GOOSEOUT_31
543	PSL	Virtual Output32	DDB_GOOSEOUT_32
544	PSL	Unused	DDB_UNUSED_544
545	PSL	Unused	DDB_UNUSED_545
546	PSL	Unused	DDB_UNUSED_546
547	PSL	Unused	DDB_UNUSED_547
548	PSL	Unused	DDB_UNUSED_548
549	PSL	Unused	DDB_UNUSED_549
550	PSL	Unused	DDB_UNUSED_550
551	PSL	Unused	DDB_UNUSED_551
552	PSL	Unused	DDB_UNUSED_552
553	PSL	Unused	DDB_UNUSED_553
554	PSL	Unused	DDB_UNUSED_554
555	PSL	Unused	DDB_UNUSED_555
556	PSL	Unused	DDB_UNUSED_556
557	PSL	Unused	DDB_UNUSED_557
558	PSL	Unused	DDB_UNUSED_558
559	PSL	Unused	DDB_UNUSED_559
560	PSL	Unused	DDB_UNUSED_560
561	PSL	Unused	DDB_UNUSED_561
562	PSL	Unused	DDB_UNUSED_562
563	PSL	Unused	DDB_UNUSED_563
564	PSL	Unused	DDB_UNUSED_564
565	PSL	Unused	DDB_UNUSED_565

DDB No	Source	Description	Element Name
566	PSL	Unused	DDB_UNUSED_566
567	PSL	Unused	DDB_UNUSED_567
568	PSL	Unused	DDB_UNUSED_568
569	PSL	Unused	DDB_UNUSED_569
570	PSL	Unused	DDB_UNUSED_570
571	PSL	Unused	DDB_UNUSED_571
572	PSL	Unused	DDB_UNUSED_572
573	PSL	Unused	DDB_UNUSED_573
574	PSL	Unused	DDB_UNUSED_574
575	PSL	Unused	DDB_UNUSED_575
576	SW	InterMiCOM in 1	DDB_INTERIN_1
577	SW	InterMiCOM in 2	DDB_INTERIN_2
578	SW	InterMiCOM in 3	DDB_INTERIN_3
579	SW	InterMiCOM in 4	DDB_INTERIN_4
580	SW	InterMiCOM in 5	DDB_INTERIN_5
581	SW	InterMiCOM in 6	DDB_INTERIN_6
582	SW	InterMiCOM in 7	DDB_INTERIN_7
583	SW	InterMiCOM in 8	DDB_INTERIN_8
584	PSL	InterMiCOM out 1	DDB_INTEROUT_1
585	PSL	InterMiCOM out 2	DDB_INTEROUT_2
586	PSL	InterMiCOM out 3	DDB_INTEROUT_3
587	PSL	InterMiCOM out 4	DDB_INTEROUT_4
588	PSL	InterMiCOM out 5	DDB_INTEROUT_5
589	PSL	InterMiCOM out 6	DDB_INTEROUT_6
590	PSL	InterMiCOM out 7	DDB_INTEROUT_7
591	PSL	InterMiCOM out 8	DDB_INTEROUT_8
592	PSL	Unused	DDB_UNUSED_592
593	PSL	Unused	DDB_UNUSED_593
594	PSL	Unused	DDB_UNUSED_594
595	PSL	Unused	DDB_UNUSED_595
596	PSL	Unused	DDB_UNUSED_596
597	PSL	Unused	DDB_UNUSED_597
598	PSL	Unused	DDB_UNUSED_598
599	PSL	Unused	DDB_UNUSED_599
600	PSL	Unused	DDB_UNUSED_600
601	PSL	Unused	DDB_UNUSED_601
602	PSL	Unused	DDB_UNUSED_602
603	PSL	Unused	DDB_UNUSED_603
604	PSL	Unused	DDB_UNUSED_604
605	PSL	Unused	DDB_UNUSED_605
606	PSL	Unused	DDB_UNUSED_606
607	PSL	Unused	DDB_UNUSED_607
608	SW	Control Input 1	DDB_CTRL_IP_1
609	SW	Control Input 2	DDB_CTRL_IP_2

DDB No	Source	Description	Element Name
610	SW	Control Input 3	DDB_CTRL_IP_3
611	SW	Control Input 4	DDB_CTRL_IP_4
612	SW	Control Input 5	DDB_CTRL_IP_5
613	SW	Control Input 6	DDB_CTRL_IP_6
614	SW	Control Input 7	DDB_CTRL_IP_7
615	SW	Control Input 8	DDB_CTRL_IP_8
616	SW	Control Input 9	DDB_CTRL_IP_9
617	SW	Control Input 10	DDB_CTRL_IP_10
618	SW	Control Input 11	DDB_CTRL_IP_11
619	SW	Control Input 12	DDB_CTRL_IP_12
620	SW	Control Input 13	DDB_CTRL_IP_13
621	SW	Control Input 14	DDB_CTRL_IP_14
622	SW	Control Input 15	DDB_CTRL_IP_15
623	SW	Control Input 16	DDB_CTRL_IP_16
624	SW	Control Input 17	DDB_CTRL_IP_17
625	SW	Control Input 18	DDB_CTRL_IP_18
626	SW	Control Input 19	DDB_CTRL_IP_19
627	SW	Control Input 20	DDB_CTRL_IP_20
628	SW	Control Input 21	DDB_CTRL_IP_21
629	SW	Control Input 22	DDB_CTRL_IP_22
630	SW	Control Input 23	DDB_CTRL_IP_23
631	SW	Control Input 24	DDB_CTRL_IP_24
632	SW	Control Input 25	DDB_CTRL_IP_25
633	SW	Control Input 26	DDB_CTRL_IP_26
634	SW	Control Input 27	DDB_CTRL_IP_27
635	SW	Control Input 28	DDB_CTRL_IP_28
636	SW	Control Input 29	DDB_CTRL_IP_29
637	SW	Control Input 30	DDB_CTRL_IP_30
638	SW	Control Input 31	DDB_CTRL_IP_31
639	SW	Control Input 32	DDB_CTRL_IP_32
640	SW	LED 1 Red	DDB_OUTPUT_TRI_LED_1_RED
641	SW	LED 1 Grn	DDB_OUTPUT_TRI_LED_1_GRN
642	SW	LED 2 Red	DDB_OUTPUT_TRI_LED_2_RED
643	SW	LED 2 Grn	DDB_OUTPUT_TRI_LED_2_GRN
644	SW	LED 3 Red	DDB_OUTPUT_TRI_LED_3_RED
645	SW	LED 3 Grn	DDB_OUTPUT_TRI_LED_3_GRN
646	SW	LED 4 Red	DDB_OUTPUT_TRI_LED_4_RED
647	SW	LED 4 Grn	DDB_OUTPUT_TRI_LED_4_GRN
648	SW	LED 5 Red	DDB_OUTPUT_TRI_LED_5_RED
649	SW	LED 5 Grn	DDB_OUTPUT_TRI_LED_5_GRN
650	SW	LED 6 Red	DDB_OUTPUT_TRI_LED_6_RED
651	SW	LED 6 Grn	DDB_OUTPUT_TRI_LED_6_GRN
652	SW	LED 7 Red	DDB_OUTPUT_TRI_LED_7_RED
653	SW	LED 7 Grn	DDB_OUTPUT_TRI_LED_7_GRN

DDB No	Source	Description	Element Name
654	SW	LED 8 Red	DDB_OUTPUT_TRI_LED_8_RED
655	SW	LED 8 Grn	DDB_OUTPUT_TRI_LED_8_GRN
656	SW	FnKey LED 1 Red	DDB_OUTPUT_TRI_LED_9_RED
657	SW	FnKey LED 1 Grn	DDB_OUTPUT_TRI_LED_9_GRN
658	SW	FnKey LED 2 Red	DDB_OUTPUT_TRI_LED_10_RED
659	SW	FnKey LED 2 Grn	DDB_OUTPUT_TRI_LED_10_GRN
660	SW	FnKey LED 3 Red	DDB_OUTPUT_TRI_LED_11_RED
661	SW	FnKey LED 3 Grn	DDB_OUTPUT_TRI_LED_11_GRN
662	SW	FnKey LED 4 Red	DDB_OUTPUT_TRI_LED_12_RED
663	SW	FnKey LED 4 Grn	DDB_OUTPUT_TRI_LED_12_GRN
664	SW	FnKey LED 5 Red	DDB_OUTPUT_TRI_LED_13_RED
665	SW	FnKey LED 5 Grn	DDB_OUTPUT_TRI_LED_13_GRN
666	SW	FnKey LED 6 Red	DDB_OUTPUT_TRI_LED_14_RED
667	SW	FnKey LED 6 Grn	DDB_OUTPUT_TRI_LED_14_GRN
668	SW	FnKey LED 7 Red	DDB_OUTPUT_TRI_LED_15_RED
669	SW	FnKey LED 7 Grn	DDB_OUTPUT_TRI_LED_15_GRN
670	SW	FnKey LED 8 Red	DDB_OUTPUT_TRI_LED_16_RED
671	SW	FnKey LED 8 Grn	DDB_OUTPUT_TRI_LED_16_GRN
672	SW	FnKey LED 9 Red	DDB_OUTPUT_TRI_LED_17_RED
673	SW	FnKey LED 9 Grn	DDB_OUTPUT_TRI_LED_17_GRN
674	SW	FnKey LED 10 Red	DDB_OUTPUT_TRI_LED_18_RED
675	SW	FnKey LED 10 Grn	DDB_OUTPUT_TRI_LED_18_GRN
676	SW	Function Key 1	DDB_FN_KEY_1
677	SW	Function Key 2	DDB_FN_KEY_2
678	SW	Function Key 3	DDB_FN_KEY_3
679	SW	Function Key 4	DDB_FN_KEY_4
680	SW	Function Key 5	DDB_FN_KEY_5
681	SW	Function Key 6	DDB_FN_KEY_6
682	SW	Function Key 7	DDB_FN_KEY_7
683	SW	Function Key 8	DDB_FN_KEY_8
684	SW	Function Key 9	DDB_FN_KEY_9
685	SW	Function Key 10	DDB_FN_KEY_10
686	PSL	Unused	DDB_UNUSED_686
687	PSL	Unused	DDB_UNUSED_687
688	PSL	Unused	DDB_UNUSED_688
689	PSL	Unused	DDB_UNUSED_689
690	PSL	Unused	DDB_UNUSED_690
691	PSL	Unused	DDB_UNUSED_691
692	PSL	Unused	DDB_UNUSED_692
693	PSL	Unused	DDB_UNUSED_693
694	PSL	Unused	DDB_UNUSED_694
695	PSL	Unused	DDB_UNUSED_695
696	PSL	Unused	DDB_UNUSED_696
697	PSL	Unused	DDB_UNUSED_697

DDB No	Source	Description	Element Name
698	PSL	Unused	DDB_UNUSED_698
699	PSL	Unused	DDB_UNUSED_699
700	PSL	Relay 1	DDB_OUTPUT_CON_1
701	PSL	Relay 2	DDB_OUTPUT_CON_2
702	PSL	Relay 3	DDB_OUTPUT_CON_3
703	PSL	Relay 4	DDB_OUTPUT_CON_4
704	PSL	Relay 5	DDB_OUTPUT_CON_5
705	PSL	Relay 6	DDB_OUTPUT_CON_6
706	PSL	Relay 7	DDB_OUTPUT_CON_7
707	PSL	Relay 8	DDB_OUTPUT_CON_8
708	PSL	Relay 9	DDB_OUTPUT_CON_9
709	PSL	Relay 10	DDB_OUTPUT_CON_10
710	PSL	Relay 11	DDB_OUTPUT_CON_11
711	PSL	Relay 12	DDB_OUTPUT_CON_12
712	PSL	Relay 13	DDB_OUTPUT_CON_13
713	PSL	Relay 14	DDB_OUTPUT_CON_14
714	PSL	Relay 15	DDB_OUTPUT_CON_15
715	PSL	Relay 16	DDB_OUTPUT_CON_16
716	PSL	Relay 17	DDB_OUTPUT_CON_17
717	PSL	Relay 18	DDB_OUTPUT_CON_18
718	PSL	Relay 19	DDB_OUTPUT_CON_19
719	PSL	Relay 20	DDB_OUTPUT_CON_20
720	PSL	Relay 21	DDB_OUTPUT_CON_21
721	PSL	Relay 22	DDB_OUTPUT_CON_22
722	PSL	Relay 23	DDB_OUTPUT_CON_23
723	PSL	Relay 24	DDB_OUTPUT_CON_24
724	PSL	Relay 25	DDB_OUTPUT_CON_25
725	PSL	Relay 26	DDB_OUTPUT_CON_26
726	PSL	Relay 27	DDB_OUTPUT_CON_27
727	PSL	Relay 28	DDB_OUTPUT_CON_28
728	PSL	Relay 29	DDB_OUTPUT_CON_29
729	PSL	Relay 30	DDB_OUTPUT_CON_30
730	PSL	Relay 31	DDB_OUTPUT_CON_31
731	PSL	Relay 32	DDB_OUTPUT_CON_32
732	PSL	Relay 33	DDB_OUTPUT_CON_33
733	PSL	Relay 34	DDB_OUTPUT_CON_34
734	PSL	Relay 35	DDB_OUTPUT_CON_35
735	PSL	Relay 36	DDB_OUTPUT_CON_36
736	PSL	Relay 37	DDB_OUTPUT_CON_37
737	PSL	Relay 38	DDB_OUTPUT_CON_38
738	PSL	Relay 39	DDB_OUTPUT_CON_39
739	PSL	Relay 40	DDB_OUTPUT_CON_40
740	PSL	Relay 41	DDB_OUTPUT_CON_41
741	PSL	Relay 42	DDB_OUTPUT_CON_42

DDB No	Source	Description	Element Name
742	PSL	Relay 43	DDB_OUTPUT_CON_43
743	PSL	Relay 44	DDB_OUTPUT_CON_44
744	PSL	Relay 45	DDB_OUTPUT_CON_45
745	PSL	Relay 46	DDB_OUTPUT_CON_46
746	PSL	Relay 47	DDB_OUTPUT_CON_47
747	PSL	Relay 48	DDB_OUTPUT_CON_48
748	PSL	Relay 49	DDB_OUTPUT_CON_49
749	PSL	Relay 50	DDB_OUTPUT_CON_50
750	PSL	Relay 51	DDB_OUTPUT_CON_51
751	PSL	Relay 52	DDB_OUTPUT_CON_52
752	PSL	Relay 53	DDB_OUTPUT_CON_53
753	PSL	Relay 54	DDB_OUTPUT_CON_54
754	PSL	Relay 55	DDB_OUTPUT_CON_55
755	PSL	Relay 56	DDB_OUTPUT_CON_56
756	PSL	Relay 57	DDB_OUTPUT_CON_57
757	PSL	Relay 58	DDB_OUTPUT_CON_58
758	PSL	Relay 59	DDB_OUTPUT_CON_59
759	PSL	Relay 60	DDB_OUTPUT_CON_60
760	PSL	Relay 61	DDB_OUTPUT_CON_61
761	PSL	Relay 62	DDB_OUTPUT_CON_62
762	PSL	Relay 63	DDB_OUTPUT_CON_63
763	PSL	Relay 64	DDB_OUTPUT_CON_64
764	PSL	LED 1 Red Condit	DDB_TRI_LED_RED_CON_1
765	PSL	LED 1 Grn Condit	DDB_TRI_LED_GRN_CON_1
766	PSL	LED 2 Red Condit	DDB_TRI_LED_RED_CON_2
767	PSL	LED 2 Grn Condit	DDB_TRI_LED_GRN_CON_2
768	PSL	LED 3 Red Condit	DDB_TRI_LED_RED_CON_3
769	PSL	LED 3 Grn Condit	DDB_TRI_LED_GRN_CON_3
770	PSL	LED 4 Red Condit	DDB_TRI_LED_RED_CON_4
771	PSL	LED 4 Grn Condit	DDB_TRI_LED_GRN_CON_4
772	PSL	LED 5 Red Condit	DDB_TRI_LED_RED_CON_5
773	PSL	LED 5 Grn Condit	DDB_TRI_LED_GRN_CON_5
774	PSL	LED 6 Red Condit	DDB_TRI_LED_RED_CON_6
775	PSL	LED 6 Grn Condit	DDB_TRI_LED_GRN_CON_6
776	PSL	LED 7 Red Condit	DDB_TRI_LED_RED_CON_7
777	PSL	LED 7 Grn Condit	DDB_TRI_LED_GRN_CON_7
778	PSL	LED 8 Red Condit	DDB_TRI_LED_RED_CON_8
779	PSL	LED 8 Grn Condit	DDB_TRI_LED_GRN_CON_8
780	PSL	FnKey LED 1 Red	DDB_TRI_LED_RED_CON_9
781	PSL	FnKey LED 1 Grn	DDB_TRI_LED_GRN_CON_9
782	PSL	FnKey LED 2 Red	DDB_TRI_LED_RED_CON_10
783	PSL	FnKey LED 2 Grn	DDB_TRI_LED_GRN_CON_10
784	PSL	FnKey LED 3 Red	DDB_TRI_LED_RED_CON_11
785	PSL	FnKey LED 3 Grn	DDB_TRI_LED_GRN_CON_11

DDB No	Source	Description	Element Name
786	PSL	FnKey LED 4 Red	DDB_TRI_LED_RED_CON_12
787	PSL	FnKey LED 4 Grn	DDB_TRI_LED_GRN_CON_12
788	PSL	FnKey LED 5 Red	DDB_TRI_LED_RED_CON_13
789	PSL	FnKey LED 5 Grn	DDB_TRI_LED_GRN_CON_13
790	PSL	FnKey LED 6 Red	DDB_TRI_LED_RED_CON_14
791	PSL	FnKey LED 6 Grn	DDB_TRI_LED_GRN_CON_14
792	PSL	FnKey LED 7 Red	DDB_TRI_LED_RED_CON_15
793	PSL	FnKey LED 7 Grn	DDB_TRI_LED_GRN_CON_15
794	PSL	FnKey LED 8 Red	DDB_TRI_LED_RED_CON_16
795	PSL	FnKey LED 8 Grn	DDB_TRI_LED_GRN_CON_16
796	PSL	FnKey LED 9 Red	DDB_TRI_LED_RED_CON_17
797	PSL	FnKey LED 9 Grn	DDB_TRI_LED_GRN_CON_17
798	PSL	FnKey LED 10 Red	DDB_TRI_LED_RED_CON_18
799	PSL	FnKey LED 10 Grn	DDB_TRI_LED_GRN_CON_18
800	PSL	Unused	DDB_UNUSED_800
801	PSL	Unused	DDB_UNUSED_801
802	PSL	Unused	DDB_UNUSED_802
803	PSL	Unused	DDB_UNUSED_803
804	PSL	Unused	DDB_UNUSED_804
805	PSL	Unused	DDB_UNUSED_805
806	PSL	Unused	DDB_UNUSED_806
807	PSL	Unused	DDB_UNUSED_807
808	PSL	Unused	DDB_UNUSED_808
809	PSL	Unused	DDB_UNUSED_809
810	PSL	Unused	DDB_UNUSED_810
811	PSL	Unused	DDB_UNUSED_811
812	PSL	Unused	DDB_UNUSED_812
813	PSL	Unused	DDB_UNUSED_813
814	PSL	Unused	DDB_UNUSED_814
815	PSL	Unused	DDB_UNUSED_815
816	PSL	Unused	DDB_UNUSED_816
817	PSL	Unused	DDB_UNUSED_817
818	PSL	Unused	DDB_UNUSED_818
819	PSL	Unused	DDB_UNUSED_819
820	PSL	Unused	DDB_UNUSED_820
821	PSL	Unused	DDB_UNUSED_821
822	PSL	Unused	DDB_UNUSED_822
823	PSL	Unused	DDB_UNUSED_823
824	PSL	Unused	DDB_UNUSED_824
825	PSL	Unused	DDB_UNUSED_825
826	PSL	Unused	DDB_UNUSED_826
827	PSL	Unused	DDB_UNUSED_827
828	PSL	Unused	DDB_UNUSED_828
829	PSL	Unused	DDB_UNUSED_829

DDB No	Source	Description	Element Name
830	PSL	Timer in 1	DDB_TIMERIN_1
831	PSL	Timer in 2	DDB_TIMERIN_2
832	PSL	Timer in 3	DDB_TIMERIN_3
833	PSL	Timer in 4	DDB_TIMERIN_4
834	PSL	Timer in 5	DDB_TIMERIN_5
835	PSL	Timer in 6	DDB_TIMERIN_6
836	PSL	Timer in 7	DDB_TIMERIN_7
837	PSL	Timer in 8	DDB_TIMERIN_8
838	PSL	Timer in 9	DDB_TIMERIN_9
839	PSL	Timer in 10	DDB_TIMERIN_10
840	PSL	Timer in 11	DDB_TIMERIN_11
841	PSL	Timer in 12	DDB_TIMERIN_12
842	PSL	Timer in 13	DDB_TIMERIN_13
843	PSL	Timer in 14	DDB_TIMERIN_14
844	PSL	Timer in 15	DDB_TIMERIN_15
845	PSL	Timer in 16	DDB_TIMERIN_16
846	SW	Timer out 1	DDB_TIMEROUT_1
847	SW	Timer out 2	DDB_TIMEROUT_2
848	SW	Timer out 3	DDB_TIMEROUT_3
849	SW	Timer out 4	DDB_TIMEROUT_4
850	SW	Timer out 5	DDB_TIMEROUT_5
851	SW	Timer out 6	DDB_TIMEROUT_6
852	SW	Timer out 7	DDB_TIMEROUT_7
853	SW	Timer out 8	DDB_TIMEROUT_8
854	SW	Timer out 9	DDB_TIMEROUT_9
855	SW	Timer out 10	DDB_TIMEROUT_10
856	SW	Timer out 11	DDB_TIMEROUT_11
857	SW	Timer out 12	DDB_TIMEROUT_12
858	SW	Timer out 13	DDB_TIMEROUT_13
859	SW	Timer out 14	DDB_TIMEROUT_14
860	SW	Timer out 15	DDB_TIMEROUT_15
861	SW	Timer out 16	DDB_TIMEROUT_16
862	PSL	Unused	DDB_UNUSED_862
863	PSL	Unused	DDB_UNUSED_863
864	PSL	Unused	DDB_UNUSED_864
865	PSL	Unused	DDB_UNUSED_865
866	PSL	Unused	DDB_UNUSED_866
867	PSL	Unused	DDB_UNUSED_867
868	PSL	Unused	DDB_UNUSED_868
869	PSL	Unused	DDB_UNUSED_869
870	PSL	Unused	DDB_UNUSED_870
871	PSL	Unused	DDB_UNUSED_871
872	PSL	Unused	DDB_UNUSED_872
873	PSL	Unused	DDB_UNUSED_873

DDB No	Source	Description	Element Name
874	PSL	Unused	DDB_UNUSED_874
875	PSL	Unused	DDB_UNUSED_875
876	PSL	Unused	DDB_UNUSED_876
877	PSL	Unused	DDB_UNUSED_877
878	PSL	Unused	DDB_UNUSED_878
879	PSL	Unused	DDB_UNUSED_879
880	PSL	Unused	DDB_UNUSED_880
881	PSL	Unused	DDB_UNUSED_881
882	PSL	Unused	DDB_UNUSED_882
883	PSL	Unused	DDB_UNUSED_883
884	PSL	Unused	DDB_UNUSED_884
885	PSL	Unused	DDB_UNUSED_885
886	PSL	Unused	DDB_UNUSED_886
887	PSL	Unused	DDB_UNUSED_887
888	PSL	Unused	DDB_UNUSED_888
889	PSL	Unused	DDB_UNUSED_889
890	PSL	Unused	DDB_UNUSED_890
891	PSL	Unused	DDB_UNUSED_891
892	PSL	Unused	DDB_UNUSED_892
893	PSL	Unused	DDB_UNUSED_893
894	PSL	Unused	DDB_UNUSED_894
895	PSL	Unused	DDB_UNUSED_895
896	PSL	Unused	DDB_UNUSED_896
897	PSL	Unused	DDB_UNUSED_897
898	PSL	Unused	DDB_UNUSED_898
899	PSL	Unused	DDB_UNUSED_899
900	PSL	Unused	DDB_UNUSED_900
901	PSL	Unused	DDB_UNUSED_901
902	PSL	Unused	DDB_UNUSED_902
903	PSL	Unused	DDB_UNUSED_903
904	PSL	Unused	DDB_UNUSED_904
905	PSL	Unused	DDB_UNUSED_905
906	PSL	Unused	DDB_UNUSED_906
907	PSL	Unused	DDB_UNUSED_907
908	PSL	Unused	DDB_UNUSED_908
909	PSL	Unused	DDB_UNUSED_909
910	PSL	Unused	DDB_UNUSED_910
911	PSL	Unused	DDB_UNUSED_911
912	PSL	Unused	DDB_UNUSED_912
913	PSL	Unused	DDB_UNUSED_913
914	PSL	Unused	DDB_UNUSED_914
915	PSL	Unused	DDB_UNUSED_915
916	PSL	Unused	DDB_UNUSED_916
917	PSL	Unused	DDB_UNUSED_917

DDB No	Source	Description	Element Name
918	PSL	Unused	DDB_UNUSED_918
919	PSL	Unused	DDB_UNUSED_919
920	PSL	Unused	DDB_UNUSED_920
921	PSL	Unused	DDB_UNUSED_921
922	PSL	Unused	DDB_UNUSED_922
923	PSL	Int. Node 923	DDB_PSLINT_1
924	PSL	Int. Node 924	DDB_PSLINT_2
925	PSL	Int. Node 925	DDB_PSLINT_3
926	PSL	Int. Node 926	DDB_PSLINT_4
927	PSL	Int. Node 927	DDB_PSLINT_5
928	PSL	Int. Node 928	DDB_PSLINT_6
929	PSL	Int. Node 929	DDB_PSLINT_7
930	PSL	Int. Node 930	DDB_PSLINT_8
931	PSL	Int. Node 931	DDB_PSLINT_9
932	PSL	Int. Node 932	DDB_PSLINT_10
933	PSL	Int. Node 933	DDB_PSLINT_11
934	PSL	Int. Node 934	DDB_PSLINT_12
935	PSL	Int. Node 935	DDB_PSLINT_13
936	PSL	Int. Node 936	DDB_PSLINT_14
937	PSL	Int. Node 937	DDB_PSLINT_15
938	PSL	Int. Node 938	DDB_PSLINT_16
939	PSL	Int. Node 939	DDB_PSLINT_17
940	PSL	Int. Node 940	DDB_PSLINT_18
941	PSL	Int. Node 941	DDB_PSLINT_19
942	PSL	Int. Node 942	DDB_PSLINT_20
943	PSL	Int. Node 943	DDB_PSLINT_21
944	PSL	Int. Node 944	DDB_PSLINT_22
945	PSL	Int. Node 945	DDB_PSLINT_23
946	PSL	Int. Node 946	DDB_PSLINT_24
947	PSL	Int. Node 947	DDB_PSLINT_25
948	PSL	Int. Node 948	DDB_PSLINT_26
949	PSL	Int. Node 949	DDB_PSLINT_27
950	PSL	Int. Node 950	DDB_PSLINT_28
951	PSL	Int. Node 951	DDB_PSLINT_29
952	PSL	Int. Node 952	DDB_PSLINT_30
953	PSL	Int. Node 953	DDB_PSLINT_31
954	PSL	Int. Node 954	DDB_PSLINT_32
955	PSL	Int. Node 955	DDB_PSLINT_33
956	PSL	Int. Node 956	DDB_PSLINT_34
957	PSL	Int. Node 957	DDB_PSLINT_35
958	PSL	Int. Node 958	DDB_PSLINT_36
959	PSL	Int. Node 959	DDB_PSLINT_37
960	PSL	Int. Node 960	DDB_PSLINT_38
961	PSL	Int. Node 961	DDB_PSLINT_39

DDB No	Source	Description	Element Name
962	PSL	Int. Node 962	DDB_PSLINT_40
963	PSL	Int. Node 963	DDB_PSLINT_41
964	PSL	Int. Node 964	DDB_PSLINT_42
965	PSL	Int. Node 965	DDB_PSLINT_43
966	PSL	Int. Node 966	DDB_PSLINT_44
967	PSL	Int. Node 967	DDB_PSLINT_45
968	PSL	Int. Node 968	DDB_PSLINT_46
969	PSL	Int. Node 969	DDB_PSLINT_47
970	PSL	Int. Node 970	DDB_PSLINT_48
971	PSL	Int. Node 971	DDB_PSLINT_49
972	PSL	Int. Node 972	DDB_PSLINT_50
973	PSL	Int. Node 973	DDB_PSLINT_51
974	PSL	Int. Node 974	DDB_PSLINT_52
975	PSL	Int. Node 975	DDB_PSLINT_53
976	PSL	Int. Node 976	DDB_PSLINT_54
977	PSL	Int. Node 977	DDB_PSLINT_55
978	PSL	Int. Node 978	DDB_PSLINT_56
979	PSL	Int. Node 979	DDB_PSLINT_57
980	PSL	Int. Node 980	DDB_PSLINT_58
981	PSL	Int. Node 981	DDB_PSLINT_59
982	PSL	Int. Node 982	DDB_PSLINT_60
983	PSL	Int. Node 983	DDB_PSLINT_61
984	PSL	Int. Node 984	DDB_PSLINT_62
985	PSL	Int. Node 985	DDB_PSLINT_63
986	PSL	Int. Node 986	DDB_PSLINT_64
987	PSL	Int. Node 987	DDB_PSLINT_65
988	PSL	Int. Node 988	DDB_PSLINT_66
989	PSL	Int. Node 989	DDB_PSLINT_67
990	PSL	Int. Node 990	DDB_PSLINT_68
991	PSL	Int. Node 991	DDB_PSLINT_69
992	PSL	Int. Node 992	DDB_PSLINT_70
993	PSL	Int. Node 993	DDB_PSLINT_71
994	PSL	Int. Node 994	DDB_PSLINT_72
995	PSL	Int. Node 995	DDB_PSLINT_73
996	PSL	Int. Node 996	DDB_PSLINT_74
997	PSL	Int. Node 997	DDB_PSLINT_75
998	PSL	Int. Node 998	DDB_PSLINT_76
999	PSL	Int. Node 999	DDB_PSLINT_77
1000	PSL	Int. Node 1000	DDB_PSLINT_78
1001	PSL	Int. Node 1001	DDB_PSLINT_79
1002	PSL	Int. Node 1002	DDB_PSLINT_80
1003	PSL	Int. Node 1003	DDB_PSLINT_81
1004	PSL	Int. Node 1004	DDB_PSLINT_82
1005	PSL	Int. Node 1005	DDB_PSLINT_83

DDB No	Source	Description	Element Name
1006	PSL	Int. Node 1006	DDB_PSLINT_84
1007	PSL	Int. Node 1007	DDB_PSLINT_85
1008	PSL	Int. Node 1008	DDB_PSLINT_86
1009	PSL	Int. Node 1009	DDB_PSLINT_87
1010	PSL	Int. Node 1010	DDB_PSLINT_88
1011	PSL	Int. Node 1011	DDB_PSLINT_89
1012	PSL	Int. Node 1012	DDB_PSLINT_90
1013	PSL	Int. Node 1013	DDB_PSLINT_91
1014	PSL	Int. Node 1014	DDB_PSLINT_92
1015	PSL	Int. Node 1015	DDB_PSLINT_93
1016	PSL	Int. Node 1016	DDB_PSLINT_94
1017	PSL	Int. Node 1017	DDB_PSLINT_95
1018	PSL	Int. Node 1018	DDB_PSLINT_96
1019	PSL	Int. Node 1019	DDB_PSLINT_97
1020	PSL	Int. Node 1020	DDB_PSLINT_98
1021	PSL	Int. Node 1021	DDB_PSLINT_99
1022	PSL	Int. Node 1022	DDB_PSLINT_100
1023	PSL	Int. Node 1023	DDB_PSLINT_101
1024	PSL	Trip LED	DDB_INP_TRIP_LED
1025	PSL	CB Aux A (52-A)	DDB_INP_52A_A
1026	PSL	CB Aux A (52-B)	DDB_INP_52B_A
1027	PSL	CB Aux B (52-A)	DDB_INP_52A_B
1028	PSL	CB Aux B (52-B)	DDB_INP_52B_B
1029	PSL	CB Aux C (52-A)	DDB_INP_52A_C
1030	PSL	CB Aux C (52-B)	DDB_INP_52B_C
1031	PSL	SPAR Enable	DDB_INP_SPAR
1032	PSL	TPAR Enable	DDB_INP_TPAR
1033	PSL	A/R Internal	DDB_INP_AR_INTERNAL
1034	PSL	I A/R 1p In Prog	DDB_INP_AR_CYCLE_1P
1035	PSL	I A/R 3p In Pr.	DDB_INP_AR_CYCLE_3P
1036	PSL	I A/R Close	DDB_INP_AR_CLOSING
1037	PSL	I A/R Reclaim	DDB_INP_RECLAIM
1038	PSL	BAR	DDB_INP_BAR
1039	PSL	Ext Chk Synch OK	DDB_INP_CTL_CHECK_SYNCH
1040	PSL	CB Healthy	DDB_INP_CB_HEALTHY
1041	PSL	BLK Protection	DDB_INP_BLK_PROTECTION
1042	PSL	Force 3P Trip	DDB_INP_TRP_3P
1043	PSL	Man. Close CB	DDB_INP_CB_MAN
1044	PSL	Man. Trip CB	DDB_INP_CB_TRIP_MAN
1045	PSL	CB Discrepancy	DDB_INP_DISC
1046	PSL	External Trip A	DDB_INP_PROTA
1047	PSL	External Trip B	DDB_INP_PROTB
1048	PSL	External Trip C	DDB_INP_PROTC
1049	PSL	DIST. Chan Recv	DDB_INP_CR

DDB No	Source	Description	Element Name
1050	PSL	DEF. Chan Recv	DDB_INP_CR_DEF
1051	PSL	DIST. COS	DDB_INP_COS
1052	PSL	DEF. COS	DDB_INP_COS_DEF
1053	PSL	Z1X Extension	DDB_INP_Z1X_EXT
1054	PSL	MCB/VTS Synchro	DDB_INP_MCB_VTS_BUS
1055	PSL	MCB/VTS Main	DDB_INP_MCB_VTS_LINE
1056	PSL	IN>1 Timer Block	DDB_INP_SBEF_TIMER_BLOCK_1
1057	PSL	IN>2 Timer Block	DDB_INP_SBEF_TIMER_BLOCK_2
1058	PSL	IN>3 Timer Block	DDB_INP_SBEF_TIMER_BLOCK_3
1059	PSL	IN>4 Timer Block	DDB_INP_SBEF_TIMER_BLOCK_4
1060	PSL	DEF Timer Block	DDB_INP_DEF_TIMER_BLOCK
1061	PSL	I>1 Timer Block	DDB_INP_PHOC_TIMER_BLOCK_1
1062	PSL	I>2 Timer Block	DDB_INP_PHOC_TIMER_BLOCK_2
1063	PSL	I>3 Timer Block	DDB_INP_PHOC_TIMER_BLOCK_3
1064	PSL	I>4 Timer Block	DDB_INP_PHOC_TIMER_BLOCK_4
1065	PSL	I2>1 Timer Block	DDB_INP_NPS_TIMER_BLOCK_1
1066	PSL	I2>2 Timer Block	DDB_INP_NPS_TIMER_BLOCK_2
1067	PSL	I2>3 Timer Block	DDB_INP_NPS_TIMER_BLOCK_3
1068	PSL	I2>4 Timer Block	DDB_INP_NPS_TIMER_BLOCK_4
1069	PSL	V<1 Timer Block	DDB_INP_UNDU_TIMER_BLOCK_1
1070	PSL	V<2 Timer Block	DDB_INP_UNDU_TIMER_BLOCK_2
1071	PSL	V<3 Timer Block	DDB_INP_UNDU_TIMER_BLOCK_3
1072	PSL	V<4 Timer Block	DDB_INP_UNDU_TIMER_BLOCK_4
1073	PSL	V>1 Timer Block	DDB_INP_OVEU_TIMER_BLOCK_1
1074	PSL	V>2 Timer Block	DDB_INP_OVEU_TIMER_BLOCK_2
1075	PSL	V>3 Timer Block	DDB_INP_OVEU_TIMER_BLOCK_3
1076	PSL	V>4 Timer Block	DDB_INP_OVEU_TIMER_BLOCK_4
1077	PSL	VN>1 Timer Block	DDB_INP_OVEU0_TIMER_BLOCK_1
1078	PSL	VN>2 Timer Block	DDB_INP_OVEU0_TIMER_BLOCK_2
1079	PSL	DIST. Tim. Block	DDB_INP_DISTANCE_TIMER_BLOCK
1080	PSL	Reset Lockout	DDB_INP_CB_RESET_LOCKOUT
1081	PSL	Reset All values	DDB_INP_CB_RESET_ALL_VALUES
1082	PSL	Reset Latches	DDB_INP_RESET_RELAYS_LEDS
1083	PSL	Stub Bus Enable	DDB_INP_STUB_BUS
1084	PSL	User Trip A	DDB_INP_TRIP_A_USER
1085	PSL	User Trip B	DDB_INP_TRIP_B_USER
1086	PSL	User Trip C	DDB_INP_TRIP_C_USER
1087	PSL	ZSP Timer Block	DDB_INP_ZSP_TIMER_BLOCK
1088	PSL	PAP TeleTrip CR	DDB_INP_PAP_TELETRIP_REC
1089	PSL	PAP TeleT. Heath	DDB_INP_PAP_TELETRIP_HEALT
1090	PSL	PAP Timer Block	DDB_INP_PAP_TIMER_BLOCK
1091	PSL	Reset Thermal	DDB_INP_RESET_THERMAL
1092	PSL	Time Synch	DDB_INP_TIMESYNC
1093	PSL	Select CS(NCIT)	DDB_INP_SELECT_CS_NCIT

DDB No	Source	Description	Element Name
1094	PSL	T1 Timer Block	DDB_INP_T1_TIMER_BLOCK
1095	PSL	T2 Timer Block	DDB_INP_T2_TIMER_BLOCK
1096	PSL	TZp Timer Block	DDB_INP_TZP_TIMER_BLOCK
1097	PSL	TZq Timer Block	DDB_INP_TZQ_TIMER_BLOCK
1098	PSL	T3 Timer Block	DDB_INP_T3_TIMER_BLOCK
1099	PSL	T4 Timer Block	DDB_INP_T4_TIMER_BLOCK
1100	PSL	F<1 Timer Block	DDB_INP_UNDF_TIMER_BLOCK_1
1101	PSL	F<2 Timer Block	DDB_INP_UNDF_TIMER_BLOCK_2
1102	PSL	F<3 Timer Block	DDB_INP_UNDF_TIMER_BLOCK_3
1103	PSL	F<4 Timer Block	DDB_INP_UNDF_TIMER_BLOCK_4
1104	PSL	F>1 Timer Block	DDB_INP_OVEF_TIMER_BLOCK_1
1105	PSL	F>2 Timer Block	DDB_INP_OVEF_TIMER_BLOCK_2
1106	PSL	I<1 Block	DDB_INP_PHUC_BLOCK_1
1107	PSL	I<2 Block	DDB_INP_PHUC_BLOCK_2
1108	PSL	I<1 Timer Block	DDB_INP_PHUC_TIMER_BLOCK_1
1109	PSL	I<2 Timer Block	DDB_INP_PHUC_TIMER_BLOCK_2
1110	PSL	103 MonitorBlock	DDB_INP_CS103_BLOCK
1111	PSL	103 CommandBlock	DDB_INP_CS103_CMD_BLOCK
1112	PSL	RP1 Read Only	DDB_INP_REMOTEREADONLY_RP1
1113	PSL	RP2 Read Only	DDB_INP_REMOTEREADONLY_RP2
1114	PSL	NIC Read Only	DDB_INP_REMOTEREADONLY_NIC
1115	PSL	SBO InterLock 1	DDB_INP_INTERLOCK_ORG1
1116	PSL	SBO DPI1 Org1	DDB_INP_DPI1_ORG1
1117	PSL	SBO DPI2 Org1	DDB_INP_DPI2_ORG1
1118	PSL	SBO Command 1	DDB_INP_COMMAND_ORG1
1119	PSL	SBO InterLock 2	DDB_INP_INTERLOCK_ORG2
1120	PSL	SBO DPI1 Org2	DDB_INP_DPI1_ORG2
1121	PSL	SBO DPI2 Org2	DDB_INP_DPI2_ORG2
1122	PSL	SBO Command 2	DDB_INP_COMMAND_ORG2
1123	PSL	SBO InterLock 3	DDB_INP_INTERLOCK_ORG3
1124	PSL	SBO DPI1 Org3	DDB_INP_DPI1_ORG3
1125	PSL	SBO DPI2 Org3	DDB_INP_DPI2_ORG3
1126	PSL	SBO Command 3	DDB_INP_COMMAND_ORG3
1127	PSL	SBO InterLock 4	DDB_INP_INTERLOCK_ORG4
1128	PSL	SBO DPI1 Org4	DDB_INP_DPI1_ORG4
1129	PSL	SBO DPI2 Org4	DDB_INP_DPI2_ORG4
1130	PSL	SBO Command 4	DDB_INP_COMMAND_ORG4
1131	PSL	Unused	DDB_UNUSED_1131
1132	PSL	Unused	DDB_UNUSED_1132
1133	PSL	Unused	DDB_UNUSED_1133
1134	PSL	Unused	DDB_UNUSED_1134
1135	PSL	Unused	DDB_UNUSED_1135
1136	PSL	Unused	DDB_UNUSED_1136
1137	PSL	Unused	DDB_UNUSED_1137

DDB No	Source	Description	Element Name
1138	PSL	Unused	DDB_UNUSED_1138
1139	PSL	Unused	DDB_UNUSED_1139
1140	PSL	Unused	DDB_UNUSED_1140
1141	PSL	Unused	DDB_UNUSED_1141
1142	PSL	Unused	DDB_UNUSED_1142
1143	PSL	Unused	DDB_UNUSED_1143
1144	PSL	Unused	DDB_UNUSED_1144
1145	PSL	Unused	DDB_UNUSED_1145
1146	PSL	Unused	DDB_UNUSED_1146
1147	PSL	Unused	DDB_UNUSED_1147
1148	PSL	Unused	DDB_UNUSED_1148
1149	PSL	Unused	DDB_UNUSED_1149
1150	PSL	Unused	DDB_UNUSED_1150
1151	PSL	Unused	DDB_UNUSED_1151
1152	PSL	Unused	DDB_UNUSED_1152
1153	PSL	Unused	DDB_UNUSED_1153
1154	PSL	Unused	DDB_UNUSED_1154
1155	PSL	Unused	DDB_UNUSED_1155
1156	PSL	Unused	DDB_UNUSED_1156
1157	PSL	Unused	DDB_UNUSED_1157
1158	PSL	Unused	DDB_UNUSED_1158
1159	PSL	Unused	DDB_UNUSED_1159
1160	PSL	Unused	DDB_UNUSED_1160
1161	PSL	Unused	DDB_UNUSED_1161
1162	PSL	Unused	DDB_UNUSED_1162
1163	PSL	Unused	DDB_UNUSED_1163
1164	PSL	Unused	DDB_UNUSED_1164
1165	PSL	Unused	DDB_UNUSED_1165
1166	PSL	Unused	DDB_UNUSED_1166
1167	PSL	Unused	DDB_UNUSED_1167
1168	PSL	Unused	DDB_UNUSED_1168
1169	PSL	Unused	DDB_UNUSED_1169
1170	PSL	Unused	DDB_UNUSED_1170
1171	PSL	Unused	DDB_UNUSED_1171
1172	PSL	Unused	DDB_UNUSED_1172
1173	PSL	Unused	DDB_UNUSED_1173
1174	PSL	Unused	DDB_UNUSED_1174
1175	PSL	Unused	DDB_UNUSED_1175
1176	PSL	Unused	DDB_UNUSED_1176
1177	PSL	Unused	DDB_UNUSED_1177
1178	PSL	Unused	DDB_UNUSED_1178
1179	PSL	Unused	DDB_UNUSED_1179
1180	PSL	Unused	DDB_UNUSED_1180
1181	PSL	Unused	DDB_UNUSED_1181

DDB No	Source	Description	Element Name
1182	PSL	Unused	DDB_UNUSED_1182
1183	PSL	Unused	DDB_UNUSED_1183
1184	PSL	Unused	DDB_UNUSED_1184
1185	PSL	Unused	DDB_UNUSED_1185
1186	PSL	Unused	DDB_UNUSED_1186
1187	PSL	Unused	DDB_UNUSED_1187
1188	PSL	Unused	DDB_UNUSED_1188
1189	PSL	Unused	DDB_UNUSED_1189
1190	PSL	Unused	DDB_UNUSED_1190
1191	PSL	Unused	DDB_UNUSED_1191
1192	PSL	Unused	DDB_UNUSED_1192
1193	PSL	Unused	DDB_UNUSED_1193
1194	PSL	Unused	DDB_UNUSED_1194
1195	PSL	Unused	DDB_UNUSED_1195
1196	PSL	Unused	DDB_UNUSED_1196
1197	PSL	Unused	DDB_UNUSED_1197
1198	PSL	Unused	DDB_UNUSED_1198
1199	PSL	Unused	DDB_UNUSED_1199
1200	PSL	Unused	DDB_UNUSED_1200
1201	PSL	Unused	DDB_UNUSED_1201
1202	PSL	Unused	DDB_UNUSED_1202
1203	PSL	Unused	DDB_UNUSED_1203
1204	PSL	Unused	DDB_UNUSED_1204
1205	PSL	Unused	DDB_UNUSED_1205
1206	PSL	Unused	DDB_UNUSED_1206
1207	PSL	Unused	DDB_UNUSED_1207
1208	PSL	Unused	DDB_UNUSED_1208
1209	PSL	Unused	DDB_UNUSED_1209
1210	PSL	Unused	DDB_UNUSED_1210
1211	PSL	Unused	DDB_UNUSED_1211
1212	PSL	Unused	DDB_UNUSED_1212
1213	PSL	Unused	DDB_UNUSED_1213
1214	PSL	Unused	DDB_UNUSED_1214
1215	PSL	Unused	DDB_UNUSED_1215
1216	PSL	Unused	DDB_UNUSED_1216
1217	PSL	Unused	DDB_UNUSED_1217
1218	PSL	Unused	DDB_UNUSED_1218
1219	PSL	Unused	DDB_UNUSED_1219
1220	PSL	Unused	DDB_UNUSED_1220
1221	PSL	Unused	DDB_UNUSED_1221
1222	PSL	Unused	DDB_UNUSED_1222
1223	PSL	Unused	DDB_UNUSED_1223
1224	SW	Virtual Input 1	DDB_GOOSEIN_1
1225	SW	Virtual Input 2	DDB_GOOSEIN_2

DDB No	Source	Description	Element Name
1226	SW	Virtual Input 3	DDB_GOOSEIN_3
1227	SW	Virtual Input 4	DDB_GOOSEIN_4
1228	SW	Virtual Input 5	DDB_GOOSEIN_5
1229	SW	Virtual Input 6	DDB_GOOSEIN_6
1230	SW	Virtual Input 7	DDB_GOOSEIN_7
1231	SW	Virtual Input 8	DDB_GOOSEIN_8
1232	SW	Virtual Input 9	DDB_GOOSEIN_9
1233	SW	Virtual Input 10	DDB_GOOSEIN_10
1234	SW	Virtual Input 11	DDB_GOOSEIN_11
1235	SW	Virtual Input 12	DDB_GOOSEIN_12
1236	SW	Virtual Input 13	DDB_GOOSEIN_13
1237	SW	Virtual Input 14	DDB_GOOSEIN_14
1238	SW	Virtual Input 15	DDB_GOOSEIN_15
1239	SW	Virtual Input 16	DDB_GOOSEIN_16
1240	SW	Virtual Input 17	DDB_GOOSEIN_17
1241	SW	Virtual Input 18	DDB_GOOSEIN_18
1242	SW	Virtual Input 19	DDB_GOOSEIN_19
1243	SW	Virtual Input 20	DDB_GOOSEIN_20
1244	SW	Virtual Input 21	DDB_GOOSEIN_21
1245	SW	Virtual Input 22	DDB_GOOSEIN_22
1246	SW	Virtual Input 23	DDB_GOOSEIN_23
1247	SW	Virtual Input 24	DDB_GOOSEIN_24
1248	SW	Virtual Input 25	DDB_GOOSEIN_25
1249	SW	Virtual Input 26	DDB_GOOSEIN_26
1250	SW	Virtual Input 27	DDB_GOOSEIN_27
1251	SW	Virtual Input 28	DDB_GOOSEIN_28
1252	SW	Virtual Input 29	DDB_GOOSEIN_29
1253	SW	Virtual Input 30	DDB_GOOSEIN_30
1254	SW	Virtual Input 31	DDB_GOOSEIN_31
1255	SW	Virtual Input 32	DDB_GOOSEIN_32
1256	SW	Virtual Input 33	DDB_GOOSEIN_33
1257	SW	Virtual Input 34	DDB_GOOSEIN_34
1258	SW	Virtual Input 35	DDB_GOOSEIN_35
1259	SW	Virtual Input 36	DDB_GOOSEIN_36
1260	SW	Virtual Input 37	DDB_GOOSEIN_37
1261	SW	Virtual Input 38	DDB_GOOSEIN_38
1262	SW	Virtual Input 39	DDB_GOOSEIN_39
1263	SW	Virtual Input 40	DDB_GOOSEIN_40
1264	SW	Virtual Input 41	DDB_GOOSEIN_41
1265	SW	Virtual Input 42	DDB_GOOSEIN_42
1266	SW	Virtual Input 43	DDB_GOOSEIN_43
1267	SW	Virtual Input 44	DDB_GOOSEIN_44
1268	SW	Virtual Input 45	DDB_GOOSEIN_45
1269	SW	Virtual Input 46	DDB_GOOSEIN_46

DDB No	Source	Description	Element Name
1270	SW	Virtual Input 47	DDB_GOOSEIN_47
1271	SW	Virtual Input 48	DDB_GOOSEIN_48
1272	SW	Virtual Input 49	DDB_GOOSEIN_49
1273	SW	Virtual Input 50	DDB_GOOSEIN_50
1274	SW	Virtual Input 51	DDB_GOOSEIN_51
1275	SW	Virtual Input 52	DDB_GOOSEIN_52
1276	SW	Virtual Input 53	DDB_GOOSEIN_53
1277	SW	Virtual Input 54	DDB_GOOSEIN_54
1278	SW	Virtual Input 55	DDB_GOOSEIN_55
1279	SW	Virtual Input 56	DDB_GOOSEIN_56
1280	SW	Virtual Input 57	DDB_GOOSEIN_57
1281	SW	Virtual Input 58	DDB_GOOSEIN_58
1282	SW	Virtual Input 59	DDB_GOOSEIN_59
1283	SW	Virtual Input 60	DDB_GOOSEIN_60
1284	SW	Virtual Input 61	DDB_GOOSEIN_61
1285	SW	Virtual Input 62	DDB_GOOSEIN_62
1286	SW	Virtual Input 63	DDB_GOOSEIN_63
1287	SW	Virtual Input 64	DDB_GOOSEIN_64
1288	PSL	Unused	DDB_UNUSED_1288
1289	PSL	Unused	DDB_UNUSED_1289
1290	PSL	Unused	DDB_UNUSED_1290
1291	PSL	Unused	DDB_UNUSED_1291
1292	PSL	Unused	DDB_UNUSED_1292
1293	PSL	Unused	DDB_UNUSED_1293
1294	PSL	Unused	DDB_UNUSED_1294
1295	PSL	Unused	DDB_UNUSED_1295
1296	PSL	Unused	DDB_UNUSED_1296
1297	PSL	Unused	DDB_UNUSED_1297
1298	PSL	Unused	DDB_UNUSED_1298
1299	PSL	Unused	DDB_UNUSED_1299
1300	PSL	Unused	DDB_UNUSED_1300
1301	PSL	Unused	DDB_UNUSED_1301
1302	PSL	Unused	DDB_UNUSED_1302
1303	PSL	Unused	DDB_UNUSED_1303
1304	PSL	Unused	DDB_UNUSED_1304
1305	PSL	Unused	DDB_UNUSED_1305
1306	PSL	Unused	DDB_UNUSED_1306
1307	PSL	Unused	DDB_UNUSED_1307
1308	PSL	Unused	DDB_UNUSED_1308
1309	PSL	Unused	DDB_UNUSED_1309
1310	PSL	Unused	DDB_UNUSED_1310
1311	PSL	Unused	DDB_UNUSED_1311
1312	PSL	Unused	DDB_UNUSED_1312
1313	PSL	Unused	DDB_UNUSED_1313

DDB No	Source	Description	Element Name
1314	PSL	Unused	DDB_UNUSED_1314
1315	PSL	Unused	DDB_UNUSED_1315
1316	PSL	Unused	DDB_UNUSED_1316
1317	PSL	Unused	DDB_UNUSED_1317
1318	PSL	Unused	DDB_UNUSED_1318
1319	PSL	Unused	DDB_UNUSED_1319
1320	PSL	Unused	DDB_UNUSED_1320
1321	PSL	Unused	DDB_UNUSED_1321
1322	PSL	Unused	DDB_UNUSED_1322
1323	PSL	Unused	DDB_UNUSED_1323
1324	PSL	Unused	DDB_UNUSED_1324
1325	PSL	Unused	DDB_UNUSED_1325
1326	PSL	Unused	DDB_UNUSED_1326
1327	PSL	Unused	DDB_UNUSED_1327
1328	PSL	Unused	DDB_UNUSED_1328
1329	PSL	Unused	DDB_UNUSED_1329
1330	PSL	Unused	DDB_UNUSED_1330
1331	PSL	Unused	DDB_UNUSED_1331
1332	PSL	Unused	DDB_UNUSED_1332
1333	PSL	Unused	DDB_UNUSED_1333
1334	PSL	Unused	DDB_UNUSED_1334
1335	PSL	Unused	DDB_UNUSED_1335
1336	PSL	Unused	DDB_UNUSED_1336
1337	PSL	Unused	DDB_UNUSED_1337
1338	PSL	Unused	DDB_UNUSED_1338
1339	PSL	Unused	DDB_UNUSED_1339
1340	PSL	Unused	DDB_UNUSED_1340
1341	PSL	Unused	DDB_UNUSED_1341
1342	PSL	Unused	DDB_UNUSED_1342
1343	PSL	Unused	DDB_UNUSED_1343
1344	PSL	Unused	DDB_UNUSED_1344
1345	PSL	Unused	DDB_UNUSED_1345
1346	PSL	Unused	DDB_UNUSED_1346
1347	PSL	Unused	DDB_UNUSED_1347
1348	PSL	Unused	DDB_UNUSED_1348
1349	PSL	Unused	DDB_UNUSED_1349
1350	PSL	Unused	DDB_UNUSED_1350
1351	PSL	Unused	DDB_UNUSED_1351
1352	SW	Quality VIP 1	DDB_VIP_QUALITY_1
1353	SW	Quality VIP 2	DDB_VIP_QUALITY_2
1354	SW	Quality VIP 3	DDB_VIP_QUALITY_3
1355	SW	Quality VIP 4	DDB_VIP_QUALITY_4
1356	SW	Quality VIP 5	DDB_VIP_QUALITY_5
1357	SW	Quality VIP 6	DDB_VIP_QUALITY_6

DDB No	Source	Description	Element Name
1358	SW	Quality VIP 7	DDB_VIP_QUALITY_7
1359	SW	Quality VIP 8	DDB_VIP_QUALITY_8
1360	SW	Quality VIP 9	DDB_VIP_QUALITY_9
1361	SW	Quality VIP 10	DDB_VIP_QUALITY_10
1362	SW	Quality VIP 11	DDB_VIP_QUALITY_11
1363	SW	Quality VIP 12	DDB_VIP_QUALITY_12
1364	SW	Quality VIP 13	DDB_VIP_QUALITY_13
1365	SW	Quality VIP 14	DDB_VIP_QUALITY_14
1366	SW	Quality VIP 15	DDB_VIP_QUALITY_15
1367	SW	Quality VIP 16	DDB_VIP_QUALITY_16
1368	SW	Quality VIP 17	DDB_VIP_QUALITY_17
1369	SW	Quality VIP 18	DDB_VIP_QUALITY_18
1370	SW	Quality VIP 19	DDB_VIP_QUALITY_19
1371	SW	Quality VIP 20	DDB_VIP_QUALITY_20
1372	SW	Quality VIP 21	DDB_VIP_QUALITY_21
1373	SW	Quality VIP 22	DDB_VIP_QUALITY_22
1374	SW	Quality VIP 23	DDB_VIP_QUALITY_23
1375	SW	Quality VIP 24	DDB_VIP_QUALITY_24
1376	SW	Quality VIP 25	DDB_VIP_QUALITY_25
1377	SW	Quality VIP 26	DDB_VIP_QUALITY_26
1378	SW	Quality VIP 27	DDB_VIP_QUALITY_27
1379	SW	Quality VIP 28	DDB_VIP_QUALITY_28
1380	SW	Quality VIP 29	DDB_VIP_QUALITY_29
1381	SW	Quality VIP 30	DDB_VIP_QUALITY_30
1382	SW	Quality VIP 31	DDB_VIP_QUALITY_31
1383	SW	Quality VIP 32	DDB_VIP_QUALITY_32
1384	SW	Quality VIP 33	DDB_VIP_QUALITY_33
1385	SW	Quality VIP 34	DDB_VIP_QUALITY_34
1386	SW	Quality VIP 35	DDB_VIP_QUALITY_35
1387	SW	Quality VIP 36	DDB_VIP_QUALITY_36
1388	SW	Quality VIP 37	DDB_VIP_QUALITY_37
1389	SW	Quality VIP 38	DDB_VIP_QUALITY_38
1390	SW	Quality VIP 39	DDB_VIP_QUALITY_39
1391	SW	Quality VIP 40	DDB_VIP_QUALITY_40
1392	SW	Quality VIP 41	DDB_VIP_QUALITY_41
1393	SW	Quality VIP 42	DDB_VIP_QUALITY_42
1394	SW	Quality VIP 43	DDB_VIP_QUALITY_43
1395	SW	Quality VIP 44	DDB_VIP_QUALITY_44
1396	SW	Quality VIP 45	DDB_VIP_QUALITY_45
1397	SW	Quality VIP 46	DDB_VIP_QUALITY_46
1398	SW	Quality VIP 47	DDB_VIP_QUALITY_47
1399	SW	Quality VIP 48	DDB_VIP_QUALITY_48
1400	SW	Quality VIP 49	DDB_VIP_QUALITY_49
1401	SW	Quality VIP 50	DDB_VIP_QUALITY_50

DDB No	Source	Description	Element Name
1402	SW	Quality VIP 51	DDB_VIP_QUALITY_51
1403	SW	Quality VIP 52	DDB_VIP_QUALITY_52
1404	SW	Quality VIP 53	DDB_VIP_QUALITY_53
1405	SW	Quality VIP 54	DDB_VIP_QUALITY_54
1406	SW	Quality VIP 55	DDB_VIP_QUALITY_55
1407	SW	Quality VIP 56	DDB_VIP_QUALITY_56
1408	SW	Quality VIP 57	DDB_VIP_QUALITY_57
1409	SW	Quality VIP 58	DDB_VIP_QUALITY_58
1410	SW	Quality VIP 59	DDB_VIP_QUALITY_59
1411	SW	Quality VIP 60	DDB_VIP_QUALITY_60
1412	SW	Quality VIP 61	DDB_VIP_QUALITY_61
1413	SW	Quality VIP 62	DDB_VIP_QUALITY_62
1414	SW	Quality VIP 63	DDB_VIP_QUALITY_63
1415	SW	Quality VIP 64	DDB_VIP_QUALITY_64
1416	PSL	Unused	DDB_UNUSED_1416
1417	PSL	Unused	DDB_UNUSED_1417
1418	PSL	Unused	DDB_UNUSED_1418
1419	PSL	Unused	DDB_UNUSED_1419
1420	PSL	Unused	DDB_UNUSED_1420
1421	PSL	Unused	DDB_UNUSED_1421
1422	PSL	Unused	DDB_UNUSED_1422
1423	PSL	Unused	DDB_UNUSED_1423
1424	PSL	Unused	DDB_UNUSED_1424
1425	PSL	Unused	DDB_UNUSED_1425
1426	PSL	Unused	DDB_UNUSED_1426
1427	PSL	Unused	DDB_UNUSED_1427
1428	PSL	Unused	DDB_UNUSED_1428
1429	PSL	Unused	DDB_UNUSED_1429
1430	PSL	Unused	DDB_UNUSED_1430
1431	PSL	Unused	DDB_UNUSED_1431
1432	PSL	Unused	DDB_UNUSED_1432
1433	PSL	Unused	DDB_UNUSED_1433
1434	PSL	Unused	DDB_UNUSED_1434
1435	PSL	Unused	DDB_UNUSED_1435
1436	PSL	Unused	DDB_UNUSED_1436
1437	PSL	Unused	DDB_UNUSED_1437
1438	PSL	Unused	DDB_UNUSED_1438
1439	PSL	Unused	DDB_UNUSED_1439
1440	PSL	Unused	DDB_UNUSED_1440
1441	PSL	Unused	DDB_UNUSED_1441
1442	PSL	Unused	DDB_UNUSED_1442
1443	PSL	Unused	DDB_UNUSED_1443
1444	PSL	Unused	DDB_UNUSED_1444
1445	PSL	Unused	DDB_UNUSED_1445

DDB No	Source	Description	Element Name
1446	PSL	Unused	DDB_UNUSED_1446
1447	PSL	Unused	DDB_UNUSED_1447
1448	PSL	Unused	DDB_UNUSED_1448
1449	PSL	Unused	DDB_UNUSED_1449
1450	PSL	Unused	DDB_UNUSED_1450
1451	PSL	Unused	DDB_UNUSED_1451
1452	PSL	Unused	DDB_UNUSED_1452
1453	PSL	Unused	DDB_UNUSED_1453
1454	PSL	Unused	DDB_UNUSED_1454
1455	PSL	Unused	DDB_UNUSED_1455
1456	PSL	Unused	DDB_UNUSED_1456
1457	PSL	Unused	DDB_UNUSED_1457
1458	PSL	Unused	DDB_UNUSED_1458
1459	PSL	Unused	DDB_UNUSED_1459
1460	PSL	Unused	DDB_UNUSED_1460
1461	PSL	Unused	DDB_UNUSED_1461
1462	PSL	Unused	DDB_UNUSED_1462
1463	PSL	Unused	DDB_UNUSED_1463
1464	PSL	Unused	DDB_UNUSED_1464
1465	PSL	Unused	DDB_UNUSED_1465
1466	PSL	Unused	DDB_UNUSED_1466
1467	PSL	Unused	DDB_UNUSED_1467
1468	PSL	Unused	DDB_UNUSED_1468
1469	PSL	Unused	DDB_UNUSED_1469
1470	PSL	Unused	DDB_UNUSED_1470
1471	PSL	Unused	DDB_UNUSED_1471
1472	PSL	Unused	DDB_UNUSED_1472
1473	PSL	Unused	DDB_UNUSED_1473
1474	PSL	Unused	DDB_UNUSED_1474
1475	PSL	Unused	DDB_UNUSED_1475
1476	PSL	Unused	DDB_UNUSED_1476
1477	PSL	Unused	DDB_UNUSED_1477
1478	PSL	Unused	DDB_UNUSED_1478
1479	PSL	Unused	DDB_UNUSED_1479
1480	SW	PubPres VIP 1	DDB_VIP_PUB_PRES_1
1481	SW	PubPres VIP 2	DDB_VIP_PUB_PRES_2
1482	SW	PubPres VIP 3	DDB_VIP_PUB_PRES_3
1483	SW	PubPres VIP 4	DDB_VIP_PUB_PRES_4
1484	SW	PubPres VIP 5	DDB_VIP_PUB_PRES_5
1485	SW	PubPres VIP 6	DDB_VIP_PUB_PRES_6
1486	SW	PubPres VIP 7	DDB_VIP_PUB_PRES_7
1487	SW	PubPres VIP 8	DDB_VIP_PUB_PRES_8
1488	SW	PubPres VIP 9	DDB_VIP_PUB_PRES_9
1489	SW	PubPres VIP 10	DDB_VIP_PUB_PRES_10

DDB No	Source	Description	Element Name
1490	SW	PubPres VIP 11	DDB_VIP_PUB_PRES_11
1491	SW	PubPres VIP 12	DDB_VIP_PUB_PRES_12
1492	SW	PubPres VIP 13	DDB_VIP_PUB_PRES_13
1493	SW	PubPres VIP 14	DDB_VIP_PUB_PRES_14
1494	SW	PubPres VIP 15	DDB_VIP_PUB_PRES_15
1495	SW	PubPres VIP 16	DDB_VIP_PUB_PRES_16
1496	SW	PubPres VIP 17	DDB_VIP_PUB_PRES_17
1497	SW	PubPres VIP 18	DDB_VIP_PUB_PRES_18
1498	SW	PubPres VIP 19	DDB_VIP_PUB_PRES_19
1499	SW	PubPres VIP 20	DDB_VIP_PUB_PRES_20
1500	SW	PubPres VIP 21	DDB_VIP_PUB_PRES_21
1501	SW	PubPres VIP 22	DDB_VIP_PUB_PRES_22
1502	SW	PubPres VIP 23	DDB_VIP_PUB_PRES_23
1503	SW	PubPres VIP 24	DDB_VIP_PUB_PRES_24
1504	SW	PubPres VIP 25	DDB_VIP_PUB_PRES_25
1505	SW	PubPres VIP 26	DDB_VIP_PUB_PRES_26
1506	SW	PubPres VIP 27	DDB_VIP_PUB_PRES_27
1507	SW	PubPres VIP 28	DDB_VIP_PUB_PRES_28
1508	SW	PubPres VIP 29	DDB_VIP_PUB_PRES_29
1509	SW	PubPres VIP 30	DDB_VIP_PUB_PRES_30
1510	SW	PubPres VIP 31	DDB_VIP_PUB_PRES_31
1511	SW	PubPres VIP 32	DDB_VIP_PUB_PRES_32
1512	SW	PubPres VIP 33	DDB_VIP_PUB_PRES_33
1513	SW	PubPres VIP 34	DDB_VIP_PUB_PRES_34
1514	SW	PubPres VIP 35	DDB_VIP_PUB_PRES_35
1515	SW	PubPres VIP 36	DDB_VIP_PUB_PRES_36
1516	SW	PubPres VIP 37	DDB_VIP_PUB_PRES_37
1517	SW	PubPres VIP 38	DDB_VIP_PUB_PRES_38
1518	SW	PubPres VIP 39	DDB_VIP_PUB_PRES_39
1519	SW	PubPres VIP 40	DDB_VIP_PUB_PRES_40
1520	SW	PubPres VIP 41	DDB_VIP_PUB_PRES_41
1521	SW	PubPres VIP 42	DDB_VIP_PUB_PRES_42
1522	SW	PubPres VIP 43	DDB_VIP_PUB_PRES_43
1523	SW	PubPres VIP 44	DDB_VIP_PUB_PRES_44
1524	SW	PubPres VIP 45	DDB_VIP_PUB_PRES_45
1525	SW	PubPres VIP 46	DDB_VIP_PUB_PRES_46
1526	SW	PubPres VIP 47	DDB_VIP_PUB_PRES_47
1527	SW	PubPres VIP 48	DDB_VIP_PUB_PRES_48
1528	SW	PubPres VIP 49	DDB_VIP_PUB_PRES_49
1529	SW	PubPres VIP 50	DDB_VIP_PUB_PRES_50
1530	SW	PubPres VIP 51	DDB_VIP_PUB_PRES_51
1531	SW	PubPres VIP 52	DDB_VIP_PUB_PRES_52
1532	SW	PubPres VIP 53	DDB_VIP_PUB_PRES_53
1533	SW	PubPres VIP 54	DDB_VIP_PUB_PRES_54

DDB No	Source	Description	Element Name
1534	SW	PubPres VIP 55	DDB_VIP_PUB_PRES_55
1535	SW	PubPres VIP 56	DDB_VIP_PUB_PRES_56
1536	SW	PubPres VIP 57	DDB_VIP_PUB_PRES_57
1537	SW	PubPres VIP 58	DDB_VIP_PUB_PRES_58
1538	SW	PubPres VIP 59	DDB_VIP_PUB_PRES_59
1539	SW	PubPres VIP 60	DDB_VIP_PUB_PRES_60
1540	SW	PubPres VIP 61	DDB_VIP_PUB_PRES_61
1541	SW	PubPres VIP 62	DDB_VIP_PUB_PRES_62
1542	SW	PubPres VIP 63	DDB_VIP_PUB_PRES_63
1543	SW	PubPres VIP 64	DDB_VIP_PUB_PRES_64
1544	PSL	Unused	DDB_UNUSED_1544
1545	PSL	Unused	DDB_UNUSED_1545
1546	PSL	Unused	DDB_UNUSED_1546
1547	PSL	Unused	DDB_UNUSED_1547
1548	PSL	Unused	DDB_UNUSED_1548
1549	PSL	Unused	DDB_UNUSED_1549
1550	PSL	Unused	DDB_UNUSED_1550
1551	PSL	Unused	DDB_UNUSED_1551
1552	PSL	Unused	DDB_UNUSED_1552
1553	PSL	Unused	DDB_UNUSED_1553
1554	PSL	Unused	DDB_UNUSED_1554
1555	PSL	Unused	DDB_UNUSED_1555
1556	PSL	Unused	DDB_UNUSED_1556
1557	PSL	Unused	DDB_UNUSED_1557
1558	PSL	Unused	DDB_UNUSED_1558
1559	PSL	Unused	DDB_UNUSED_1559
1560	PSL	Unused	DDB_UNUSED_1560
1561	PSL	Unused	DDB_UNUSED_1561
1562	PSL	Unused	DDB_UNUSED_1562
1563	PSL	Unused	DDB_UNUSED_1563
1564	PSL	Unused	DDB_UNUSED_1564
1565	PSL	Unused	DDB_UNUSED_1565
1566	PSL	Unused	DDB_UNUSED_1566
1567	PSL	Unused	DDB_UNUSED_1567
1568	PSL	Unused	DDB_UNUSED_1568
1569	PSL	Unused	DDB_UNUSED_1569
1570	PSL	Unused	DDB_UNUSED_1570
1571	PSL	Unused	DDB_UNUSED_1571
1572	PSL	Unused	DDB_UNUSED_1572
1573	PSL	Unused	DDB_UNUSED_1573
1574	PSL	Unused	DDB_UNUSED_1574
1575	PSL	Unused	DDB_UNUSED_1575
1576	PSL	Unused	DDB_UNUSED_1576
1577	PSL	Unused	DDB_UNUSED_1577

DDB No	Source	Description	Element Name
1578	PSL	Unused	DDB_UNUSED_1578
1579	PSL	Unused	DDB_UNUSED_1579
1580	PSL	Unused	DDB_UNUSED_1580
1581	PSL	Unused	DDB_UNUSED_1581
1582	PSL	Unused	DDB_UNUSED_1582
1583	PSL	Unused	DDB_UNUSED_1583
1584	PSL	Unused	DDB_UNUSED_1584
1585	PSL	Unused	DDB_UNUSED_1585
1586	PSL	Unused	DDB_UNUSED_1586
1587	PSL	Unused	DDB_UNUSED_1587
1588	PSL	Unused	DDB_UNUSED_1588
1589	PSL	Unused	DDB_UNUSED_1589
1590	PSL	Unused	DDB_UNUSED_1590
1591	PSL	Unused	DDB_UNUSED_1591
1592	PSL	Unused	DDB_UNUSED_1592
1593	PSL	Unused	DDB_UNUSED_1593
1594	PSL	Unused	DDB_UNUSED_1594
1595	PSL	Unused	DDB_UNUSED_1595
1596	PSL	Unused	DDB_UNUSED_1596
1597	PSL	Unused	DDB_UNUSED_1597
1598	PSL	Unused	DDB_UNUSED_1598
1599	PSL	Unused	DDB_UNUSED_1599
1600	PSL	Unused	DDB_UNUSED_1600
1601	PSL	Unused	DDB_UNUSED_1601
1602	PSL	Unused	DDB_UNUSED_1602
1603	PSL	Unused	DDB_UNUSED_1603
1604	PSL	Unused	DDB_UNUSED_1604
1605	PSL	Unused	DDB_UNUSED_1605
1606	PSL	Unused	DDB_UNUSED_1606
1607	PSL	Unused	DDB_UNUSED_1607
1608	PSL	Unused	DDB_UNUSED_1608
1609	PSL	Unused	DDB_UNUSED_1609
1610	PSL	Unused	DDB_UNUSED_1610
1611	PSL	Unused	DDB_UNUSED_1611
1612	PSL	Unused	DDB_UNUSED_1612
1613	PSL	Unused	DDB_UNUSED_1613
1614	PSL	Unused	DDB_UNUSED_1614
1615	PSL	Unused	DDB_UNUSED_1615
1616	PSL	Unused	DDB_UNUSED_1616
1617	PSL	Unused	DDB_UNUSED_1617
1618	PSL	Unused	DDB_UNUSED_1618
1619	PSL	Unused	DDB_UNUSED_1619
1620	PSL	Unused	DDB_UNUSED_1620
1621	PSL	Unused	DDB_UNUSED_1621

DDB No	Source	Description	Element Name
1622	PSL	Unused	DDB_UNUSED_1622
1623	PSL	Unused	DDB_UNUSED_1623
1624	PSL	Unused	DDB_UNUSED_1624
1625	PSL	Unused	DDB_UNUSED_1625
1626	PSL	Unused	DDB_UNUSED_1626
1627	PSL	Unused	DDB_UNUSED_1627
1628	PSL	Unused	DDB_UNUSED_1628
1629	PSL	Unused	DDB_UNUSED_1629
1630	PSL	Unused	DDB_UNUSED_1630
1631	PSL	Unused	DDB_UNUSED_1631
1632	PSL	Unused	DDB_UNUSED_1632
1633	PSL	Unused	DDB_UNUSED_1633
1634	PSL	Unused	DDB_UNUSED_1634
1635	PSL	Unused	DDB_UNUSED_1635
1636	PSL	Unused	DDB_UNUSED_1636
1637	PSL	Unused	DDB_UNUSED_1637
1638	PSL	Unused	DDB_UNUSED_1638
1639	PSL	Unused	DDB_UNUSED_1639
1640	PSL	Unused	DDB_UNUSED_1640
1641	PSL	Unused	DDB_UNUSED_1641
1642	PSL	Unused	DDB_UNUSED_1642
1643	PSL	Unused	DDB_UNUSED_1643
1644	PSL	Unused	DDB_UNUSED_1644
1645	PSL	Unused	DDB_UNUSED_1645
1646	PSL	Unused	DDB_UNUSED_1646
1647	PSL	Unused	DDB_UNUSED_1647
1648	PSL	Unused	DDB_UNUSED_1648
1649	PSL	Unused	DDB_UNUSED_1649
1650	PSL	Unused	DDB_UNUSED_1650
1651	PSL	Unused	DDB_UNUSED_1651
1652	PSL	Unused	DDB_UNUSED_1652
1653	PSL	Unused	DDB_UNUSED_1653
1654	PSL	Unused	DDB_UNUSED_1654
1655	PSL	Unused	DDB_UNUSED_1655
1656	PSL	Unused	DDB_UNUSED_1656
1657	PSL	Unused	DDB_UNUSED_1657
1658	PSL	Unused	DDB_UNUSED_1658
1659	PSL	Unused	DDB_UNUSED_1659
1660	PSL	Unused	DDB_UNUSED_1660
1661	PSL	Unused	DDB_UNUSED_1661
1662	PSL	Unused	DDB_UNUSED_1662
1663	PSL	Unused	DDB_UNUSED_1663
1664	PSL	Unused	DDB_UNUSED_1664
1665	PSL	Unused	DDB_UNUSED_1665

DDB No	Source	Description	Element Name
1666	PSL	Unused	DDB_UNUSED_1666
1667	PSL	Unused	DDB_UNUSED_1667
1668	PSL	Unused	DDB_UNUSED_1668
1669	PSL	Unused	DDB_UNUSED_1669
1670	PSL	Unused	DDB_UNUSED_1670
1671	PSL	Unused	DDB_UNUSED_1671
1672	SW	LN1 Analog Alarm	DDB_LN1_NOPRESENTS_ACQ
1673	SW	LN2 Analog Alarm	DDB_LN2_NOPRESENTS_ACQ
1674	SW	LN3 Analog Alarm	DDB_LN3_NOPRESENTS_ACQ
1675	SW	LN4 Analog Alarm	DDB_LN4_NOPRESENTS_ACQ
1676	SW	LN5 Analog Alarm	DDB_LN5_NOPRESENTS_ACQ
1677	SW	LN6 Analog Alarm	DDB_LN6_NOPRESENTS_ACQ
1678	SW	LN7 Analog Alarm	DDB_LN7_NOPRESENTS_ACQ
1679	SW	LN8 Analog Alarm	DDB_LN8_NOPRESENTS_ACQ
1680	SW	LN1 Test Mode	DDB_LN1_MODE_TEST_ACQ
1681	SW	LN2 Test Mode	DDB_LN2_MODE_TEST_ACQ
1682	SW	LN3 Test Mode	DDB_LN3_MODE_TEST_ACQ
1683	SW	LN4 Test Mode	DDB_LN4_MODE_TEST_ACQ
1684	SW	LN5 Test Mode	DDB_LN5_MODE_TEST_ACQ
1685	SW	LN6 Test Mode	DDB_LN6_MODE_TEST_ACQ
1686	SW	LN7 Test Mode	DDB_LN7_MODE_TEST_ACQ
1687	SW	LN8 Test Mode	DDB_LN8_MODE_TEST_ACQ
1688	SW	LN1 Async	DDB_LN1_ASYNC_CLOCK
1689	SW	LN2 Async	DDB_LN2_ASYNC_CLOCK
1690	SW	LN3 Async	DDB_LN3_ASYNC_CLOCK
1691	SW	LN4 Async	DDB_LN4_ASYNC_CLOCK
1692	SW	LN5 Async	DDB_LN5_ASYNC_CLOCK
1693	SW	LN6 Async	DDB_LN6_ASYNC_CLOCK
1694	SW	LN7 Async	DDB_LN7_ASYNC_CLOCK
1695	SW	LN7 Async	DDB_LN8_ASYNC_CLOCK
1696	SW	LN1 Val Quest	DDB_LN1_VAL_QUESTIONABLE
1697	SW	LN2 Val Quest	DDB_LN2_VAL_QUESTIONABLE
1698	SW	LN3 Val Quest	DDB_LN3_VAL_QUESTIONABLE
1699	SW	LN4 Val Quest	DDB_LN4_VAL_QUESTIONABLE
1700	SW	LN5 Val Quest	DDB_LN5_VAL_QUESTIONABLE
1701	SW	LN6 Val Quest	DDB_LN6_VAL_QUESTIONABLE
1702	SW	LN7 Val Quest	DDB_LN7_VAL_QUESTIONABLE
1703	SW	LN8 Val Quest	DDB_LN8_VAL_QUESTIONABLE
1704	SW	LN1 Val Fail	DDB_LN1_VAL_FAILURE_ACQ
1705	SW	LN2 Val Fail	DDB_LN2_VAL_FAILURE_ACQ
1706	SW	LN3 Val Fail	DDB_LN3_VAL_FAILURE_ACQ
1707	SW	LN4 Val Fail	DDB_LN4_VAL_FAILURE_ACQ
1708	SW	LN5 Val Fail	DDB_LN5_VAL_FAILURE_ACQ
1709	SW	LN6 Val Fail	DDB_LN6_VAL_FAILURE_ACQ

DDB No	Source	Description	Element Name
1710	SW	LN7 Val Fail	DDB_LN7_VAL_FAILURE_ACQ
1711	SW	LN8 Val Fail	DDB_LN8_VAL_FAILURE_ACQ
1712	PSL	Unused	DDB_UNUSED_1712
1713	PSL	Unused	DDB_UNUSED_1713
1714	PSL	Unused	DDB_UNUSED_1714
1715	PSL	Unused	DDB_UNUSED_1715
1716	PSL	Unused	DDB_UNUSED_1716
1717	PSL	Unused	DDB_UNUSED_1717
1718	PSL	Unused	DDB_UNUSED_1718
1719	PSL	Unused	DDB_UNUSED_1719
1720	PSL	Unused	DDB_UNUSED_1720
1721	PSL	Unused	DDB_UNUSED_1721
1722	PSL	Unused	DDB_UNUSED_1722
1723	PSL	Unused	DDB_UNUSED_1723
1724	PSL	Unused	DDB_UNUSED_1724
1725	PSL	Unused	DDB_UNUSED_1725
1726	PSL	Unused	DDB_UNUSED_1726
1727	PSL	Unused	DDB_UNUSED_1727
1728	PSL	Unused	DDB_UNUSED_1728
1729	PSL	Unused	DDB_UNUSED_1729
1730	PSL	Unused	DDB_UNUSED_1730
1731	PSL	Unused	DDB_UNUSED_1731
1732	PSL	Unused	DDB_UNUSED_1732
1733	PSL	Unused	DDB_UNUSED_1733
1734	PSL	Unused	DDB_UNUSED_1734
1735	PSL	Unused	DDB_UNUSED_1735
1736	PSL	Unused	DDB_UNUSED_1736
1737	PSL	Unused	DDB_UNUSED_1737
1738	PSL	Unused	DDB_UNUSED_1738
1739	PSL	Unused	DDB_UNUSED_1739
1740	PSL	Unused	DDB_UNUSED_1740
1741	PSL	Unused	DDB_UNUSED_1741
1742	PSL	Unused	DDB_UNUSED_1742
1743	PSL	Unused	DDB_UNUSED_1743
1744	PSL	Unused	DDB_UNUSED_1744
1745	PSL	Unused	DDB_UNUSED_1745
1746	PSL	Unused	DDB_UNUSED_1746
1747	PSL	Unused	DDB_UNUSED_1747
1748	PSL	Unused	DDB_UNUSED_1748
1749	PSL	Unused	DDB_UNUSED_1749
1750	PSL	Unused	DDB_UNUSED_1750
1751	PSL	Unused	DDB_UNUSED_1751
1752	PSL	Unused	DDB_UNUSED_1752
1753	PSL	Unused	DDB_UNUSED_1753

DDB No	Source	Description	Element Name
1754	PSL	Unused	DDB_UNUSED_1754
1755	PSL	Unused	DDB_UNUSED_1755
1756	PSL	Unused	DDB_UNUSED_1756
1757	PSL	Unused	DDB_UNUSED_1757
1758	PSL	Unused	DDB_UNUSED_1758
1759	PSL	Unused	DDB_UNUSED_1759
1760	PSL	Unused	DDB_UNUSED_1760
1761	PSL	Unused	DDB_UNUSED_1761
1762	PSL	Unused	DDB_UNUSED_1762
1763	PSL	Unused	DDB_UNUSED_1763
1764	PSL	Unused	DDB_UNUSED_1764
1765	PSL	Unused	DDB_UNUSED_1765
1766	PSL	Unused	DDB_UNUSED_1766
1767	PSL	Unused	DDB_UNUSED_1767
1768	PSL	Unused	DDB_UNUSED_1768
1769	PSL	Unused	DDB_UNUSED_1769
1770	PSL	Unused	DDB_UNUSED_1770
1771	PSL	Unused	DDB_UNUSED_1771
1772	PSL	Unused	DDB_UNUSED_1772
1773	PSL	Unused	DDB_UNUSED_1773
1774	PSL	Unused	DDB_UNUSED_1774
1775	PSL	Unused	DDB_UNUSED_1775
1776	PSL	Unused	DDB_UNUSED_1776
1777	PSL	Unused	DDB_UNUSED_1777
1778	PSL	Unused	DDB_UNUSED_1778
1779	PSL	Unused	DDB_UNUSED_1779
1780	PSL	Unused	DDB_UNUSED_1780
1781	PSL	Unused	DDB_UNUSED_1781
1782	PSL	Unused	DDB_UNUSED_1782
1783	PSL	Unused	DDB_UNUSED_1783
1784	PSL	Unused	DDB_UNUSED_1784
1785	PSL	Unused	DDB_UNUSED_1785
1786	PSL	Unused	DDB_UNUSED_1786
1787	PSL	Unused	DDB_UNUSED_1787
1788	PSL	Unused	DDB_UNUSED_1788
1789	PSL	Unused	DDB_UNUSED_1789
1790	PSL	Unused	DDB_UNUSED_1790
1791	PSL	Unused	DDB_UNUSED_1791
1792	PSL	Unused	DDB_UNUSED_1792
1793	PSL	Unused	DDB_UNUSED_1793
1794	PSL	Unused	DDB_UNUSED_1794
1795	PSL	Unused	DDB_UNUSED_1795
1796	PSL	Unused	DDB_UNUSED_DR
1797	SW	ETH Link 1 Fail	DDB_NIC_LINK_1_FAIL

DDB No	Source	Description	Element Name
1798	SW	ETH Link 2 Fail	DDB_NIC_LINK_2_FAIL
1799	SW	ETH Link 3 Fail	DDB_NIC_LINK_3_FAIL
1800	SW	User logged into UI	DDB_UI_LOGGEDIN
1801	SW	User logged into front port courier	DDB_FCUR_LOGGEDIN
1802	SW	User logged into Rear Port1 courier	DDB_RP1_LOGGEDIN
1803	SW	User logged into Rear Port2 courier	DDB_RP2_LOGGEDIN
1804	SW	User logged into turnneled courier	DDB_TNL_LOGGEDIN
1805	SW	User logged into co-processor courier	DDB_CPR_LOGGEDIN
1806	PSL	SR User Alarm 1	DDB_USER_ALARM_1
1807	PSL	SR User Alarm 2	DDB_USER_ALARM_2
1808	PSL	SR User Alarm 3	DDB_USER_ALARM_3
1809	PSL	SR User Alarm 4	DDB_USER_ALARM_4
1810	PSL	SR User Alarm 5	DDB_USER_ALARM_5
1811	PSL	SR User Alarm 6	DDB_USER_ALARM_6
1812	PSL	SR User Alarm 7	DDB_USER_ALARM_7
1813	PSL	SR User Alarm 8	DDB_USER_ALARM_8
1814	PSL	SR User Alarm 9	DDB_USER_ALARM_9
1815	PSL	SR User Alarm 10	DDB_USER_ALARM_10
1816	PSL	SR User Alarm 11	DDB_USER_ALARM_11
1817	PSL	SR User Alarm 12	DDB_USER_ALARM_12
1818	PSL	SR User Alarm 13	DDB_USER_ALARM_13
1819	PSL	SR User Alarm 14	DDB_USER_ALARM_14
1820	PSL	SR User Alarm 15	DDB_USER_ALARM_15
1821	PSL	SR User Alarm 16	DDB_USER_ALARM_16
1822	PSL	MR User Alarm 17	DDB_USER_ALARM_17
1823	PSL	MR User Alarm 18	DDB_USER_ALARM_18
1824	PSL	MR User Alarm 19	DDB_USER_ALARM_19
1825	PSL	MR User Alarm 20	DDB_USER_ALARM_20
1826	PSL	MR User Alarm 21	DDB_USER_ALARM_21
1827	PSL	MR User Alarm 22	DDB_USER_ALARM_22
1828	PSL	MR User Alarm 23	DDB_USER_ALARM_23
1829	PSL	MR User Alarm 24	DDB_USER_ALARM_24
1830	PSL	MR User Alarm 25	DDB_USER_ALARM_25
1831	PSL	MR User Alarm 26	DDB_USER_ALARM_26
1832	PSL	MR User Alarm 27	DDB_USER_ALARM_27
1833	PSL	MR User Alarm 28	DDB_USER_ALARM_28
1834	PSL	MR User Alarm 29	DDB_USER_ALARM_29
1835	PSL	MR User Alarm 30	DDB_USER_ALARM_30
1836	PSL	MR User Alarm 31	DDB_USER_ALARM_31
1837	PSL	MR User Alarm 32	DDB_USER_ALARM_32
1838	PSL	Unused	DDB_UNUSED_1838
1839	PSL	Unused	DDB_UNUSED_1839
1840	PSL	Unused	DDB_UNUSED_1840
1841	PSL	Unused	DDB_UNUSED_1841

DDB No	Source	Description	Element Name
1842	PSL	Unused	DDB_UNUSED_1842
1843	PSL	Unused	DDB_UNUSED_1843
1844	PSL	Unused	DDB_UNUSED_1844
1845	PSL	Unused	DDB_UNUSED_1845
1846	PSL	Unused	DDB_UNUSED_1846
1847	PSL	Unused	DDB_UNUSED_1847
1848	PSL	Unused	DDB_UNUSED_1848
1849	PSL	Unused	DDB_UNUSED_1849
1850	PSL	Unused	DDB_UNUSED_1850
1851	PSL	Unused	DDB_UNUSED_1851
1852	PSL	Unused	DDB_UNUSED_1852
1853	PSL	Unused	DDB_UNUSED_1853
1854	PSL	Unused	DDB_UNUSED_1854
1855	PSL	Unused	DDB_UNUSED_1855
1856	PSL	Unused	DDB_UNUSED_1856
1857	PSL	Unused	DDB_UNUSED_1857
1858	PSL	Unused	DDB_UNUSED_1858
1859	PSL	Unused	DDB_UNUSED_1859
1860	PSL	Unused	DDB_UNUSED_1860
1861	PSL	Unused	DDB_UNUSED_1861
1862	PSL	Unused	DDB_UNUSED_1862
1863	PSL	Unused	DDB_UNUSED_1863
1864	PSL	Unused	DDB_UNUSED_1864
1865	PSL	Unused	DDB_UNUSED_1865
1866	PSL	Unused	DDB_UNUSED_1866
1867	PSL	Unused	DDB_UNUSED_1867
1868	PSL	Unused	DDB_UNUSED_1868
1869	PSL	Unused	DDB_UNUSED_1869
1870	PSL	Unused	DDB_UNUSED_1870
1871	PSL	Unused	DDB_UNUSED_1871
1872	PSL	Unused	DDB_UNUSED_1872
1873	PSL	Unused	DDB_UNUSED_1873
1874	PSL	Unused	DDB_UNUSED_1874
1875	PSL	Unused	DDB_UNUSED_1875
1876	PSL	Unused	DDB_UNUSED_1876
1877	PSL	Unused	DDB_UNUSED_1877
1878	PSL	Unused	DDB_UNUSED_1878
1879	PSL	Unused	DDB_UNUSED_1879
1880	PSL	Unused	DDB_UNUSED_1880
1881	PSL	Unused	DDB_UNUSED_1881
1882	PSL	Unused	DDB_UNUSED_1882
1883	PSL	Unused	DDB_UNUSED_1883
1884	PSL	Unused	DDB_UNUSED_1884
1885	PSL	Unused	DDB_UNUSED_1885

DDB No	Source	Description	Element Name
1886	PSL	Unused	DDB_UNUSED_1886
1887	PSL	Unused	DDB_UNUSED_1887
1888	PSL	Unused	DDB_UNUSED_1888
1889	PSL	Unused	DDB_UNUSED_1889
1890	PSL	Unused	DDB_UNUSED_1890
1891	PSL	Unused	DDB_UNUSED_1891
1892	PSL	Unused	DDB_UNUSED_1892
1893	PSL	Unused	DDB_UNUSED_1893
1894	PSL	Unused	DDB_UNUSED_1894
1895	PSL	Unused	DDB_UNUSED_1895
1896	PSL	Unused	DDB_UNUSED_1896
1897	PSL	Unused	DDB_UNUSED_1897
1898	PSL	Unused	DDB_UNUSED_1898
1899	PSL	Unused	DDB_UNUSED_1899
1900	PSL	Unused	DDB_UNUSED_1900
1901	PSL	Unused	DDB_UNUSED_1901
1902	PSL	Unused	DDB_UNUSED_1902
1903	PSL	Unused	DDB_UNUSED_1903
1904	PSL	Unused	DDB_UNUSED_1904
1905	PSL	Unused	DDB_UNUSED_1905
1906	PSL	Unused	DDB_UNUSED_1906
1907	PSL	Unused	DDB_UNUSED_1907
1908	PSL	Unused	DDB_UNUSED_1908
1909	PSL	Unused	DDB_UNUSED_1909
1910	PSL	Unused	DDB_UNUSED_1910
1911	PSL	Unused	DDB_UNUSED_1911
1912	PSL	Unused	DDB_UNUSED_1912
1913	PSL	Unused	DDB_UNUSED_1913
1914	PSL	Unused	DDB_UNUSED_1914
1915	PSL	Unused	DDB_UNUSED_1915
1916	PSL	Unused	DDB_UNUSED_1916
1917	PSL	Unused	DDB_UNUSED_1917
1918	PSL	Unused	DDB_UNUSED_1918
1919	PSL	Unused	DDB_UNUSED_1919
1920	PSL	Unused	DDB_UNUSED_1920
1921	PSL	Unused	DDB_UNUSED_1921
1922	PSL	Unused	DDB_UNUSED_1922
1923	PSL	Unused	DDB_UNUSED_1923
1924	PSL	Unused	DDB_UNUSED_1924
1925	PSL	Unused	DDB_UNUSED_1925
1926	PSL	Unused	DDB_UNUSED_1926
1927	PSL	Unused	DDB_UNUSED_1927
1928	PSL	Unused	DDB_UNUSED_1928
1929	PSL	Unused	DDB_UNUSED_1929

DDB No	Source	Description	Element Name
1930	PSL	Unused	DDB_UNUSED_1930
1931	PSL	Unused	DDB_UNUSED_1931
1932	PSL	Unused	DDB_UNUSED_1932
1933	PSL	Unused	DDB_UNUSED_1933
1934	PSL	Unused	DDB_UNUSED_1934
1935	PSL	Unused	DDB_UNUSED_1935
1936	PSL	Unused	DDB_UNUSED_1936
1937	PSL	Unused	DDB_UNUSED_1937
1938	PSL	Unused	DDB_UNUSED_1938
1939	PSL	Unused	DDB_UNUSED_1939
1940	PSL	Unused	DDB_UNUSED_1940
1941	PSL	Unused	DDB_UNUSED_1941
1942	PSL	Unused	DDB_UNUSED_1942
1943	PSL	Unused	DDB_UNUSED_1943
1944	PSL	Unused	DDB_UNUSED_1944
1945	PSL	Unused	DDB_UNUSED_1945
1946	PSL	Unused	DDB_UNUSED_1946
1947	PSL	Unused	DDB_UNUSED_1947
1948	PSL	Unused	DDB_UNUSED_1948
1949	PSL	Unused	DDB_UNUSED_1949
1950	PSL	Unused	DDB_UNUSED_1950
1951	PSL	Unused	DDB_UNUSED_1951
1952	PSL	Unused	DDB_UNUSED_1952
1953	PSL	Unused	DDB_UNUSED_1953
1954	PSL	Unused	DDB_UNUSED_1954
1955	PSL	Unused	DDB_UNUSED_1955
1956	PSL	Unused	DDB_UNUSED_1956
1957	PSL	Unused	DDB_UNUSED_1957
1958	PSL	Unused	DDB_UNUSED_1958
1959	PSL	Unused	DDB_UNUSED_1959
1960	PSL	Unused	DDB_UNUSED_1960
1961	PSL	Unused	DDB_UNUSED_1961
1962	PSL	Unused	DDB_UNUSED_1962
1963	PSL	Unused	DDB_UNUSED_1963
1964	PSL	Unused	DDB_UNUSED_1964
1965	PSL	Unused	DDB_UNUSED_1965
1966	PSL	Unused	DDB_UNUSED_1966
1967	PSL	Unused	DDB_UNUSED_1967
1968	PSL	Unused	DDB_UNUSED_1968
1969	PSL	Unused	DDB_UNUSED_1969
1970	PSL	Unused	DDB_UNUSED_1970
1971	PSL	Unused	DDB_UNUSED_1971
1972	PSL	Unused	DDB_UNUSED_1972
1973	PSL	Unused	DDB_UNUSED_1973

DDB No	Source	Description	Element Name
1974	PSL	Unused	DDB_UNUSED_1974
1975	PSL	Unused	DDB_UNUSED_1975
1976	PSL	Unused	DDB_UNUSED_1976
1977	PSL	Unused	DDB_UNUSED_1977
1978	PSL	Unused	DDB_UNUSED_1978
1979	PSL	Unused	DDB_UNUSED_1979
1980	PSL	Unused	DDB_UNUSED_1980
1981	PSL	Unused	DDB_UNUSED_1981
1982	PSL	Unused	DDB_UNUSED_1982
1983	PSL	Unused	DDB_UNUSED_1983
1984	PSL	Unused	DDB_UNUSED_1984
1985	PSL	Unused	DDB_UNUSED_1985
1986	PSL	Unused	DDB_UNUSED_1986
1987	PSL	Unused	DDB_UNUSED_1987
1988	PSL	Unused	DDB_UNUSED_1988
1989	PSL	Unused	DDB_UNUSED_1989
1990	PSL	Unused	DDB_UNUSED_1990
1991	PSL	Unused	DDB_UNUSED_1991
1992	PSL	Unused	DDB_UNUSED_1992
1993	PSL	Unused	DDB_UNUSED_1993
1994	PSL	Unused	DDB_UNUSED_1994
1995	PSL	Unused	DDB_UNUSED_1995
1996	PSL	Unused	DDB_UNUSED_1996
1997	PSL	Unused	DDB_UNUSED_1997
1998	PSL	Unused	DDB_UNUSED_1998
1999	PSL	Unused	DDB_UNUSED_1999
2000	PSL	Unused	DDB_UNUSED_2000
2001	PSL	Unused	DDB_UNUSED_2001
2002	PSL	Unused	DDB_UNUSED_2002
2003	PSL	Unused	DDB_UNUSED_2003
2004	PSL	Unused	DDB_UNUSED_2004
2005	PSL	Unused	DDB_UNUSED_2005
2006	PSL	Unused	DDB_UNUSED_2006
2007	PSL	Unused	DDB_UNUSED_2007
2008	PSL	Unused	DDB_UNUSED_2008
2009	PSL	Unused	DDB_UNUSED_2009
2010	PSL	Unused	DDB_UNUSED_2010
2011	PSL	Unused	DDB_UNUSED_2011
2012	PSL	Unused	DDB_UNUSED_2012
2013	PSL	Unused	DDB_UNUSED_2013
2014	PSL	Unused	DDB_UNUSED_2014
2015	PSL	Unused	DDB_UNUSED_2015
2016	PSL	Unused	DDB_UNUSED_2016
2017	PSL	Unused	DDB_UNUSED_2017

DDB No	Source	Description	Element Name
2018	PSL	Unused	DDB_UNUSED_2018
2019	PSL	Unused	DDB_UNUSED_2019
2020	PSL	Unused	DDB_UNUSED_2020
2021	PSL	Unused	DDB_UNUSED_2021
2022	PSL	Unused	DDB_UNUSED_2022
2023	PSL	Unused	DDB_UNUSED_2023
2024	PSL	Unused	DDB_UNUSED_2024
2025	PSL	Unused	DDB_UNUSED_2025
2026	PSL	Unused	DDB_UNUSED_2026
2027	PSL	Unused	DDB_UNUSED_2027
2028	PSL	Unused	DDB_UNUSED_2028
2029	PSL	Unused	DDB_UNUSED_2029
2030	PSL	Unused	DDB_UNUSED_2030
2031	SW	Unused	DDB_61850_INT1
2032	SW	Unused	DDB_61850_INT2
2033	SW	Unused	DDB_61850_INT3
2034	SW	Unused	DDB_61850_INT4
2035	SW	Unused	DDB_61850_INT5
2036	SW	Unused	DDB_61850_INT6
2037	SW	Unused	DDB_61850_INT7
2038	SW	Unused	DDB_61850_INT8

Table 1 - Digital database point list sorted by DDB number

Note	"IRIG-B Valid" DDB means IRIG-B card fitted & IRIG-B signal is present.

3 FACTORY DEFAULT PROGRAMMABLE SCHEME LOGIC

3.1 Logic Input Mapping

The default mappings for each of the opto-isolated inputs are as shown in the following table (PSL are equivalent for P442 and P444):

Relay Contact No	P442 Relay	P444 Relay
1	Channel Receive (Distance or DEF)	Channel Receive (Distance or DEF)
2	Channel out of Service (Distance or DEF)	Channel out of Service (Distance or DEF)
3	MCB/VTS Main (Z measurement-Dist)	MCB/VTS Main (Z measurement-Dist)
4	Block Autoreclose (BAR) (Lockout)	Block Autoreclose (BAR) (Lockout)
5	Circuit Breaker Healthy	Circuit Breaker Healthy
6	Circuit breaker Manual Close external order	Circuit breaker Manual Close external order
7	Reset Lockout	Reset Lockout
8	Disable Autoreclose (1-pole and 3-pole)	Disable Autoreclose (1-pole and 3-pole)
9	Not allocated	Not allocated
10	Not allocated	Not allocated
11	Not allocated	Not allocated
12	Not allocated	Not allocated
13	Not allocated	Not allocated
14	Not allocated	Not allocated
15	Not allocated	Not allocated
16	Not allocated	Not allocated
17		Not allocated
18		Not allocated
19		Not allocated
20		Not allocated
21		Not allocated
22		Not allocated
23		Not allocated
24		Not allocated

Table 2 - Logic input mapping

3.2 Relay Output Contact Mapping

The default mappings and conditioning for each of the relay output contacts are shown in the following table (PSL are equivalent for P442/P444):

Relay Contact No	P442 Relay	P444 Relay
1	TripA+B+C & Z1 [straight]	TripA+B+C & Z1 [straight]
2	Any Trip Phase A [straight]	Any Trip Phase A [straight]
3	Any Trip Phase B [straight]	Any Trip Phase B [straight]
4	Any Trip Phase C [straight]	Any Trip Phase C [straight]
5	Signal send (Dist. or DEF) [straight]	Signal send (Dist. or DEF) [straight]
6	Any Protection Start [straight]	Any Protection Start [straight]
7	Any Trip [straight]	Any Trip [straight]
8	General Alarm [straight]	General Alarm [straight]
9	DEF A+B+C Trip + IN>2Trip + IN>3Trip [straight]	DEF A+B+C Trip + IN>2Trip + IN>3Trip [straight]
10	Dist. Trip & Any Zone & Dist Unb CR [straight]	Dist. Trip & Any Zone & Dist Unb CR [straight]
11	Autoreclose lockout [straight]	Autoreclose lockout [straight]
12	Autoreclose 1P + 3P cycle in progress [straight]	Autoreclose 1P + 3P cycle in progress [straight]
13	A/R Close [straight]	A/R Close [straight]
14	Power Swing Detected [straight]	Power Swing Detected [straight]
15	Not allocated	Not allocated
16	Not allocated	Not allocated
17	Not allocated	Not allocated
18	Not allocated	Not allocated
19	Not allocated	Not allocated
20	Not allocated	Not allocated
21	Not allocated	Not allocated
22	Not allocated	Not allocated
23		Not allocated
24		Not allocated
25		Not allocated
26		Not allocated
27		Not allocated
28		Not allocated
29		Not allocated
30		Not allocated
31		Not allocated
32		Not allocated

Table 3 - Relay Output Contact Mapping

Note that when 3-pole tripping mode is selected in the menu ‘Distance Schemes / Trip mode’, all the relay contacts connected to a trip (trip A, trip B, trip C, and Any Trip) close simultaneously.

The following relay logic conditions (time-delays, straigth condition) can be used to set the PSL relay design:

- Pulse Timer
- Pick UP/Drop Off Timer
- Dwell Timer
- Pick Up Timer
- Drop Off Timer
- Latching
- Straight (transparent)

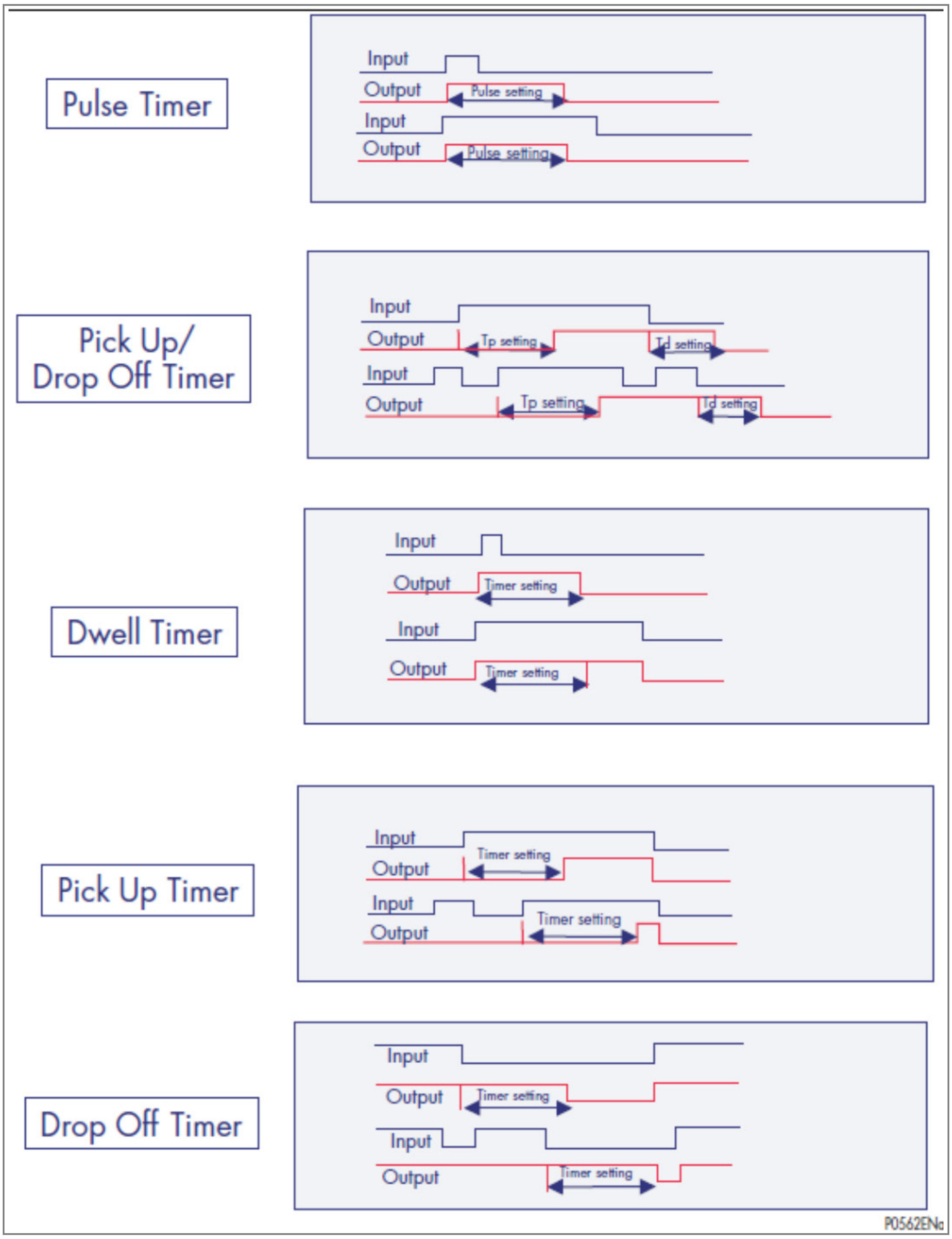

Figure 1 - Time-delay definition in PSL

3.3 Programmable LED Output Mapping

The default mappings for each of the programmable LEDs are as shown in the following table:

LED No.	P442 Relay	P444 Relay
1	Any Trip A	Any Trip A
2	Any Trip B	Any Trip B
3	Any Trip C	Any Trip C
4	Any Start	Any Start
5	Z1+Aided Trip	Z1+Aided Trip
6	Dist Fwd	Dist Fwd
7	Dist Rev	Dist Rev
8	A/R Enable	A/R Enable

Table 4 - Programmable LED output mapping

Note	*All the LEDs are latched in the default PSL*

3.4 Fault Recorder Trigger

The default PSL trigger which initiates a fault record is shown in the following table:

P442 Relay	P444 Relay
Any Start	Any Start
Any Trip	Any Trip

Table 5 - Fault recorder trigger

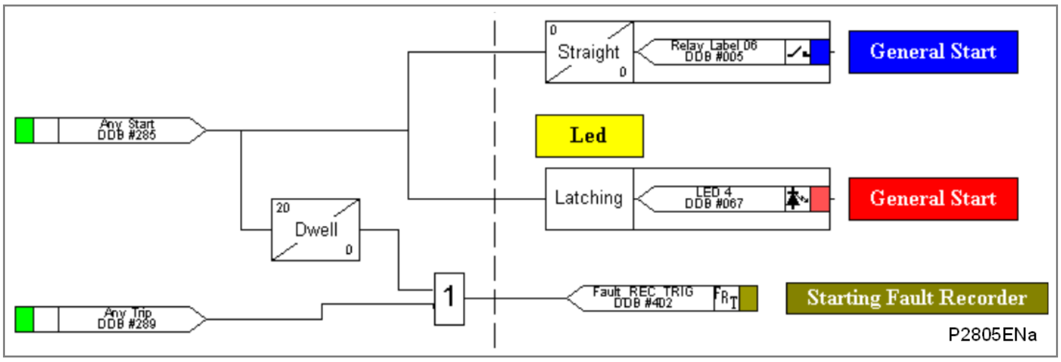

Figure 2 - Fault recorder trigger

If the fault recorder trigger is not assigned in the PSL, no Fault recorder can be initiated and displayed in the list by the LCD front panel.

4 DEFAULT PROGRAMMABLE SCHEME LOGIC (PSL)

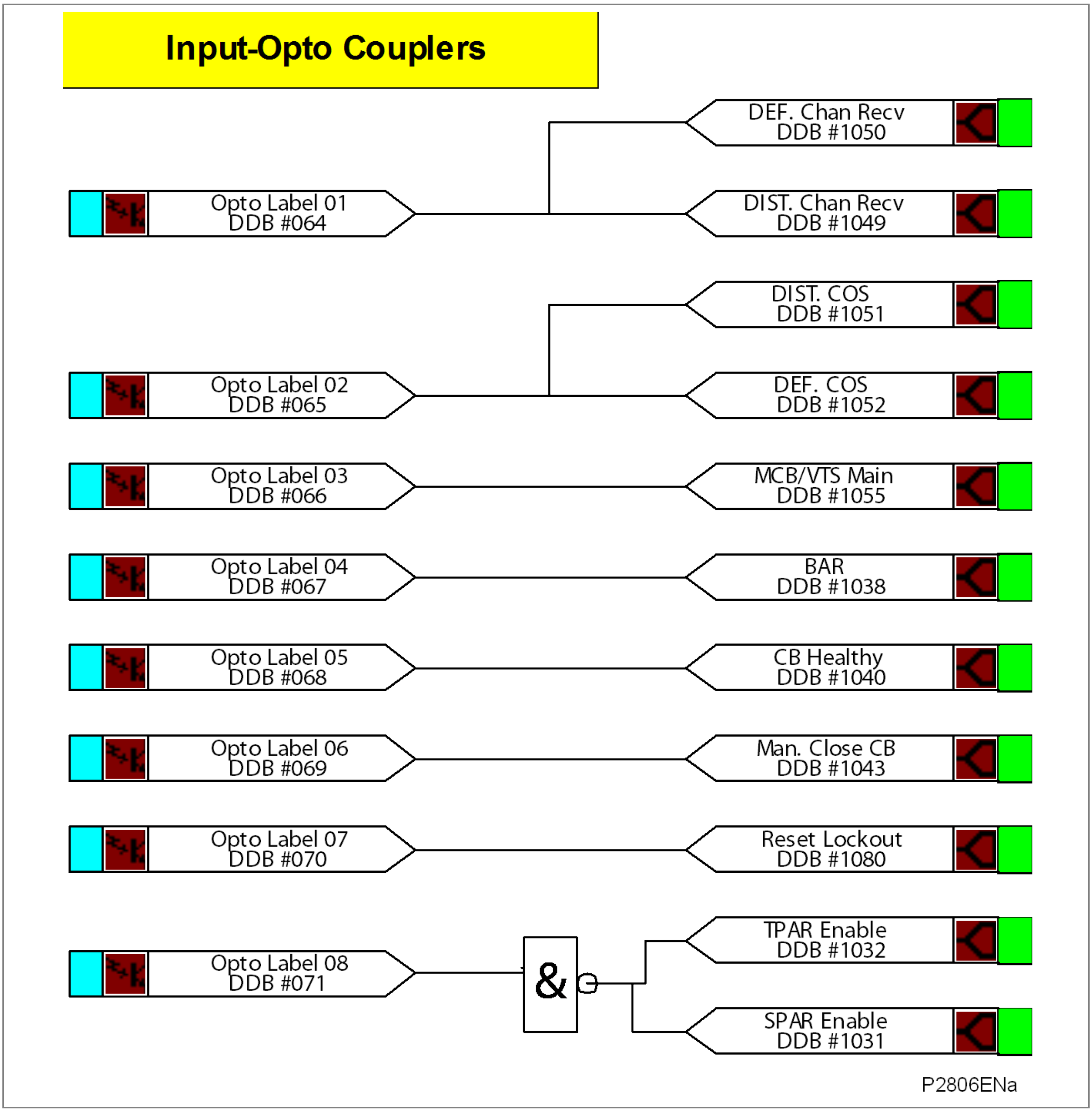

Figure 3 - Input opto couplers

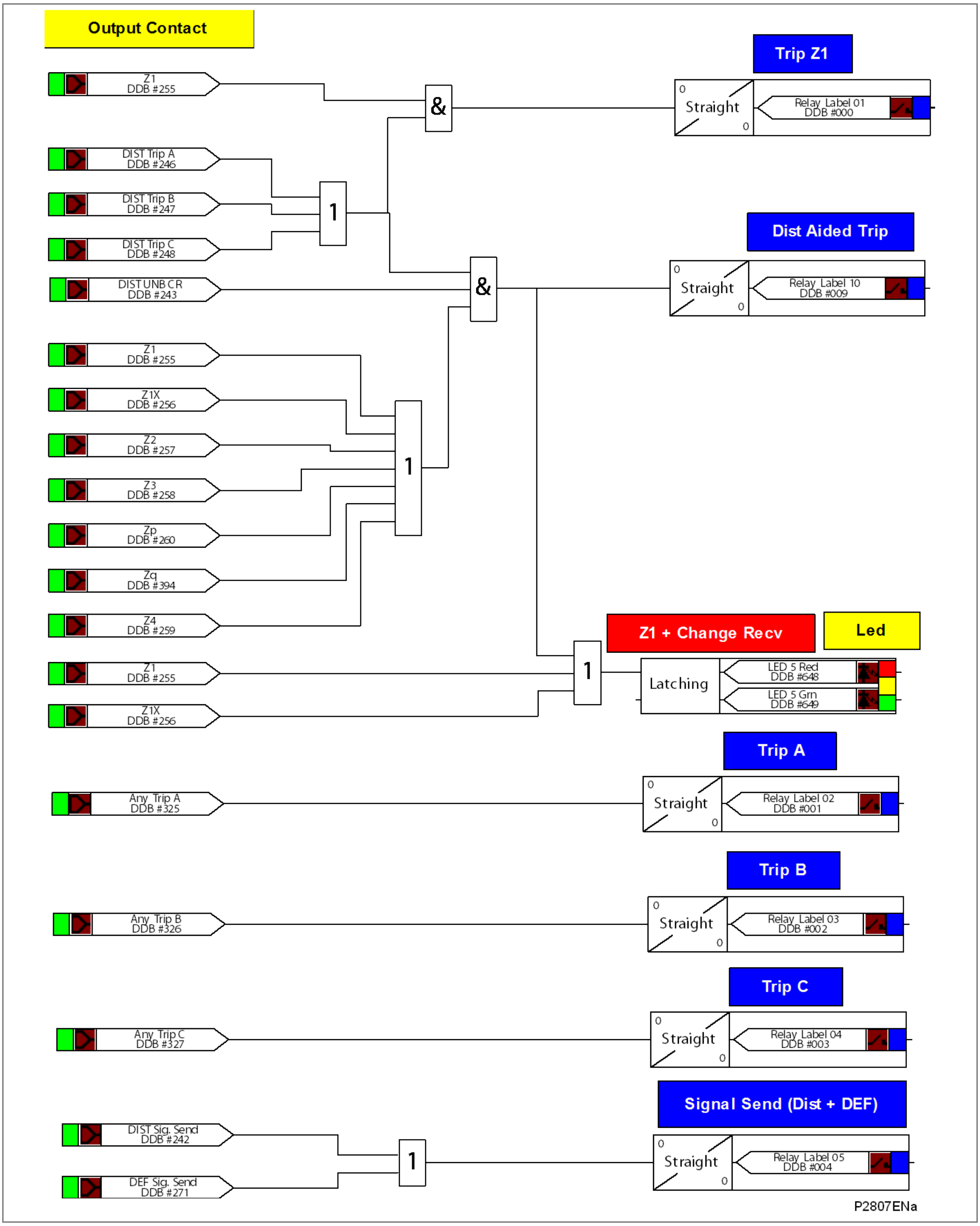

Figure 4 - Output contact

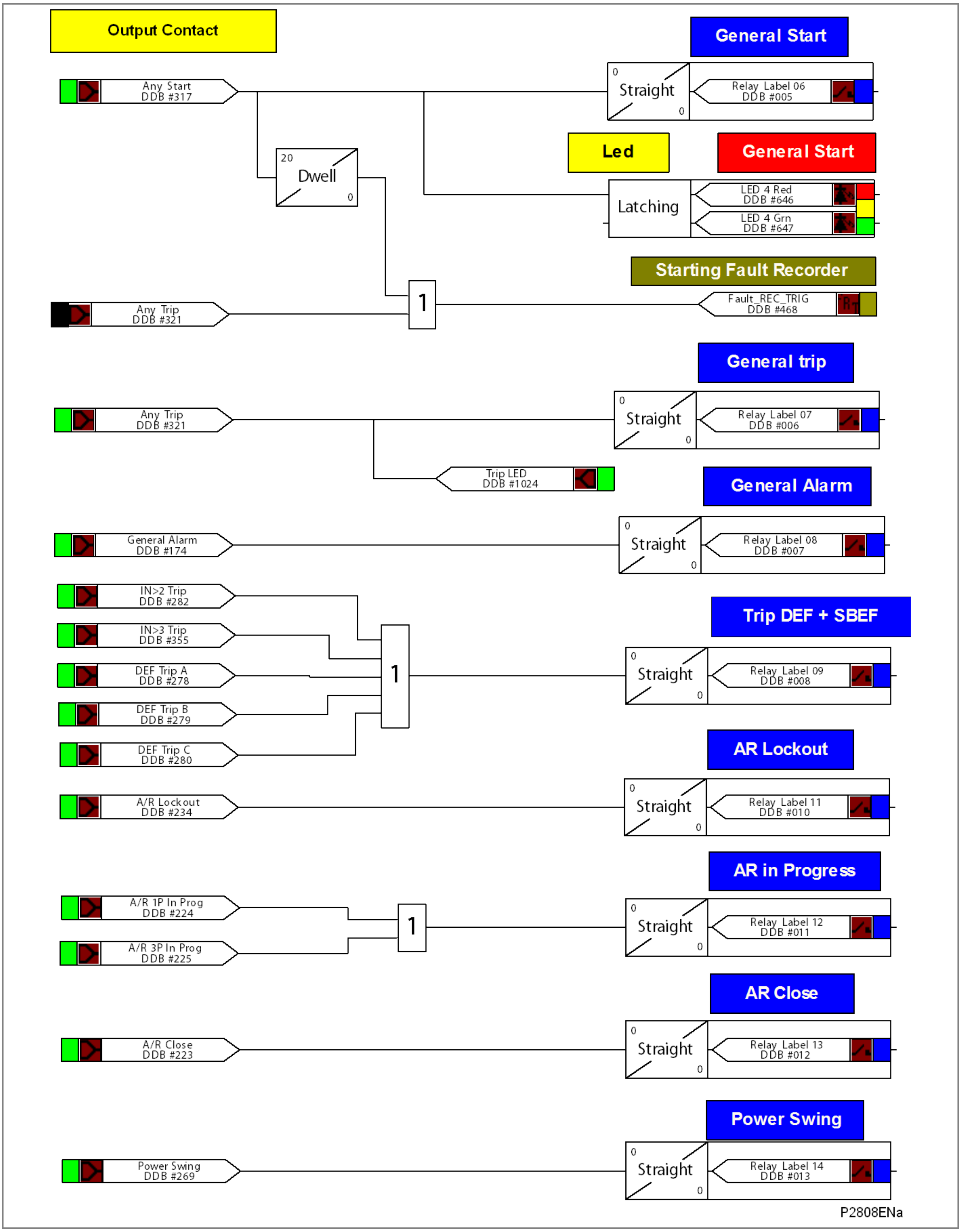

Figure 5 - Output contact

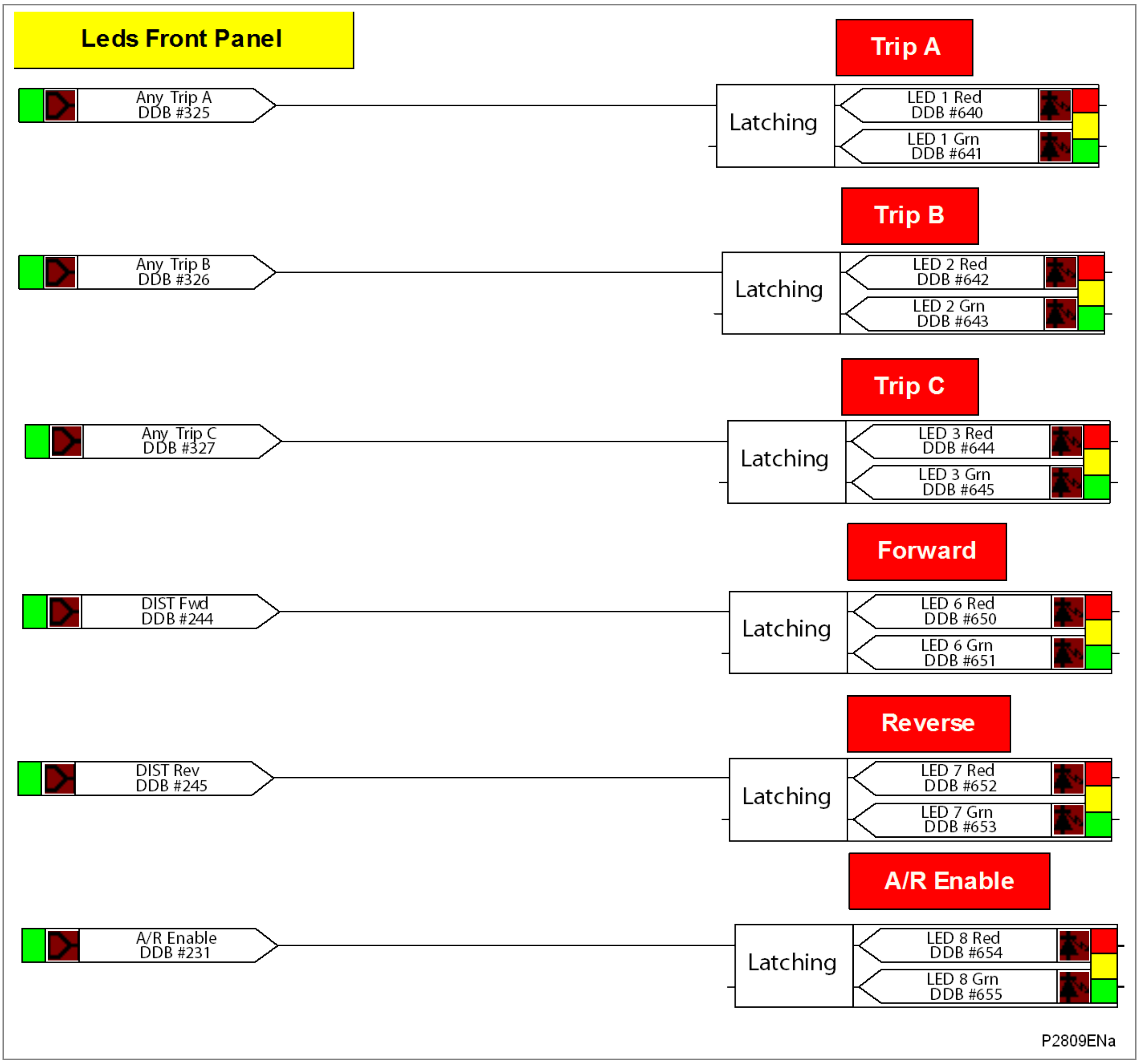

Figure 6 - LEDs front panel

Notes:

MEASUREMENTS AND RECORDING

CHAPTER 8

Date:	01/2017
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:	M
Software version:	E1
Connection diagrams:	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)

CONTENTS

FIGURES

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 AND FAULT RECORDER

2.1 Event Recorder ("View Records" Menu)

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 249. This selects the required event record from the possible 250 that may be stored. A value of 0 corresponds to the latest event and so on.
Menu Cell Ref	Latched alarm active, Latched alarm inactive, Self reset alarm active, Self reset alarm inactive, Relay event, Opto-isolated input event, Protection event, General event, Fault record event, Maintenance record event
Time & Date	Time & Date Stamp for the event given by the internal Real Time Clock
Event Text	Up to 32 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 5 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.
Distance	Distance protection trip: Trip Z1 aided, Trip Z1X aided, Trip Z2 aided, Trip Z3 aided, Trip Zp aided, Trip Zq aided, Trip Z5 aided,
Started Phase	A, B, C or N
Tripped phase	A, B, C or N
Overcurrent	Start I>1, Start I>2, Start I>3 or Start I>4
Overcurrent	Trip I>1, Trip I>2, Trip I>3 or Trip I>4
Neg Seq O/C	Negative sequence Overcurrent: Start I2>1, Start I2>2, Start I2>3 or Start I2>4
Neg Seq O/C	Negative sequence Overcurrent: Trip I2>1, Trip I2>2, Trip I2>3 or Trip I2>4
Broken conductor trip	
Earth Fault	Start IN>1, Start IN>2, Start IN>3 or Start IN>4
Earth Fault	Trip IN>1, Trip IN>2, Trip IN>3 or Trip IN>4
Aided DEF	DEF> Start
Aided DEF	DEF> Trip

VIEW RECORDS	
LCD Reference	**Description**
Undercurrent	Start I<1, Start I<2
Undercurrent	Trip I<1, Trip I<2
Undervoltage	Start V<1, Start V<2, Start V<3 or Start V<4
Undervoltage	Trip V<1, Trip V<2, Trip V<3 or Trip V<4
Overvoltage	Start V>1, Start V>2, Start V>3 or Start V>4
Overvoltage	Trip V>1, Trip V>2, Trip V>3 or Trip V>4
Overfrequency	Start F>1 or Start F>2
Overfrequency	Trip F>1 or Trip F>2
Underfrequency	Start F<1, Start F<2, Start F<3 or Start F<4
Underfrequency	Trip F<1, Trip F<2, Trip F<3 or Trip F<4
Res. Overvoltage	Start VN>1 or Start VN>2
Res. Overvoltage	Trip VN>1 or Trip VN>2
Breaker Fail	CB Fail 1 or CB Fail 2
Supervision	CTS, VTS or CVTS
LOL	Trip
SOTF/TOR	Trip
TOC	Start
TOC	Trip
Weak infeed	Trip
ZSP	Start
ZSP	Trip
User	Trip
Faulted Phase	Phase initiating fault recorder starts : Start A, Start B, Start C, Start N, Trip A, Trip B, Trip C, Trip N
Start Elements	General Start, Start I>1, Start I>2, Start I>3, Start I>4, Start I2>1, Start IN>1, Start IN>2, Start IN>3, Start IN>4, Start DEF, Start V<1, Start V<2, Start V>1, Start V>2, Start Broken Cond, Start LOL, Start Distance, Start TOC, Start Zero Seq. Pow., Start PAP, Thermal Alarm, Start I2>2, Start I2>3, Start I2>4, Start VN>1 or Start VN>2
Trip Elements1	Any Trip, Trip I>1, Trip I>2, Trip I>3, Trip I>4, Trip I2>1, Trip IN>1, Trip IN>2, Trip IN>3, Trip IN>4, Trip DEF, Trip V<1, Trip V<2, Trip V>1, Trip V>2, Trip Broken line, Trip Z1, Trip Z2, Trip Z3, Trip Zp, Trip Z4, Trip Z2 Aided, Trip LOL, Trip Soft Tor, Trip WI, Trip CB Fail1, Trip CB Fail2, Trip Zero Seq. Pow., Trip PAP, Trip Thermal or Trip User
Validities	“Measurements and Location are not valid” or “Measurements is valid” or “Location is valid”
Time & Date	Time & Date Stamp for the event given by the internal Real Time Clock.
Fault Alarms	VT Fail Alarm, CT Fail Alarm, CB Status Alarm, AR Lockout Shot >, V<1 Alarm, V<2 Alarm, V>1 Alarm, V>2 Alarm, COS Alarm, CVT Fail Alarm, V<3 Alarm, V<4 Alarm, V>3 Alarm or V>4 Alarm
System Frequency	50.00 Hz, 60.00 Hz
Fault duration	Duration of the fault
Relay Trip Time	Time and date of fault relay tripping
Fault Location	When calculated the fault location can be found (distance in km or miles, impedance or percentage of line length, set in ‘MEASUREMENT SETUP’ column). See section 0.
IA	Magnitude of phase A current
IB	Magnitude of phase B current
IC	Magnitude of phase C current
VAN	Magnitude of phase A voltage
VBN	Magnitude of phase B voltage
VCN	Magnitude of phase C voltage

VIEW RECORDS	
LCD Reference	**Description**
Fault Resistance	Fault resistance
Fault in Zone	None, Zone 1, Zone 2, Zone P, Zone Q, Zone 3 or Zone 4
Trip Elements 2	Trip I2>2, Trip I2>3, Trip I2>4, Trip VN>1, Trip VN>2, Trip Zq, Trip V<3, Trip V<4, Trip V>3, Trip V>4, Trip I<1, Trip I<2, Trip F<1, Trip F<2, Trip F<3, Trip F<4, Trip F>1, Trip F>2
Start Elements 2	Start V<3, Start V<4, Start V>3, Start V>4, Start I<1, Start I<2, Start F<1, Start F<2, Start F<3 ,Start F<4, Start F>1 or Start F>2
Select Report	Setting range from 0 to 4. This selects the required maintenance report from the possible 5 that may be stored. A value of 0 corresponds to the latest report and so on.
Report Text	Up to 32 Character description of the occurrence (refer to following sections)
Report Type	These cells are numbers representative of the occurrence. They form a specific error code which should be quoted in any related correspondence to Schneider Electric.
Report Data	
Reset Indication	Either Yes or No. This serves to reset the trip LED indications provided that the relevant protection element has reset.

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:

2.2 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”
“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 P24x or P44x the Event Value is an 8 or 16 bit word.* *For P34x or P64x it is an 8, 12, 16, 24 or 32-bit word.* *For P445 it is an 8, 12 or 16-bit word.* *For P44y, P54x, P547 or P841, it is an 8, 12, 16 or 24-bit word.* *For P74x it is a 12, 16, 24 or 32-bit word.* *For P746 or P849 it is a 32-bit word.*

2.3 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 Contacts
Event Value 0101010101010101010
```

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 P24x the Event Value is is a 7 or 16-bit word.*
For P34x or P64x it is an 7, 11, 14, 15, 16, 22, 24 or 32-bit word.
For P445 it is an 8, 12 or 16-bit word.
For P44x it is a 7, 14 or 21 bit word.
For P44y, P54x, P547 or P841, it is an 8, 12, 16, 24 or 32 bit word.
For P74x it is a 12, 16, 24 or 32 bit word.
For P746 or P849 it is a 24-bit word.

2.4 Relay Alarm Conditions

Any alarm conditions generated by the relays are logged as individual events. The following 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

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.

Alarm 1	Event Text	Explanation	Alarm 1	Event Text	Explanation
Bit 0	Unused	Unused	Bit 16	Lockout Alarm	Lockout Alarm
Bit 1	Unused	Unused	Bit 17	CB Status Alarm	CB Status Alarm
Bit 2	General Alarm	General Alarm	Bit 18	Man CB Trip Fail	CB Fail Trip Control
Bit 3	Prot'n Disabled	Protection Disabled	Bit 19	Man CB Cls Fail	CB Fail Close Control
Bit 4	F out of Range	Frequency Out of Range	Bit 20	Man CB Unhealthy	No Healthy Control Close
Bit 5	VT Fail Alarm	VTS Alarm	Bit 21	Control No C/S	No C/S control Close
Bit 6	CT Fail Alarm	CTS Alarm	Bit 22	AR Lockout Shot>	A/R Lockout max shots
Bit 7	CB Fail Alarm	CB Trip Fail Protection	Bit 23	SG-opto Invalid	Setting Group via Optos Invalid
Bit 8	I^ Maint Alarm	Broken Current Maintenance Alarm	Bit 24	A/R Fail	CB Fail to A/R
Bit 9	I^ Lockout Alarm	Broken Current Lockout Alarm	Bit 25	V<1 Alarm	V<1 Alarm

Alarm 1	Event Text	Explanation	Alarm 1	Event Text	Explanation
Bit 10	CB Ops Maint	No of CB Ops Maintenance Alarm	Bit 26	V<2 Alarm	V<2 Alarm
Bit 11	CB Ops Lockout	No of CB Ops Lockout Alarm	Bit 27	V>1 Alarm	V>1 Alarm
Bit 12	CB Op Time Maint	CB Op Time Maintenance Alarm	Bit 28	V>2 Alarm	V>2 Alarm
Bit 13	CB Op Time Lock	CB Op Time Lockout Alarm	Bit 29	COS Alarm	COS Alarm
Bit 14	F.F. Pre Lockout	Pre-alarm for Lockout	Bit 30	Brok. Cond. Alarm	Broken Conductor Alarm
Bit 15	F.F. Lock	Excessive Fault Frequency Lockout Alarm	Bit 31	CVT Alarm	CVT Fail Alarm

Table 1 - Alarm 1 status

Alarm 2	Event Text	Explanation	Alarm 2	Event Text	Explanation
Bit 0	Alarm NCIT	NCIT Alarm	Bit 16	Unused	Unused
Bit 1	Unused	Unused	Bit 17	Unused	Unused
Bit 2	Unused	Unused	Bit 18	Unused	Unused
Bit 3	Unused	Unused	Bit 19	Unused	Unused
Bit 4	Unused	Unused	Bit 20	Unused	Unused
Bit 5	Unused	Unused	Bit 21	Unused	Unused
Bit 6	Unused	Unused	Bit 22	Unused	Unused
Bit 7	Unused	Unused	Bit 23	Unused	Unused
Bit 8	Unused	Unused	Bit 24	Unused	Unused
Bit 9	V<3 Alarm	V<3 Alarm	Bit 25	Unused	Unused
Bit 10	V<4 Alarm	V<4 Alarm	Bit 26	Unused	Unused
Bit 11	V>3 Alarm	V>3 Alarm	Bit 27	Unused	Unused
Bit 12	V>4 Alarm	V>4 Alarm	Bit 28	Unused	Unused
Bit 13	On load Alarm	On Load Alarm	Bit 29	Unused	Unused
Bit 14	Unused	Unused	Bit 30	Unused	Unused
Bit 15	Unused	Unused	Bit 31	Unused	Unused

Table 2 - Alarm 2 status

Alarm 3	Event Text	Explanation	Alarm 3	Event Text	Explanation
Bit 0	Battery Fail	Battery Fail	Bit 16	IM Channel Fail	InterMiCOM Channel Fail
Bit 1	Field Volt Fail	Field Voltage Fail	Bit 17	Backup Setting	Backup Setting Alarm
Bit 2	Comm2 H/W FAIL	Rear Communication Fail	Bit 18	Bad DNP Settings	Bad DNP Setting
Bit 3	GOOSE IED Absent	GOOSE IED Absent	Bit 19	Unused	Unused
Bit 4	NIC Not Fitted	NIC Not Fitted	Bit 20	Full DR Alarm	Disturbance Record is Full
Bit 5	NIC No Response	NIC No Response	Bit 21	Invalid DNPoE IP	Invalid DNPoE IP Configuration
Bit 6	NIC Fatal Error	NIC Fatal Error	Bit 22	Invalid Config.	Invalid IEC61850 Configuration
Bit 7	Unused	Unused	Bit 23	Test Mode Alm	Test Mode Alarm
Bit 8	Unused	Unused	Bit 24	Contacts Blk Alm	Contacts Block Alarm
Bit 9	Unused	Unused	Bit 25	NIC HW Mismatch	Hardware Mismatch Alarm
Bit 10	Unused	Unused	Bit 26	NIC APP Mismatch	Ethernet Card Software Edition Mismatch Alarm

Alarm 3	Event Text	Explanation	Alarm 3	Event Text	Explanation
Bit 11	NIC SW Mis-Match	Software Mismatch Alarm	Bit 27	Simul.GOOSE Alm	Simulation GOOSE Alarm
Bit 12	IP Addr Conflict	IP Address Conflict	Bit 28	Unused	Unused
Bit 13	IM Loopback	InterMiCOM Loopback	Bit 29	Unused	Unused
Bit 14	IM Message Fail	InterMiCOM Message Fail	Bit 30	Unused	Unused
Bit 15	IM Data CD Fail	InterMiCOM Data CD Fail	Bit 31	Unused	Unused

Table 3 - Alarm 3 status

User Alarm	Event Text	Explanation	User Alarm	Event Text	Explanation
Bit 0	SR User Alarm 1	Self-reset User Alarm 1	Bit 16	MR User Alarm 1	Manual-reset User Alarm 1
Bit 1	SR User Alarm 2	Self-reset User Alarm 2	Bit 17	MR User Alarm 2	Manual-reset User Alarm 2
Bit 2	SR User Alarm 3	Self-reset User Alarm 3	Bit 18	MR User Alarm 3	Manual-reset User Alarm 3
Bit 3	SR User Alarm 4	Self-reset User Alarm 4	Bit 19	MR User Alarm 4	Manual-reset User Alarm 4
Bit 4	SR User Alarm 5	Self-reset User Alarm 5	Bit 20	MR User Alarm 5	Manual-reset User Alarm 5
Bit 5	SR User Alarm 6	Self-reset User Alarm 6	Bit 21	MR User Alarm 6	Manual-reset User Alarm 6
Bit 6	SR User Alarm 7	Self-reset User Alarm 7	Bit 22	MR User Alarm 7	Manual-reset User Alarm 7
Bit 7	SR User Alarm 8	Self-reset User Alarm 8	Bit 23	MR User Alarm 8	Manual-reset User Alarm 8
Bit 8	SR User Alarm 9	Self-reset User Alarm 9	Bit 24	MR User Alarm 9	Manual-reset User Alarm 9
Bit 9	SR User Alarm 10	Self-reset User Alarm 10	Bit 25	MR User Alarm 10	Manual-reset User Alarm 10
Bit 10	SR User Alarm 11	Self-reset User Alarm 11	Bit 26	MR User Alarm 11	Manual-reset User Alarm 11
Bit 11	SR User Alarm 12	Self-reset User Alarm 12	Bit 27	MR User Alarm 12	Manual-reset User Alarm 12
Bit 12	SR User Alarm 13	Self-reset User Alarm 13	Bit 28	MR User Alarm 13	Manual-reset User Alarm 13
Bit 13	SR User Alarm 14	Self-reset User Alarm 14	Bit 29	MR User Alarm 14	Manual-reset User Alarm 14
Bit 14	SR User Alarm 15	Self-reset User Alarm 15	Bit 30	MR User Alarm 15	Manual-reset User Alarm 15
Bit 15	SR User Alarm 16	Self-reset User Alarm 16	Bit 31	MR User Alarm 16	Manual-reset User Alarm 16

Table 4 – User (SR & MR) alarm status

2.5 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.

2.6 General Events

A number of events come under the heading of 'General Events'. The following list items are stored as events.

- Recognition of change of state of logic (optically isolated) inputs
- Recognition of change of state of output relays
- Alarms
- Maintenance records
- Settings changes (local and remote)

A complete list of the 'General Events' is given in the Relay Menu Database, which is a separate document.

2.7 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 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.

2.8 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 5 such 'events' 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 and in further detail in the following table (the list is not exhaustive):

Text	Explanation
Bus Failure	Bus Check Failure
SRAM Failure	SRAM Failure
BB RAM Failure	BB RAM Failure

Text	Explanation
LCD Failure	LCD Failure
Watchdog 1 Fail	Watchdog 1 Failure (Fast)
Watchdog 2 Fail	Watchdog 2 Failure (Slow)
Field Volt Fail	Field Voltage Failure
FlashEEPROM Fail	Flash EPROM Failure
EEPROM Fail	EEPROM Failure
Cal EEPROM Fail	Cal EEPROM Failure
Invalid H/W	Incorrect Hardware Configuration
Power Up Boot	Power Up Boot
Soft Reboot	Soft Reboot

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.

2.9 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'.*

2.10 Viewing Event Records via MiCOM S1 Studio 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 November 2010 15:32:49 GMT I>1 Start ON 2147483881

MiCOM
Model Number: P442
Address: 001 Column: 00 Row: 23
Event Type: Protection operation

Monday 03 November 2010 15:32:52 GMT Fault Recorded 0

MiCOM
Model Number: P442
Address: 001 Column: 01 Row: 00
Event Type: Fault record

Monday 03 November 2010 15:33:11 GMT Logic Inputs 00000000

MiCOM
Model Number: P442
Address: 001 Column: 00 Row: 20
Event Type: Logic input changed state

Monday 03 November 2010 15:34:54 GMT Output Contacts 0010000

MiCOM
Model Number: P442
Address: 001 Column: 00 Row: 21
Event Type: relay output changed state

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 *Relay Menu Database* document. This standalone document not included in this manual.

```
+ Wednesday 02 July 2010 10:59:24.403 st Z1 OFF
+ Wednesday 02 July 2010 10:59:24.391 st General Alarm ON
− Wednesday 02 July 2010 10:59:24.388 st Output Contacts1
  70-132 Rev.9 : Dorinne 70kV
  Model Number: P442211B3A0070B
  Address: 001  Column: 00  Row: 21
  Event Type: Device output changed state
  Event Value      00000100001111
    ON    0  General TRIP D1
    ON    1  General TRIP D2
    ON    2  General Start
    ON    3  Start A
    OFF   4  Start B
    OFF   5  Start C
    OFF   6  Start N
    OFF   7  Not used
    ON    8  AR Start
    OFF   9  Not Used
    OFF  10  Not Used
    OFF  11  Not used
    OFF  12  Not Used
    OFF  13  CB Close
+ Wednesday 02 July 2010 10:59:24.388 st 3P Trip ON
+ Wednesday 02 July 2010 10:59:24.388 st Any Trip C ON
+ Wednesday 02 July 2010 10:59:24.388 st Any Trip B ON
```

P0384ENa

Figure 1 - Date/time stamps and descriptions

2.11 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.

For further information on events and their specific meaning, see the *Relay Menu Database* document.

3 DISTURBANCE RECORDER

The integral disturbance recorder ("Disturb recorder" menu) has an area of memory specifically set aside for record storage. The number of records that may be stored depends on the selected recording duration but the relays can typically store a minimum of 20 records, each of 10.5 seconds duration.

Note 1	*Compressed Disturbance Recorder used for Kbus/Modbus/DNP3 reach that typical size value (10.5 sec duration)*
Note 2	*Uncompressed Disturbance Recorder used for IEC 60870-5/103 could be limited to 2 or 3 seconds.*

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 which are taken at a rate of 24 samples per cycle.

It is not possible to view the disturbance records locally via the LCD; they must be extracted using suitable software such as MiCOM S1 Studio. This process is fully explained in the SCADA Communications section.

Note	*In some cases, where relays do not belong to a system, and are only connected to a PC with MiCOM S1 Studio via one rear port, it is desirable not to loose any disturbance records, as they are overwritten when memory is full.*

A DDB alarm ('Full DR Alarm', software version D6.x) can be set to notify disturbance records exceed 70% of the memory storage capacity.

4 FAULT LOCATOR

The relay has an integral fault locator that uses information from the current and voltage inputs to provide a distance to fault measurement. The sampled data from the analogue input circuits is written to a cyclic buffer until a fault condition is detected. The data in the input buffer is then held to allow the fault calculation to be made. When the fault calculation is complete the fault location information is available in the relay fault record.

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 km, miles, impedance or percentage of line length. The fault locator can store data for up to five faults. This ensures that fault location can be calculated for all shots on a typical multiple reclose sequence, whilst also retaining data for at least the previous fault.

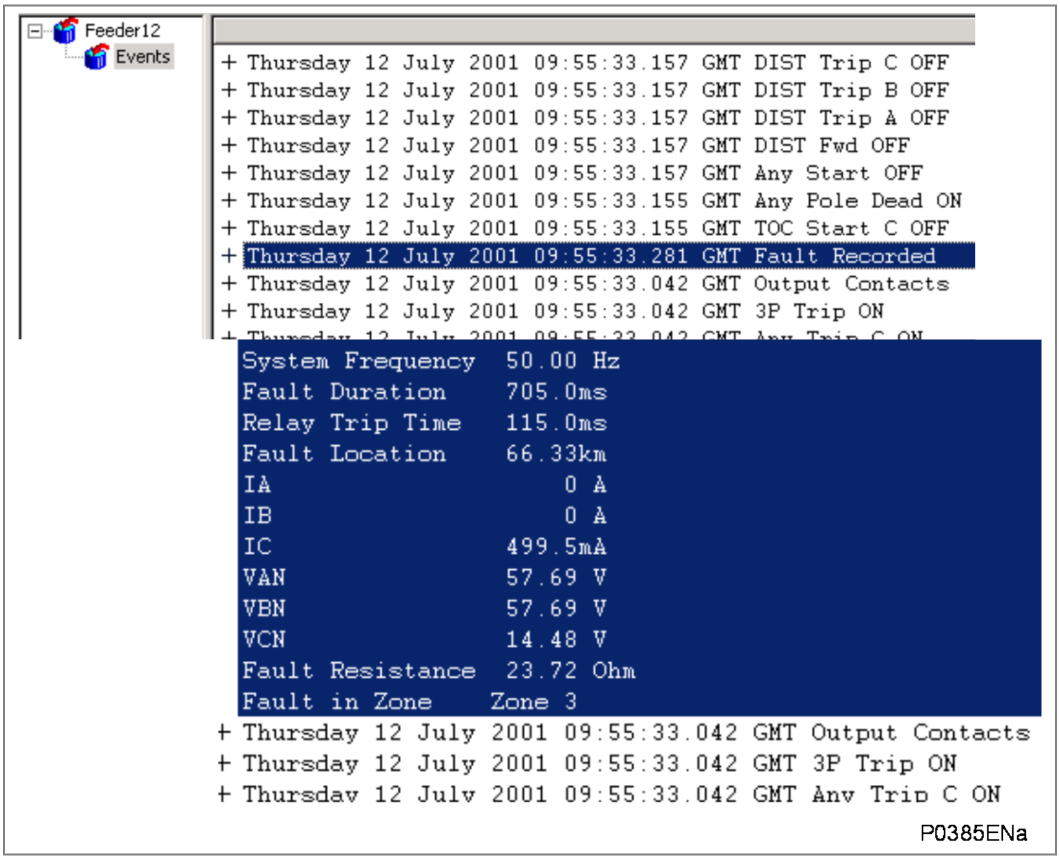

Figure 2 - Fault location information included in an event

5 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:

5.1 Measured Currents

The relay produces current values. They are produced directly from the DFT (Discrete Fourier Transform) used by the relay protection functions and present both magnitude and phase angle measurement.

5.2 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.

5.3 Self-Check Setting and Impedance Monitoring

Self-check setting and impedance monitoring (Software Version D6.x) is intended to propose a way to monitor and display impedance values and margin (in %) between start / tripping threshold and measured value on the front panel.

Load Impedance Value:

If there is no fault (loop inside the distance characteristic), the impedance value is the measured impedance (Z_{meas}).

As soon as there is a “Zone Start” (loop outside distance characteristic), impedance module and argument will be:

- The minimum of the 3 bi-passed impedance if there is not residual current,
- The minimum of the six impedances (bi or mono-phased) if a residual current is measured.

The MiCOM P44x displays (menu “MEASUREMENTS 1”

- “impedance module”: algebraic values of the impedances (in ohms),
- “impedance Argument”: corresponding angle (in degrees).

Monitoring of "% of Start":

If loop is outside the distance characteristic, the "% to start" displayed will be calculated and displayed as follow:

- Percentage of Z_{meas} to monoloop start ("% Zone Mono") =
  "measured resistance" – "Resistance of monoloop start characteristic" *
- Percentage of Z_{meas} to biphase loop start ("% Zone bi") =
  "measured resistance" – "Resistance of biphase start characteristic" *

*: In general, Z3/Z4

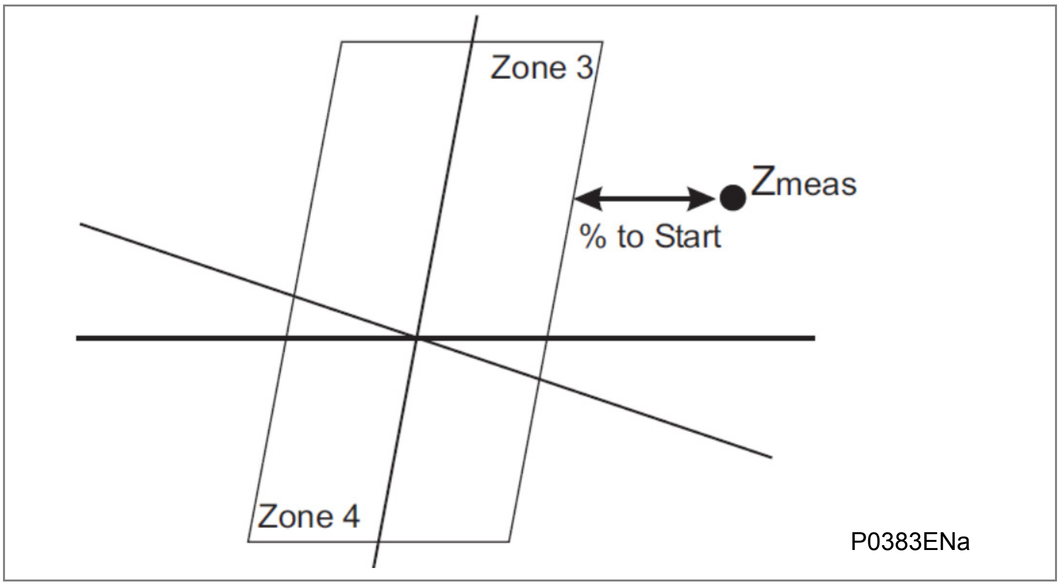

Figure 3 - Measured impedance

5.4 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:

5.5 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.

5.5.1 Measurements 1

P442	P444	MEASUREMENTS 1
Yes	Yes	IA Magnitude
Yes	Yes	IA phase Angle
Yes	Yes	IB Magnitude
Yes	Yes	IB Phase Angle
Yes	Yes	IC Magnitude

P442	P444	MEASUREMENTS 1
Yes	Yes	IC Phase Angle
Yes	Yes	IN Derived mag
Yes	Yes	IN Derived Ang
Yes	Yes	I1 Magnitude
Yes	Yes	I2 Magnitude
Yes	Yes	I0 magnitude
Yes	Yes	VAB Magnitude
Yes	Yes	VAB Phase Angle
Yes	Yes	VBC Magnitude
Yes	Yes	VBC Phase Angle
Yes	Yes	VCA Magnitude
Yes	Yes	VCA Phase Angle
Yes	Yes	VAN Magnitude
Yes	Yes	VAN Phase Angle
Yes	Yes	VBN Magnitude
Yes	Yes	VBN Phase Angle
Yes	Yes	VCN Magnitude
Yes	Yes	VCN Phase Angle
Yes	Yes	VN Derived Mag
Yes	Yes	VN Derived Ang
Yes	Yes	V1 Magnitude
Yes	Yes	V2 Magnitude
Yes	Yes	V0 Magnitude
Yes	Yes	Frequency
Yes	Yes	C/S Voltage Mag
Yes	Yes	C/S Voltage Ang
Yes	Yes	IM Magnitude
Yes	Yes	IM Angle
Yes	Yes	Slip frequency
Yes	Yes	Impedance module*
Yes	Yes	Impedance Argument*
Yes	Yes	% Zone bi*
Yes	Yes	% Zone Mono*
*: software version D6.x		

5.5.2 Measurements 2

P442	P444	MEASUREMENTS 2
Yes	Yes	Thermal Status
Yes	Yes	Reset Thermal
Yes	Yes	A Phase Watts
Yes	Yes	B Phase Watts
Yes	Yes	C Phase Watts
Yes	Yes	A Phase Vars
Yes	Yes	B Phase Vars
Yes	Yes	C Phase Vars
Yes	Yes	A Phase VA
Yes	Yes	B Phase VA
Yes	Yes	C Phase VA
Yes	Yes	3 Phase Watts
Yes	Yes	3 Phase Vars
Yes	Yes	3 Phase VA
Yes	Yes	Zero Seq power
Yes	Yes	3Ph Power Factor
Yes	Yes	Aph Power Factor
Yes	Yes	Bph Power Factor
Yes	Yes	Cph Power Factor
Yes	Yes	3 Ph W Fix Dem
Yes	Yes	3 Ph Vars Fix Dem
Yes	Yes	3Ph W Peak Dem
Yes	Yes	3Ph Vars Peak Dem
Yes	Yes	Reset Demand

Notes:

PRODUCT DESIGN

CHAPTER 9

Date:	01/2017
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:	M
Software version:	E1
Connection diagrams:	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)

CONTENTS

FIGURES

TABLES

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.

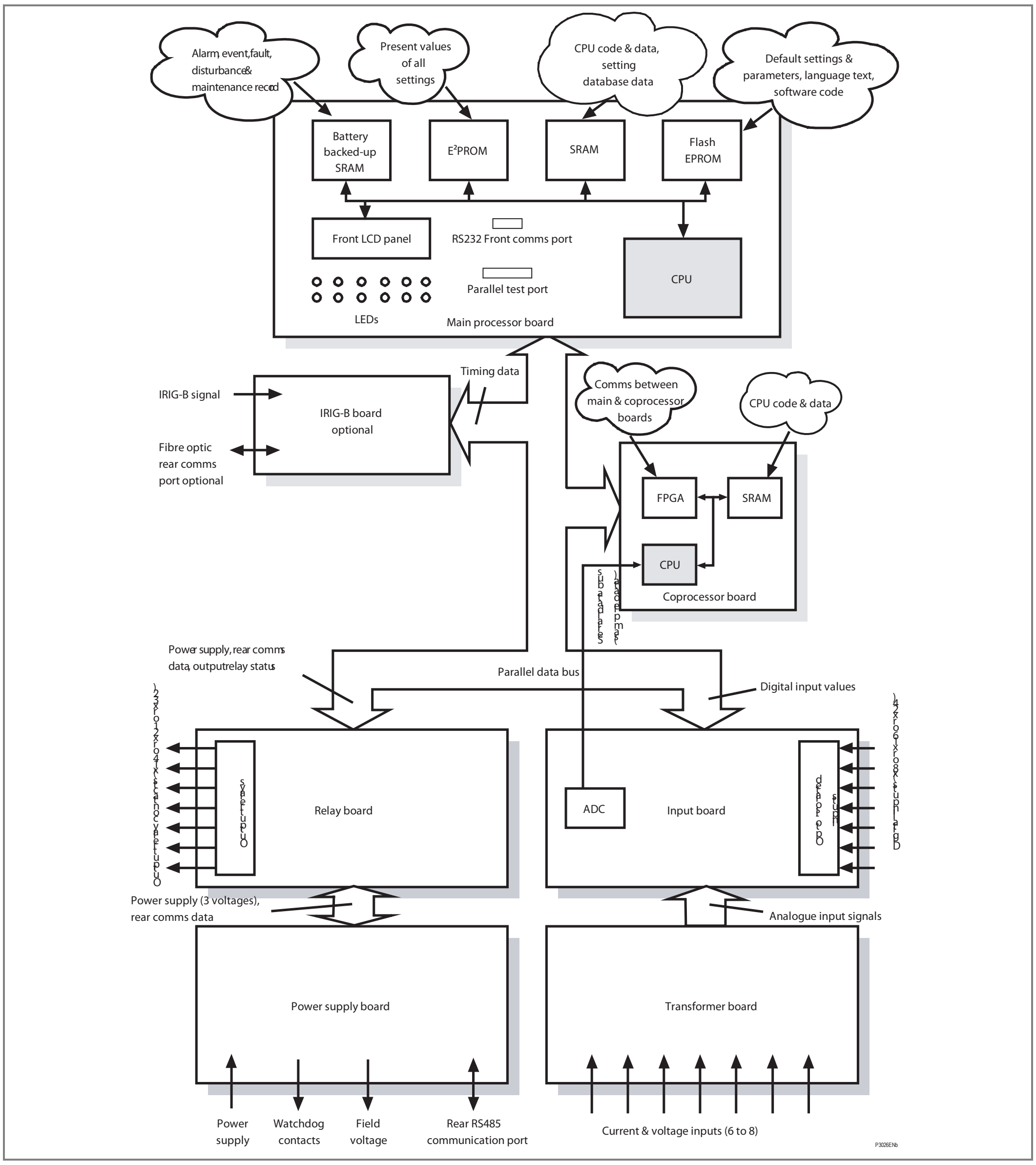

Figure 1 - Relay modules and information flow

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 accept either 1 A or 5 A nominal current (selected using relay menu) and the voltage inputs are specified for 110 V nominal voltage. 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 secondaries provide differential input signals to the main input board to reduce noise..

1.5.2 Input and Output Boards

	P442	P444
Opto-inputs	16 x UNI(1)	24 x UNI(1)
Relay outputs	9 normally open + 12 change over	24 normally open + 8 change over (2)
Notes:	(1) Universal voltage range opto inputs	(2) Up to 46 outputs (in option)

Table 1 - Inputs and Outputs

1.5.3 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

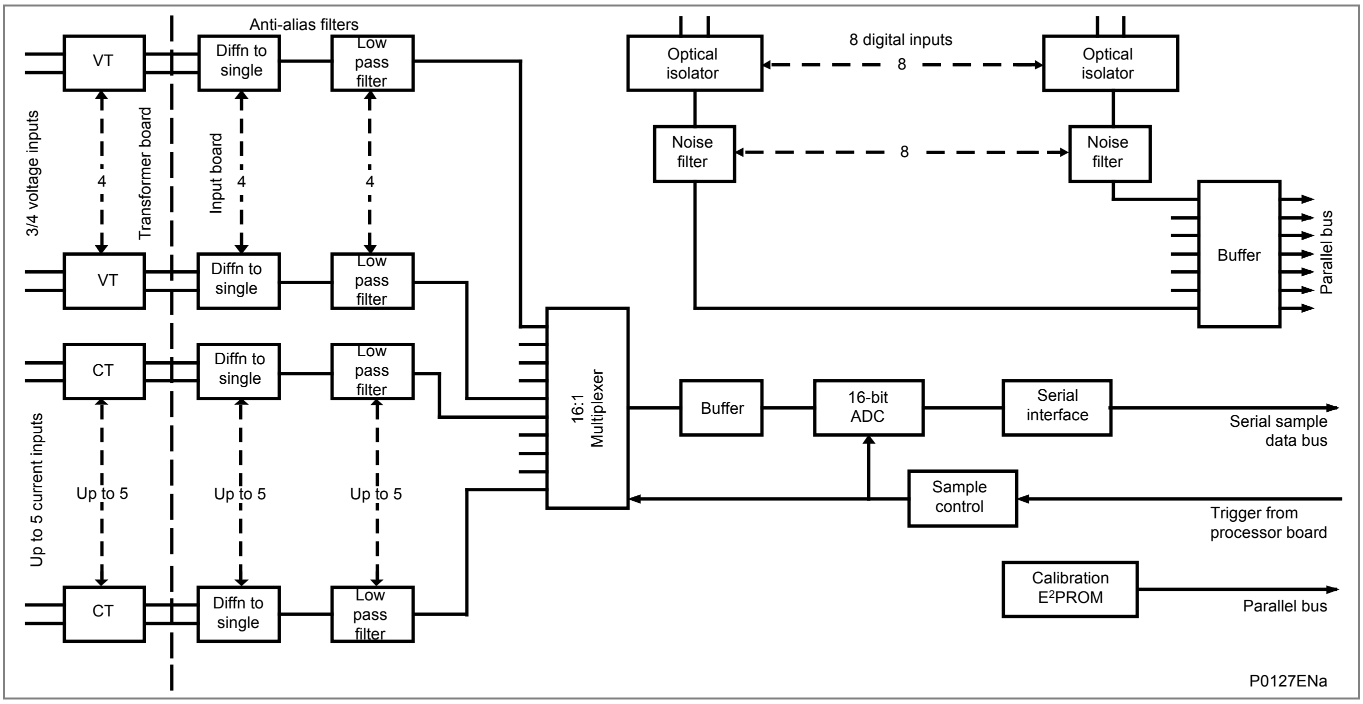

Figure 2 - Main input board

1.5.4 Universal Opto Isolated Logic Inputs

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. i.e. thereby allowing different voltages for different circuits e.g. signalling, tripping. They nominally provide a Logic 1 or On value for Voltages ≥80% of the set voltage and a Logic 0 or Off value for the voltages ≤60% of the set 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.

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.

Each input also has selectable filtering which can be utilised.

This series of relays have universal opto-isolated logic inputs that can be programmed for the nominal battery voltage of the circuit of which they are a part. This allows different voltages for different circuits such as signaling and tripping. They can also be programmed as Standard 60% - 80% or 50% - 70% to satisfy different operating constraints.
Threshold levels are shown in this table:

Nominal battery voltage (Vdc)	Standard 60% - 80%		50% - 70%	
	No operation (Logic 0) Vdc	Operation (Logic 1) Vdc	No operation (Logic 0) Vdc	Operation (Logic 1) Vdc
24/27	<16.2	>19.2	<12.0	>16.8
30/34	<20.4	>24.0	<15.0	>21.0
48/54	<32.4	>38.4	<24.0	>33.6
110/125	<75.0	>88.0	<55.0	>77.0
220/250	<150.0	>176.0	<110	>154

Table 2 - Threshold levels

This lower value eliminates fleeting pick-ups 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 selectable filtering. This allows a pre-set ½ cycle filter to be used to prevent induced noise on the wiring. However, although the ½ cycle filter is secure it can be slow, particularly for intertripping. If the ½ cycle filter is switched off to improve speed, double pole switching or screened twisted cable may be needed on the input to reduce ac noise.

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 RS485 Communication Interface)

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 3 - 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 provides two output relay contacts, one normally open and one normally closed which are driven by the processor board. These are provided to give an indication that the relay is in a healthy state.

1.6.2 Output Relay Board

The output relay board holds seven relays, three with normally open contacts and four with changeover contacts.

The relays are driven from the 22V power supply line. The relays' state is written to or read from using the parallel data bus.

Depending on the relay model, seven additional output contacts may be provided, through the use of up to three extra relay boards.

1.6.3 High Break Relay Board

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:

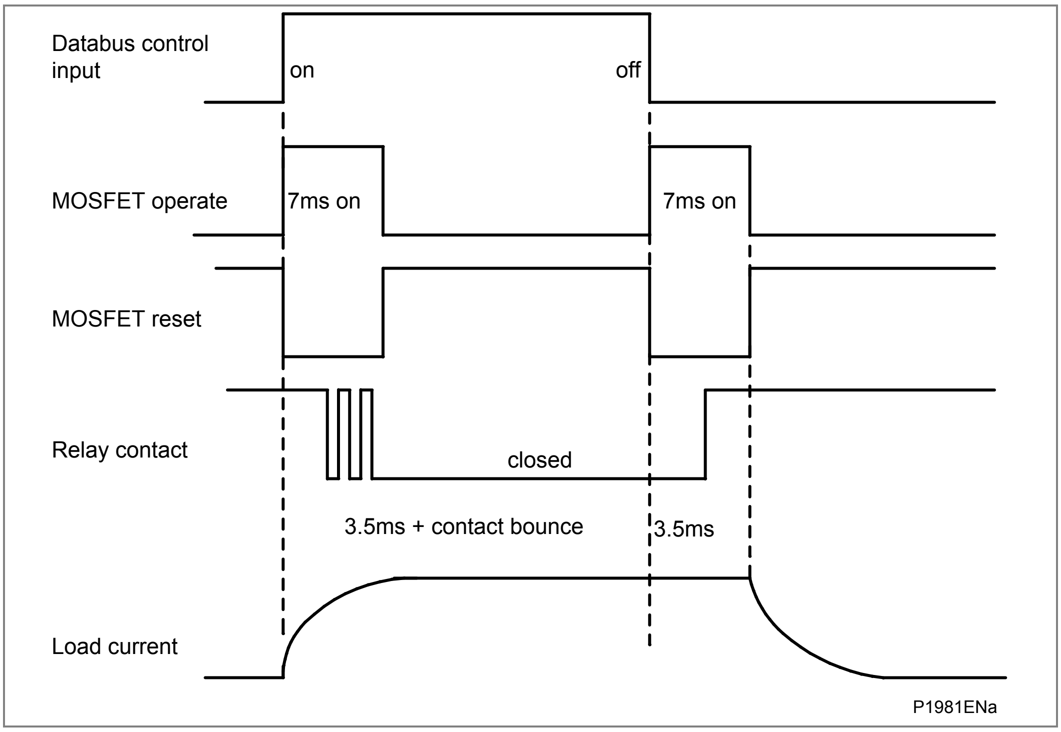

Figure 3 - High break contact operation

1.7 Hardware Communication 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, Redundant Ethernet, PRP, HSR, Dual IP, Self-Healing Ring, RSTP, Dual Homing Star, Second Rear Comms Ports, Optical Fibre connections). 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.

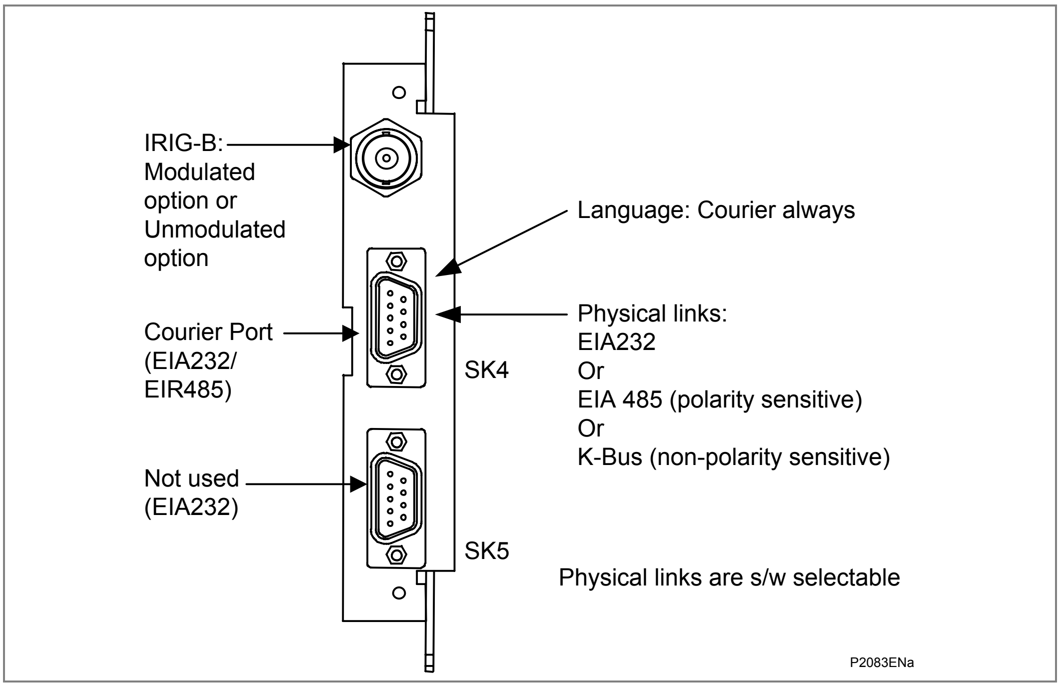

Figure 4 - Rear comms. Port

1.10 Ethernet Board (Options)

This is a mandatory board for IEC 61850 enabled relays. It provides network connectivity through either copper or fiber media at rates of 10Mb/s (copper only) or 100Mb/s. There is also an option on this board to specify IRIG-B board port (modulated and/or un-modulated). This board, the IRIG-B board mentioned in the Hardware Communications Options section and second rear comms. board mentioned in the IRIG-B Board section 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. 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 10/100 Mbits/s Copper and modulated/unmodulated IRIG-B connectivity)
- single-port Ethernet boards (which use 100MBits/s optical fibre connectivity)
- Redundant Ethernet Self-Healing Ring with one or more multi-mode fibre optic ports and modulated/unmodulated IRIG-B connectivity
- Redundant Ethernet RSTP with one or more multi-mode fibre optic ports and modulated/unmodulated IRIG-B connectivity
- Redundant Ethernet Dual Homing Star with one or more multi-mode fibre optic ports and modulated/unmodulated IRIG-B connectivity
- Redundant Ethernet Parallel Redundancy Protocol (PRP) with one or more multi-mode fibre optic ports 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 IEC 61850 communications through the Ethernet board, the rear EIA(RS)485 and front EIA(RS)232 ports are also available for simultaneous use, both using the Courier protocol.

One example of an Ethernet board is shown in this *Ethernet board connectors* diagram:

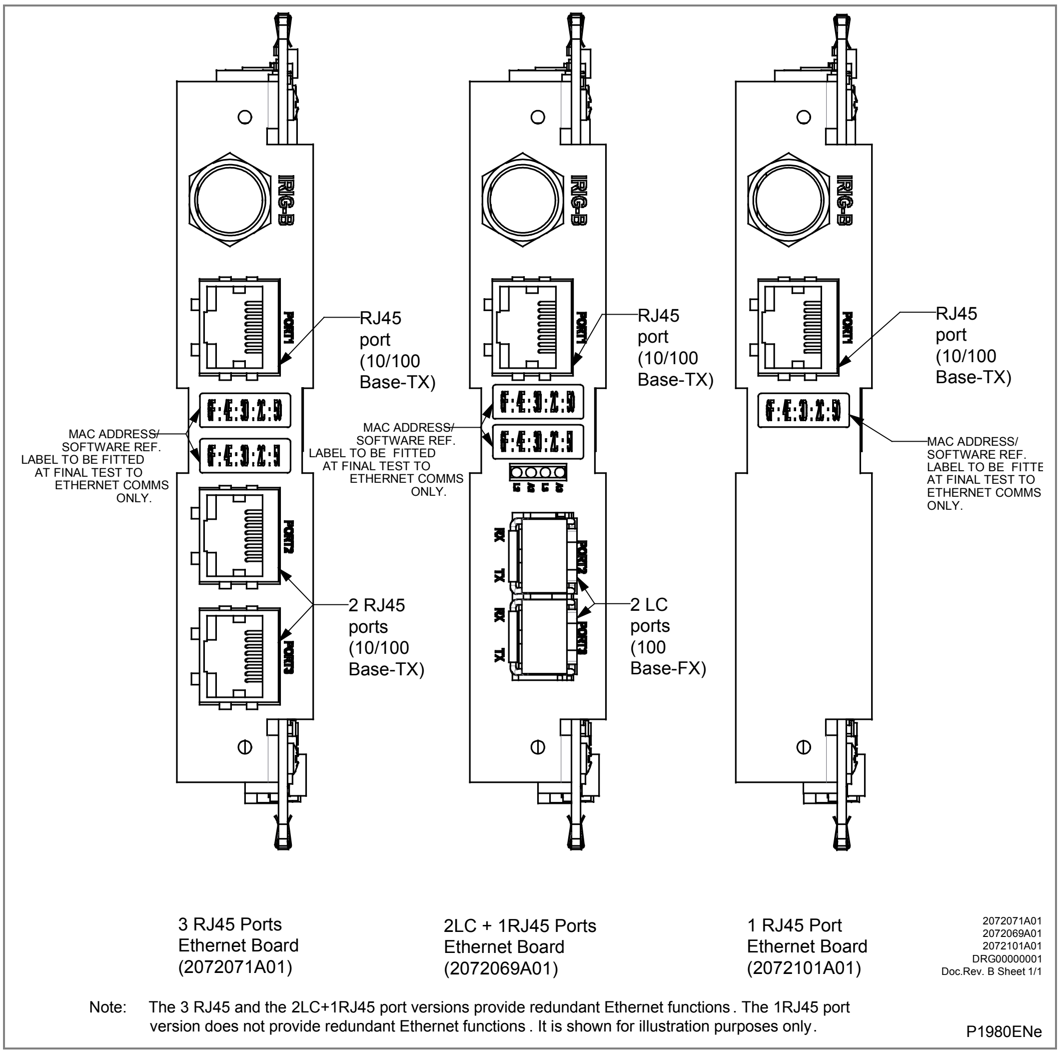

Figure 5 - Ethernet board connectors (3 RJ45 or 2 LC + RJ45 or 1 RJ45)

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.

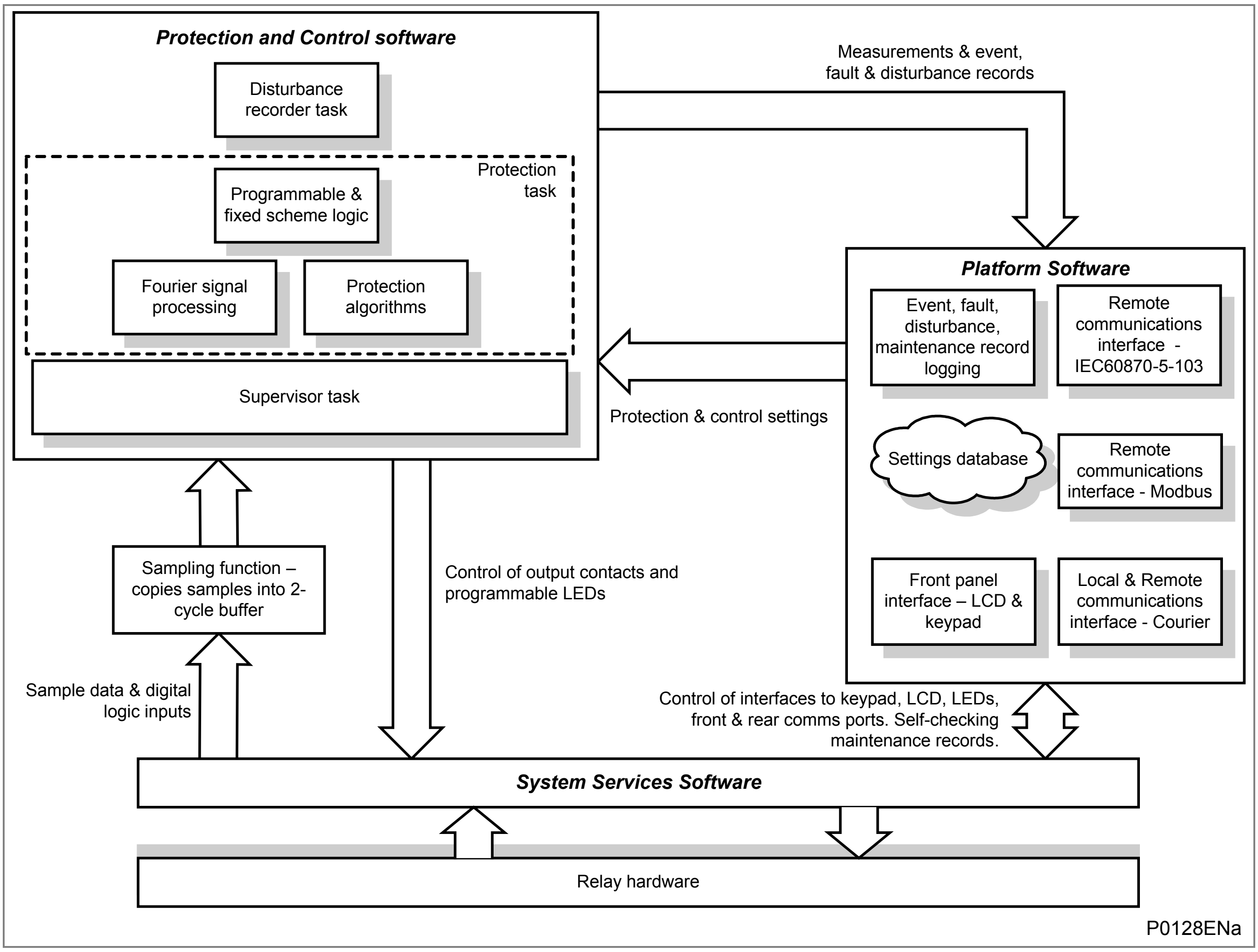

Figure 6 – Relay software structure

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 96 alarms (with 64 application alarms: 32 alarms in alarm status 1 and another group of 32 alarms in alarm status 2 and 32 alarms platform (see GC annex for mapping), 250 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 initialisation 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 P44x distance protection relay, the protection task is executed twice per cycle, i.e. after every 24 samples for the sample rate of 48 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.

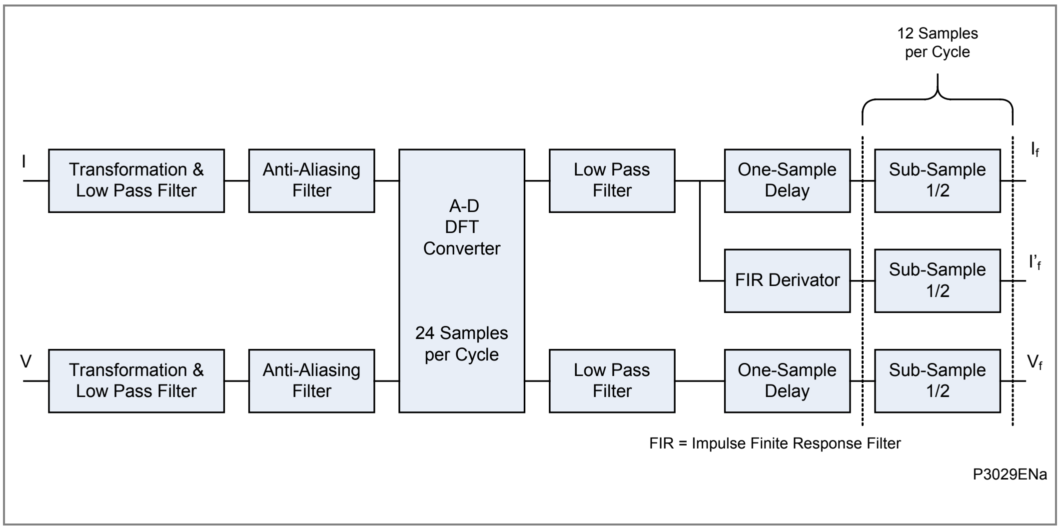

Figure 7 - Signal acquisition and processing

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 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.

2.4.4 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.

2.4.5 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 (internal or external fault)
- Operating time
- Primary or Secondary RMS values of prefault phase and neutral currents or angle of each winding
- Primary or Secondary RMS values of fault phase and neutral currents or angle of each winding
- Primary or Secondary RMS values of differential and biased current of each phase

2.4.6 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 8 analogue channels and the values of up to 32 digital signals. The recording time is user selectable up to a maximum of 10 seconds (the maximum storage capacity is 84s). 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. It attempts to limit the demands on memory space by saving the analogue data in compressed format whenever possible. This is done by detecting changes in the analogue input signals and compressing the recording of the waveform when it is in a steady-state condition. The disturbance records can be extracted by MiCOM S1 Studio 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.

4 SELF-TESTING & 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 5 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.

COMMISSIONING

CHAPTER 10

Date:	01/2017
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:	M
Software version:	E1
Connection diagrams:	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)

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TABLES

FIGURES

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, it is only necessary to verify that the hardware is functioning correctly and the application-specific software settings have been applied to the relay. It is considered unnecessary to test every function of the relay if the settings have been verified by one of the following 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.

Blank commissioning test and setting records are provided within this manual for completion as required.

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 Safety Information chapter/Safety Guide SFTY/5L M/L11 or later issue, the Technical Data chapter and the ratings on the equipment rating label.**

Caution	**The relay must not be disassembled in any way during commissioning.**

2 RELAY COMMISSIONING TOOLS

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 P44x		
Menu Text	**Default Setting**	**Settings**
Opto I/P Status	-	-
Relay O/P Status	-	-
Test Port Status	-	-
LED Status	-	-
Monitor Bit 1	0 - (RELAY 1)	0 to 2047
Monitor Bit 2	1 - (RELAY 2)	0 to 2047
Monitor Bit 3	2 - (RELAY 3)	0 to 2047
Monitor Bit 4	3 - (RELAY 4)	0 to 2047
Monitor Bit 5	4 - (RELAY 5)	0 to 2047
Monitor Bit 6	5 - (RELAY 6)	0 to 2047
Monitor Bit 7	6 - (RELAY 7)	0 to 2047
Monitor Bit 8	7 - (RELAY 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		-
Green LED Status		-
Note *See Relay Menu Database for details of DDB signals*		

Table 1 - Commission Tests

2.1 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.

2.2 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.*

2.3 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.

2.4 LED Status

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.

2.5 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.

2.6 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.

2.7 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.

2.8 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.*

2.9 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**'.

2.10 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 relay 3. If the PSL has been changed, it is essential that this signal remains mapped to relay 3 for the '**Test Auto-reclose**' facility to work.*

2.11 Red LED Status and Green LED Status

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.

2.12 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.

3 SETTING FAMILIARISATION

When first commissioning a relay, allow sufficient time to become familiar with how to apply the settings.

The *Relay Menu Database document* and the *Introduction* or *Settings* chapters contain a detailed description of the menu structure of Schneider Electric relays. The relay 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 MiCOM S1 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.

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

5.1 Introduction to 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 password protection is enabled, and the customer has changed password 2 that prevents unauthorized changes to some of the settings, either the revised password 2 should be provided, or the customer should restore the original password before testing is started.

Note	*If the password has been lost, a recovery password can be obtained from Schneider Electric by quoting the serial number of the relay. The recovery password is unique to that relay and will not work on any other 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.**

5.2 With the Relay De-energised

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.

5.2.1 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.

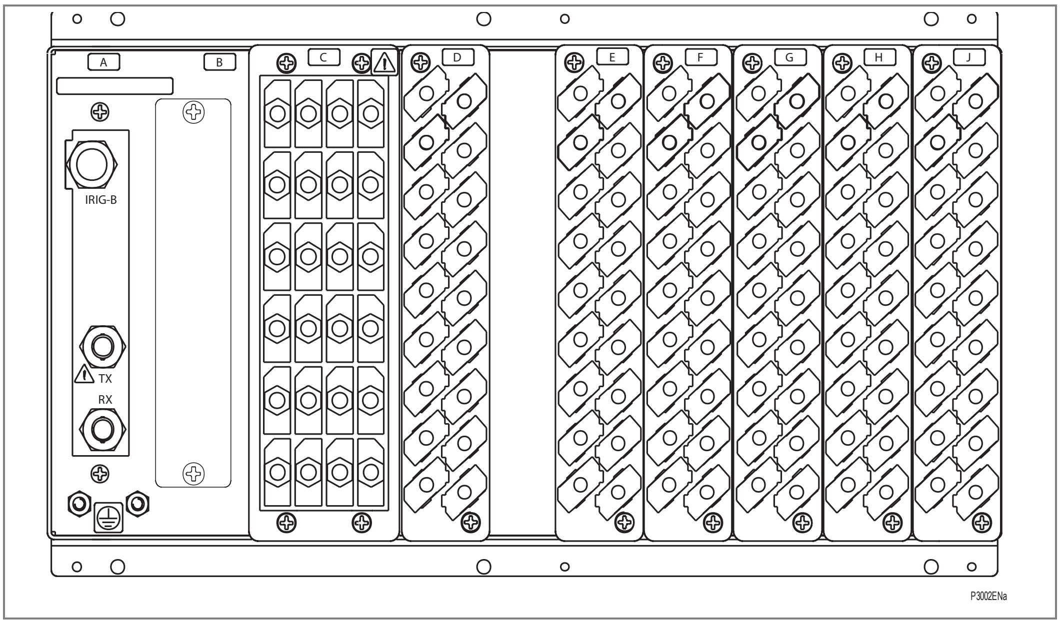


Figure 1 - Rear terminal blocks on size 60TE case (P442)

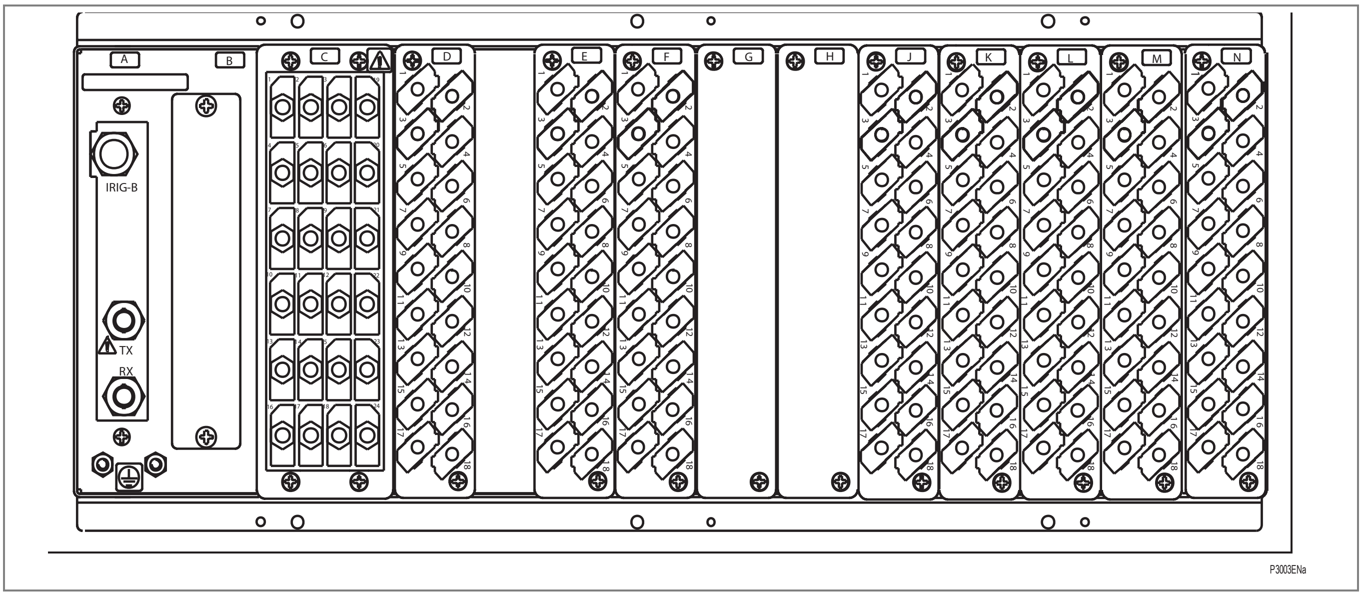


Figure 2 - Rear terminal blocks on size 80TE case (P444)

5.2.2 Current Transformer Shorting Contacts

If required, the current transformer shorting contacts can be checked to ensure that they close when the heavy duty terminal block shown in the following figure(s) is disconnected from the current input PCB. The heavy duty terminal block location depends on the relay model.

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.

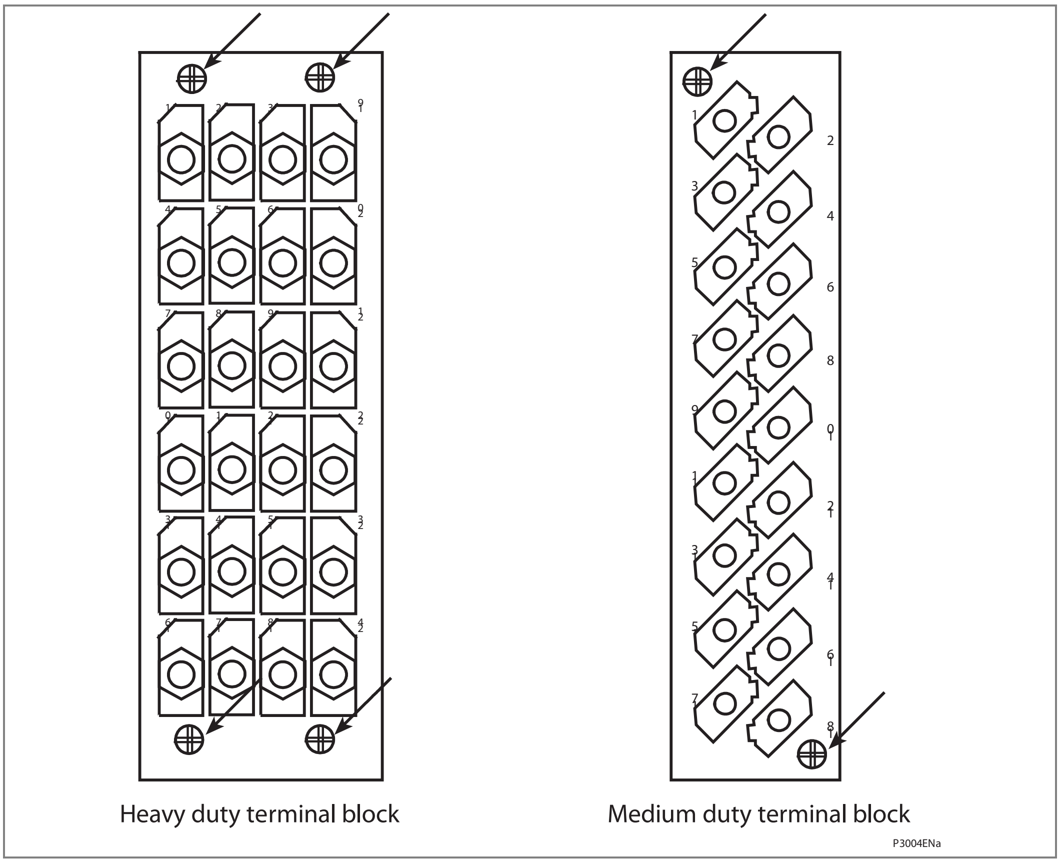


Figure 3 - Location of securing screws for terminal blocks

Current Input	Shorting contact between terminals	
	1A CT's	5A CT's
IA	C3-C2	C1-C2
IB	C6-C5	C4-C5
IC	C9-C8	C7-C8
IM	C12-C11	C10-C11

Table 3 - Current transformer shorting contact locations

5.2.3 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:

a) Voltage transformer circuits
b) Current transformer circuits
c) Auxiliary voltage supply
d) Field voltage output and opto-isolated control inputs
e) Relay contacts
f) EIA(RS)485 communication port
g) 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.

5.2.4 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 (colored orange with the odd numbered terminals 1, 3, 5, 7, and so on). The auxiliary supply is normally routed through terminals 13 (supply positive) and 15 (supply negative), with terminals 14 and 16 connected to the relay's positive and negative auxiliary supply terminals respectively. However, check the wiring against the schematic diagram for the installation to ensure compliance with the customer's normal practice.

5.2.5 Watchdog Contacts

Using a continuity tester, check that the watchdog contacts are in the states shown in the *Watchdog contact statu*s table for a de-energized relay.

Terminals		Contact State	
		Relay De-energised	Relay Energised
J11-J12 N11-N12	(P442) (P444)	Closed	Open
J13-J14 N13-N14	(P442) (P444)	Open	Closed

Table 4 - Watchdog contact status

5.2.6 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**	**dc**	**ac**
24 - 32V dc	-	19 - 38V dc	-
48 - 110V dc	-	37 - 150V dc	-
110 - 250V dc	100 - 240V ac rms	87 - 300V dc	80 - 265V ac

Table 5 - Operational range of auxiliary supply

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.

5.3 With the Relay Energised

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.

5.3.1 Watchdog Contacts

Using a continuity tester, check the watchdog contacts are in the states given in Table 5 for an energized relay.

5.3.2 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 SNTP via Ethernet.

5.3.3 With an IRIG-B signal (models P442 or P444 only)

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.

5.3.4 Without an IRIG-B 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.

5.3.5 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.*

5.3.5.1 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.

5.3.5.2 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.

5.3.5.3 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.

5.3.6 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	
	P442	P444
+48 V dc	J7 & J8	N7 & N8
–48 V dc	J9 & J10	N9 & N10

Table 6 - Field voltage terminals

5.3.7 Input Opto-isolators

This test checks that all the opto-isolated inputs on the relay are functioning correctly.

Model	Opto-Insulated Inputs
P442	16
P444	24

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.

P44x				
Opto Input No	Apply field voltage to terminals			
	P442		P444	
	-ve	+ve	-ve	+ve
Opto input 1	D1	D2	D1	D2
Opto input 2	D3	D4	D3	D4
Opto input 3	D5	D6	D5	D6
Opto input 4	D7	D8	D7	D8
Opto input 5	D9	D10	D9	D10
Opto input 6	D11	D12	D11	D12
Opto input 7	D13	D14	D13	D14
Opto input 8	D15	D16	D15	D16
Opto input 9	E1	E2	E1	E2
Opto input 10	E3	E4	E3	E4
Opto input 11	E5	E6	E5	E6
Opto input 12	E7	E8	E7	E8
Opto input 13	E9	E10	E9	E10
Opto input 14	E11	E12	E11	E12
Opto input 15	E13	E14	E13	E14
Opto input 16	E15	E16	E15	E16
Opto input 17			F1	F2
Opto input 18			F3	F4
Opto input 19			F5	F6
Opto input 20			F7	F8
Opto input 21			F9	F10
Opto input 22			F11	F12
Opto input 23			F13	F14
Opto input 24			F15	F16

Table 8 - Opto-isolated input terminals

5.3.8 Output Relays

This test checks that all the output relays are functioning correctly.

Model	Outputs
P442	21
P444	32

Ensure that the cell [xxxx: COMMISSIONING TESTS, Test Mode] is set to **Contacts Blocked**. (xxxx = 0F0E for P44x/P44y, 0F0D for P14x, P24x, P34x, P54x, P547, P64x or P841).

The output relays should be energized one at a time. To select output relay 1 for testing, set cell [xxxx: COMMISSIONING TESTS, Test Pattern] to 00000000000000000000000000000001. (xxxx = 0F0F for P44x/P44y, 0F0E for P14x, P24x, P34x, P445, P54x, P547, P64x or P841).

Connect a continuity tester across the terminals corresponding to output relay 1 as shown in the relevant external connection diagram in the *Installation* chapter.

To operate the output relay, set cell [xxxx: 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. (xxxx = 0F11 for P44x, 0F0F for P14x, P24x, P34x, P44y, P445, P54x, P547, P64x or P841).

Reset the output relay by setting cell [xxxx: COMMISSIONING TESTS, Contact Test] to **Remove Test**. (xxxx = 0F11 for P44x, 0F0F for P14x, P24x, P34x, P44y, P445, P54x, P547 or P64x).

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**.

MiCOM P442						
Output	**N/C**	**N/O**		**Output**	**N/C**	**N/O**
Without high break relay board (all models except P442×××C)						
Relay 1	-	H1-H2		Relay 12	G10-G12	G11-G12
Relay 2	-	H3-H4		Relay 13	G13-G15	G14-G15
Relay 3	-	H5-H6		Relay 14	G16-G18	G17-G18
Relay 4	H7-H9	H8-H9		Relay 15	-	F1-F2
Relay 5	H10-H12	H11-H12		Relay 16	-	F3-F4
Relay 6	H13-H15	H14-H15		Relay 17	-	F5-F6
Relay 7	H16-H18	H17-H18		Relay 18	F7-F9	F8-F9
Relay 8	-	G1-G2		Relay 19	F10-F12	F11-F12
Relay 9	-	G3-G4		Relay 20	F13-F15	F14-F15
Relay 10	-	G5-G6		Relay 21	F16-F18	F17-F18
Relay 11	G7-G9	G8-G9				
With high break relay board (model P442×××C)						
Output	N/C	N/O		Output	N/C	N/O
Relay 1	-	H1-H2		Relay 10	-	G5-G6
Relay 2	-	H3-H4		Relay 11	G7-G9	G8-G9
Relay 3	-	H5-H6		Relay 12	G10-G12	G11-G12
Relay 4	H7-H9	H8-H9		Relay 13	G13-G15	G14-G15
Relay 5	H10-H12	H11-H12		Relay 14	G16-G18	G17-G18
Relay 6	H13-H15	H14-H15		HB relay 15	-	F3(-)-F4
Relay 7	H16-H18	H17-H18		HB relay 16	-	F7(-)-F8(+)
Relay 8	-	G1-G2		HB relay 17	-	F11(-)-F12(+)
Relay 9	-	G3-G4		HB relay 18	-	F15(-)-F16(+)

MiCOM P444						
Output	**N/C**	**N/O**		**Output**	**N/C**	**N/O**
Without high break relay board (all models except P444×××C)						
Relay 1	-	M1-M2		Relay 24	K16-K18	K17-K18
Relay 2	-	M3-M4		Relay 25	-	J1-J2
Relay 3	-	M5-M6		Relay 26	-	J3-J4
Relay 4	-	M7-M8		Relay 27	-	J5-J6
Relay 5	-	M9-M10		Relay 28	-	J7-J8
Relay 6	-	M11-M12		Relay 29	-	J9-J10
Relay 7	M13-M15	M14-M15		Relay 30	-	J11-J12
Relay 8	M16-M18	M17-M18		Relay 31	J13-J15	J14-J15
Relay 9	-	L1-L2		Relay 32	J16-J18	J17-J18
Relay 10	-	L3-L4		Relay 33	-	H1-H2
Relay 11	-	L5-L6		Relay 34	-	H3-H4
Relay 12	-	L7-L8		Relay 35	-	H5-H6
Relay 13	-	L9-L10		Relay 36	H7-H9	H8-H9
Relay 14	-	L11-L12		Relay 37	H10-H12	H11-H12
Relay 15	L13-L15	L14-L15		Relay 38	H13-H15	H14-H15
Relay 16	L16-L18	L17-L18		Relay 39	H16-H18	H17-H18
Relay 17	-	K1-K2		Relay 40	-	G1-G2
Relay 18	-	K3-K4		Relay 41	-	G3-G4
Relay 19	-	K5-K6		Relay 42	-	G5-G6
Relay 20	-	K7-K8		Relay 43	G7-G9	G8-G9
Relay 21	-	K9-K10		Relay 44	G10-G12	G11-G12
Relay 22	-	K11-K12		Relay 45	G13-G15	G14-G15
Relay 23	K13-K15	K14-K15		Relay 46	G16-G18	G17-G18

MiCOM P444						
Output	**N/C**	**N/O**		**Output**	**N/C**	**N/O**
With high break relay board (model P444×××C)						
Relay 1	-	M1-M2		HB relay 18	-	J7(-)-J8(+)
Relay 2	-	M3-M4		HB relay 19	-	J11(-)-J12(+)
Relay 3	-	M5-M6		HB relay 20	-	J15(-)-J16(+)
Relay 4	-	M7-M8		Relay 21	-	H1-H2
Relay 5	-	M9-M10		Relay 22	-	H3-H4
Relay 6	-	M11-M12		Relay 23	-	H5-H6
Relay 7	M13-M15	M14-M15		Relay 24	H7-H9	H8-H9
Relay 8	M16-M18	M17-M18		Relay 25	H10-H12	H11-H12
HB relay 9	L3(-)-L4(+)			Relay 26	H13-H15	H14-H15
HB relay 10	L7(-)-L8(+)			Relay 27	H16-H18	H17-H18
HB relay 11	L11(-)-L12(+)			Relay 28	-	G1-G2
HB relay 12	L15(-)-L16(+)			Relay 29	-	G3-G4
HB relay 13	K3(-)-K4(+)			Relay 30	-	G5-G6
HB relay 14	K7(-)-K8(+)			Relay 31	G7-G9	G8-G9
HB relay 15	K11(-)-K12(+)			Relay 32	G10-G12	G11-G12
HB relay 16	K15(-)-K16(+)			Relay 33	G13-G15	G14-G15
HB relay 17	J3(-)-J4(+)			Relay 34	G16-G18	G17-G18

Table 9 - Relay output terminals and test pattern settings

5.3.9 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:

- 5.3.9.1 - Courier Communications
- 5.3.9.2 - Modbus Communications
- 5.3.9.3 - IEC60870-5-103 (VDEW) Communications

5.3.9.1 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	**Modbus or VDEW**	**P442**	**P444**
Screen	Screen	J16	N16
1	+ve	J17	N17
2	–ve	J18	N18

Table 10 - RS485 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.

5.3.9.2 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.

5.3.9.3 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, 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.

5.3.10 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.*

MEASUREMENTS 1 Menu cell	P44x	
	Apply current to	
	1A CT	5A CT
[0201: IA1 Magnitude]	C3-C2	C1-C2
[0203: IB1 Magnitude]	C6-C5	C4-C5
[0205: IC1 Magnitude]	C9-C8	C7-C8
[0207: IA2 Magnitude]	C12-C11	C10-C11

Table 11 - Current input terminals

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.

	P44x
Menu cell	Corresponding CT ratio (in VT and CT RATIO column (0A) of menu)
[0201: IA Magnitude] [0203: IB Magnitude] [0205: IC Magnitude]	$\frac{[0A07 : Phase\ CT\ Primary]}{[0A08 : Phase\ CT\ Secondary]}$

Table 12 - CT ratio settings

5.3.11 Voltage Inputs

This test verifies that the accuracy of voltage measurement is within the acceptable tolerances.

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.

Cell in Measurements 1 Column (02)	Voltage applied to
	P44x
[021A: VAN Magnitude]	C19-C22
[021C: VBN Magnitude]	C20-C22
[021E: VCN Magnitude]	C21-C22
[022B: C/S Voltage Mag] *	C23-C24
* Voltage reference for synchrocheck. Can be PGnd or PP reference with VT bus side or VT line (see the Setting description in the Application Notes chapter).	

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)
	P44x
[021A: VAN Magnitude] [021C: VBN Magnitude] [021E: VCN Magnitude]	$\frac{[0A01 : Main\ VT\ Primary]}{[0A02 : Main\ VT\ Secondary]}$
[022B: C/S Voltage Mag]	$\frac{[0A03 : C/S\ VT\ Primary]}{[0A04 : C/S\ VT\ Secondary]}$

Table 14 - VT ratio settings

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.

If the application-specific settings are not available, ignore sections 6.1 - Apply Application-Specific Settings and section 6.2 - Check Application-Specific Settings.

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/MiCOM S1 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.

6.2 Check Application-Specific 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 (MiCOM S1 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:

6.3 Demonstrate Correct Distance Function Operation

6.3.1 Functional Tests: Start Control & Distance Characteristic Limits

Despite working in 100% numerical technology some tests can be performed to check that the relay has the right characteristics; regarding the different choices for functions and settings (protection settings & records and logic schemes (PSL Editor) settings).

The *Distance Scheme Test (If Activated)* section explains how to perform a complete check of every distance protection functions of the relay (with the factory's settings & PSL: "P&C by default").

In the event of relay or application's failure:

Warning	**RETURN TO THE BASIC CONFIGURATION (SETTINGS & PSL) AND THEN VALIDATE THE TESTS FOLLOWING THE ENCLOSED DESCRIPTION (via the LCD on the front panel (configuration/restore defaults/all settings+validate))**

The default password possibly required to confirm the settings is:

AAAA

Note	*Every action performed using a laptop can also be performed using the LCD front panel (only PSL and Text Editor require a computer).*

6.3.1.1 Measurements Check:

TEST 1	Currents	IA	0.2In	0°
		IB	0.4In	- 120°
		IC	0.8In	+ 120°
	Voltages	VAN	30V	0°
		VBN	40V	- 120°
		VCN	50V	+ 120°

Before starting the tests, perform these injections on the secondary side of the relay:

- Check the displayed values on the relay's front panel (LCD):"system/meas1"
- Secondary values in amplitude and phase
- Or primary values (control of ratios VT & CT) – If selected:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
MEASUREMENT SETUP				
…				
Remote Values	Primary	Primary/Secondary		
Control of VT & CT ratios				
Measurement Ref	VA	VA / VB / VC / IA / IB or IC		
Control of measurement reference				

Note 1	*Check the measurement reference (ref. angle of phase shift) in: "Measurt set up/Measurement ref." (VA by default).*

Monitoring can also be selected to poll the network parameters (I/U/P/Q/f…)

Note 2	*In LCD: IN=3I0*

After this step, the errors on the phase sequences, ratios of CT, VT and wiring (analogue input only) will be detected.

Note 3	*See connections drawing*
Note 4	*See LCD structure in test tools*

Check the polarisation of the protection: inject a three-phase symmetrical load according to the following table:

TEST 2	Currents	IA	IN	20°
		IB	IN	-100°
		IC	IN	+140°
	Voltages	VAN	57 V	0°
		VBN	57 V	-120°
		VCN	57 V	+120°

- If one phase is missing the output Fuse Failure alarm will pick up & the LED general alarm on the front panel will light up (see Fuse Failure description in section P44x/EN AP)

According to the chosen measurement mode, the following is obtained:

Measurement mode	0	1	2	3
P	+	-	+	-
Q	-	-	+	+

Set by:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
MEASUREMENT SETUP				
…				
Measurement Mode	0	0 / 1 / 2 or 3		

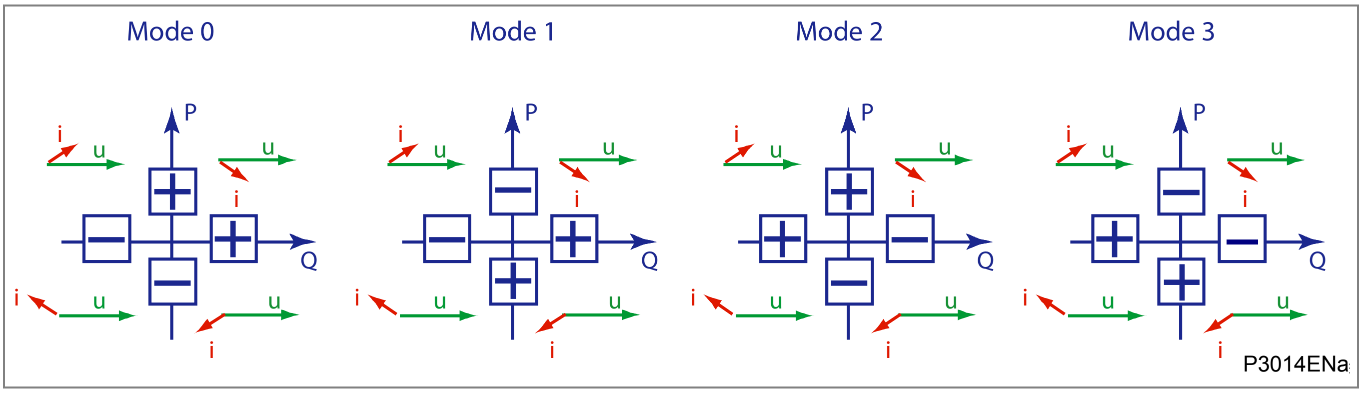


Figure 4 - Modes 0 to 3

Check the signs of values P, Q to LCD ("Measurements 2") – settable with LCD.

Note	*The primary side orientation remains to be achieved (repeat previously points with a primary injection)*

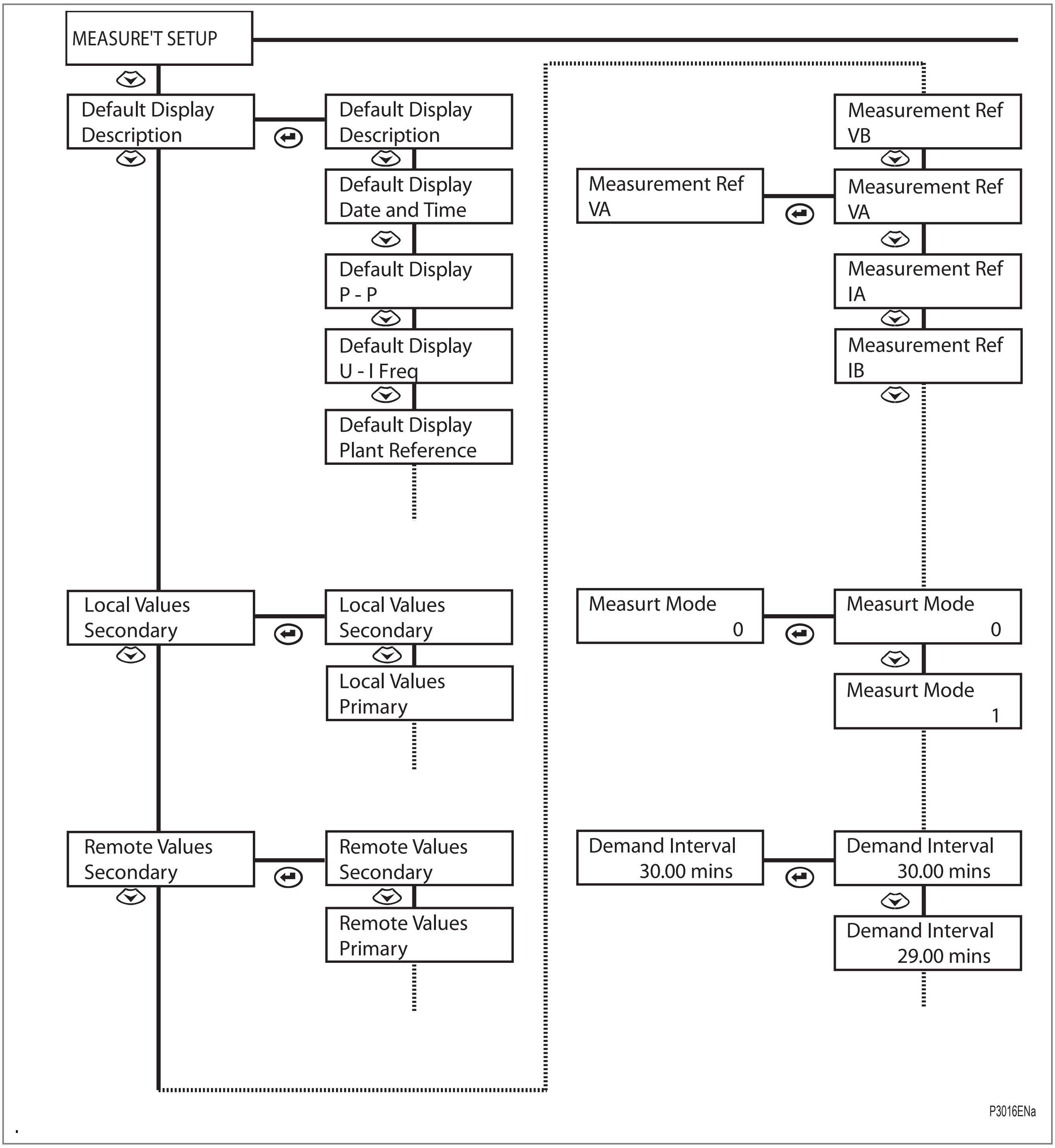


Figure 5 - Measurement setup/LCD menu

6.3.1.2 Default Simulation Principle

To Simulate a Single-Phase Fault

The distance protection detects a single-phase default in E if the impedance and phase of this point place it inside the characteristic. The relation between the impedance and phase and the injected voltage and current is as follows:

- Fault Impedance Z = Vphase/Iphase ;
- Fault Phase φ = phase-shift(Vphase, Iphase) ;
- The Vphase voltage has to remain lower than the rated voltage value

Impedance test for zone 1:

I1 = 1A

φ1 = line angle = 76°

$\frac{V1}{I1}$ = Zfault = Zd (1 + k0) + Rfault

Rfault = R loop

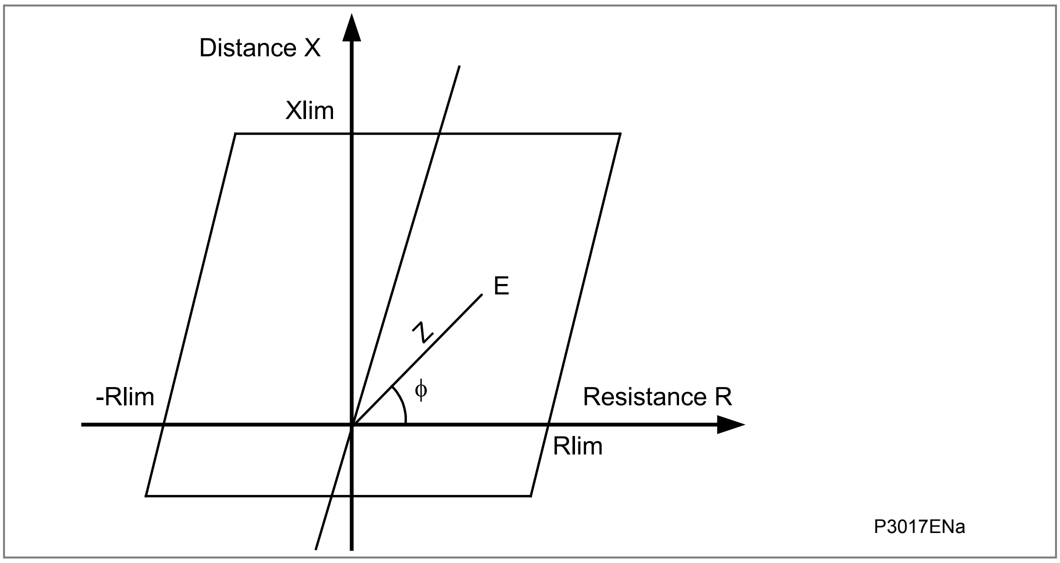


Figure 6 - Characteristic point determination (Rlim two-phase & single-phase can be different)

The characteristic angle is:

- For phase-to-phase: Argument of the positive impedance of the line (Z1)
- For phase-to-earth: Argument of 2Z1+Z0

The relay characteristic can be created and displayed with Z-Graph (MiCOM Z-Graph software is a tool delivered with the protection).

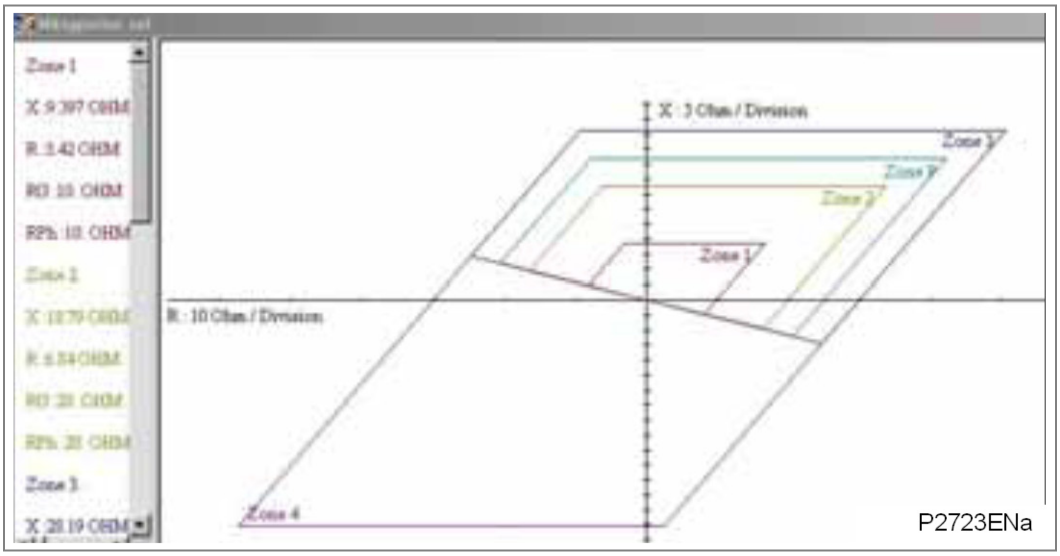


Figure 7 - Example of Z-graph screen (RIO format can be created as well)

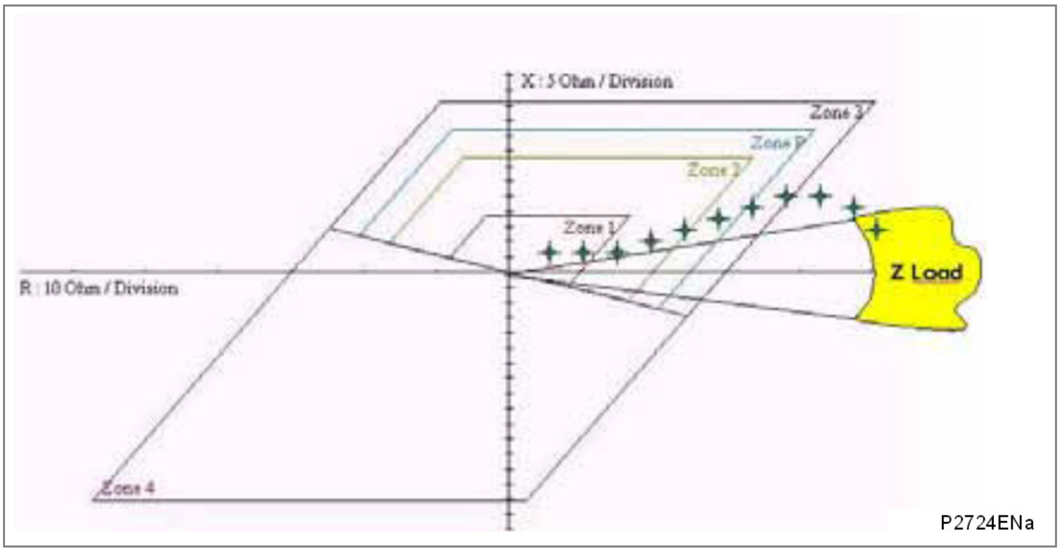


Figure 8 - Evolving impedance from the load area to the final fault impedance in zone1

To simulate a fault in a zone, it is necessary to vary the current progressively to move the point from the load area into the desired zone.

A single-phase starting characteristic with different values of K0 can be created: (K0x = (Zx0 - Z1) /(3 Z1).

(there are up to four possibilities KZ1 & KZ2, KZp, KZ3/4)

This solution is carried out in case of an underground cable/overhead line section (KZ1 ≠ KZ2 = KZp = KZ3/4) where the Z01 & Z02 angles can be very different (HV Line at 80° and cable at 45°).

Nevertheless, the most common injection devices do not allow several values of K0 to be handled (the same for Z-Graph); therefore, for accurate control of zone limits, it will be necessary to generate several characteristic files (as many Rio files as KZ values.

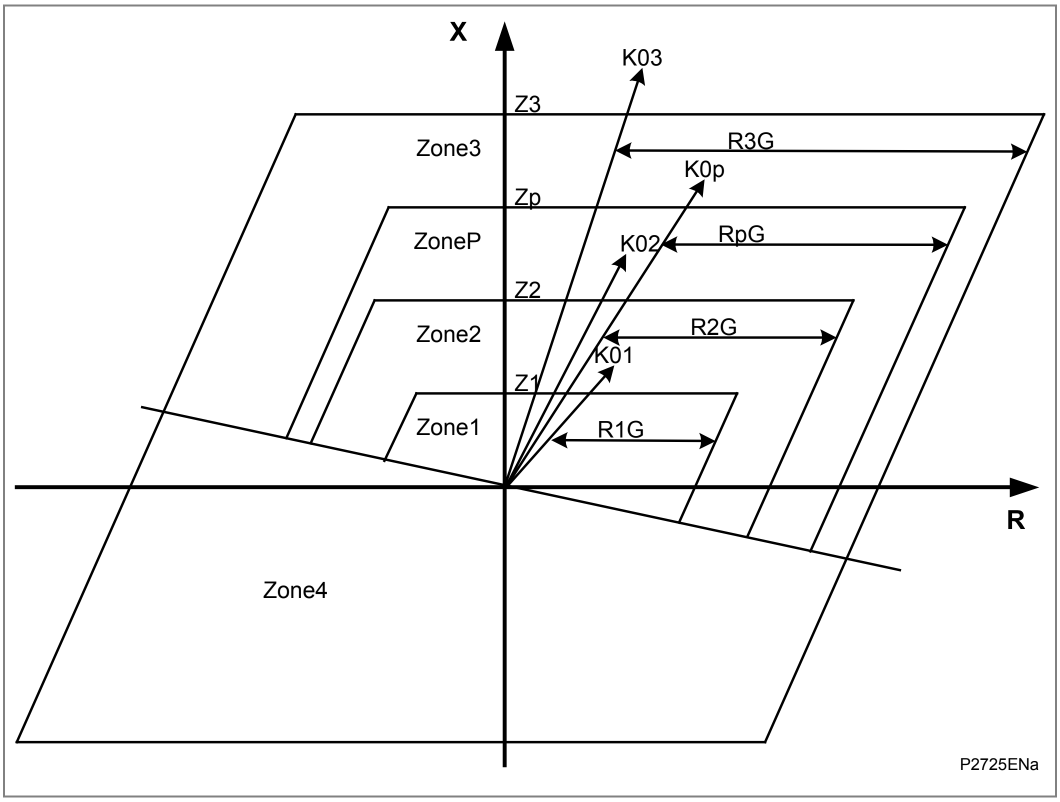


Figure 9 - Single characteristic with p forward zone

Z1, Z2, Z3, Zp, Z4 : limits of zone 1, 2, 3, p, 4

R1G, R2G, R3G, RpG: resistance limits of zone 1, 2, 3, p, 4 for single-phase fault.

K01, K02, K03, K0p : residual compensation factor of zone 1, 2, 3, p

Zone 1, 2, 3 & P can have different resistance limits and residual factors. Zones 3 and 4 (start zone) have the same resistance sensitivity and residual compensation factor. The residual compensation factor depends of the line's characteristic in each zone.

Line angle: $\varphi pg = \text{Arg}\ \frac{2x\ Z1+Zx0}{3}$

where Zx0 is the zero sequence impedance for zone x and Z1 is the positive impedance.

Zones Coverage

Different line angles for each single-phase characteristic zone can be defined, and, depending on the configuration of each zone, some encroachment between zones could occur.

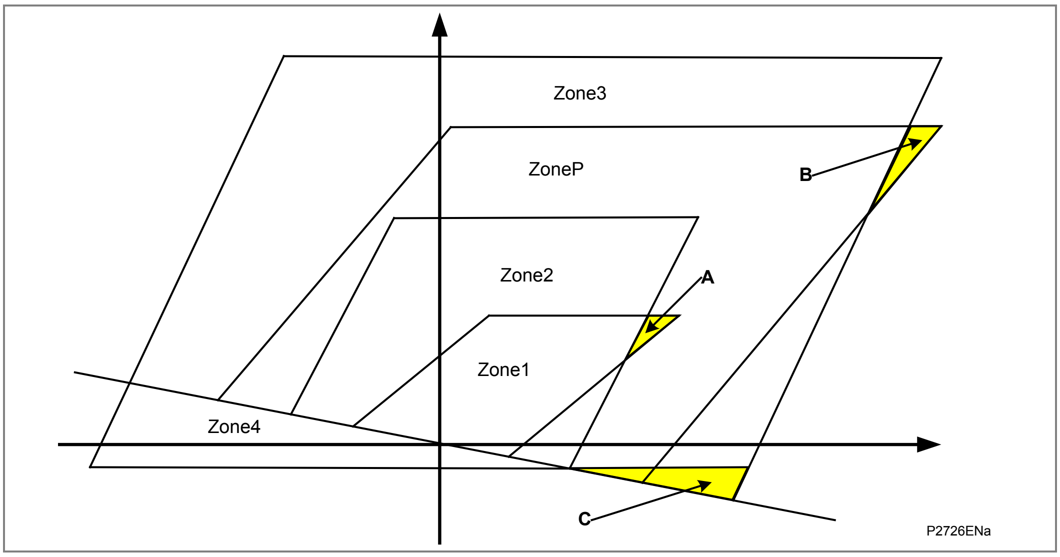


Figure 10 - Zones coverage

In the characteristic above, the parts marked A, B and C are intersections between several zones.

- The surface A is considered as being in zone 1.
- The surface B is not a part of the characteristic (no start element).
- The surface C is not a part of the starting characteristic (up to version A4.0, a new logic is implemented to keep Z1 forward detection in area C (even with a fault negative reactance value higher than the reverse limit X4))

Plausibility:

For a characteristic to be plausible, its various parameters must comply with the following equations: (no blocking plausibility check is provided by the internal logic control of the relay).

if zone P is set forward:

Z1 < Z1ext < Z2 < Zp < Z3
tZ1 < tZ2 < tZp < tZ3
R1G ≤ R2G ≤ RpG ≤ R3G
R1Ph ≤ R2Ph ≤ RpPh ≤ R3Ph

if zone P is set reverse:

Z1 < Z1ext < Z2 < Z3
Zp < Z4
tZ1 < tZ2 < tZ3
tZp < tZ4
R1G ≤ R2G ≤ R3G
RpG ≤ R4G
R1Ph ≤ R2Ph ≤ R3Ph
RpPh ≤ R4Ph

- The Z minimum value measured by the relay is: 60 mohms (Z1min set is 1ohm with CT 1Amp & 200 mohms with CT 5Amp)
- There is no limit for the R/X ratio because a floating-point processor is used for the R calculation & X calculation (separated dynamic range for each calculation). In consequence the limit will be given by the angle error of the CT.

For example in PUR with CT accuracy angle at 1° (for IN), this gives a R/X = 5,7 – to keep a 10% error in the X1 measurement.

- R limit: min. 0 /max. 80 ohms (CT 5Amp) – min. 0/max. 400 ohms (CT 1Amp)
- X limit: min. 0,2/max. 100 ohms (CT 5Amp) – min.1/max. 500 ohms (CT 1Amp)

To simulate a two-phase fault

The two-phase fault simulation principle is the same as the one used to simulate a single-phase fault but:

- the voltage reference is the line to line voltage between phases, Uab for example;
- the reference current is the difference between the phase-currents, Ia - Ib for example;
- the fault impedance Z = (Uphase-phase/(Iphase1 - Iphase2)).
- the R1M point (single phase) is replaced by the R1ph point.(Biphase) Two-phase characteristic with reverse zone P:

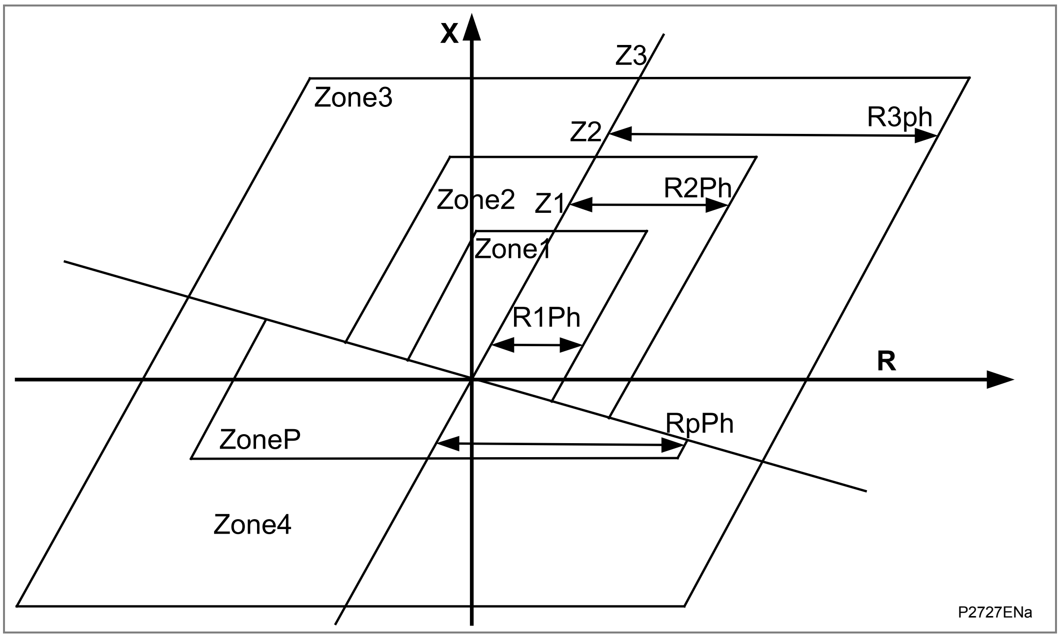


Figure 11 – Fault diagram

Fault simulation

$$\frac{U\alpha\beta}{I1} = 2 \times Zd + Rfault$$

Where:

Uαβ : phase-to-phase fault voltage

I1 : fault current

φ1 : fault angle

Rfault = R loop

For a Three-Phase Fault:

Fault simulation

$$\frac{V1}{I1} = Zd + \frac{Rfault}{2}$$

Where:

V1 : phase-to-phase fault voltage

I1 : fault current

φ1 : fault angle

Note	*Using the Z graph a Rio format characteristic can be created. This Rio file can be loaded onto a numerical injector that accepts this kind of files. The active settings (distance elements) can be modified by Z- graph and the relay can be upgraded with new distance parameters*

For more detail refer to section: Test tools: "Z graph user "

6.3.1.3 Check and Test of the Starting Characteristics

Warning	**IN THIS PART – TESTS ARE DESCRIBED WITH THE DEFAULT PARAMETERS**

Open the MiCOM characteristics file If no changes have been made, the following values are obtained (Z-graph screen):

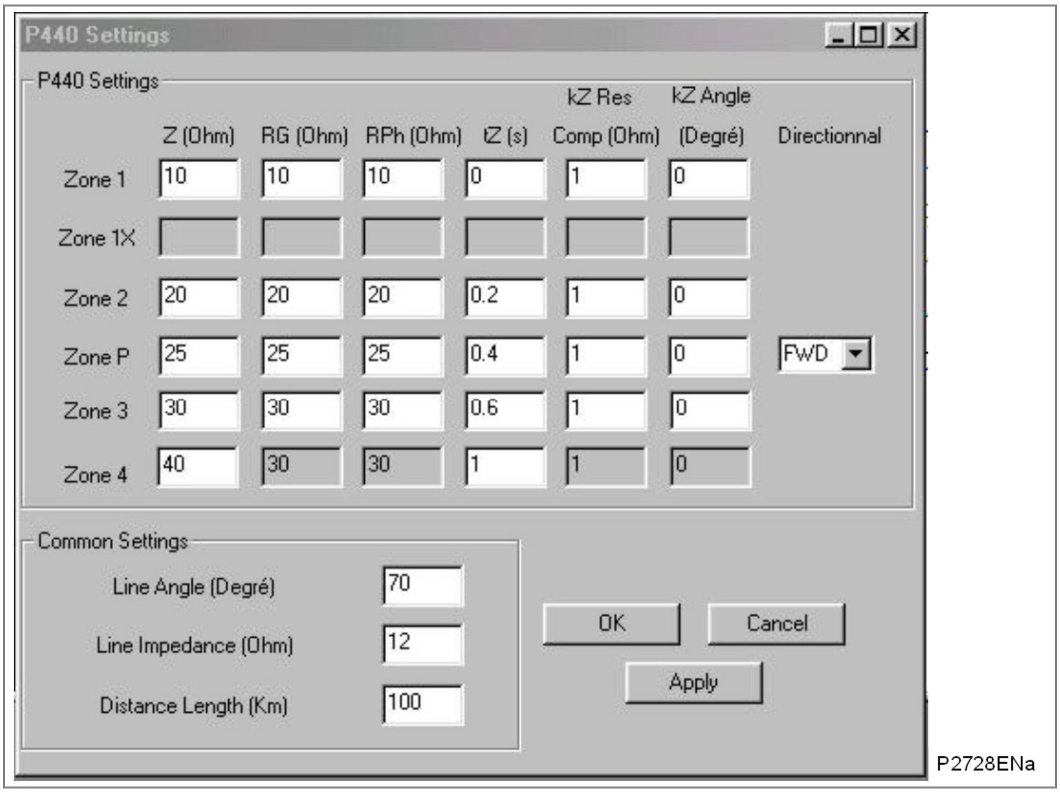


Figure 12 - P440 settings

Control of Single-Phase Fault Characteristic

CAUTION	**IF DIFFERENT K0 ARE USED – See section 5.3.1.2**

1. Energise MiCOM P44x with a healthy three-phase system (without any unbalanced condition) with a load (during a minimum time of 500ms). This is to:
   - Enable the use of the Delta algorithms
   - Avoid the start of the SOTF logic
2. Reduce the current value to obtain a relation between V and I following the appended table (for Rlim – phase-shift at 0°, for Z limit – phase-shift corresponding to Z1 (in multiphase default) or corresponding to 2Z1+Z0 (in single fault).
3. Check that the tripping order (DDB: Any trip / Any Trip A/ Any Trip B/ Any Trip C – see DDB description) is transmitted when the concerned zone time-delay expires (for a distance scheme with transmission and all distance trip logic see section P44x/EN AP).

Note	*The DDB signal any Trip A is an OR gate between Ext Trip A Int Trip A*

4. See also the test report model (end of this section).
5. Check also in the PSL (programmable scheme logic) the trip command addresses (any Trip is linked by default to the relay 7).

By default: see the wiring diagram (for assignment of inputs/outputs).

Useful tip: - To check the logic level of internal datas (DDB cells), all or some of the 8 red LEDs on the front panel could be assigned using the PSL.

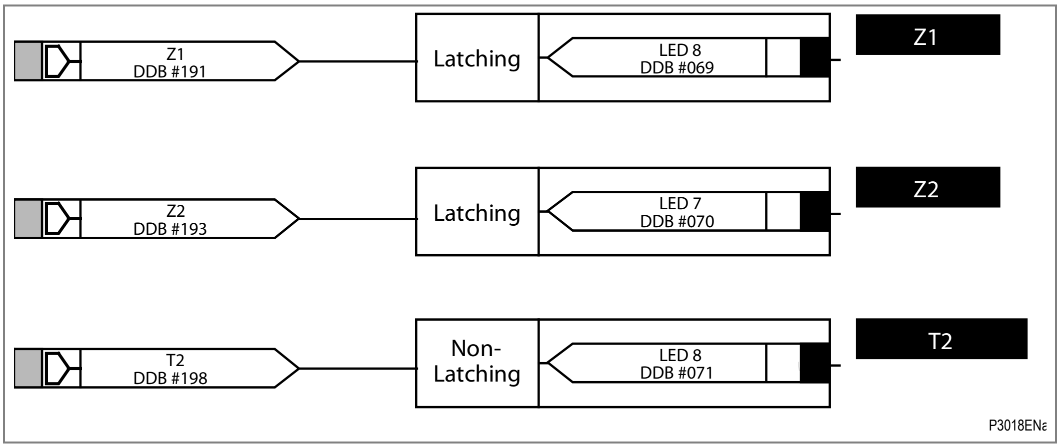


Figure 13 - DDB details for latched/non-latch LEDs

If the LEDs are latched, the reset latch could be enabled by a dedicated PSL, to avoid neadless keypad access during the tests:

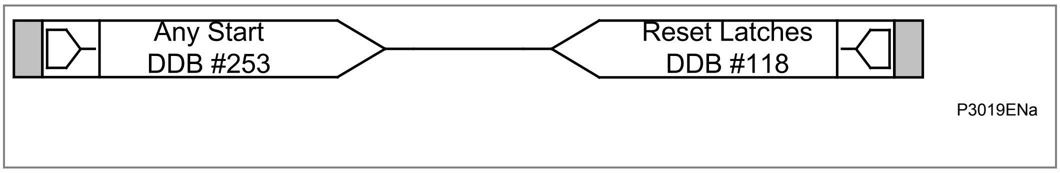


Figure 14 - DDB details for dedicated PSL

Useful tip	**To check the logic level of internal data (DDB cells), monitor bit control can be used in "commissioning Test / Opto / Relay / Test port status / Led status / Monitor bit 1 to bit 8". Any cells of the DDB can be assigned and then displayed as 1 of the 8 bits (see User Tools).**

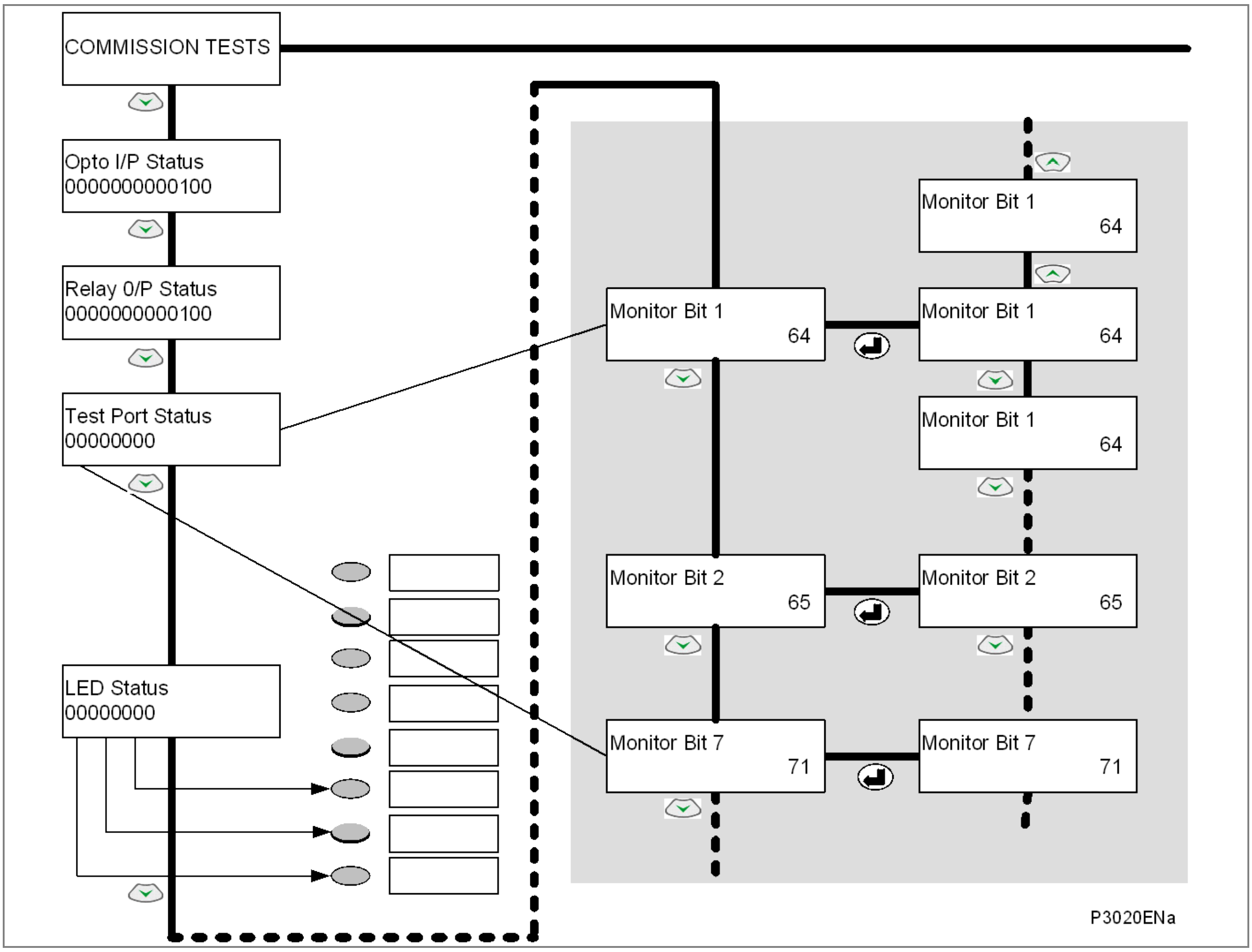


Figure 15 - LCD menu for a control of an input/output / monitor bits check

Test point B:Bi M:mono	I,V phase shift (I is behind V)	Tripping time
R1 B	0°	T1
R1 M	0°	T1
R2 B	0°	T2
R2 M	0°	T2
Rp B	0°	Tp
Rp M	0°	Tp
R3 B	0°	T3
R3 M	0°	T3
- R Lim = -R3	0°	T4
Z1 B	Arg Zd	T1
Z1 M	Arg (2Zd+Z0)	T1
Z2 B	Arg Zd	T2
Z2 M	Arg (2Zd+Z0)	T2
Zp B	Arg Zd	Tp
Zp M	Arg (2Zd+Z0)	Tp
Z3 B	Arg Zd	T3

Test point B:Bi M:mono	I,V phase shift (I is behind V)	Tripping time
Z3 M	Arg (2Zd+Z0)	T3
Z4 B	Arg Zd	T4
Z4 M	Arg (2Zd+Z0)	T4

Table 15 - Parameters of zone to test

(ZP CAN BE REVERSE OR FORWARD / EACH ZONE IS ENABLED OR DISABLED – Z IS ALWAYS ENABLED)

Note	*R3 represents the starting limit on the R axis (detection sensitivity of resistive defaults – The starting element for phase/earth can be superior to the phase/phase). If the reverse zone has been disabled (Z4), there is still a no-trip zone in the 4th quadrant below the R axis.*

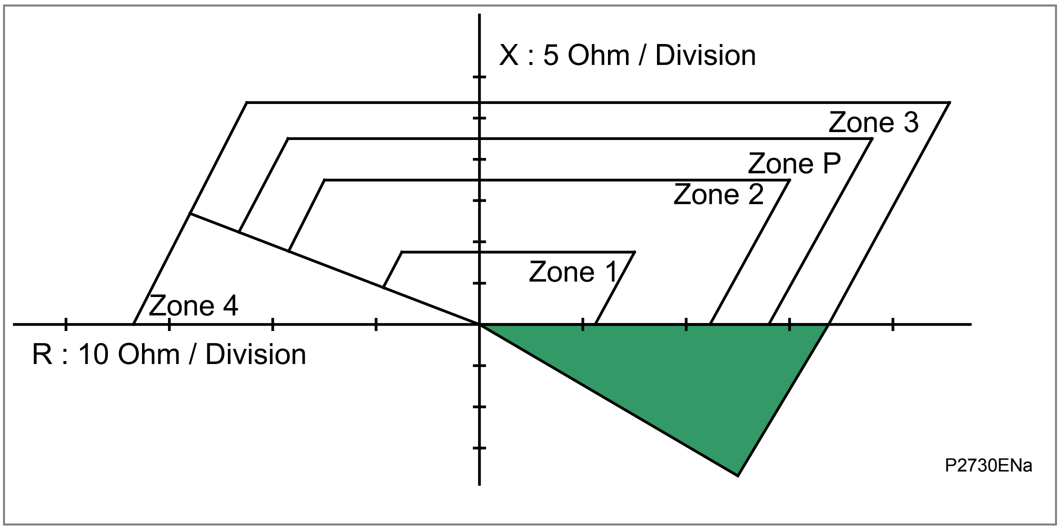


Figure 16 - No Trip Zone

If Z3 is disabled, the resistance limits R3-R4 are no longer visible.

Notes	*All other characteristic points can be tested after calculating the impedance and the phase shift between U and I.*

All these examples use the default settings.

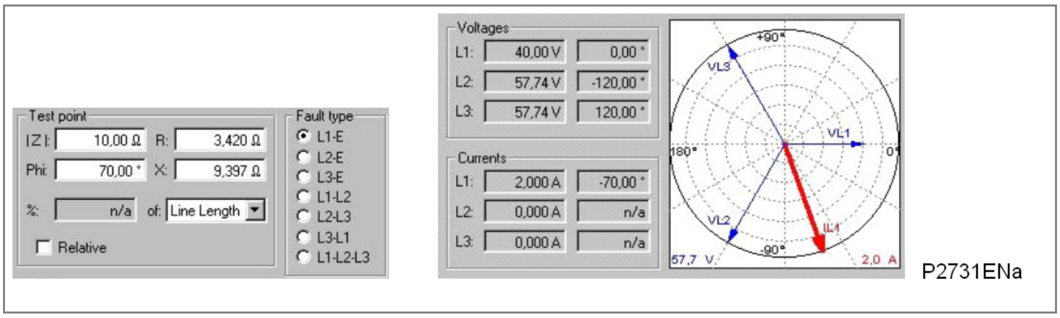


Figure 17 - Example: AN - LIM Z1

VAN/IA = Zf =Z1(1+K01)   40V/2A (phase shift of –70°) =20Ω = Z1(1+1)

Lim Z1=10Ω (if KO1=1)

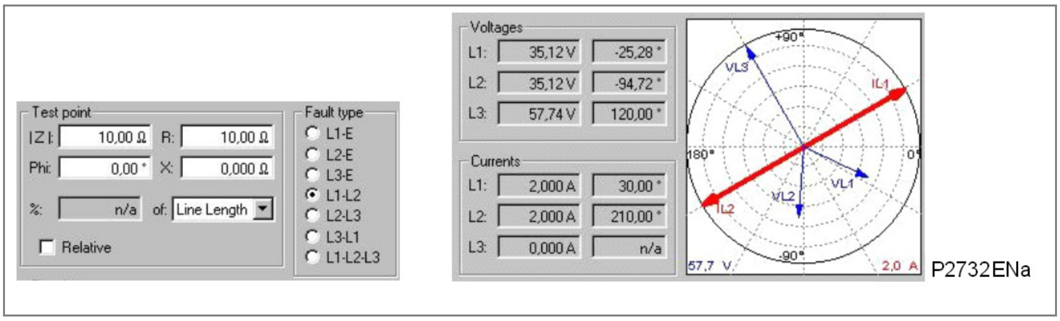


Figure 18 - Example: AB - LIMR2

VAB = 2 sin 34,72° * 35,12=40V /

IAB=2A UAB/IA (in phase) =Rf=20Ω=LimR2

LimR2 (R2 value in MiCOM S1 Studio in ohms loop).

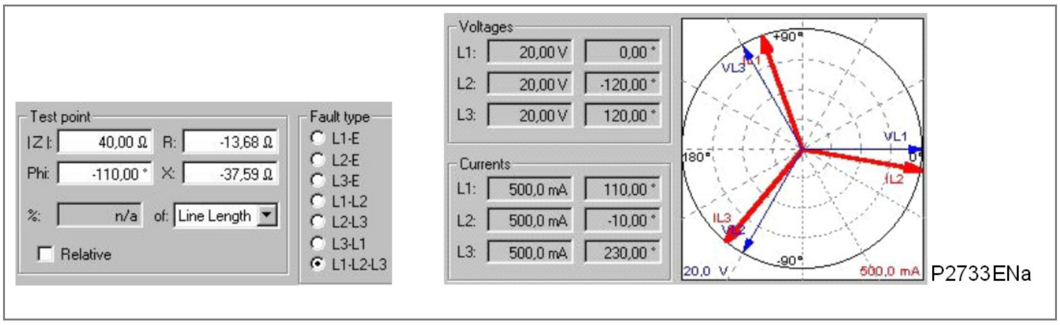


Figure 19 - Example: ABC-LIMZ4 (reverse)

VAN/IAN = Zf=Rf=20V/0,500mA=40Ω=Lim Z4 with angle(VAN/IAN)=70°-180°=-110°

Notes	*Simulator use can generate transients greater than 0.2In on currents where the generation of a fault condition can induce errors about the directional calculation with "Delta" algorithms. This error is due to the simulator boxes which do not always reflect the real conditions of fault occurrence during the transient condition. To avoid this problem during the starting zones check, we recommend inhibiting the “Delta” algorithms in the characteristics path by setting T1 to 50ms (beyond 40ms, algorithms "Delta" are no longer valid). It is the case for numerical injection boxes.*

Check in the injection device, whether any possibility of DC component could be chosen to force the start of the faulty current at 0 (If not, the model network could be unrealistic)

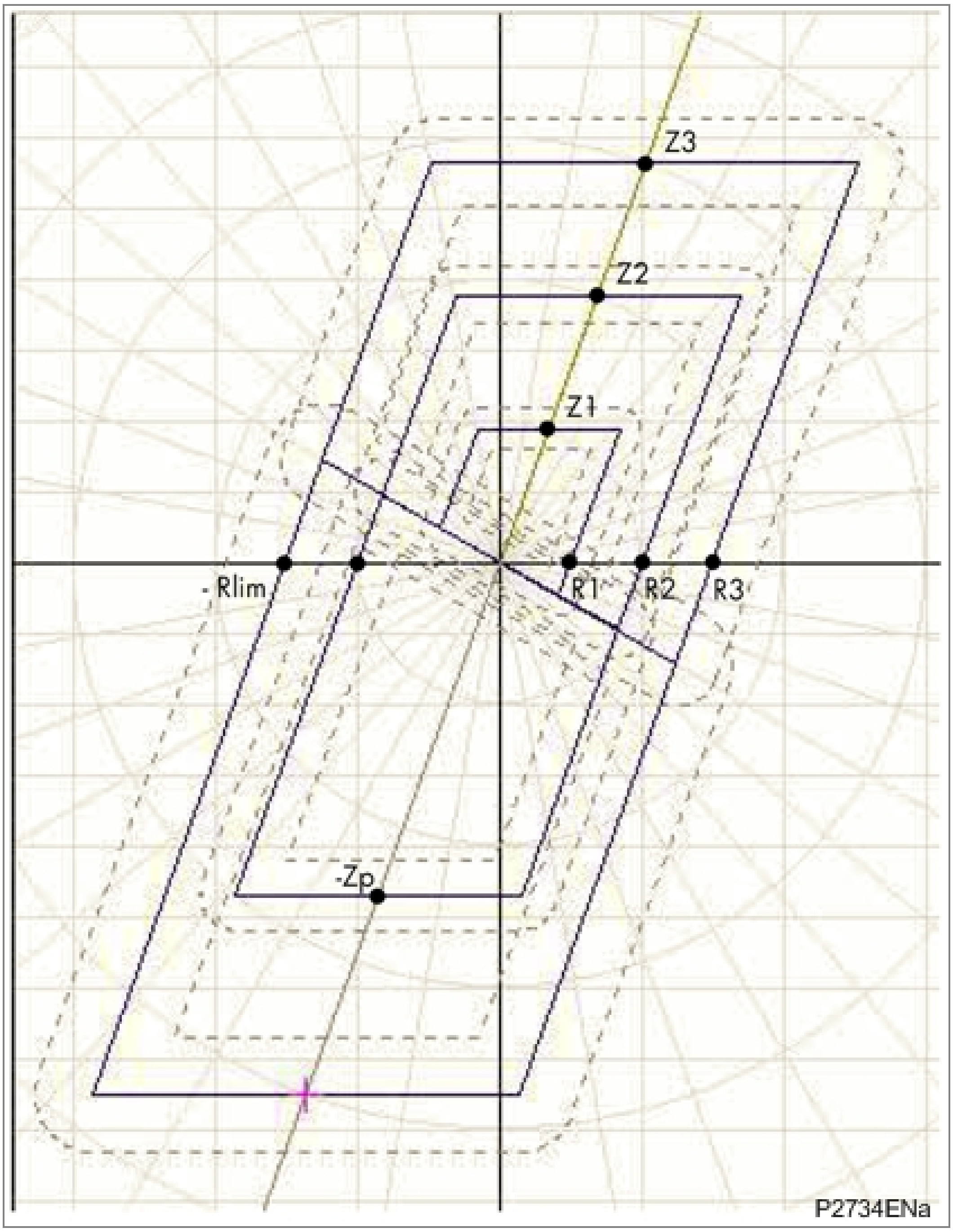


Figure 20 - Points limit of the characteristic to be tested (with zp selected as a reverse zone)

6.3.2 Distance Scheme Test (If Activated)

6.3.2.1 Control

- The type of distance scheme enabled
- The DDB cells assigned for the distance scheme
- Ref to the description feature in P44x/EN AP section "Distance protection schemes":
  - Settings
  - DDB cells
  - Internal logic

Reminder	*General equation to the tripping in distance protection*
Note	*Before testing, check the input presence / Output in PSL linked to the selected channel-aided scheme (DDB: DistCR/Dist CS). Also check the I/O condition change (on LCD in FAV in "system")*

Input:(PSL by default "P&C ") Output: (PSL by default "P&C ")

Warning **WHEN SWITCHING GROUPS VIA THE OPTOCOUPLERS: OPTOS 1 AND 2 MUST NOT BE ASSIGNED IN THE PSL.**

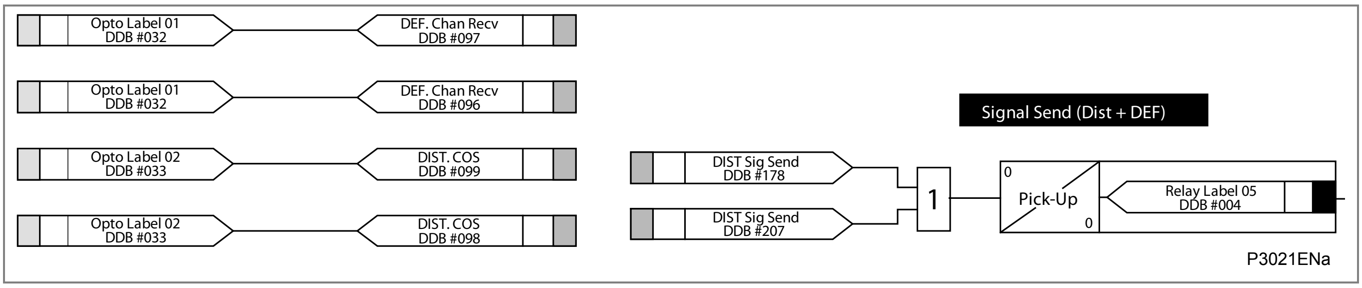


Figure 21 – Signal Send (Dist + DEF)

1. Select a mode.
2. Implement the fault indicated in the panel first column, The carrier signal input is enabled (with carrier receive).
3. Check that the trip contact have been energised at the end of the time-delay indicated in the same column (With carrier receive).
4. Repeat step 2 and 3 but without the carrier receive input and checking the indicated time-delay in the panel's 2nd column (without carrier receive).

Repeat step 2 and 4 for the other faulted zones by checking that whatever the carrier receive input state, the time-delays associated with every zone are not modified (according to the 4th column equations)

Note	*Channel-aided schemes can be simulated by inverting the optos.* *Channel-aided schemes transmissions can also be checked by generating defaults according to the 3rd column.* *To simplify the relay I/O control condition, the assignments of LEDs in the PSL can be modified.*

6.3.3 Loss of Guard/Loss of Carrier Test

Setting:

Menu text	Default setting	
GROUP 1 : DISTANCE SCHEMES		
…		
Unblocking Logic	None	None, Loss of Guard, Loss of Carrier.

Test	*Follow the truth table (section P44x/EN AP)*
Note	*In case of channel-aided loss, the scheme Z1X (out fail) will be applied if selected*

6.3.4 Weak Infeed Mode Test

From Easergy Studio (MiCOM S1 Studio)
(If Permissive schemes are enabled: 4 possible choices):fig winf1

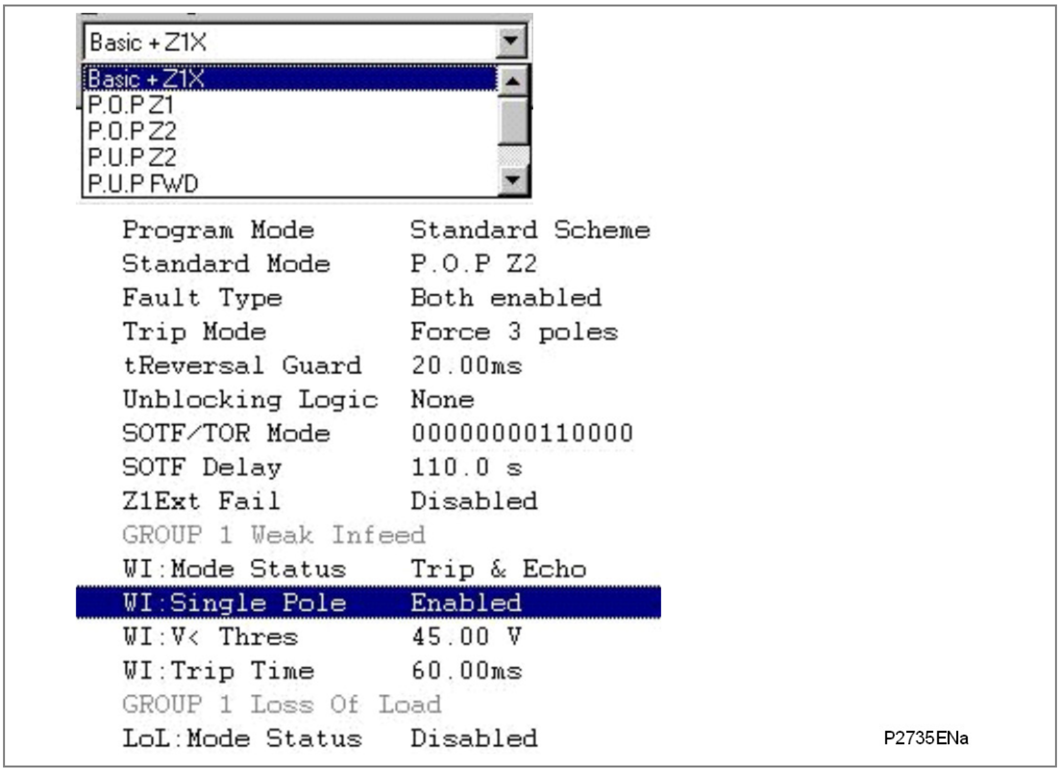
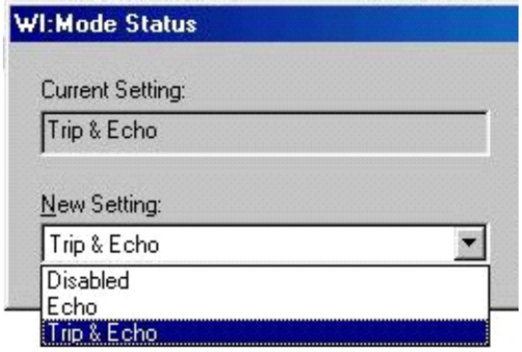


Figure 22 - WINF2

Put into service the weak infeed mode (single-pole possible except for P441) ;

1. Inhibit tripping authorisation and phase selection.
2. Enable the carrier receive input.
3. Check that:
   - the channel-aided scheme transmission signal is enabled;
   - the trip contact is not enabled.

From MiCOM S1 Studio, enable the three-phase authorisation.



P2736ENa

Figure 23 – WI: Mode Status

1. Enable the carrier receive input.
2. Check that :

    the channel-aided scheme signal is enabled

    the trip contacts closing.

From MiCOM S1 Studio, enable the minimum voltage phase selection, set undervoltage threshold to 0.4Vn, make VB = –VC = Vn, enable the single-phase tripping authorisation.

1. Enable the carrier receive input.
2. Check that:

    the channel-aided scheme transmission signal is enabled

    the protection trips phase A.

6.3.5 Protection Operation During Fuse Failure

See internal logic description in P44x/EN AP – “Voltage Transformer Supervision” section.

Relay blocking (loss of 1 or 2 phases)

1. Supply MiCOM P44x with a "healthy" system with load:
2. Remove the phase A supply .((V0) & (/I0) creation)
3. Check that:

    the fuse failure signal is activated at the end of the signal time-delay sign;

    the protection start and trip signal are not activated.

Relay unblocking

1. Keep the phase A supply cut-off and generate a fault (1- or 3-phase) which fault current (IR>3I0) is higher than the set threshold (I2 or I0).
2. Check that the trip contact is activated.

Relay locking (3 phases loss)

1. Repeat step 1 and then open the 3 voltage channels without creating a delta I. Check as in step 3

Outside sign:

1. Polarise the input: and check that the outputs change state:

Signal repercussions :

The signal (VT fail alarm) drops off if:

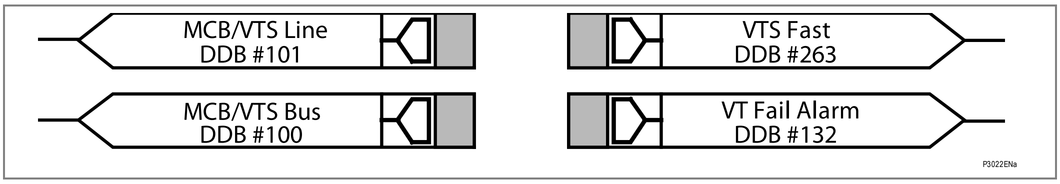


Figure 24 – VTS Signals

Fuse_Failure = 0 and
INP_FFUS_Line = 0 and
(All Poles Dead Or healthy system)

All Poles Dead

No current AND no voltage on the line or open circuit-breaker

Healthy system:

Rated voltage on the line AND

- No zero sequence voltage and current AND
- No starting AND
- No power swing.

6.4 Overcurrent Function Operation

This test, performed in 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 the test detailed test already confirms the correct functionality between current and voltage inputs, processor and outputs and earlier checks confirmed that the measurement accuracy lies within the stated tolerance.

6.4.1 Connect the Test Circuit

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.

If stage 1 is not mapped directly to an output relay in the PSL, output relay 3 should be used for the test as it operates for any trip condition.

The associated terminal numbers can be found either in the external connection diagram (P44x/EN CO) or in table 5.

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 C19 and C22.

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 set direction of operation set. Try again with the current connections reversed.*

6.4.2 Perform the Test

Ensure that the timer is reset.
Apply a current of twice the setting in cell [3504: GROUP 1 OVERCURRENT, I>1 Current Set] to the relay and note the time displayed when the timer stops.

6.4.3 Check the Operating Time

Check that the operating time recorded by the timer is within the range shown in the following table.

Note	*Except for the definite time characteristic, the operating times given in the following 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 table must be multiplied by the setting of cell [GROUP 1 OVERCURRENT, I>1 TMS] for IEC and UK characteristics or cell [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.

Note	*The cell numbers are as follows:* *[3507: GROUP 1 OVERCURRENT, I>1 TMS]* *[3508: GROUP 1 OVERCURRENT, Time Dial]*

Characteristic	**Operating Time at twice current setting and time multiplier/time dial setting of 1.0**	
	Nominal (Seconds)	**Range (Seconds)**
DT	[3505: I>1 Time-delay] setting	Setting ±2%
IEC S Inverse	10.03	9.53 - 10.53
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
IEEE M Inverse	0.64	0.61 - 0.67
IEEE V Inverse	1.42	1.35 - 1.50
IEEE E Inverse	1.46	1.39 - 1.54
US Inverse	0.46	0.44 - 0.49
US ST Inverse	0.26	0.25 - 0.28

Table 16 - Characteristic operating times for I>1

6.5 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.

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 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.

Voltage	Cell in MEASUREMENTS 1 column (02)	Corresponding VT Ratio (in 'VT and CT RATIO column (0A) of menu)
VAB	[0214: VAB Magnitude]	[0A01: Main VT Primary] [0A02: Main VT Sec'y]
VBC	[0216: VBC Magnitude]	
VCA	[0218: VCA Magnitude]	
VAN	[021A: VAN Magnitude]	
VBN	[021C: VBN Magnitude]	
VCN	[021E: VCN Magnitude]	
VCHECKSYNC	[022B: C/S Voltage Mag]	[0A03: C/S VT Primary] [0A04: C/S VT Sec'y]

Table 17 - Measured voltages and VT ratio settings

7.2 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.

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 [0F0F: COMMISSIONING TESTS, Test Mode] and [0F12: COMMISSION TESTS, Static Test] are set to '**Disabled**' (0F0D (not 0F0F) for P14x/P24x/P34x/P341/P44y/P54x/P841).

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 & SETTINGS RECORDS

CHAPTER 11

Date:	01/2017
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:	M
Software version:	E1
Connection diagrams:	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)

CONTENTS

Notes:

1 COMMISSIONING TEST RECORD

1.1 Date and Engineer Details

Date:		Engineer:	
Station:		Circuit:	
		System Frequency:	……… Hz
VT Ratio:	……… / ……… V	CT Ratio (tap in use):	……… /A

1.2 Front Plate Information

Relay type	MiCOM P…………
Model number	
Serial number	
Rated current In	
Rated voltage Vn	
Auxiliary voltage Vx	

1.3 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:	

1.4 Checklists

	Have all relevant safety instructions been followed?	Yes	☐	No	☐		
4.	**PRODUCT CHECKS**						
4.2	**With the Relay De-Energized**						
4.2.1	Visual Inspection						
	Relay Damaged?	Yes	☐	No	☐		
	Rating information correct for installation?	Yes	☐	No	☐		
	Case earth installed?	Yes	☐	No	☐		
4.2.2	Current Transformer Shorting Contacts Close?	Yes	☐	No	☐	Not checked	☐
4.2.3	Insulation Resistance >100 MΩ at 500 V dc	Yes	☐	No	☐	Not tested	☐
4.2.4	External Wiring						
	Wiring checked against diagram?	Yes	☐	No	☐		
	Test block connections checked?	Yes	☐	No	☐	N/A	☐
4.2.5	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	☐		
4.2.6	Measured Auxiliary Supply		V ac/dc				
4.3	**With the Relay Energized**						
4.3.1	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	☐		
	LCD Front Panel Display						
	LCD contrast setting used						
4.3.2	Date and Time						
4.3.3	With an IRIG-B signal (Models P442 or P444 only)						
4.3.4	Without an IRIG-B signal						
4.3.5	Light Emitting Diodes (LEDs)						
	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	☐		
	User programmable LEDS?	Yes	☐	No	☐		
4.3.6	Field Voltage Supply						
4.3.7	Input Opto-Isolators						
	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	☐		

	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	☐
4.3.8	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)						
	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			☐
				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			☐

4.3.9	Rear Communication Port							
	Communication standard			K-Bus MODBUS IEC 60870-5-103 IEC 61850			☐ ☐ ☐ ☐	
	Communications established?			Yes	☐	No	☐	
	Protocol converter tested?			Yes N/A	☐ ☐	No	☐	
4.3.10	Current Inputs							
	Displayed current			Primary	☐	Secondary	☐	
	Phase CT ratio	$\left(\frac{\text{[Phase CT Primary]}}{\text{[Phase CT Sec'y]}}\right)$		N/A	☐			
	SEF CT ratio	$\left(\frac{\text{[SEF CT Primary]}}{\text{[SEF CT Sec'y]}}\right)$		N/A	☐			
	Input CT	Applied Value		Displayed Value				
	IA	A		A				
	IB	A		A				
	IC	A		A				
	IN	A	N/A ☐	A		N/A	☐	
	ISEF	A		A				
	IA (2)	A	N/A ☐	A		N/A	☐	
	IB (2)	A	N/A ☐	A		N/A	☐	
	IC (2)	A	N/A ☐	A		N/A	☐	
4.3.11	Voltage Inputs							
	Displayed voltage			Primary	☐	Secondary	☐	
	Main VT ratio	$\left(\frac{\text{[Main VT Primary]}}{\text{[Main VT Sec'y.]}}\right)$		N/A	☐			
	NVD VT ratio	$\left(\frac{\text{[NVD VT Primary]}}{\text{[NVD VT Secondary]}}\right)$		N/A	☐			
	Input VT	Applied Value		Displayed value				
	Va	V		V				
	Vb	V		V				
	Vc	V		V				
	VN	V		V				
5.	**SETTING CHECKS**							
5.1	Application-Specific Function Settings Applied?			Yes	☐	No	☐	
	Application-Specific Programmable Scheme Logic Settings applied?			Yes	☐	No	☐	N/A ☐
5.2	Application-Specific Function Settings Verified?			Yes	☐	No	☐	N/A ☐
	Application-Specific Programmable Scheme Logic tested?			Yes	☐	No	☐	N/A ☐
5.3	Demonstrate Correct Relay Operation			Yes	☐	No	☐	
5.4	Overcurrent Function Operation			Yes	☐	No	☐	
5.5	Check Trip and Auto-reclose Cycle			Yes	☐	No	☐	
6	**On-Load Checks**							
6.1	Voltage Connections			Yes	☐	No	☐	

6.2 Current Connections

7. FINAL CHECKS

Test wiring removed?	Yes	☐	No	☐	N/A	☐
Disturbed customer wiring re-checked?	Yes	☐	No	☐	N/A	☐
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	☐

Commissioning Engineer	Customer Witness
Date:	Date:

Notes:

MAINTENANCE

CHAPTER 12

Date:	07/2016	
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

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-supervizing 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 crosshead screws. The P64x range 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 at least 30 seconds 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 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(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

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

Test	Check	Action	
1	Using the relay menu confirm whether the Commission Test/Test Mode setting is Contact Blocked. Otherwise proceed to test 2.	If the setting is Contact Blocked then disable the test mode and, verify that the Out of Service LED is extinguished.	
2	Select and view the last maintenance record from the menu (in the View Records).	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:	
		Bit	**Meaning**
		0	The application type field in the model number does not match the software ID
		1	The application field in the model number does not match the software ID
		2	The variant 1 field in the model number does not match the software ID
		3	The variant 2 field in the model number does not match the software ID
		4	The protocol field in the model number does not match the software ID
		5	The language field in the model number does not match the software ID
		6	The VT type field in the model number is incorrect (110V VTs fitted)
		7	The VT type field in the model number is incorrect (440V VTs fitted)
		8	The VT type field in the model number is incorrect (no VTs fitted)

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:

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 14

Date:	01/2017
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:	M
Software version:	E1
Connection diagrams:	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)

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TABLES

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FIGURES

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:

Protocol				
Courier	**IEC-60870-5-103**	**DNP3.0**	**Modbus**	**IEC 61850 Ethernet Interface**
Yes	Yes	Yes	Yes	Yes
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 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.

It should be noted that the descriptions contained within this section do not aim to fully detail the protocol itself. The relevant documentation for the protocol should be referred to for this information. This section serves to describe the specific implementation of the protocol in the relay.

2 CONNECTIONS TO THE COMMUNICATIONS 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.

When the K-Bus option is selected for the rear port, the two signal connections are not polarity conscious, however for MODBUS, IEC60870-5-103 and DNP3.0 care must be taken to observe the correct polarity.

The protocol provided by the relay is indicated in the relay menu in the **Communications** column. Using the keypad and LCD, firstly check that the **Comms. setting** 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 this is being used by the rear port.

2.3 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.

2.3.1 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.

2.3.2 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.

2.3.3 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.

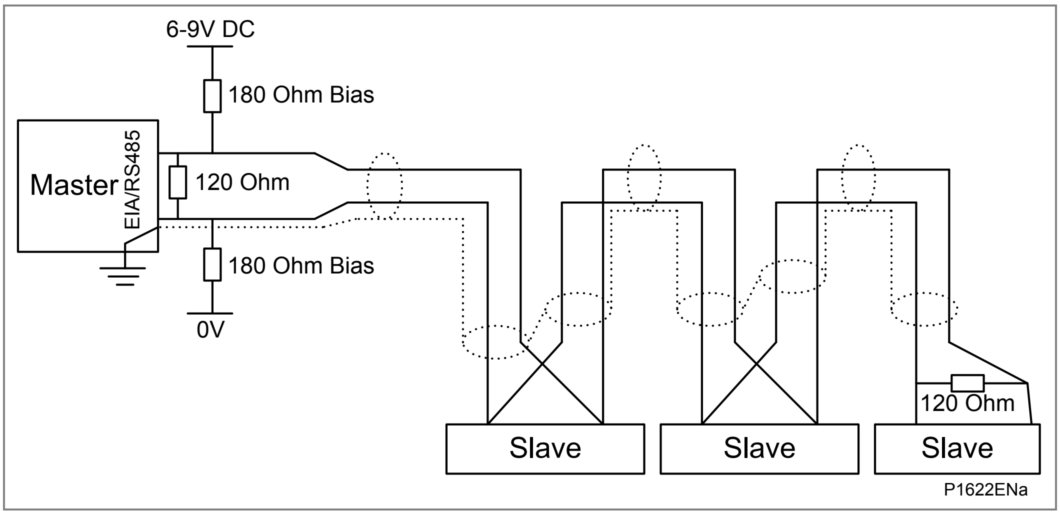

Figure 1 - EIA(RS)485 bus connection arrangements

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.**

2.3.4 Courier Communication

Courier is the communication language developed to allow remote interrogation of its range of protection relays. Courier uses a master and slave. EIA(RS)-232 on the front panel allows only one slave but EIA(RS)-485 on the back panel allows up to 32 daisy-chained slaves. Each slave unit has a database of information and responds with information from its database when requested by the master unit.

The relay is a slave unit that is designed to be used with a Courier master unit such as MiCOM S1 Studio, MiCOM S10, PAS&T or a SCADA system. MiCOM S1 Studio is compatible is specifically designed for setting changes with the relay.

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.

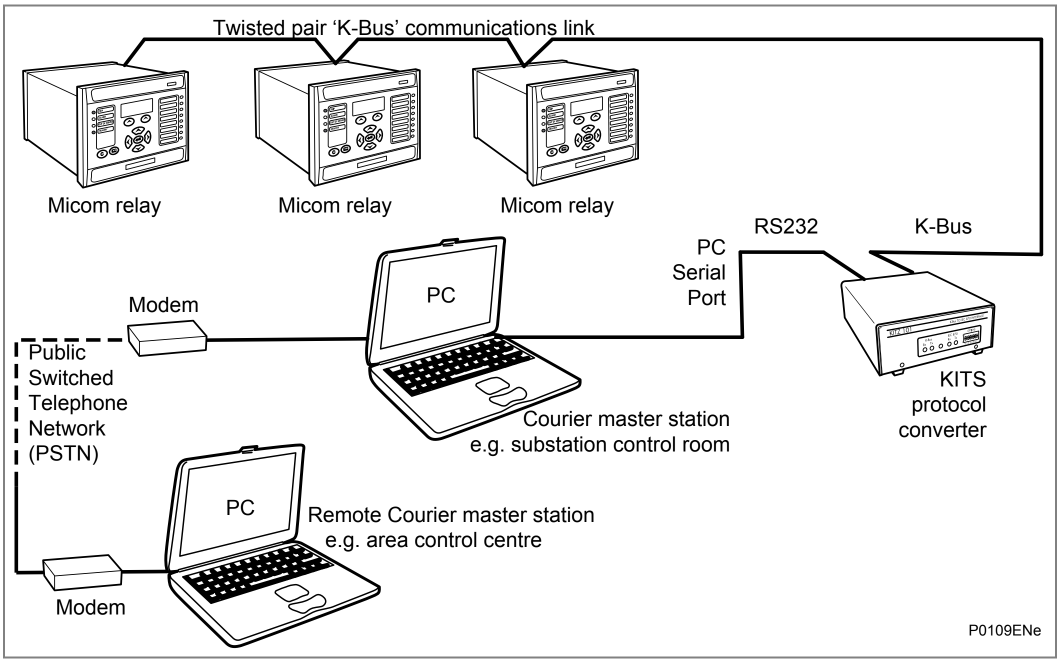

Figure 2 - Remote communication connection arrangements

3 CONFIGURING THE COMMUNICATIONS 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 MiCOM S1 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.

```
RP1 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 MiCOM S1 Studio do not require 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 MiCOM S1 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

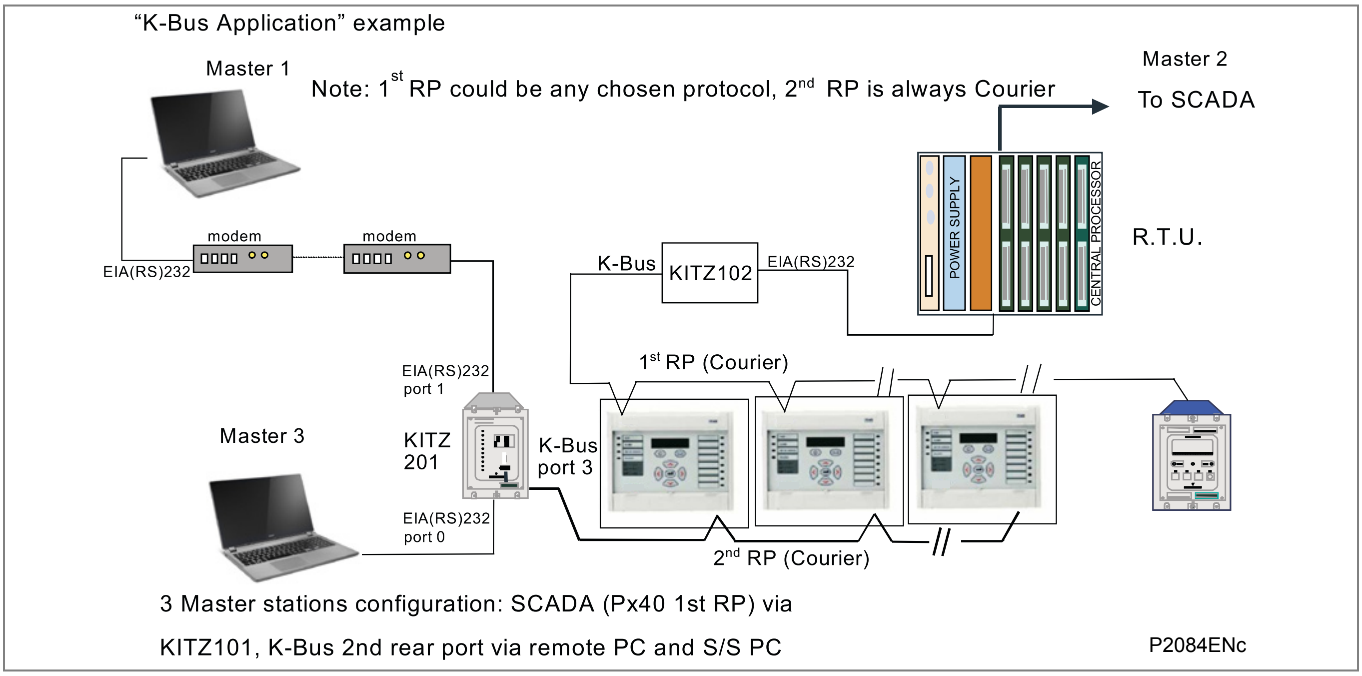

Figure 3 - Second rear port K-Bus application

3.10 Second Rear Port EIA(RS)485 Example

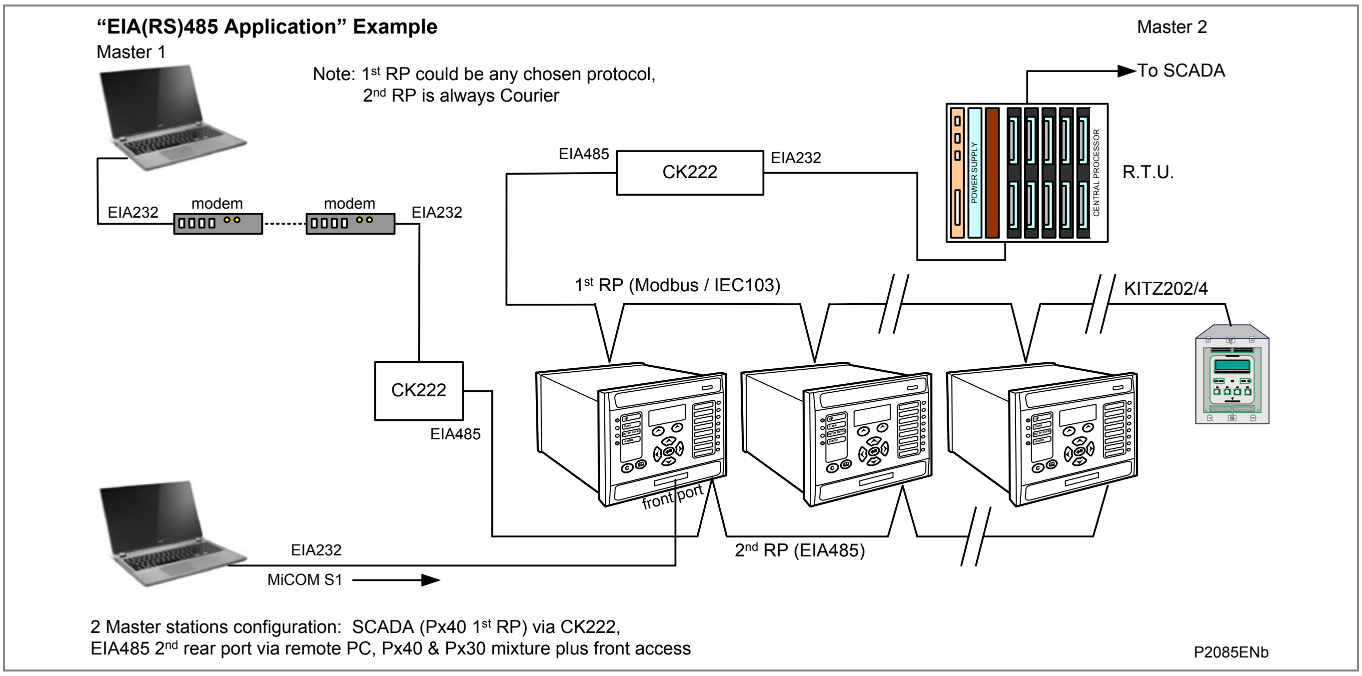

Figure 4 - Second rear port EIA(RS)485 example

3.11 Second Rear Port EIA(RS)232 Example

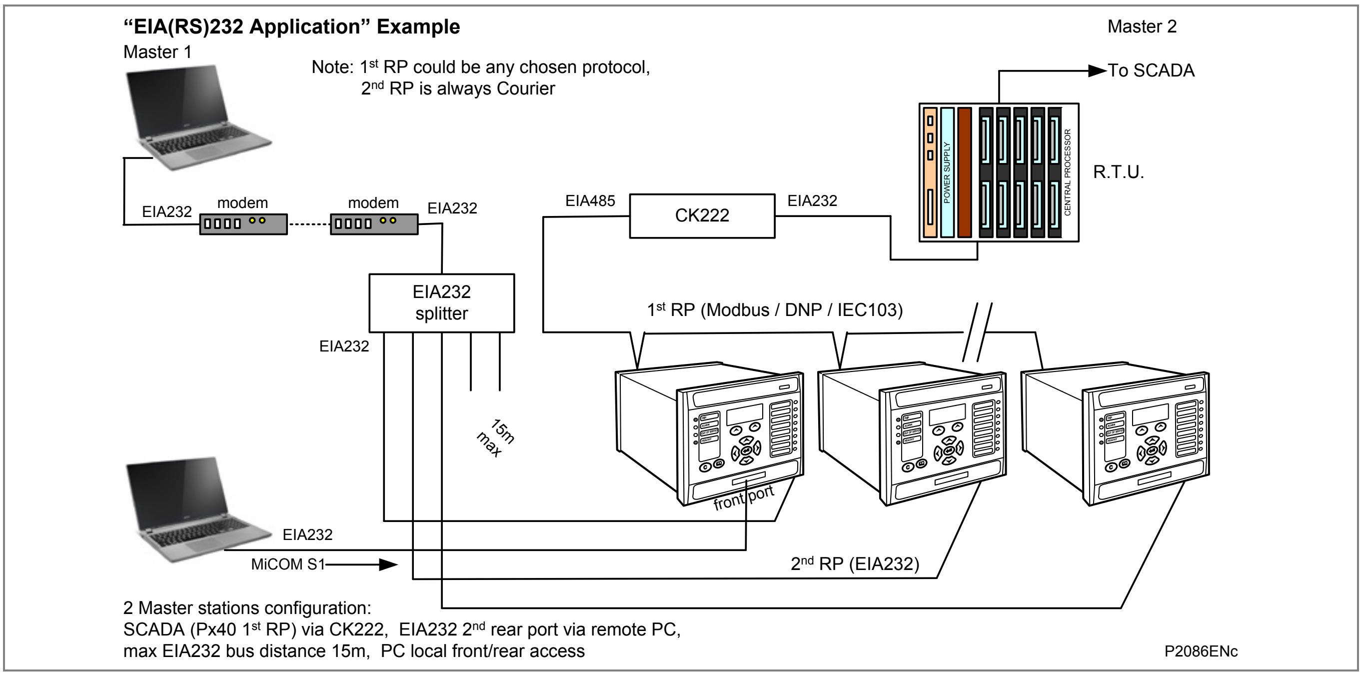

Figure 5 - Second rear port EIA(RS)232 example

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

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 MiCOM S1 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 511 to select from 512 stored events. 0 selects the most recent record and 511 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

The stored disturbance records in the relay are accessible in a compressed format through the Courier interface. The records are extracted using column B4. Cells required for extraction of uncompressed disturbance records are not supported.

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 MiCOM S1 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, MiCOM S1 Studio must be used because the data is compressed. MiCOM S1 Studio also performs checks on the validity of the settings before they are downloaded to the relay.

5 MODBUS INTERFACE

Important	The MODBUS interface does not apply to these products: P44y, P445, P54x, P547, P74x, P841

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 Serial Interface

The MODBUS interface uses the first rear EIA(RS)-485 (RS485) two-wire port “RP1” (or converted fiber optic port). The port is designated “EIA(RS)-485/K-Bus Port” on the external connection diagrams.
The interface uses the MODBUS RTU communication mode rather than the ASCII mode since it provides for more efficient use of the communication bandwidth and is in widespread use. This communication mode is defined by the MODBUS standard.

5.1.1 Character Framing

The character framing is 1 start bit, 8 data bits, either 1 parity bit and 1 stop bit, or 2 stop bits. 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 either the front panel interface or the front Courier port:

- Baud rate
- Device address
- Parity
- Inactivity time

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.

The following MODBUS function codes are supported by the relay:

Function	Description
01	Read Coil Status
02	Read Input Status
03	Read Holding Registers
04	Read Input Registers
06	Preset Single Register
08	Diagnostics
11	Fetch Communication Event Counter
12	Fetch Communication Event Log
16	Preset Multiple Registers 127 max

Table 2 – MODBUS Query functions supportedby 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 3 – MODBUS response code interpretation

5.4 Register Mapping

Memory Page	Interpretation
0xxxx	Read and write access of the output relays
1xxxx	Read only access of the opto inputs
3xxxx	Read only access of data
4xxxx	Read and write access of settings
Note xxxx represents the addresses available in the page (0 to 9999). Note The "**extended memory file**" (6xxxx) is not supported.	

A complete map of the MODBUS addresses supported by the relay is contained in the *Menu Database* of this service manual.

Table 4 - Memory page references

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.

5.5 Event Extraction

The relay supports two methods of event extraction providing either automatic or manual extraction of the stored event, fault, and maintenance records.

5.5.1 Manual Extraction Procedure

There are three registers available to manually select stored records, there are also three read only registers allowing the number of stored records to be determined.

- 40100 - Select Event, 0 to 249
- 40101 - Select Fault, 0 to 4
- 40102 - Select Maintenance Record, 0 to 4

For each of the above registers a value of 0 represents the most recent stored record.

The following registers can be read to indicate the numbers of the various types of record stored.

- 30100 - Number of stored records
- 30101 - Number of stored fault records
- 30102 - Number of stored maintenance records

Each fault or maintenance record logged causes an event record to be created by the relay. If this event record is selected the additional registers allowing the fault or maintenance record details will also become populated.

5.5.2 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 1 to the record selection register 40400 (G18 data type). The event data together with any fault/maintenance data can be read from the registers specified below. Once the data has been read the event record can be marked as having been read by writing a value of 2 to register 40400.

5.5.3 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.

Event Description	MODBUS Address	Length	Comments
Time and Date	30103	4	See G12 data type description in section 3.8.
Event Type	30107	1	See G13 data type. Indicates type of event.
Event Value	30108	2	Nature of value depends on event type. This will contain the status as a binary flag for contact, opto, alarm, and protection events.
MODBUS Address	30110	1	This indicates the MODBUS register address where the change occurred. Alarm 30011 Relays 30723 Optos 30725 Protection events – like the relay and opto addresses this will map onto the MODBUS address of the appropriate DDB status register depending on which bit of the DDB the change occurred. These will range from 30727 to 30785. For platform events, fault events and maintenance events the default is 0.
Event Index	30111	1	This register will contain the DDB ordinal for protection events or the bit number for alarm events. The direction of the change will be indicated by the most significant bit; 1 for 0 – 1 change and 0 for 1 – 0 change.
Additional Data Present	30112	1	0 means that there is no additional data. 1 means fault record data can be read from 30113 to 30199 (number of registers depends on the product). 2 means maintenance record data can be read from 30036 to 30039.

Table 5 - Record data

If a fault record or maintenance record is directly selected using the manual mechanism then the data can be read from the register ranges specified above. The event record data in registers 30103 to 30111 will not be available.

It is possible using register 40401(G6 data type) to clear independently the stored relay event/fault and maintenance records. This register also provides an option to reset the relay indications, which has the same effect on the relay as pressing the clear key within the alarm viewer using the front panel menu.

5.6 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.

5.6.1 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 6 – Disturbance record extraction 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 7 - Disturbance record status register values

5.6.2 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).

5.6.2.1 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.

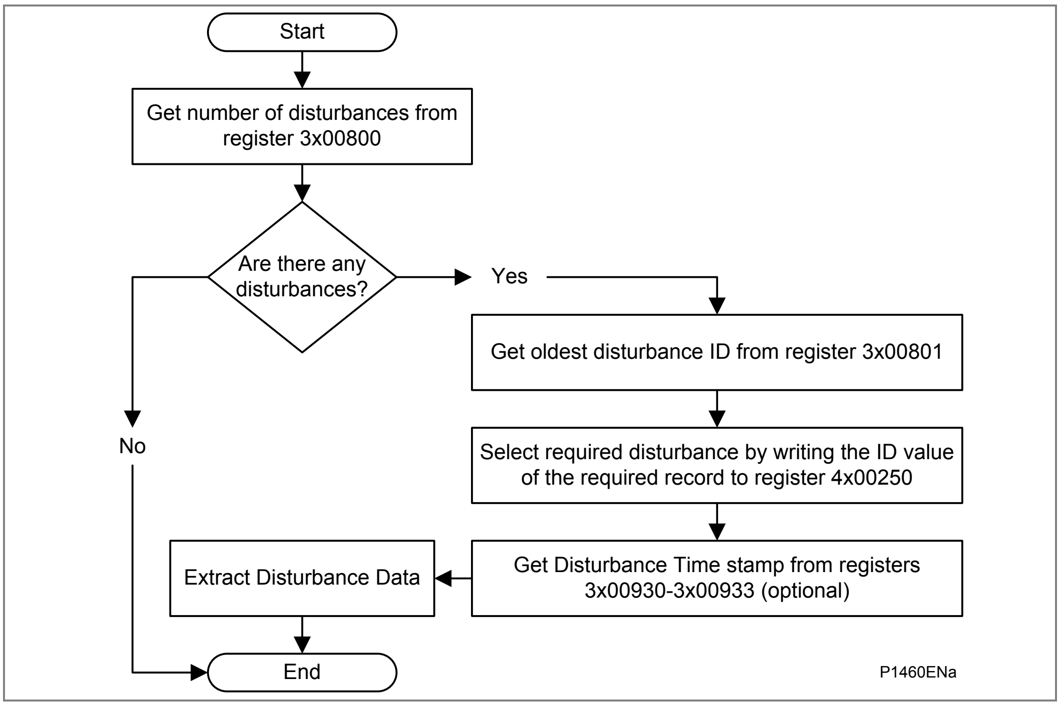

Figure 6 - Manual selection of a disturbance record

5.6.2.2 Automatic Extraction Procedure – Option 1

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.

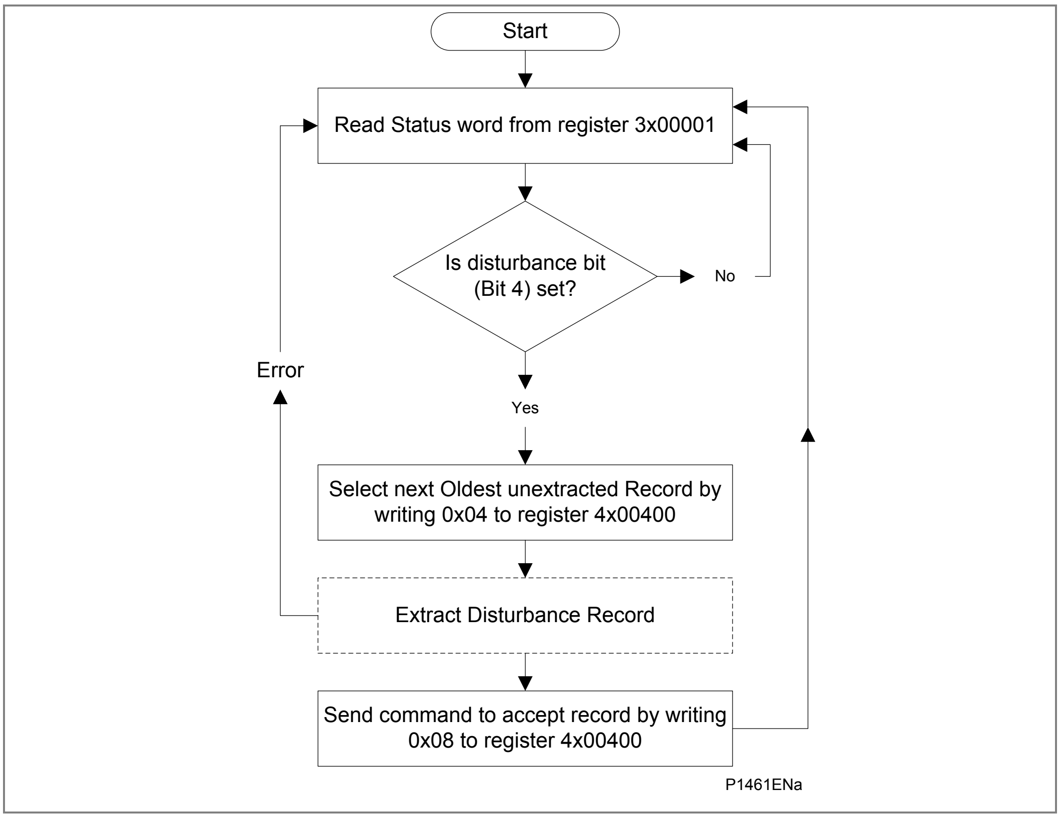

Figure 7 - Automatic selection of a disturbance record - option 1

5.6.2.3 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.

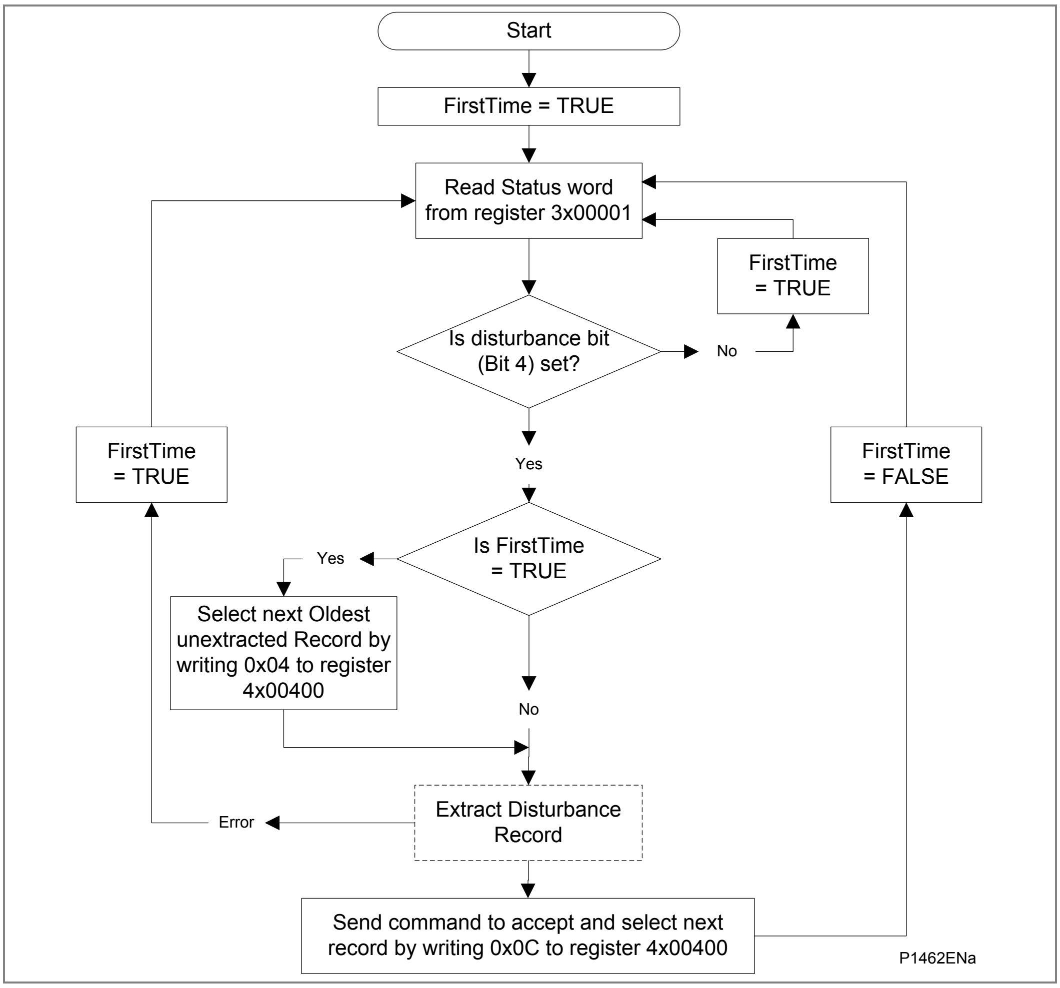

Figure 8 - Automatic selection of a disturbance – option 2

5.6.3 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.

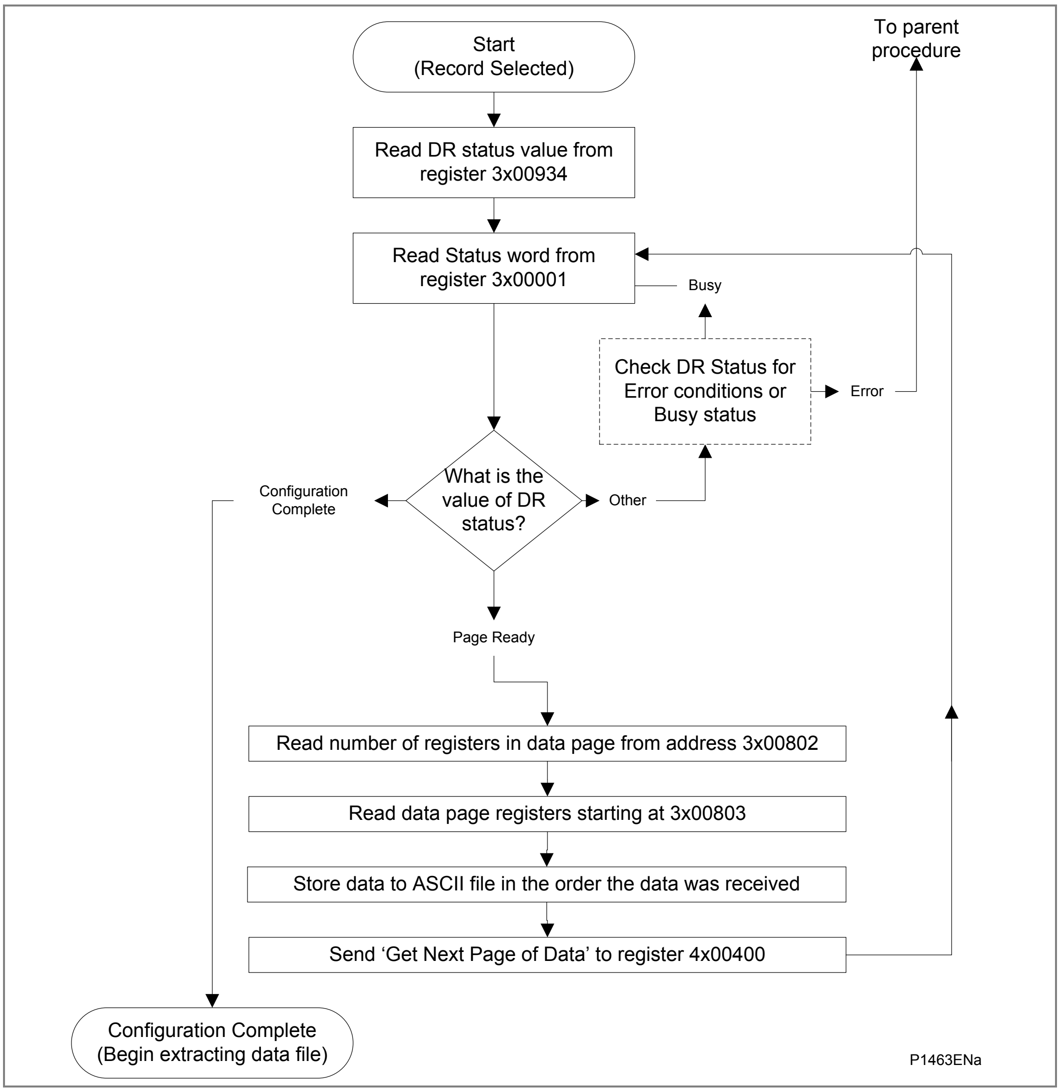

Figure 9 - Extracting the comtrade configuration file

The following figure shows how the data file is extracted:

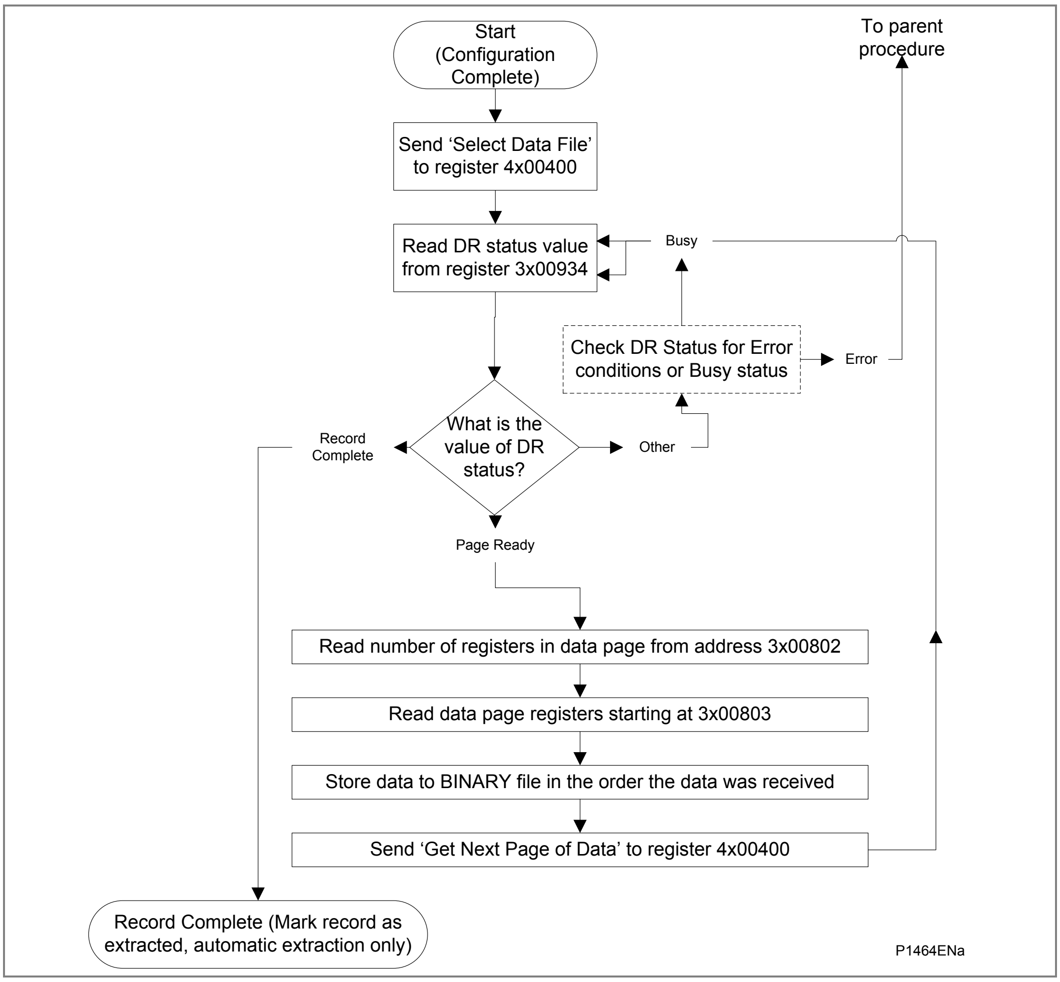

Figure 10 - Extracting the comtrade binary data file

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.

5.7 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.

5.7.1 Password Protection

The product's settings can be subject to Password protection. The level of password protection required to change a setting is indicated in the 4x register-map table in the *Relay Menu Database document*. Level 2 is the highest level of password access, level 0 indicates that no password is required.

The following registers are available to control password protection:

Models without Cyber Security

40001 & 40002 Password entry
40022 Default password level
40023 & 40024 Setting to change password level 1
40025 & 40026 Setting to change password level 2
30010   Can be read to indicate current access level

Models with Cyber Security

420008 - 420011 Setting to change password level 1
420016 - 420019 Setting to change password level 2
420024 - 420027 Setting to change password level 1

5.7.2 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 to 4x02052
- 4x10000-4x10999

5.7.3 Protection and Disturbance Recorder Settings

Setting changes to either of these areas are stored in a scratchpad area and will not be used by the relay unless a confirm or an abort operation is performed. Register 40405 can be used either to confirm or abort the setting changes within the scratchpad area. It should be noted that the relay supports four groups of protection settings.

The MODBUS addresses for each of the four groups are repeated within the following address ranges:

Group 1	41000 - 42999
Group 2	43000 - 44999
Group 3	45000 - 46999
Group 4	47000 - 48999

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.

The active protection setting groups can be selected by writing to register 40404. An illegal data response will be returned if an attempt is made to set the active group to one that has been disabled.

5.8 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 8 - G12 date & time data type structure

The seven bytes of the structure are packed into four 16-bit registers, such that byte 1 is transmitted first, 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 will be in the high-order byte position followed by byte 2 in the low-order position for the first register. The last register will contain just byte 7 in the high order position and the low order byte will have a value of zero.

Since the range of the data type is only 100 years, the century must be deduced. The century is calculated as the one that will produce 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.

5.9 Power & 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 (see P44x/EN MD) are of the G29 format.

5.9.1 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

5.9.2 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

Using either the front panel menu or the front Courier port, it is possible to disable the relay output contacts to allow secondary injection testing to be performed. This is interpreted as 'test mode' by the IEC60870-5-103 standard. An event is produced to indicate both entry to and exit from test mode. Spontaneous events and cyclic measured data transmitted while the relay is in test mode has a COT of 'test mode'.

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.

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 here 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 9 - 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 via DNP3.0. As such the points accept commands of type pulse on [null, trip, close] and latch on/off as detailed in the device profile in the *Menu Database*, 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.

The diagram below illustrates the behavior when the 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.

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 are reported as fixed-point values although they are stored inside the relay in a floating-point format. The conversion to fixed-point format requires the use of a scaling factor, which differs for the various types of data within the relay e.g. current, voltage, phase angle etc. The data types supported are listed at the end of the device profile document with each type allocated a 'D number', i.e. D1, D2, etc. In the object 30 point list each data point has a D number data type assigned to it which defines the scaling factor, default deadband setting and the range and resolution of the deadband setting. The deadband is the setting used to determine whether a change event should be generated for each point. The change events can be read via object 32 or object 60 and will be generated for any point whose value has changed by more than the deadband setting since the last time the data value was reported.

Any analog measurement that is unavailable at the time it is read will be reported as offline, e.g. 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. Note that 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 over DNP3.0. 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 DNP3.0 Configuration using MiCOM S1 Studio

A PC support package for DNP3.0 is available as part of the settings and records module of MiCOM S1 Studio. The MiCOM S1 module allows configuration of the relay's DNP3.0 response. The PC is connected to the relay via a serial cable to the 9-pin front part of the relay – see Introduction (P44X/EN IT). The configuration data is uploaded from the relay to the PC in a block of compressed format data and downloaded to the relay in a similar manner after modification. The new DNP3.0 configuration takes effect in the relay after the download is complete. The default configuration can be restored at any time by choosing 'All Settings' from the 'Restore Defaults' cell in the menu 'Configuration' column. The DNP3.0 data is displayed on a three-tabbed screen, one screen each for object 1, 20 and 30. Object 10 is not configurable.

For the IP Configuration of DNP over Ethernet, please refer to section 7.7.4.

Important	At most 10 clients are supported to connect to device at the same time in DNP3.0 over Ethernet protocol.

7.7.1 Object 1

For every point included in the device profile document there is a check box for membership of class 0 and radio buttons for class 1, 2 or 3 membership. Any point that is in class 0 must be a member of one of the change event classes 1, 2 or 3.

Points that are configured out of class 0 are by default not capable of generating change events. Furthermore, points that are not part of class 0 are effectively removed from the DNP3.0 response by renumbering the points that are in class 0 into a contiguous list starting at point number 0. The renumbered point numbers are shown at the left-hand side of the screen in S1 and can be printed out to form a revised device profile for the relay. This mechanism allows best use of available bandwidth by only reporting the data points required by the user when a poll for all points is made.

7.7.2 Object 20

The running counter value of object 20 points can be configured to be in or out of class 0. Any running counter that is in class 0 can have its frozen value selected to be in or out of the DNP3.0 response, but a frozen counter cannot be included without the corresponding running counter. As with object 1, the class 0 response will be renumbered into a contiguous list of points based on the selection of running counters. The frozen counters will also be renumbered based on the selection; note that if some of the counters that are selected as running are not also selected as frozen then the renumbering will result in the frozen counters having different point numbers to their running counterparts. For example, object 20 point 3 (running counter) might have its frozen value reported as object 21 point 1.

7.7.3 Object 30

For the analog inputs, object 30, the same selection options for classes 0, 1, 2 and 3 are available as for object 1. In addition to these options, which behave in exactly the same way as for object 1, it is possible to change the deadband setting for each point. The minimum and maximum values and the resolution of the deadband settings are defined in the device profile document; MiCOM S1 will allow the deadband to be set to any value within these constraints.

7.7.4 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 10 – 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 11 – Abbreviations of Different IP

Note *Running DNP3.0 serial and DNP3.0 over Ethernet concurrently is not recommended.*

8 IEC 61850 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. 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.

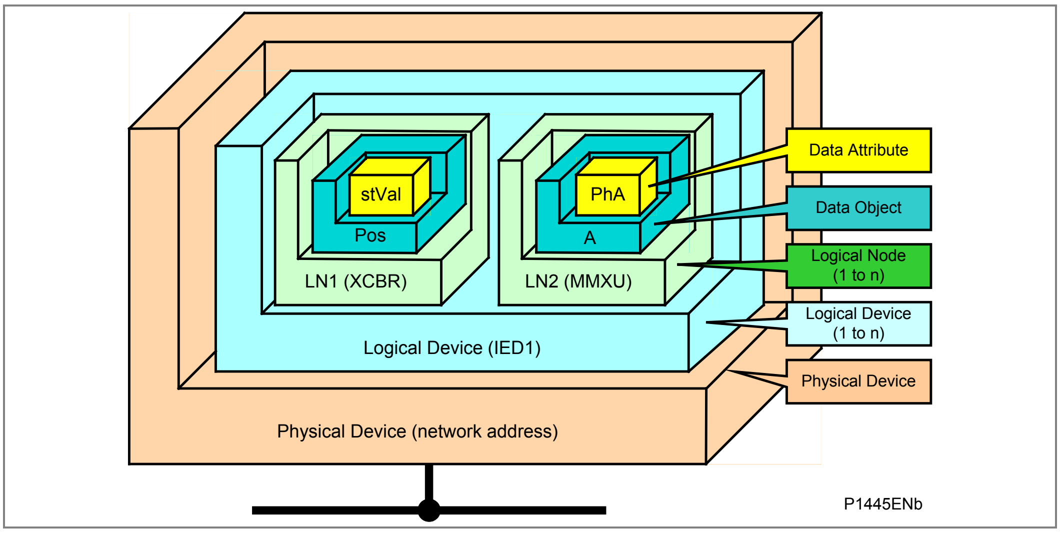

Figure 11 - Data model layers in IEC 61850

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 MiCOM S1 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 MiCOM S1 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 MiCOM Relays Data Model

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

Virtual outputs are available in the PSL which can be mapped directly to a published dataset in a GOOSE message (only 1 fixed dataset is supported). All published GOOSE signals are BOOLEAN values.

Each GOOSE signal contained in a subscribed GOOSE message can be mapped a virtual inputs in 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 can subscribe to all GOOSE messages but only these data types can be decoded and mapped to a virtual input:

- BOOLEAN
- BSTR2
- INT16
- INT32
- INT8
- UINT16
- UINT32
- UINT8

The MiCOM relay on Ed2 mode can also subscribe 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 model.

8.6.2 Simulation GOOSE Configuration

From MiCOM S1 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

Settings relating to a failed Ethernet link are available in the ‘COMMUNICATIONS’ column of the relay user interface.

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 (MiCOM S1 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 (MiCOM S1 Studio) and the IED
- Help in the prevention of modification of data between Easergy Studio (MiCOM S1 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(MiCOM S1 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 (MiCOM S1 Studio) will attempt to communicate with the device

Note	*When attempting to connect to the IED via Ethernet Easergy Studio (MiCOM S1 Studio) will first attempt 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 (MiCOM S1 Studio) is running.*

Notes:

INSTALLATION

CHAPTER 15

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	J/L	P44y (P443/P446)	K/M
	P145	J/M	P547	K
	P241	J	P54x (P543/P544/P545/P546)	K/M
	P242/P243	K	P642	J/L
	P342	J	P643	K/M
	P343/P344/P345	K	P645	K/M
	P391	A	P74x (P741/P742/P743)	J/K
	P445	J/L	P746	K/M
	P44x (P441/P442/P444)	J/K	P841	K/M
	P44x (P442/P444)	M	P849	K/M
Software version:	P14x (P141/P142/P143/P145)	43/44/46/ B0/B1/B2	P44y (P443/P446) P547	55/H4 57
	P24x (P241/P242/P243):	57	P54x (P543/P544/P545/P546)	45/55/H4
	P342/P343/P344/P345/P391	36	P64x (P642/P643/P645)	04/A0/B1/B2
	P445	35/36/J4	P74x (P741/P742/P743)	51/A0/B1
	P44x (P441/P442/P444)	C7.x/D4.x/ D5.x/D6.x/	P746	A0/B1/B2/B3/ C1/C2/C3
	P44x (P442/P444)	E0/E1	P841 P849	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)	

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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.

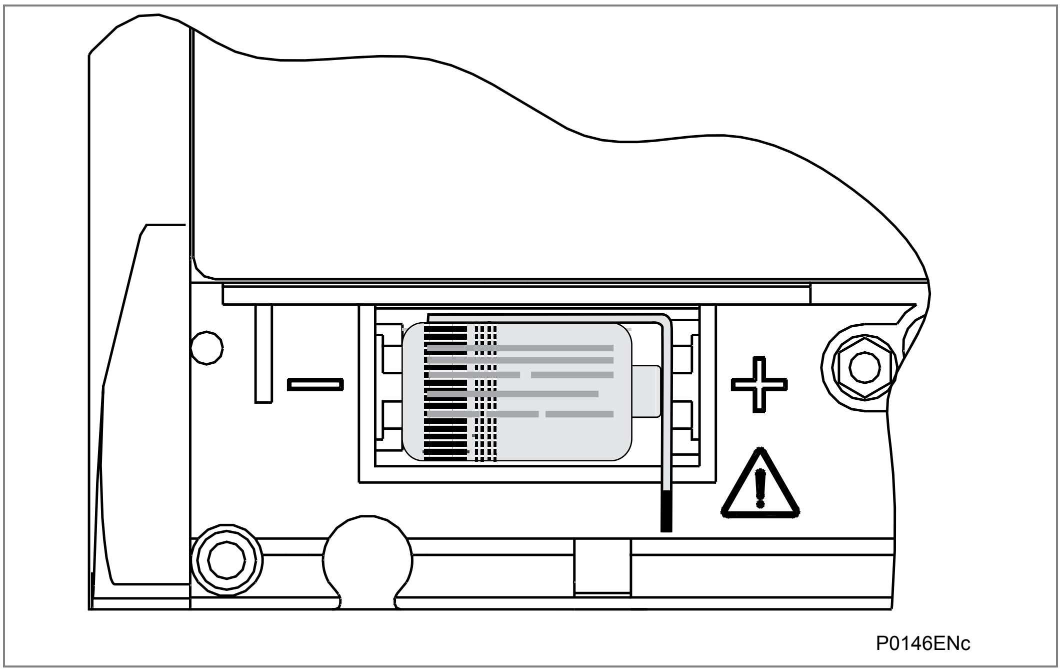


Figure 1 - Location of battery isolation strip

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.

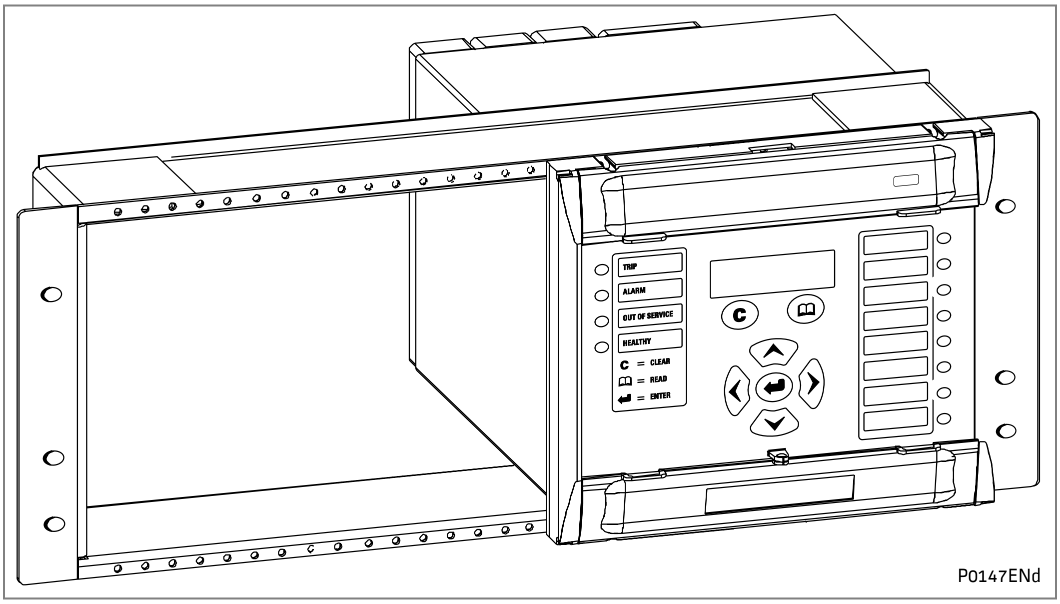


Figure 2 - Rack mounting of relays

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

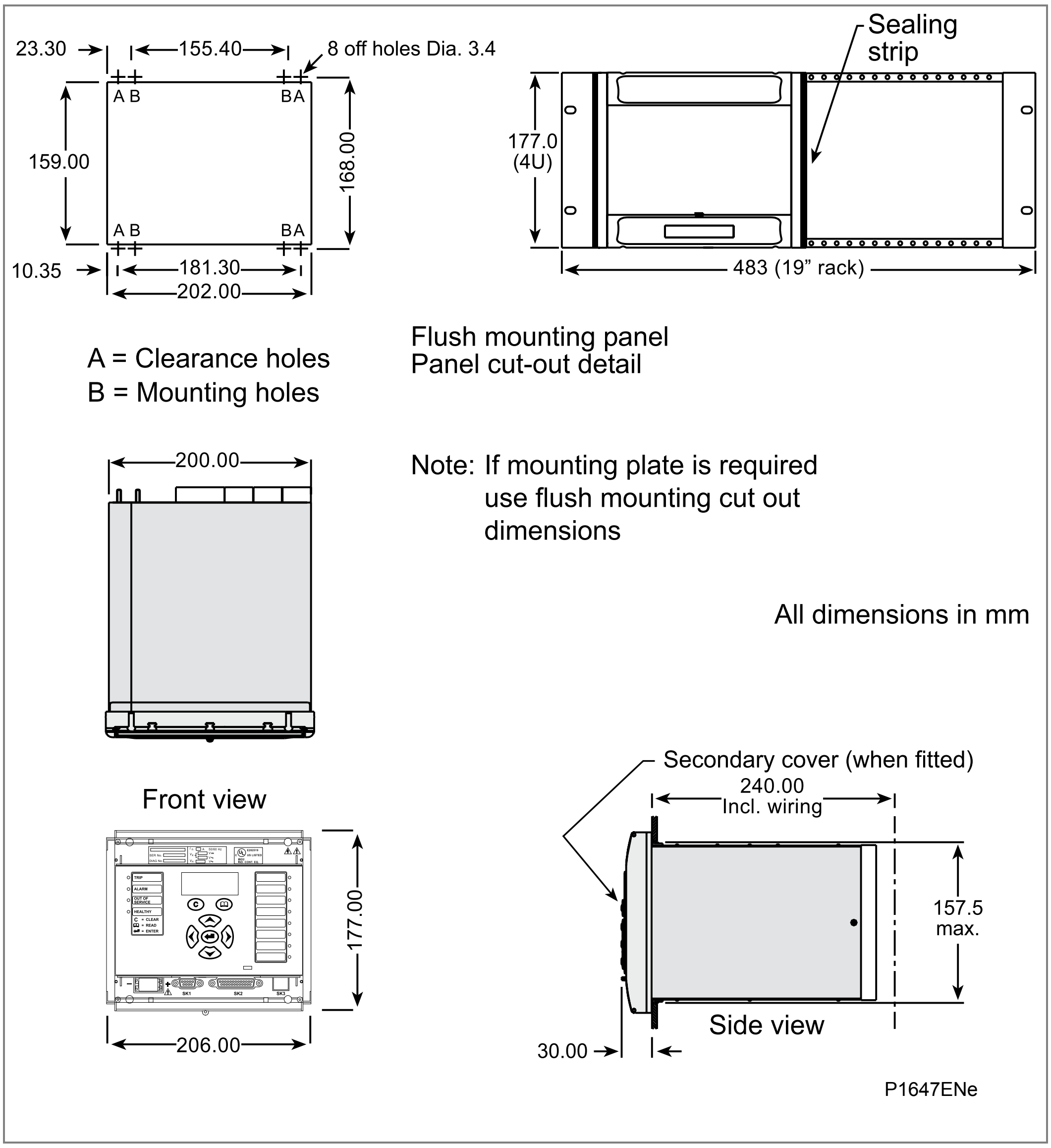


Figure 3 - 40TE Case Dimensions

5.2 60TE Case Dimensions

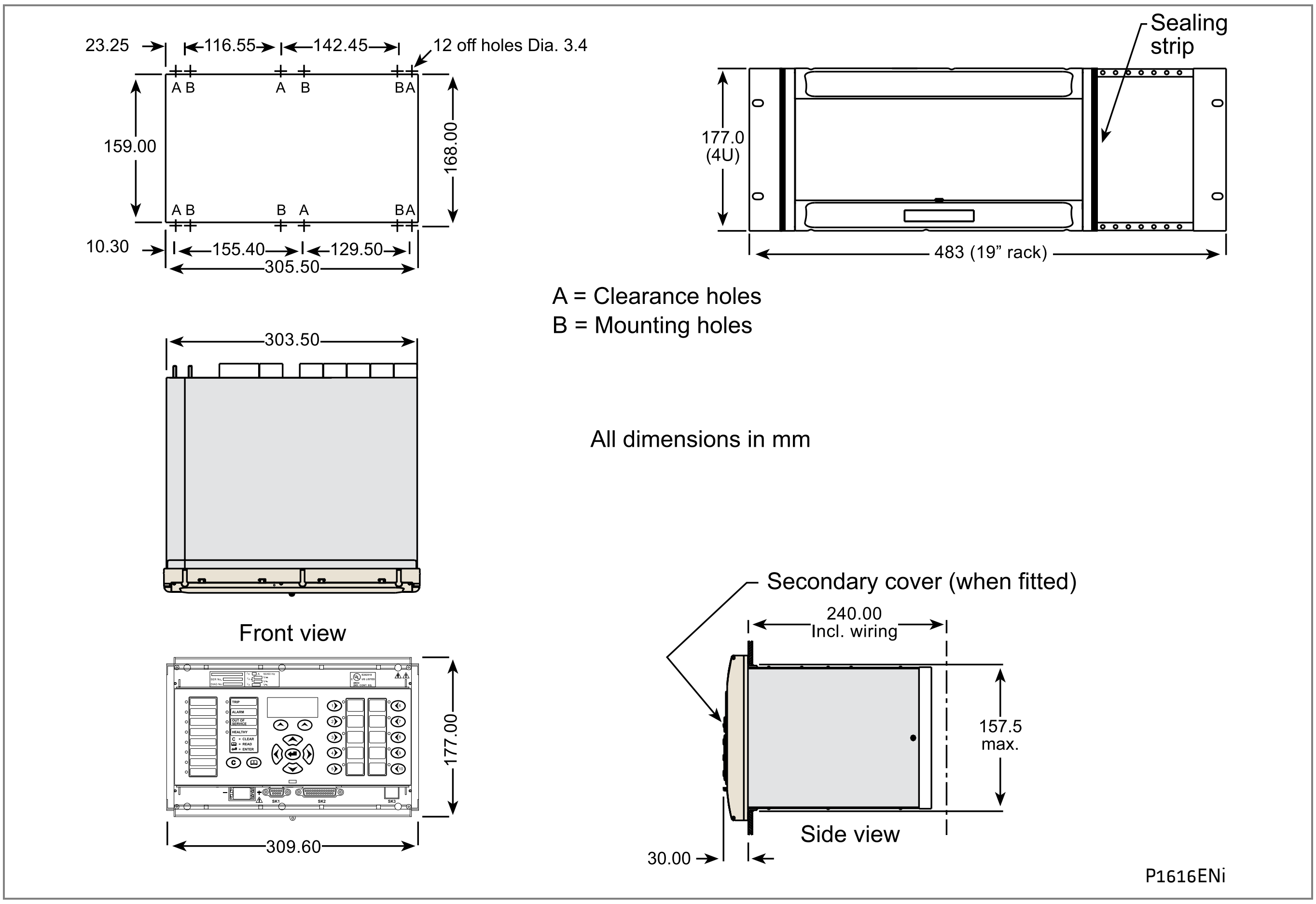


Figure 4 - 60TE Case Dimensions

5.3 80TE Case Dimensions

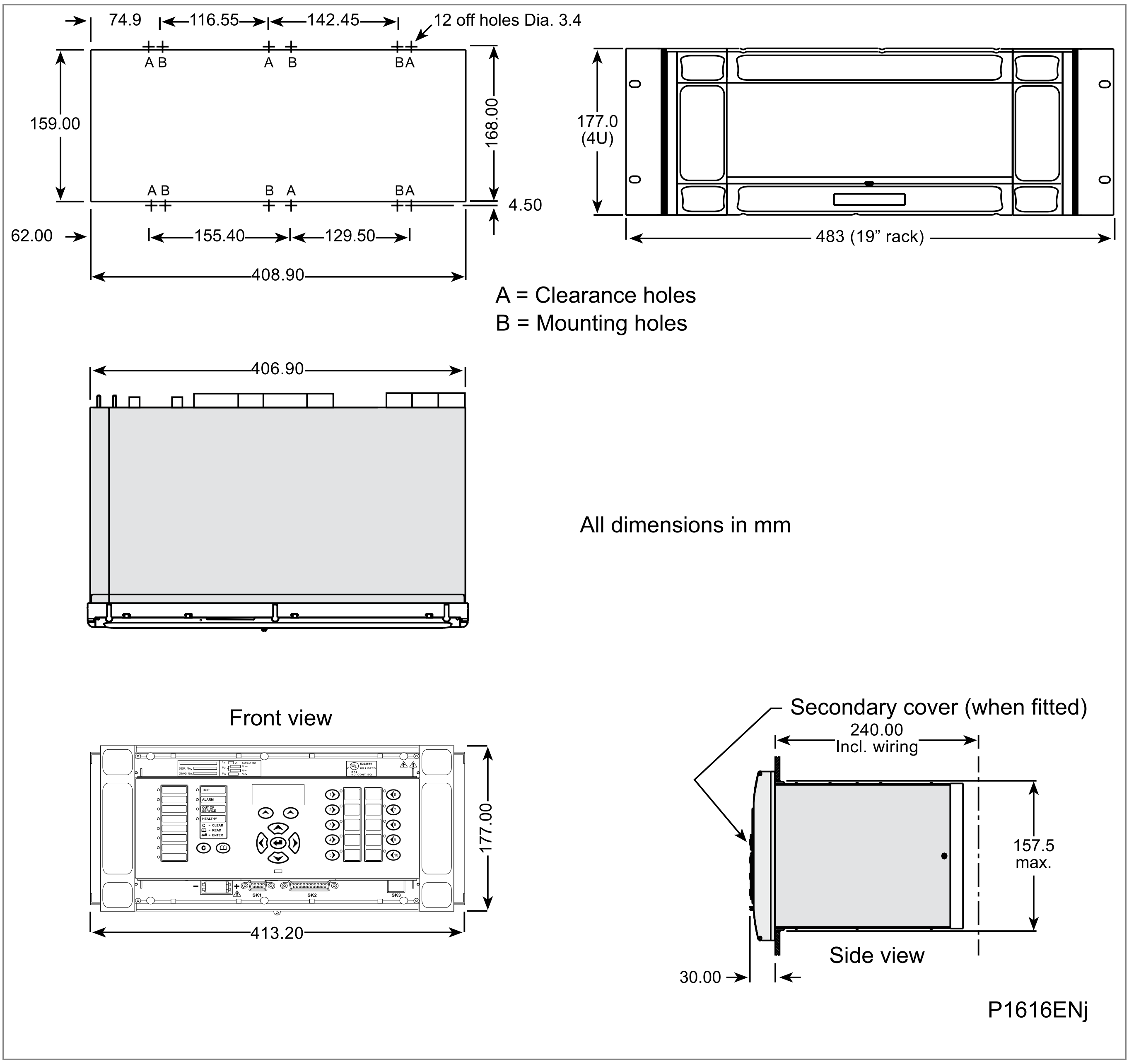


Figure 5 - 80TE Case Dimensions

CONNECTION DIAGRAMS

CHAPTER 16

Date:	01/2017
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:	M
Software version:	E1
Connection diagrams:	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)

CONTENTS

FIGURES

Notes:

1 COMMUNICATION OPTIONS MICOM PX40 PLATFORM

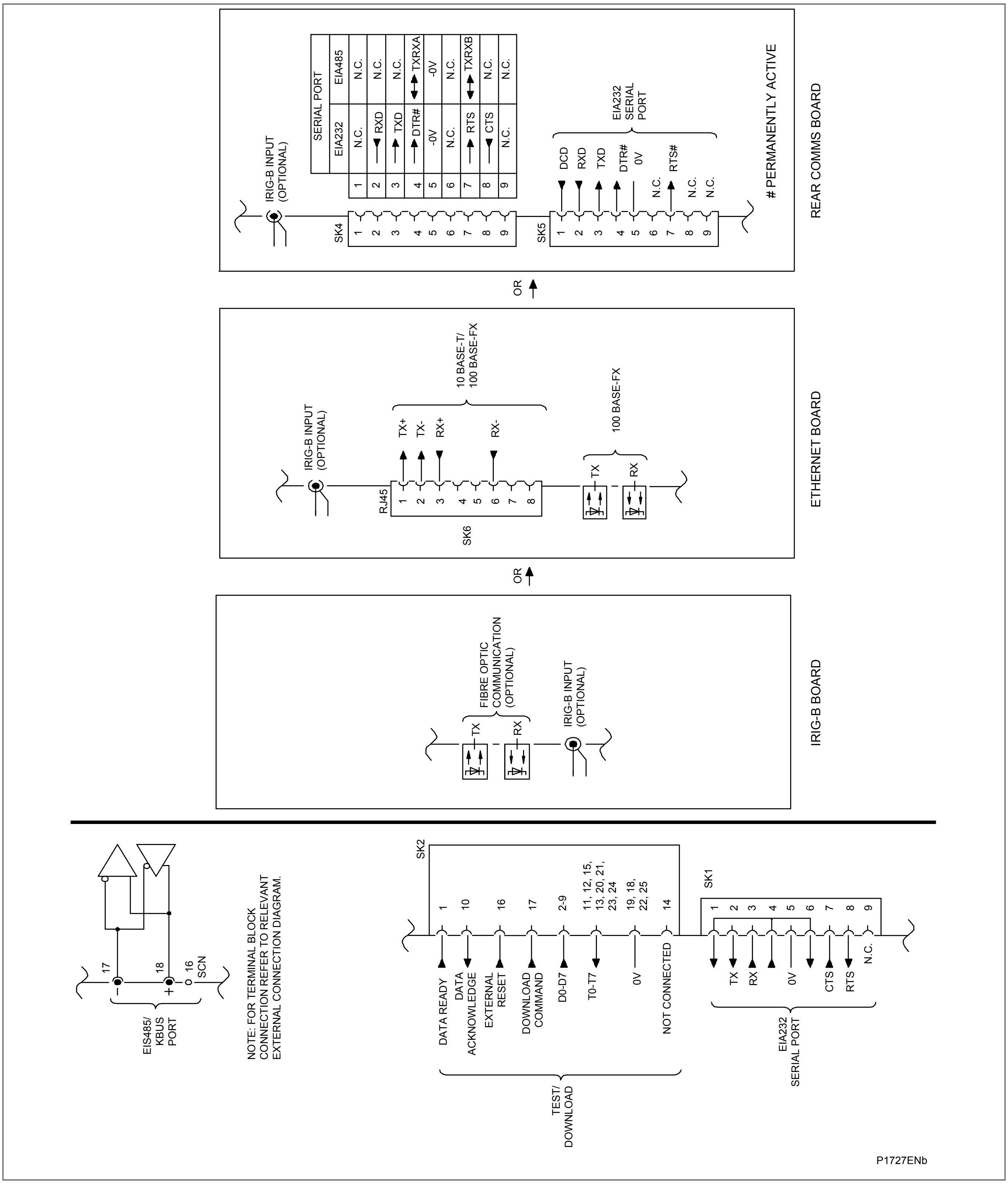


Figure 1 - Comms. Options MiCOM Px40 platform

Note	*This board is no longer available. The connections are shown for legacy boards only.*

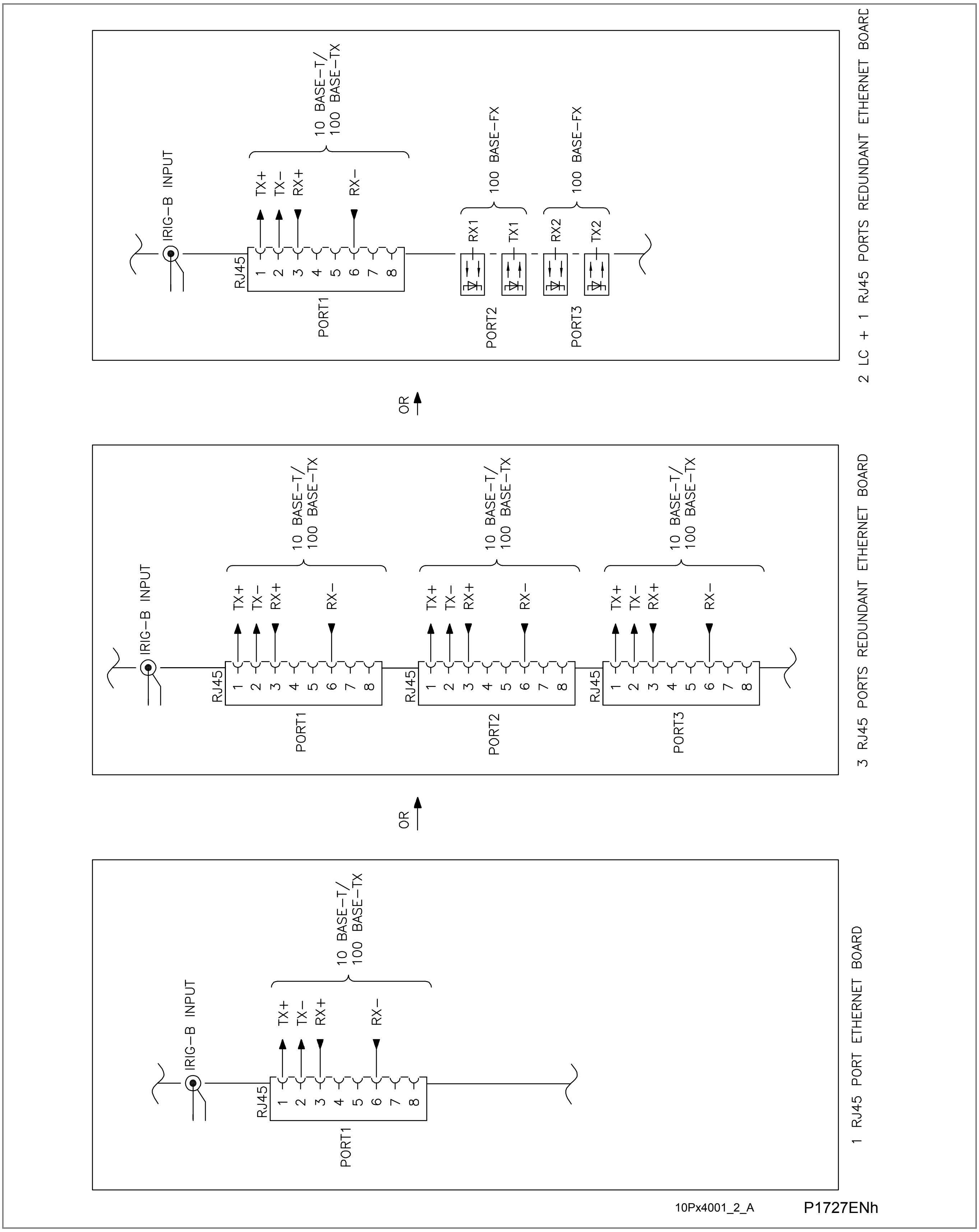


Figure 2 - Ethernet communications options MiCOM Px40 platform

2 P442 – HARDWARE, REAR AND CONNECTION DIAGRAMS

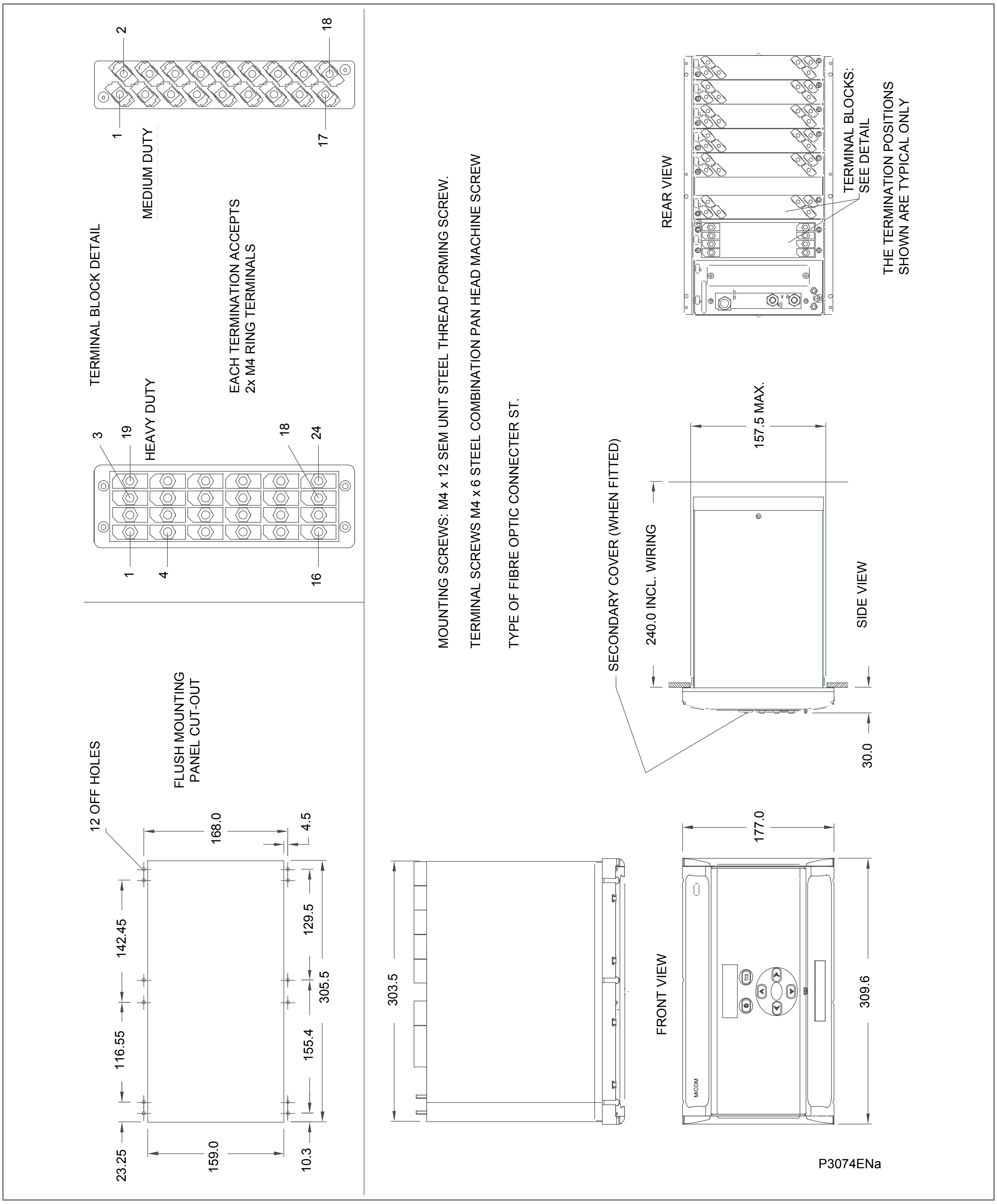
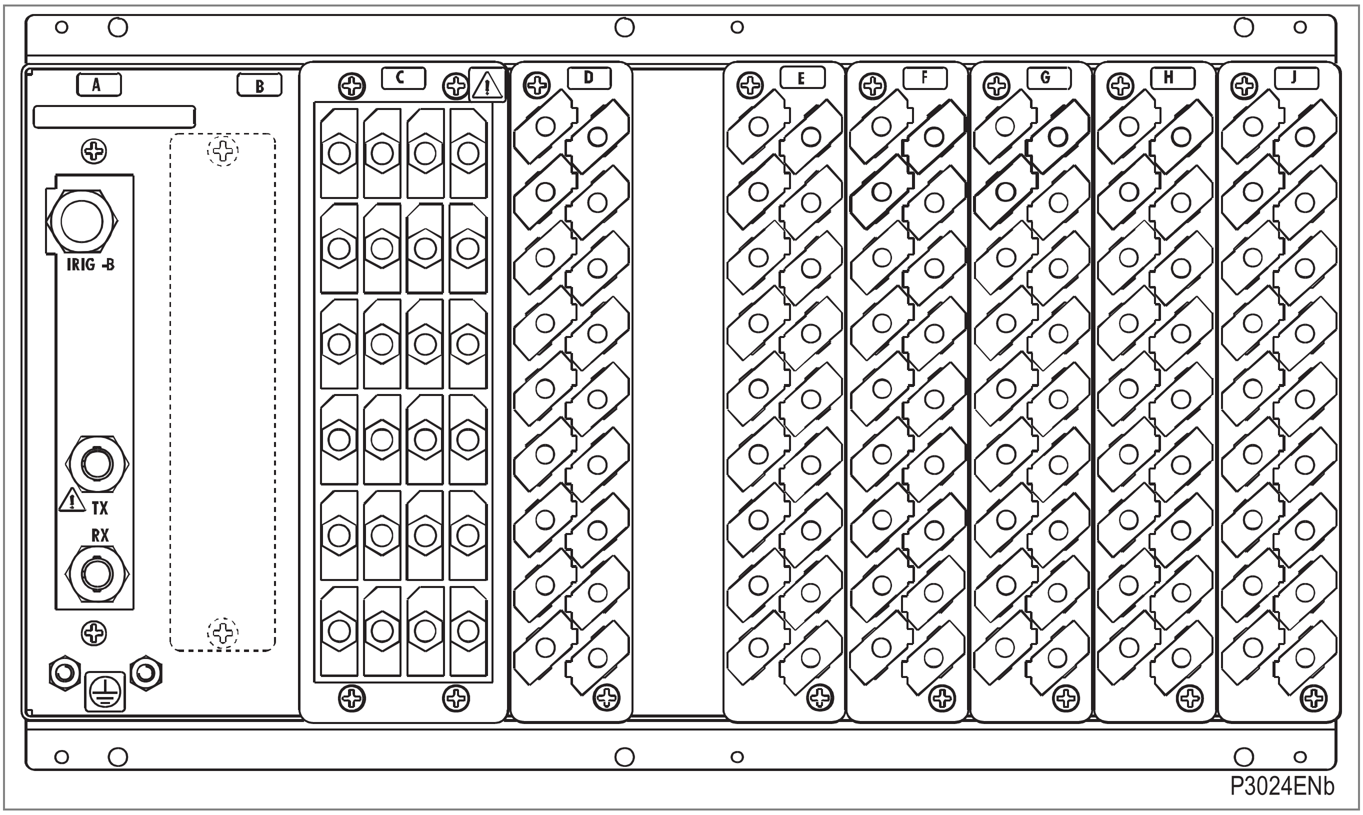


Figure 3 - P442 - Hardware description



A – Optional communications board
B – Coprocesor board
C – Current and voltage input board
D – Opto-input board
E – Opto-input board
F – Output relay/High Break board
F - Power supply board
G - Output relay board
H - Output relay board
J - Power supply board
K - Output relay/High Break board

Figure 4 - P442 - Rear view

Important	***The different options for each board are provided in the relevant tables at the end of the Introduction chapter.***

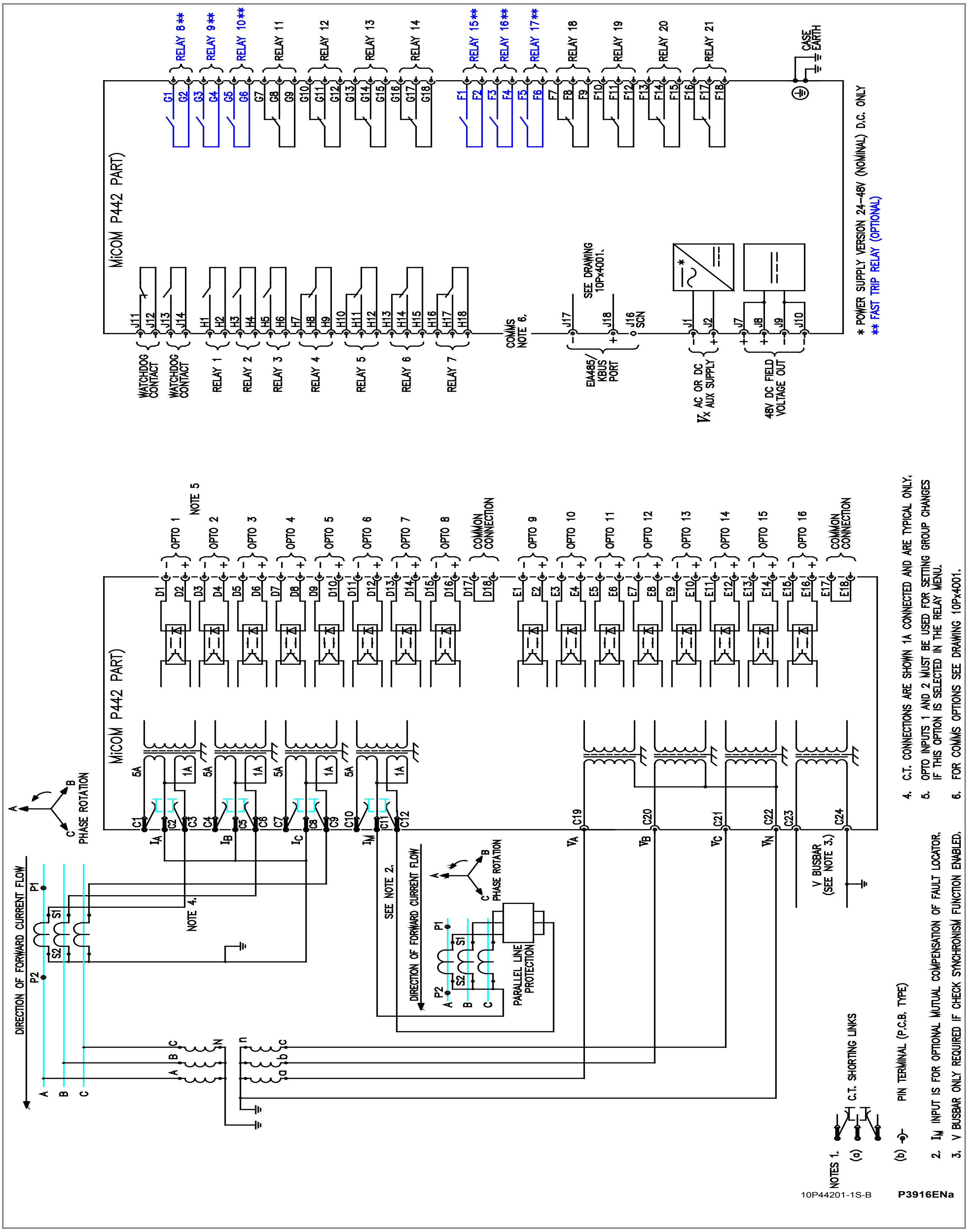


Figure 5 - P442 - Connection diagram 16 Input and 21 output version (fast trip relay options)

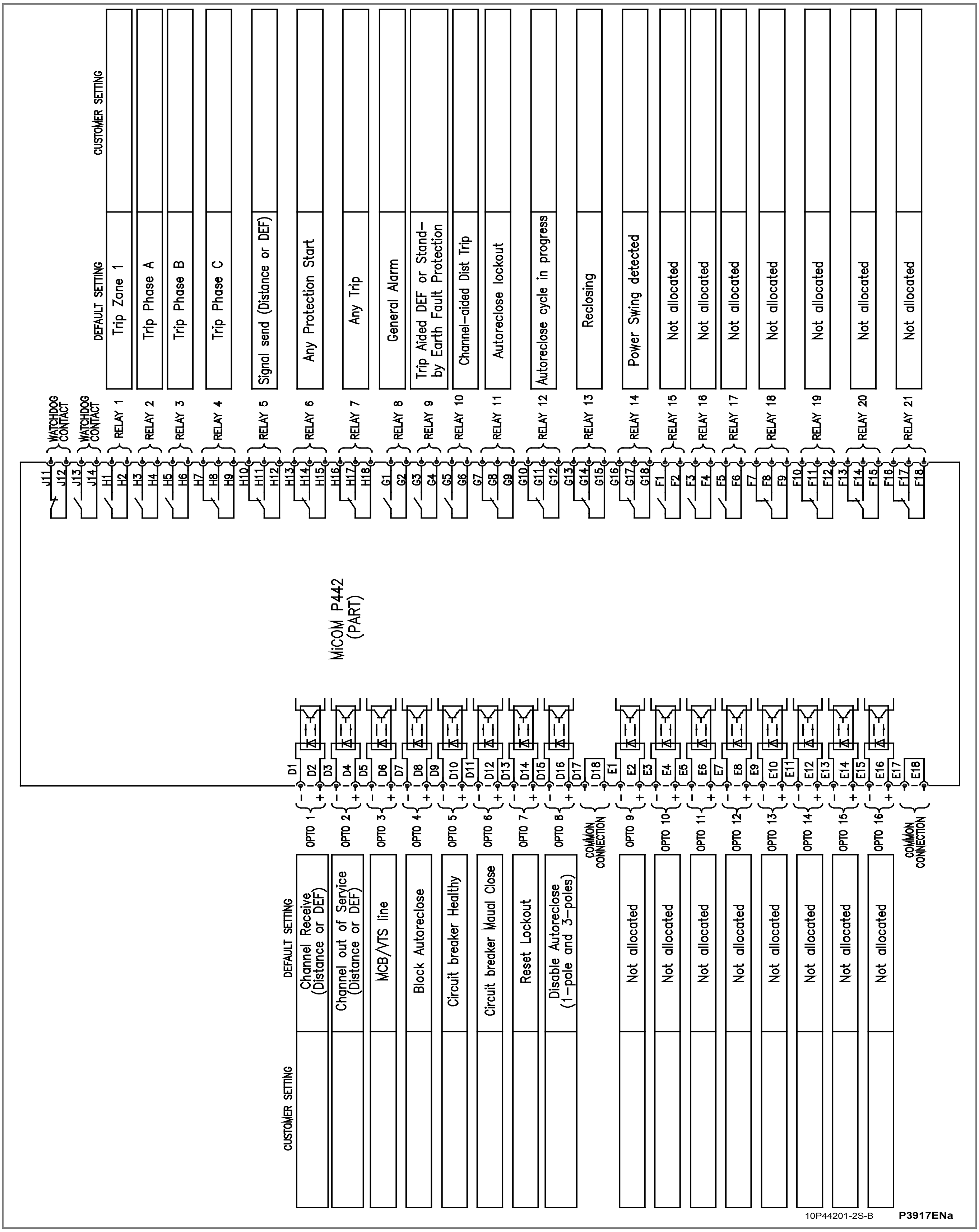


Figure 6 - P442 - Connection diagram 16 Input and 21 output version (fast trip relay options)

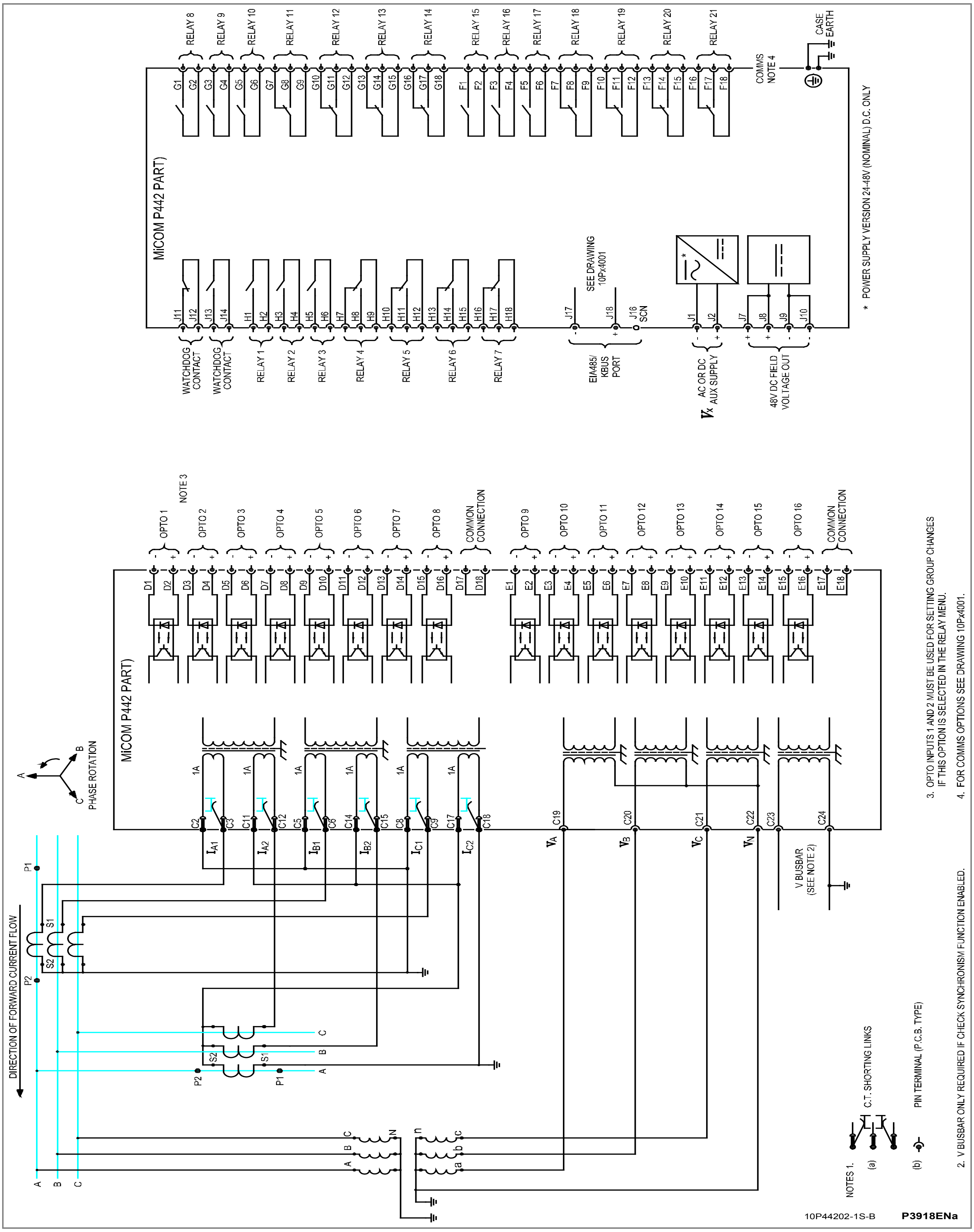


Figure 7 - P442 - Connection diagram 16 Input and 21 output version

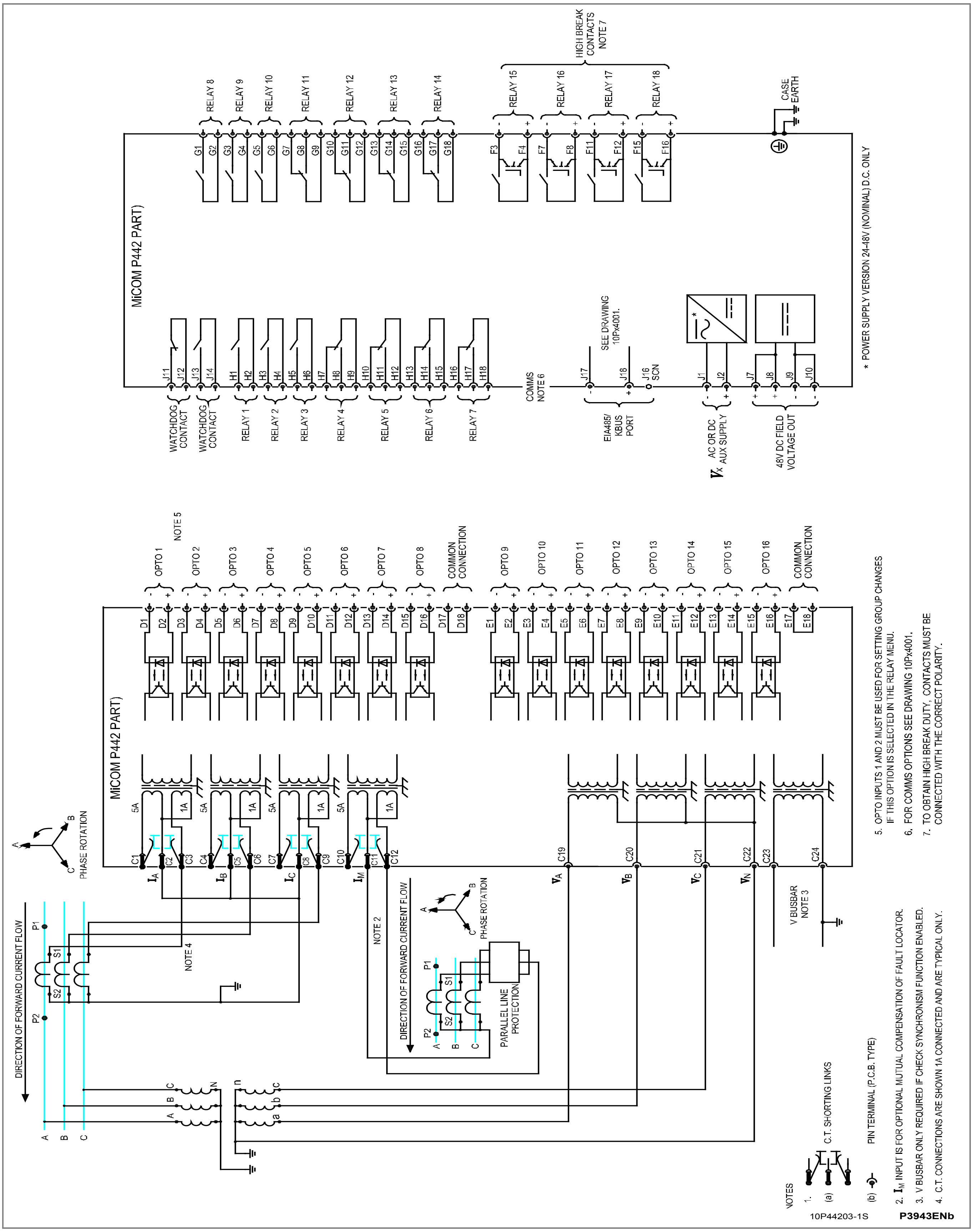


Figure 8 - P442 - Connection diagram 16 Input and 14 (plus 4 high break) output version

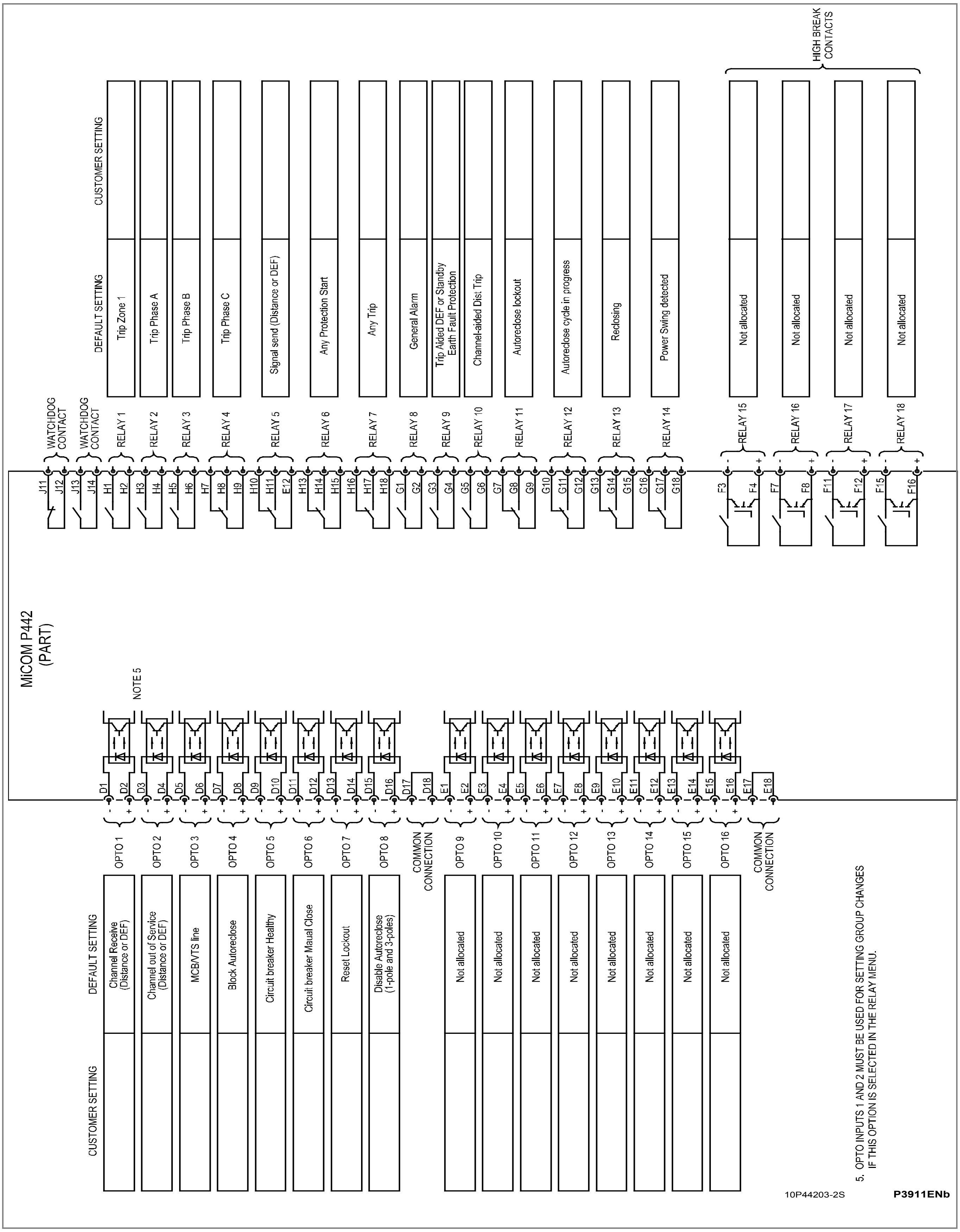


Figure 9 - P442 - Connection diagram 16 Input and 14 (plus 4 high break) output version

3 P444 - HARDWARE, REAR AND CONNECTION DIAGRAMS

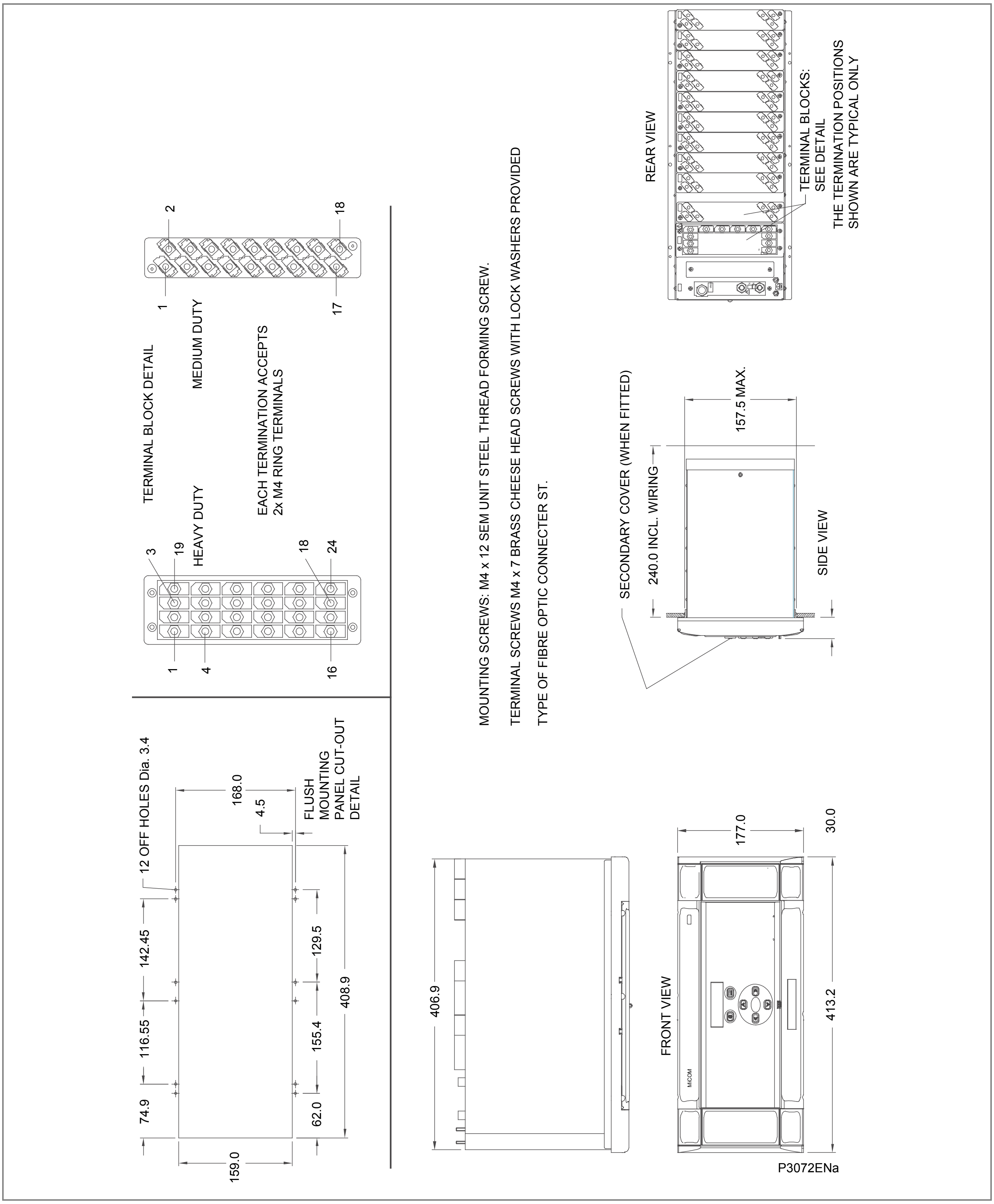
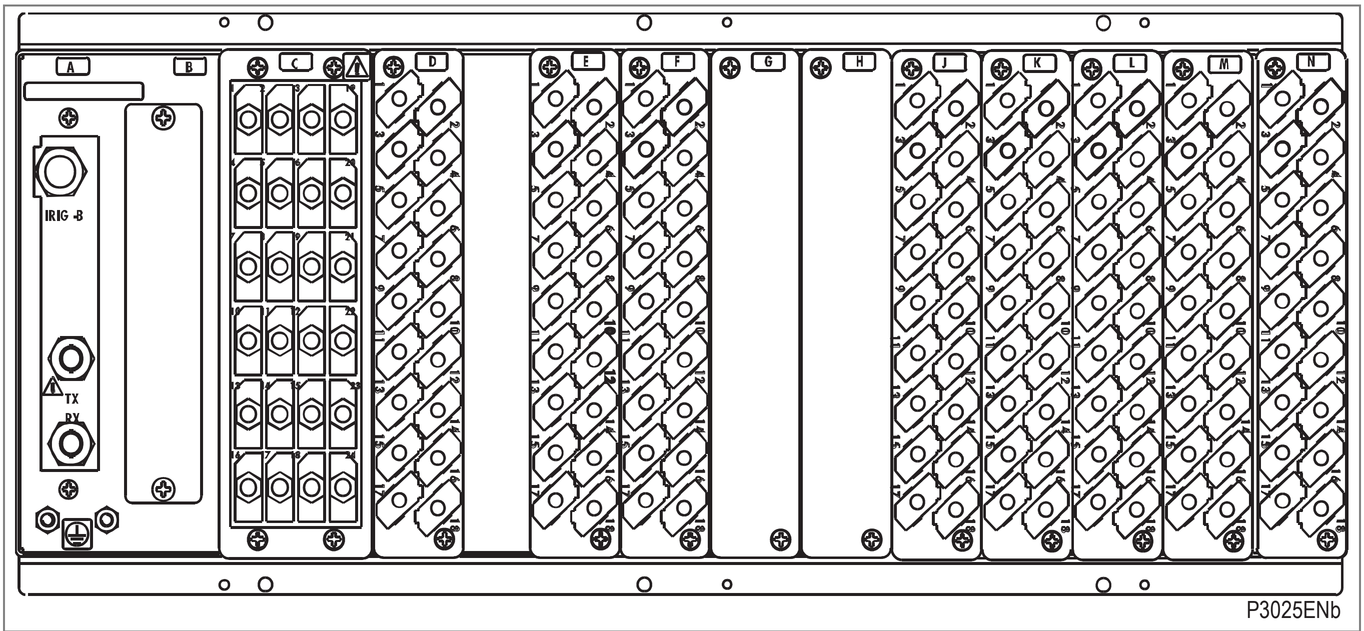


Figure 10 - P444 - Hardware description



A – Optional communications board	H – Optional Output relay board
B – Coprocesor board	J – Output relay/High Break board
C – Current and voltage input board	K – Output relay/High Break board
D – Opto-input board	L – Output relay/High Break board (2)
E – Opto-input board	M – Relay board
F – Opto Input board	N – Power supply board
G – Optional Output relay board	

Figure 11 - P444 - Rear view

Important	***The different options for each board are provided in the relevant tables at the end of the Introduction chapter.***

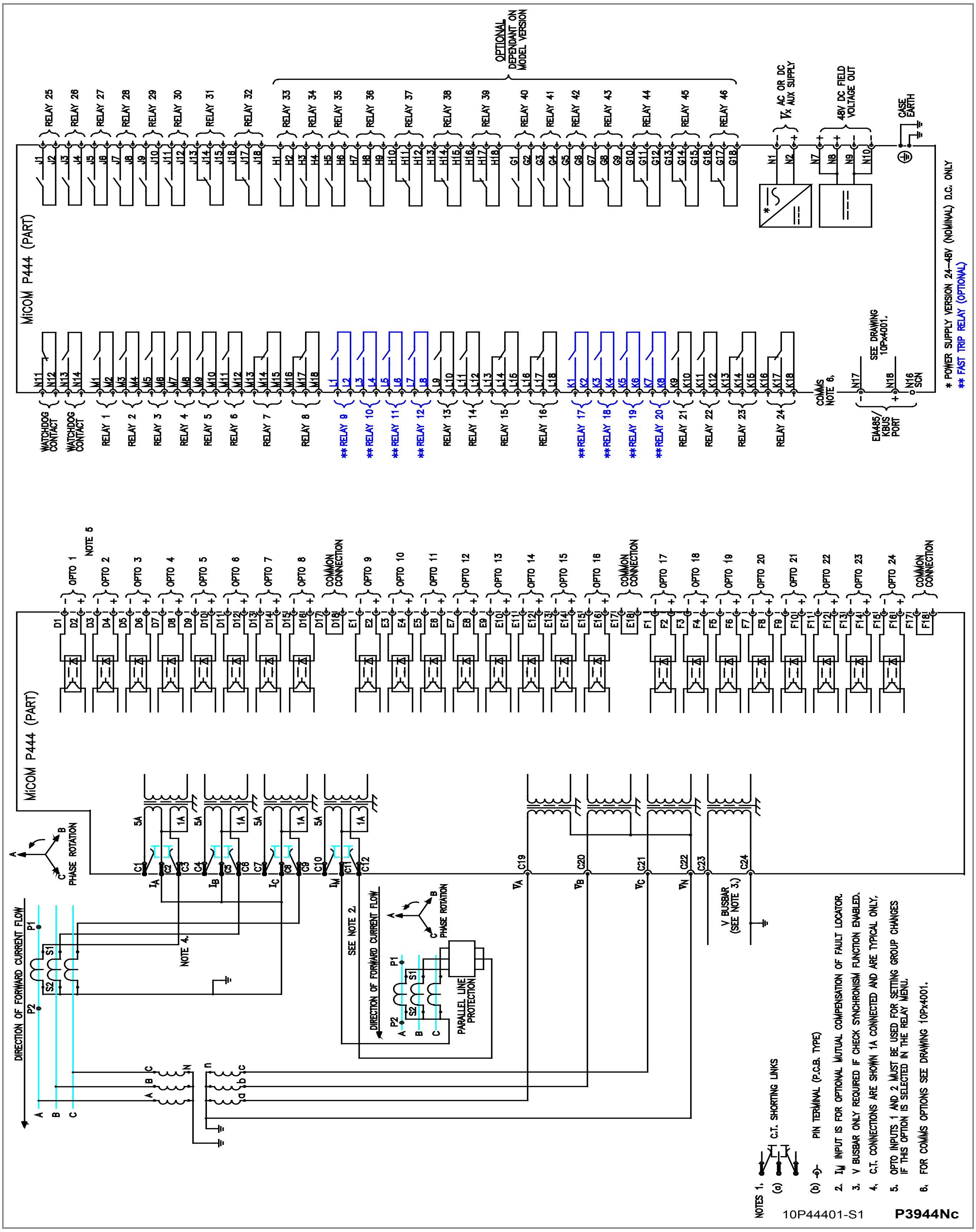


Figure 12 - P444 - Connection diagram – 24 input and 32/46 output versions

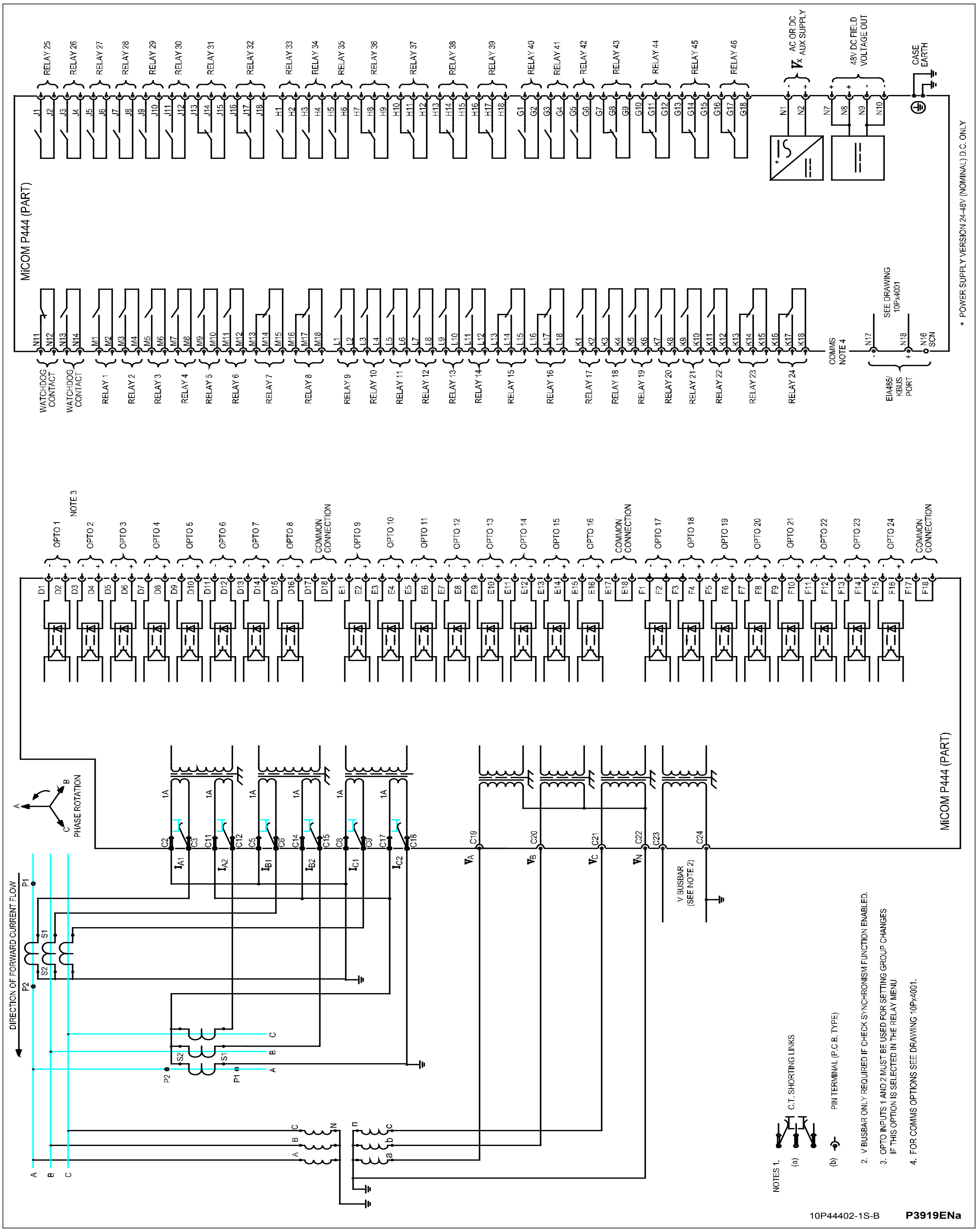


Figure 13 - P444 - Connection diagram – 24 input and 46 output versions

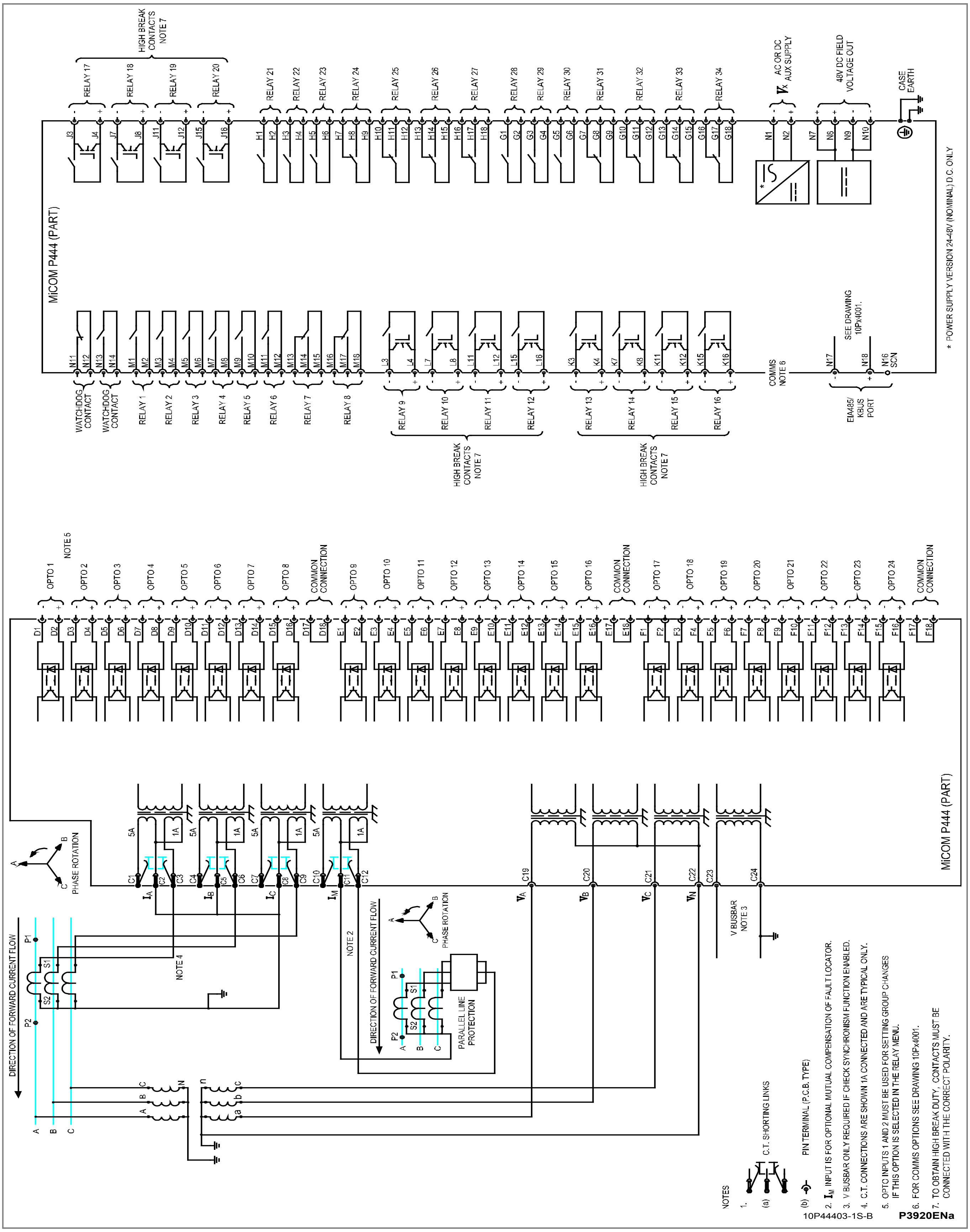


Figure 14 - P444 - Connection diagram – 24 input and 32/46 output versions

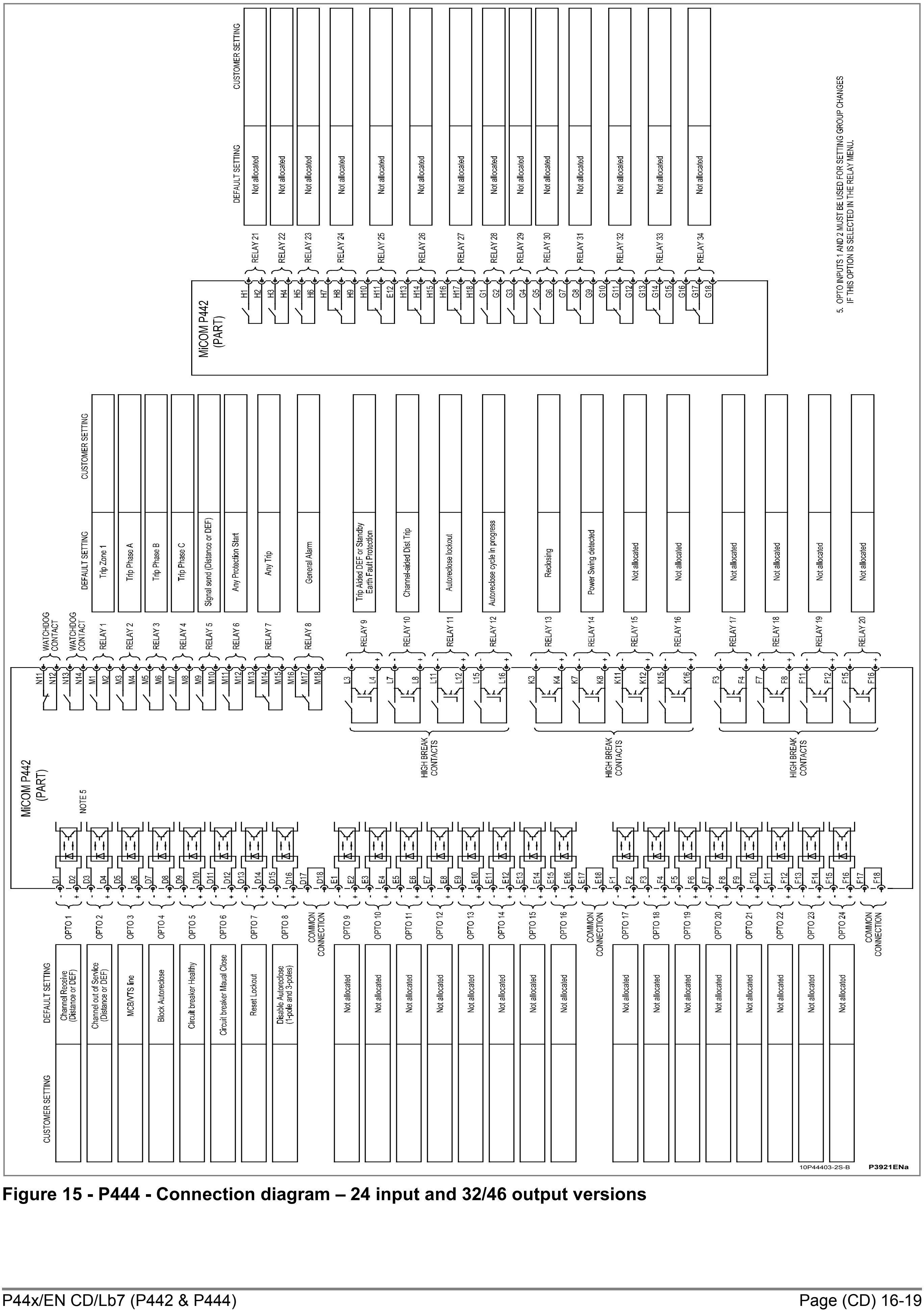


Figure 15 - P444 - Connection diagram – 24 input and 32/46 output versions

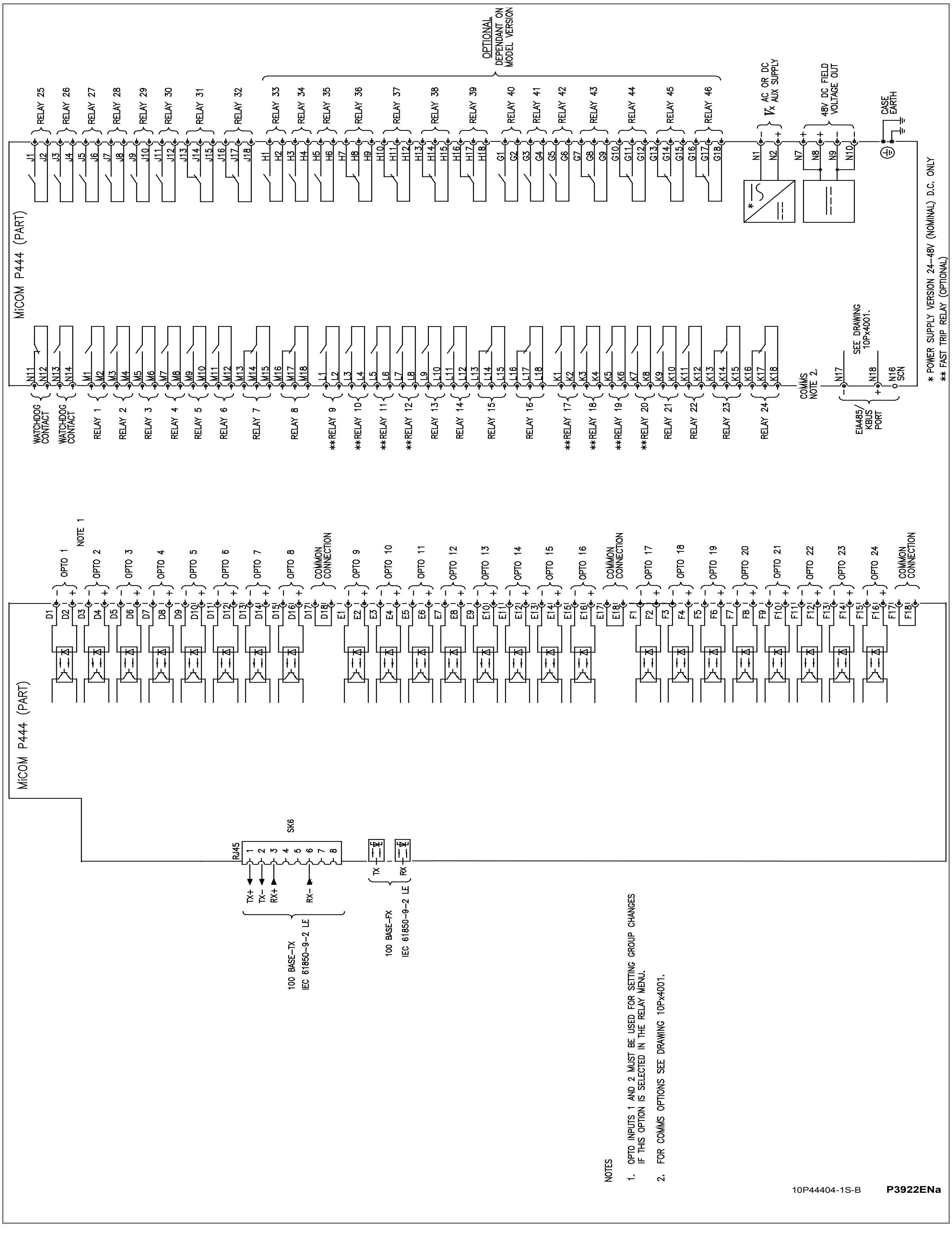


Figure 16 - P444 - Connection diagram – 24 input and 32/46 output versions

CYBER SECURITY

CHAPTER 17

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 L P145 M P445 L P44x (P442/P444) M P44y (P443/P446) M	P54x (P543/P544/P545/P546) M P642 L P643/P645 M P746 M P841A (one circuit breaker) M P841B (two circuit breakers) M P849 M
Software Version:	P14x (P141/P142/P143/P145) B2 P445 J4 P44x (P442/P444) E1 P44y (P443/P446) H4	P54x (P543/P544/P545/P546) H4 P64x (P642/P643/P645) B2 P746 B3/C3 P841A (one circuit breaker) G4 P841B (two circuit breakers) H4 P849 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) 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)	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 = 1 to 10) 10P643xx (xx = 1 to 6) 10P645xx (xx = 1 to 9) 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)
	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.*	

CONTENTS

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.

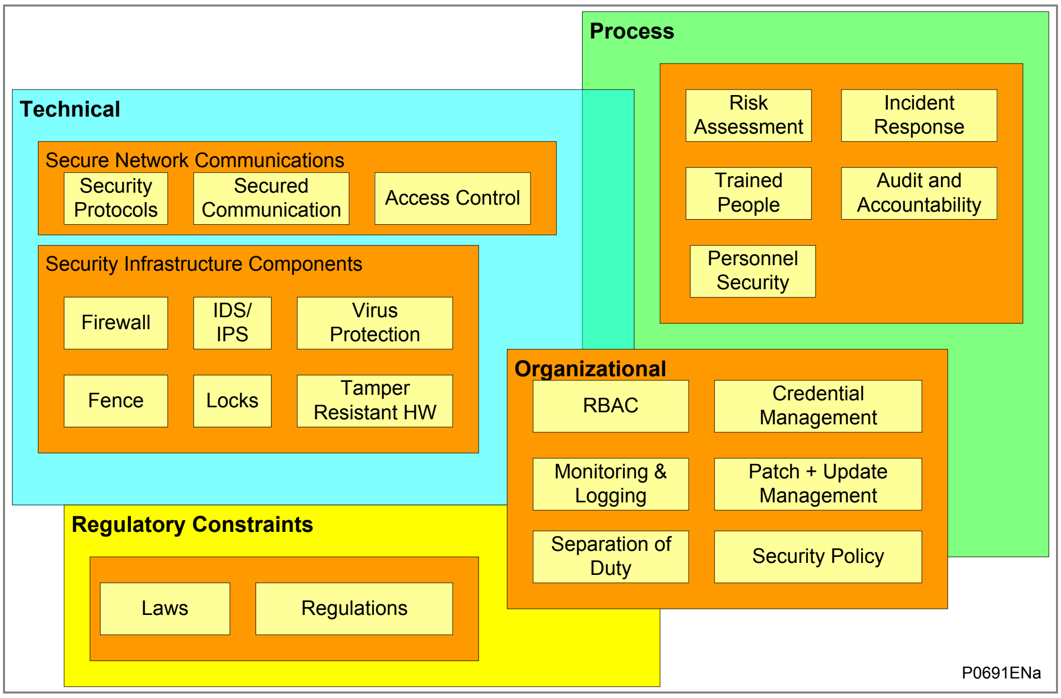


Figure 1 – Associated topics

The asset owner needs to run a continuous improvement process as outlined here:

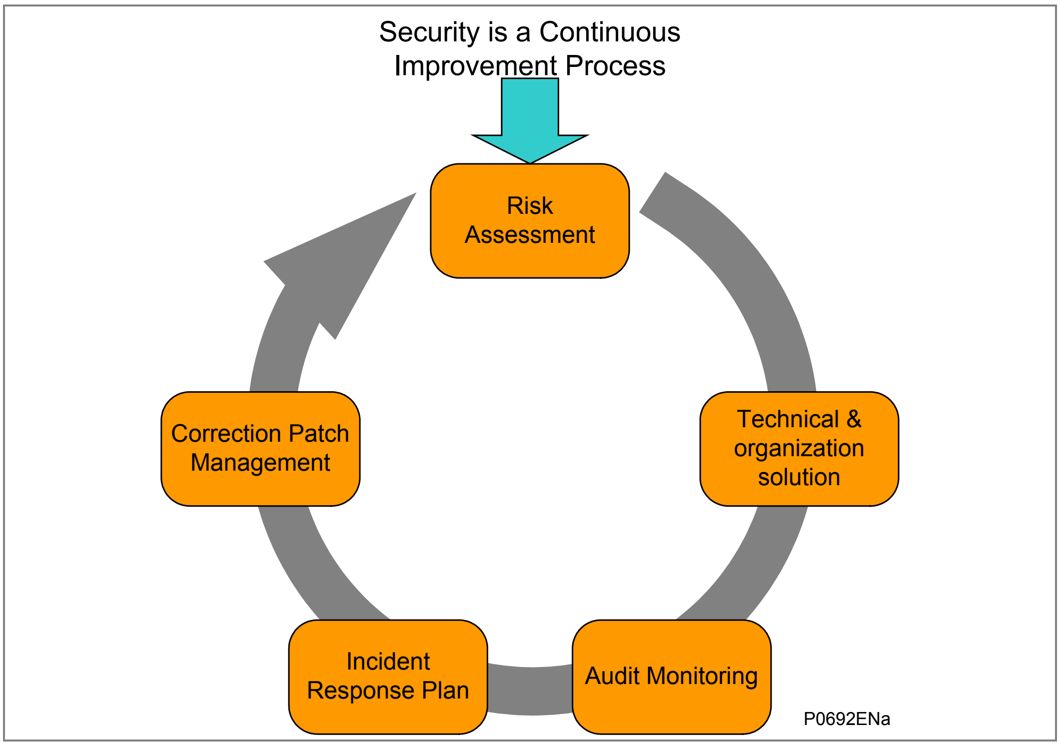


Figure 2 – Continuous improvement process

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.

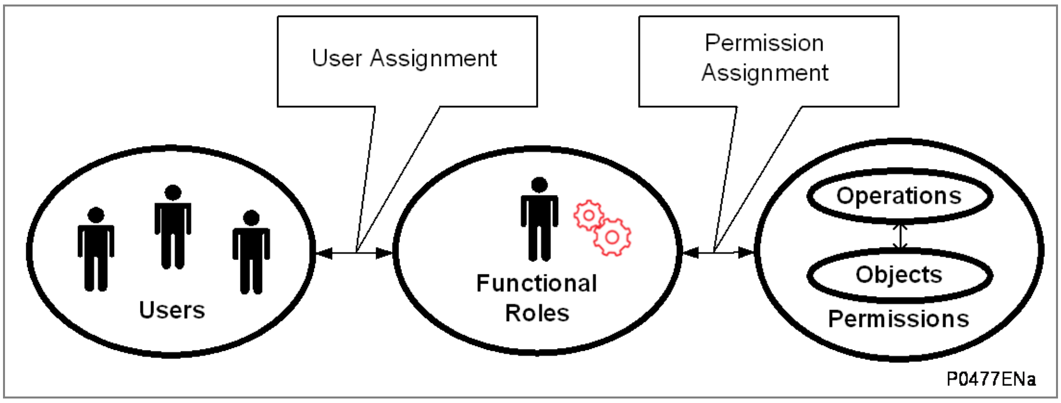


Figure 3 - RBAC Role structure

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 - Advance 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 S1 Studio or the front panel)
- Simple Network Management Protocol (SNMP)
- Security Logs

2.1.1 Password Management

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.** **MiCOM S1 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.**

The first invalid password entry sets the attempts count (actual text here) to 1 and initiates an 'attempts timer'. Further invalid passwords during the timed period increments the attempts count. When the maximum number of attempts has been reached, access is blocked. If the attempts timer expires, or the correct password is entered *before* the 'attempt count' reaches the maximum number, then the 'attempts count' is reset to 0.

Once the user entry is blocked, a 'blocking timer' is initiated. Attempts to access the interface whilst the 'blocking timer' is running results in an error message, irrespective of whether the correct password is entered or not. Only after the 'blocking timer' has expired will access to the interface be unblocked, whereupon the attempts counter is reset to zero.

Attempts to write to the password entry whilst it is blocked results in the following message, which is displayed for 2 seconds.

```
LOGIN FAILED
INCORRECT PASSWORD
```

Appropriate responses achieve the same result if the password is written through a communications port.

The attempts count, attempts timer and blocking timer are configurable at the SAT (not by the IED). Attempts remain and blocking time remain information also are visible in IED. Refer to the *Configurable cyber security settings* table for more details about the settings.

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 MiCOM S1 Studio. 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 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 Simple Network Management Protocol (SNMP)

Simple Network Management Protocol (SNMP) allows security monitoring of events and alarms. Standard third-party SNMP client software can be used to access the log of these events and alarms. Access to the SNMP MIB is given on a read-only basis. For further details of gaining access to the MIB, please contact Schneider Electric.

2.1.8 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 MiCOM S1 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

2.1.9 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 MiCOM S1 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					
SNMP client IP address	0.0.0.0		-	-	-
SNMP client IP address					

Table 12 – Configurable cyber security settings

These settings show some common information about cyber security, which are not configurable whether by SAT, or MiCOM S1 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

2.1.10 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 MiCOM S1 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/SNMP Services

The security logs/SNMP 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 MiCOM S1 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 MiCOM S1 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 MiCOM S1 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

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
SNMP	Simple Network Management Protocol (SNMP) is an "Internet-standard protocol for managing devices on IP networks
TAT	Transfer Administration Tool
Unsecured IED	Relay/IEDs with no security mechanisms.

Table 15 – Glossary for cyber security

Notes:

DUAL REDUNDANT ETHERNET BOARD (DREB)

CHAPTER 18

Date (month/year):	12/2016			
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 P445 P44x (P442/P444) P44y (P443/P446)	L M L M L M L M M	P54x (P543/P544/P545/P546) P642 P643/P645 P741/P743 P742 P746 P841A (one circuit breaker) P841B (two circuit breakers) P849	M L M M L M M M M
Software Version:	P14x (P141/P142/P143/P145) P24x (P241/P242/P243) P341 P34x (P342/P343/P344/P345) P445 P44x (P442/P444) P44y (P443/P446)	B0/B2 D0 B1/E1 B0/B1 J4/B0/B1/E0/E1 E0/E1 H4	P54x (P543/P544/P545/P546) P64x (P642/P643/P645) P746 P74x (P741/P742/P743) P841A P841B P849	H4 B1/B2 B1/B2/B3 C1/C2/C3 B0 G4 H4 B0/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) 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) 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 = 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

FIGURES

TABLES

Notes:

1 INTRODUCTION

The redundant Ethernet board assures redundancy at IED level. It is fitted into the following MiCOM IEDs from Schneider Electric.

- P141, P142, P143, P145
- P241, P242, P243
- P341, P342, P343, P344, P345
- P442, P443, P444, P445, P446
- P543, P544, P545, P546, P547
- P642, P643, P645
- 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 work 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 and HSR redundancy protocols.

- Parallel Redundancy Protocol (PRP)/High-availability Seamless Redundancy (HSR) 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 device.*

- Parallel Redundancy Protocol (PRP)/High-availability Seamless Redundancy (HSR) with 100BaseTx Ethernet ports (RJ45) and modulated/un- modulated IRIG-B input. Part number 2072071A01.

Note	*The board offers compatibility with any PRP/HSR 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 redundant protocols, the redundant Ethernet board also can be operate on Dual IP mode. In this case, each Ethernet board has two host MAC addresses.

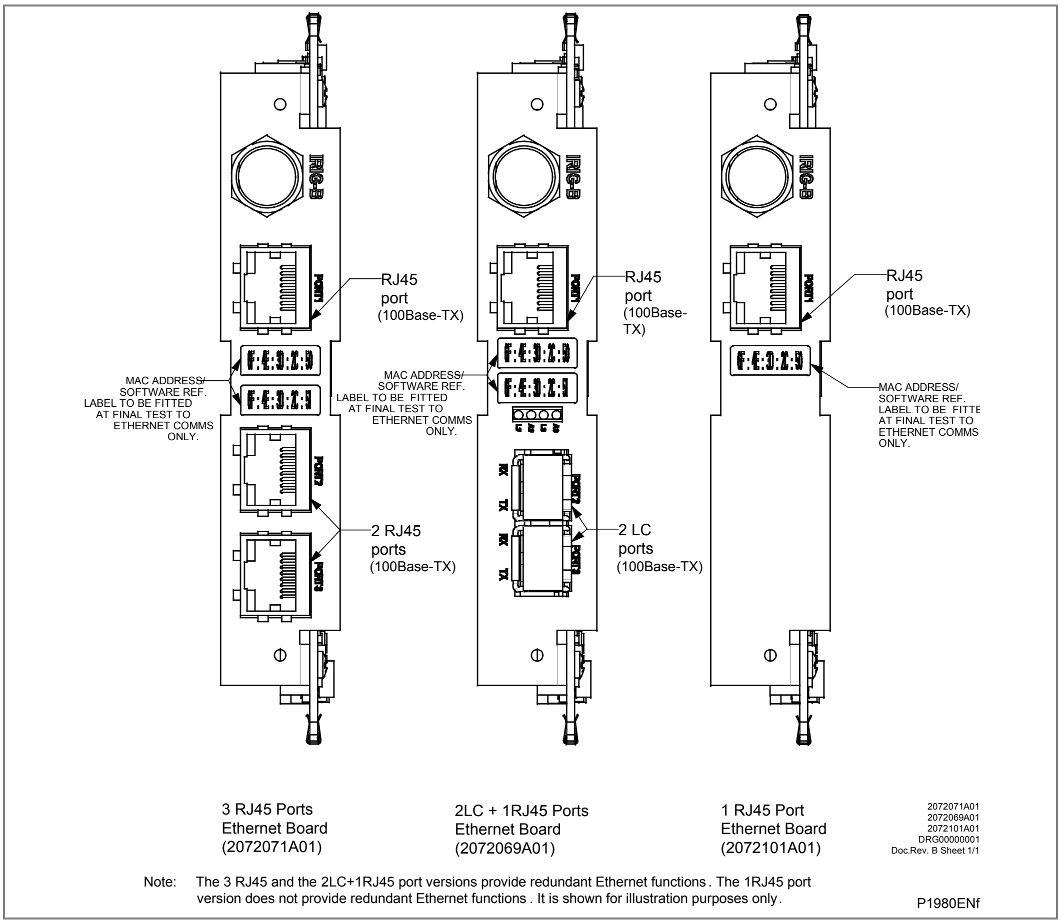


Figure 1 - Ethernet board connectors (3 RJ45 or 2 LC + RJ45 or 1 RJ45)

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
2	R_X	R_X
2	T_X	T_X
3	R_X	R_X
3	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)

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.

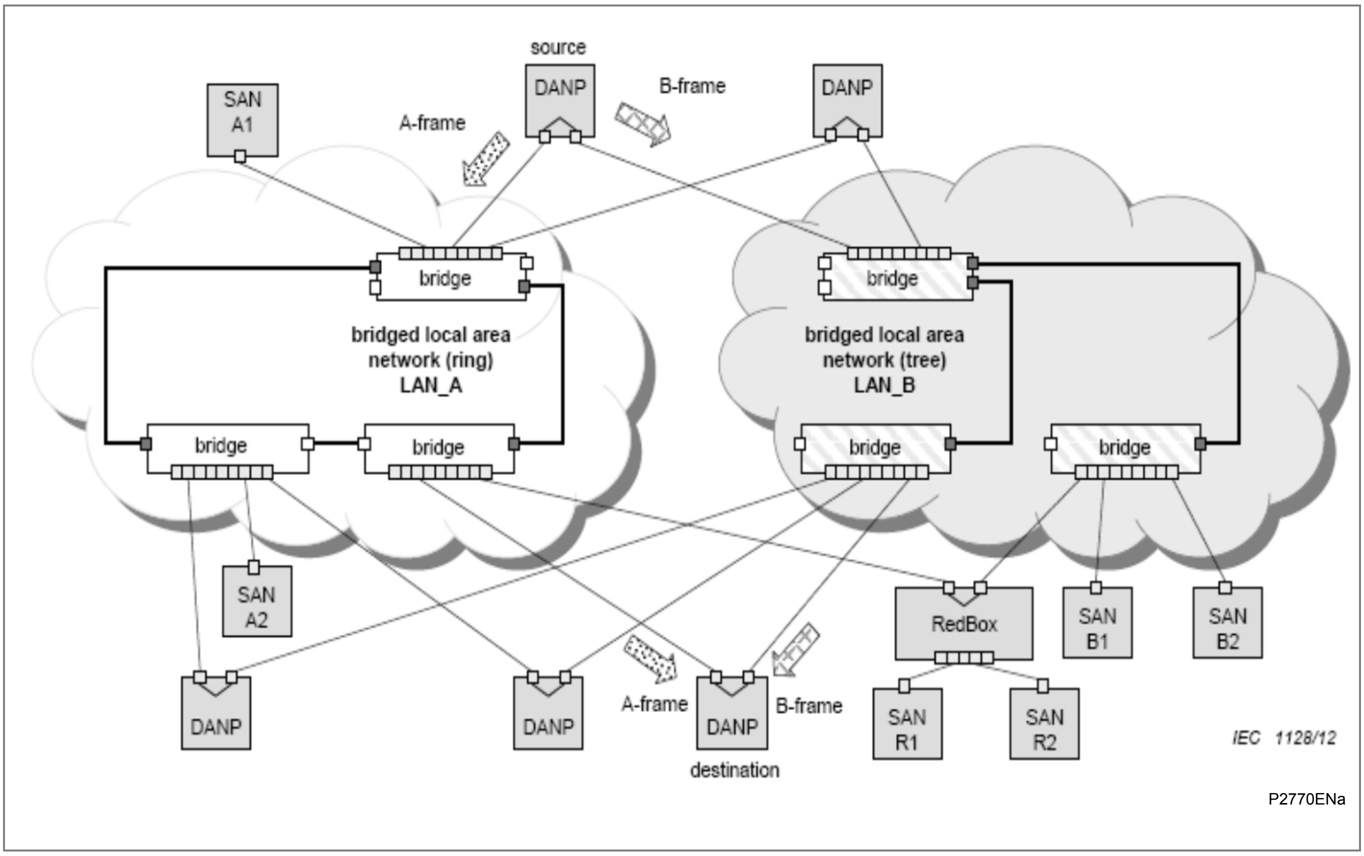


Figure 2 - PRP example of general redundant network

3.1.2 Example Configuration

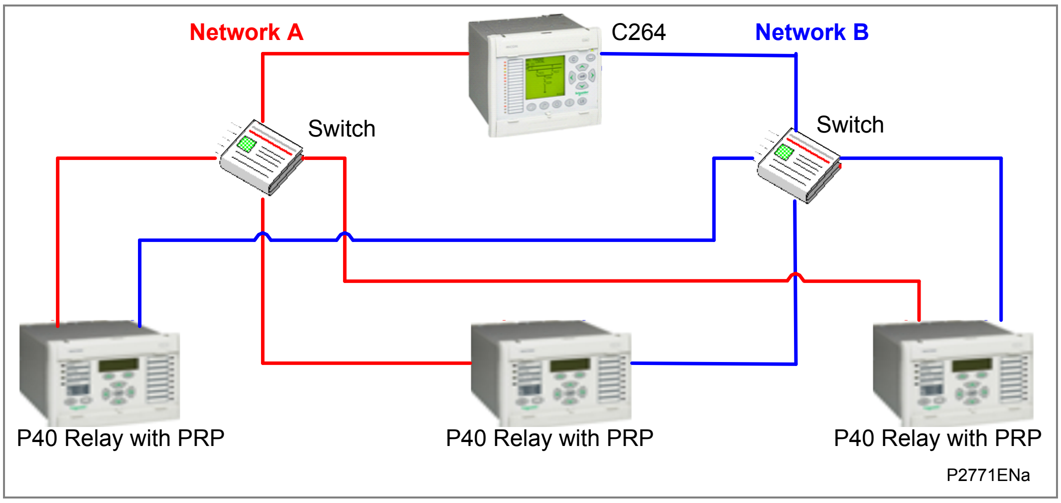


Figure 3 - PRP Relay Configuration

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)

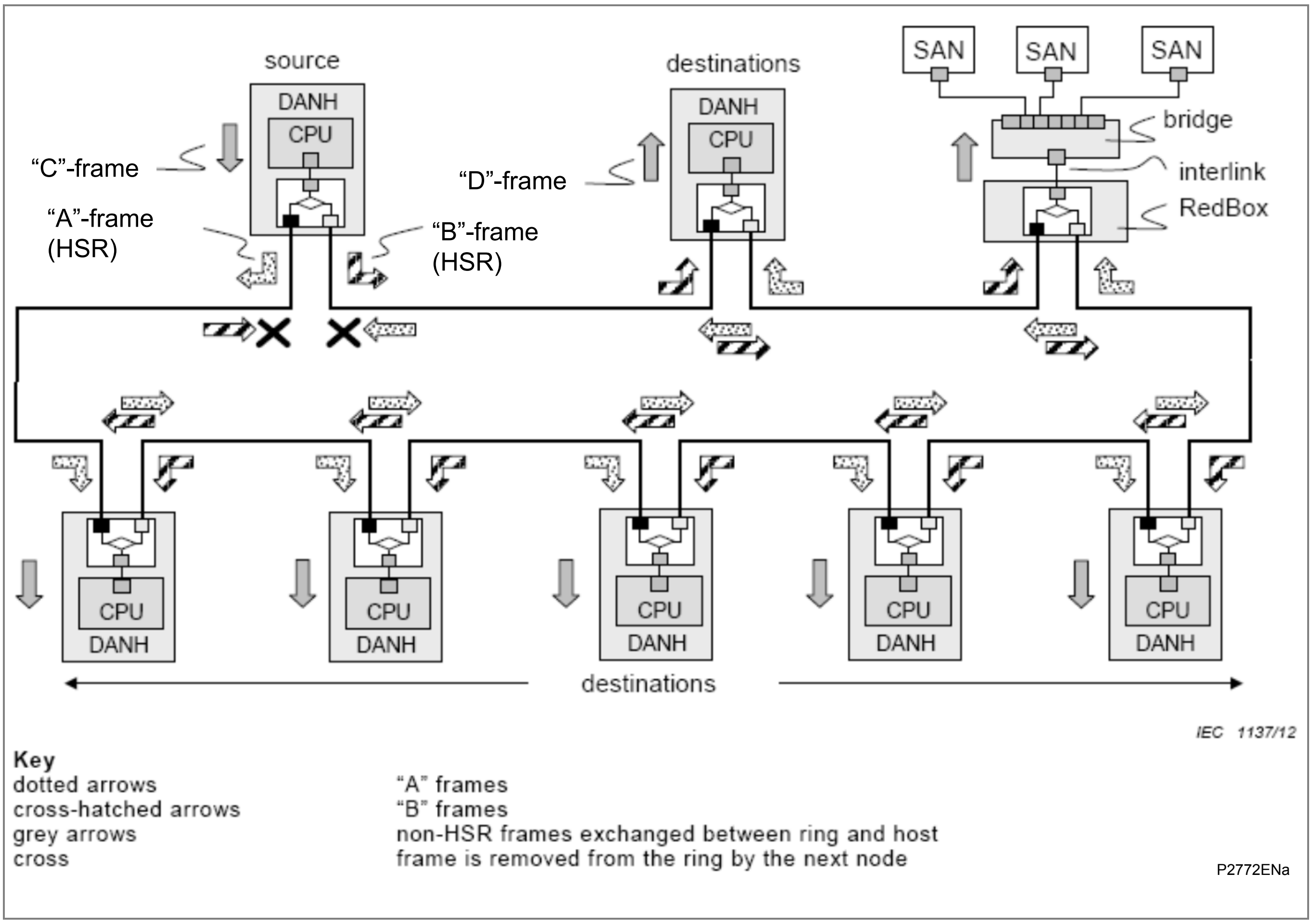


Figure 4 - HSR example of ring configuration for multicast traffic

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.

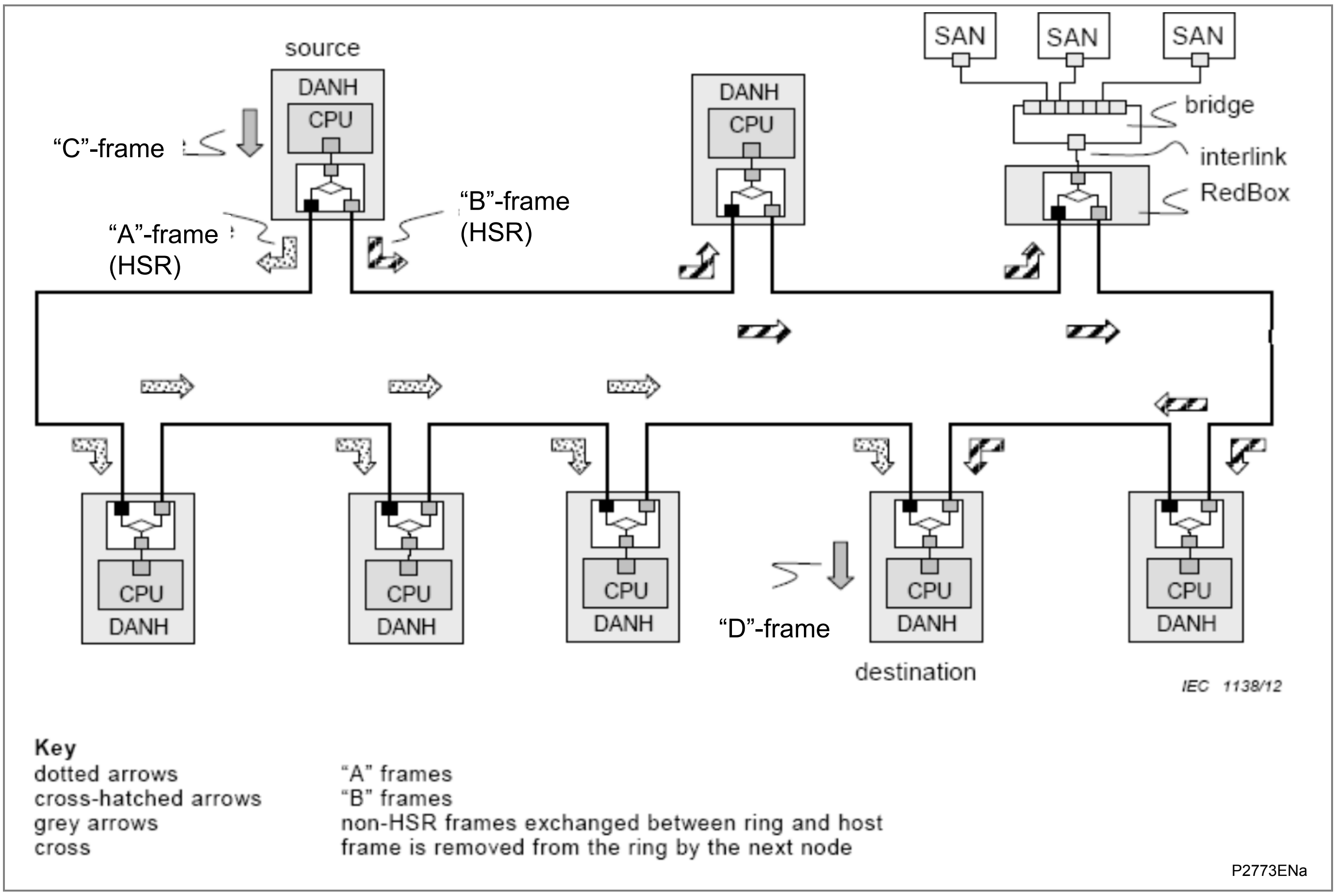


Figure 5 - HSR example of ring configuration for unicast traffic

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

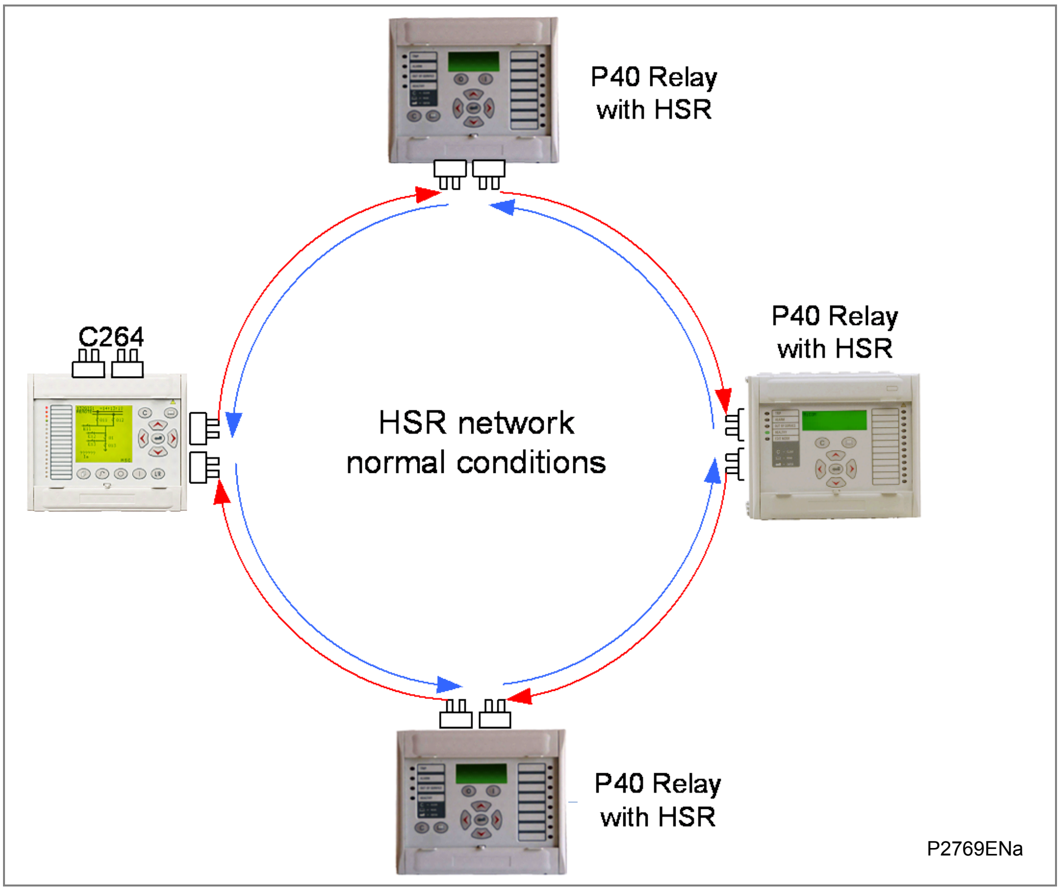


Figure 6 - HSR Relay Configuration

3.3 Generic Functions for all Redundant Ethernet Boards

The following apply to the redundant Ethernet protocols (PRP and HSR).

3.3.1 Priority Tagging

802.1p priority is enabled on all ports.

3.3.2 Simple Network Management Protocol (SNMP)

Simple Network Management Protocol (SNMP) is the network protocol developed to manage devices in an IP network. SNMP relies on a Management Information Base (MIB) that contains information about parameters to supervise. The MIB format is a tree structure, with each node in the tree identified by a numerical Object IDentifier (OID). Each OID identifies a variable that can be read or set using SNMP with the appropriate software. The information in the MIBs is standardized.

3.3.2.1 Redundant Ethernet Board MIB Structure

The IEC 62439-3 MIB provides the following objects available at the OID = .1.0.62439:

SNMP OID	Parameter name	Description
1	iso	
1	std	
1.0.62439	iec62439	
1.0.62439.2	prp	
1.0.62439.2.0	linkRedundancyEntityNotifications	
1.0.62439.2.1	linkRedundancyEntityObjects	
1.0.62439.2.1.0	lreConfiguration	
1.0.62439.2.1.0.0	lreConfigurationGeneralGroup	
1.0.62439.2.1.0.0.1	lreManufacturerName	Specifies the name of the LRE device manufacturer
1.0.62439.2.1.0.0.2	lreInterfaceCount	Total number of LREs present in this system
1.0.62439.2.1.0.1	lreConfigurationInterfaceGroup	
1.0.62439.2.1.0.1.0	lreConfigurationInterfaces	
1.0.62439.2.1.0.1.0.1	lreInterfaceConfigTable	List of PRP/HSR LREs. Each entry corresponds to one PRP/HSR Link Redundancy Entity (LRE), each representing a pair of LAN ports A and B. Basic devices supporting PRP/HSR may have only one LRE and thus one entry in the table, while more complex devices may have several entries for multiple LREs
1.0.62439.2.1.0.1.0.1.1	lreInterfaceConfigEntry	Each entry contains management information
1.0.62439.2.1.0.1.0.1.1.1	lreInterfaceConfigIndex	A unique value for each LRE
1.0.62439.2.1.0.1.0.1.1.2	lreRowStatus	Indicates the status of the LRE table entry
1.0.62439.2.1.0.1.0.1.1.3	lreNodeType	Specifies the operation mode of the LRE: PRP mode 1 (1) HSR mode (2). Note: PRP mode 0 is considered deprecated and is not supported by this revision of the MIB
1.0.62439.2.1.0.1.0.1.1.4	lreNodeName	Specifies this LRE's node name
1.0.62439.2.1.0.1.0.1.1.5	lreVersionName	Specifies the version of this LRE's software
1.0.62439.2.1.0.1.0.1.1.6	lreMacAddress	Specifies the MAC address to be used by this LRE. MAC addresses are identical for all ports of a single LRE
1.0.62439.2.1.0.1.0.1.1.7	lrePortAdminStateA	Specifies whether the port A shall be active or not Active through administrative action (Default: active)
1.0.62439.2.1.0.1.0.1.1.8	lrePortAdminStateB	Specifies whether the port B shall be active or not Active through administrative action (Default: active)

SNMP OID	Parameter name	Description
1.0.62439.2.1.0.1.0.1.1.9	lreLinkStatusA	Shows the actual link status of the LRE's port A
1.0.62439.2.1.0.1.0.1.1.10	lreLinkStatusB	Shows the actual link status of the LRE's port B
1.0.62439.2.1.0.1.0.1.1.11	lreDuplicateDiscard	Specifies whether a duplicate discard algorithm is used at reception (Default: discard)
1.0.62439.2.1.0.1.0.1.1.12	lreTransparentReception	If removeRCT is configured, the RCT is removed when forwarding to the upper layers, only applicable for PRP LRE (Default: removeRCT)
1.0.62439.2.1.0.1.0.1.1.13	lreHsrLREMode	This enumeration is only applicable if the LRE is an HSR bridging node or RedBox. It shows the mode of the HSR LRE: (1) Default mode: The HSR LRE is in mode h and bridges tagged HSR traffic (2) Optional mode: The HSR LRE is in mode n and bridging between its HSR ports is disabled. Traffic is HSR tagged (3) Optional mode: The HSR LRE is in mode t and bridges non-tagged HSR traffic between its HSR ports (4) Optional mode: The HSR LRE is in mode u and behaves like in mode h, except it does not remove unicast messages (5) Optional mode: The HSR LRE is configured in mixed mode. HSR frames are handled according to mode h. Non-HSR frames are handled according to 802.1D bridging rules
1.0.62439.2.1.0.1.0.1.1.14	lreSwitchingEndNode	This enumeration shows which feature is enabled in this particular LRE: (1): an unspecified non-bridging node, e.g. SRP. (2): an unspecified bridging node, e.g. RSTP. (3): a PRP node/RedBox. (4): an HSR RedBox with regular Ethernet traffic on its interlink. (5): an HSR switching node. (6): an HSR RedBox with HSR tagged traffic on its interlink. (7): an HSR RedBox with PRP traffic for LAN A on its interlink. (8): an HSR RedBox with PRP traffic for LAN B on its interlink.
1.0.62439.2.1.0.1.0.1.1.15	lreRedBoxIdentity	Applicable to RedBox HSR-PRP A and RedBox HSR-PRP B. One ID is used by one pair of RedBoxes (one configured to A and one configured to B) coupling an HSR ring to a PRP network. The integer value states the value of the path field a RedBox inserts into each frame it receives from its interlink and injects into the HSR ring. When interpreted as binary values, the LSB denotes the configuration of the RedBox (A or B), and the following 3 bits denote the identifier of a RedBox pair.
1.0.62439.2.1.0.1.0.1.1.16	lreEvaluateSupervision	True if the LRE evaluates received supervision frames. False if it drops the supervision frames without evaluating. Note: LREs are required to send supervision frames, but reception is optional. Default value is dependent on implementation.
1.0.62439.2.1.0.1.0.1.1.17	lreNodesTableClear	Specifies that the Node Table is to be cleared
1.0.62439.2.1.0.1.0.1.1.18	lreProxyNodeTableClear	Specifies that the Proxy Node Table is to be cleared
1.0.62439.2.1.1	lreStatistics	
1.0.62439.2.1.1.1	lreStatisticsInterfaceGroup	
1.0.62439.2.1.1.1.0	lreStatisticsInterfaces	
1.0.62439.2.1.1.1.0.1	lreInterfaceStatsTable	List of PRP/HSR LREs. Each entry corresponds to one PRP/HSR Link Redundancy Entity (LRE), each representing a pair of LAN ports A and B and a port C towards the application/interlink. Basic devices supporting PRP/HSR may have only one LRE and thus one entry in the table, while more complex devices may have several entries for multiple LREs.
1.0.62439.2.1.1.1.0.1.1	lreInterfaceStatsEntry	An entry containing management information applicable to a particular LRE
1.0.62439.2.1.1.1.0.1.1.1	lreInterfaceStatsIndex	A unique value for each LRE
1.0.62439.2.1.1.1.0.1.1.2	lreCntTxA	Number of frames sent over port A that are HSR tagged or fitted with a PRP Redundancy Control Trailer. Only frames that are HSR tagged or do have a PRP RCT are counted. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.3	lreCntTxB	Number of frames sent over port B that are HSR tagged or fitted with a PRP Redundancy Control Trailer. Only frames that are HSR tagged or do have a PRP RCT are counted. Initial value = 0.

SNMP OID	Parameter name	Description
1.0.62439.2.1.1.1.0.1.1.4	lreCntTxC	Number of frames sent towards the application interface of the DANP or DANH or over the interlink of the RedBox. All frames (with our without PRP RCT or HSR tag) are counted. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.5	lreCntErrWrongLanA	Number of frames with the wrong LAN identifier received on LRE port A. Initial value = 0. Only applicable to PRP ports.
1.0.62439.2.1.1.1.0.1.1.6	lreCntErrWrongLanB	Number of frames with the wrong LAN identifier received on LRE port B. Initial value = 0. Only applicable to PRP ports
1.0.62439.2.1.1.1.0.1.1.7	lreCntErrWrongLanC	Number of frames with the wrong LAN identifier received on the interlink of a RedBox. Only applicable to HSR RedBoxes in HSR-PRP configuration (hsrredboxprpa and hsrredboxprpb).
1.0.62439.2.1.1.1.0.1.1.8	lreCntRxA	Number of frames received on a LRE port A. Only frames that are HSR tagged or fitted with a PRP Redundancy Control Trailer are counted. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.9	lreCntRxB	Number of frames received on a LRE port B. Only frames that are HSR tagged or fitted with a PRP Redundancy Control Trailer are counted. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.10	lreCntRxC	Number of frames received from the application interface of a DANP or DANH or the number of number of frames received on the interlink of a RedBox. All frames (with our without PRP RCT or HSR tag) are counted. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.11	lreCntErrorsA	Number of frames with errors received on this LRE port A. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.12	lreCntErrorsB	Number of frames with errors received on this LRE port B. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.13	lreCntErrorsC	Number of frames with errors received on the application interface of a DANP or DANH or on the interlink of a RedBox. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.14	lreCntNodes	Number of nodes in the Nodes Table
1.0.62439.2.1.1.1.0.1.1.15	lreCntProxyNodes	Number of nodes in the Proxy Node Table. Only applicable to RedBox. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.16	lreCntUniqueRxA	Number of entries in the duplicate detection mechanism on port A for which no duplicate was received. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.17	lreCntUniqueRxB	Number of entries in the duplicate detection mechanism on port B for which no duplicate was received. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.18	lreCntUniqueRxC	Number of entries in the duplicate detection mechanism on the application interface of the DAN or the interlink of the RedBox for which no duplicate was received. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.19	lreCntDuplicateRxA	Number of entries in the duplicate detection mechanism on port A for which one single duplicate was received. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.20	lreCntDuplicateRxB	Number of entries in the duplicate detection mechanism on port B for which one single duplicate was received. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.21	lreCntDuplicateRxC	Number of entries in the duplicate detection mechanism on the application interface of the DAN or the interlink of the RedBox for which one single duplicate was received. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.22	lreCntMultiRxA	Number of entries in the duplicate detection mechanism on port A for which more than one duplicate was received. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.23	lreCntMultiRxB	Number of entries in the duplicate detection mechanism on port B for which more than one duplicate was received. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.24	lreCntMultiRxC	Number of entries in the duplicate detection mechanism on the application interface of the DAN or the interlink of the RedBox for which more than one duplicate was received. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.25	lreCntOwnRxA	Number of HSR tagged frames received on Port A that originated from this device. Frames originate from this device if the source MAC matches the MAC of the LRE, or if the source MAC appears in the proxy node table (if implemented). Applicable only to HSR. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.26	lreCntOwnRxB	Number of HSR tagged frames received on Port B that originated from this device. Frames originate from this device if the source MAC matches the MAC of the LRE, or if the source MAC appears in the proxy node table (if implemented). Applicable only to HSR. Initial value = 0.

SNMP OID	Parameter name	Description
1.0.62439.2.1.1.1.0.2	lreNodesTable	The node table (if it exists on that node) contains information about all remote LRE, which advertised themselves through supervision frames
1.0.62439.2.1.1.1.0.2.1	lreNodesEntry	Each entry in the node table (if it exists) contains information about a particular remote LRE registered in the node table, which advertised itself through supervision frames.
1.0.62439.2.1.1.1.0.2.1.1	lreNodesIndex	Unique value for each node in the LRE's node table
1.0.62439.2.1.1.1.0.2.1.2	lreNodesMacAddress	Each MAC address corresponds to a single Dual Attached Node
1.0.62439.2.1.1.1.0.2.1.3	lreTimeLastSeenA	Time in TimeTicks (1/100s) since the last frame from this remote LRE was received over LAN A. Initialized with a value of 0 upon node registration in the node table
1.0.62439.2.1.1.1.0.2.1.4	lreTimeLastSeenB	Time in TimeTicks (1/100s) since the last frame from this remote LRE was received over LAN B. Initialized with a value of 0 upon node registration in the node table.
1.0.62439.2.1.1.1.0.2.1.5	lreRemNodeType	DAN type, as indicated in the received supervision frame
1.0.62439.2.1.1.1.0.3	lreProxyNodeTable	The proxy node table (if implemented) contains information about all nodes, for which the LRE acts as a connection to the HSR/PRP network.
1.0.62439.2.1.1.1.0.3.1	lreProxyNodeEntry	Each entry in the proxy node table contains information about a particular node for which the LRE acts as a connection to the HSR/PRP network.
1.0.62439.2.1.1.1.0.3.1.1	lreProxyNodeIndex	A unique value for each node in the LRE's proxy node table.
1.0.62439.2.1.1.1.0.3.1.2	lreProxyNodeMacAddress	Each entry contains information about a particular node for which the LRE acts as a proxy for the HSR/PRP network.
1.0.62439.2.2	linkRedundancyEntityConformance	

Table 3 - Redundant Ethernet board MIB Structure

*Port number: 1 to 6 for the RJ45, port 7 management, port 8 ring

Various SNMP client software tools can be used with the MiCOM Px4x, C264 and Hx8x range. Schneider Electric recommends using an SNMP MIB browser which can perform the basic SNMP operations such as GET, GETNEXT, and RESPONSE.

Redundant agency device configuration will be required to access SNMP, refer to section 4.4 for more details.

3.3.3 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.

3.3.4 Dual Ethernet Communication (Dual IPs)

3.3.4.1 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 - Dual IP is automatically supported even if the IED is operate under HSR/PRP mode.

3.3.4.2 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/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)
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 4 - 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).

3.3.4.3 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)

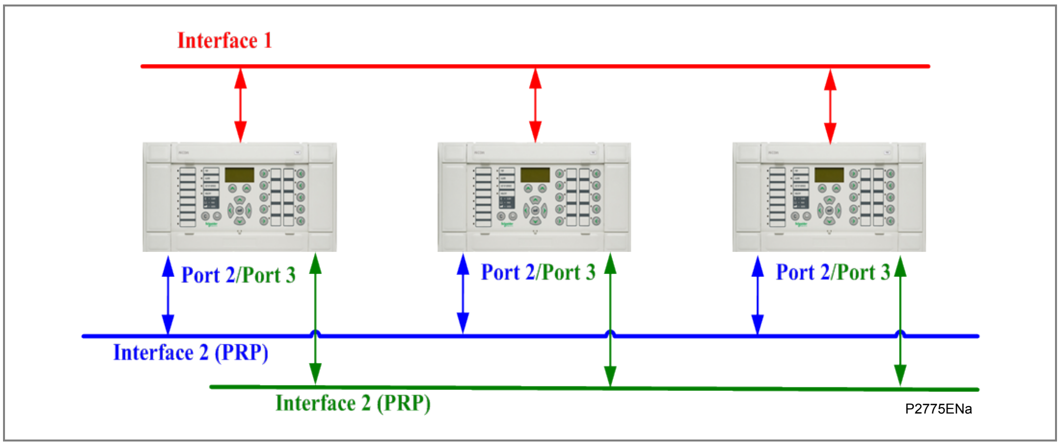


Figure 7 - PRP + Dual IP (Ethernet Mode PRP)

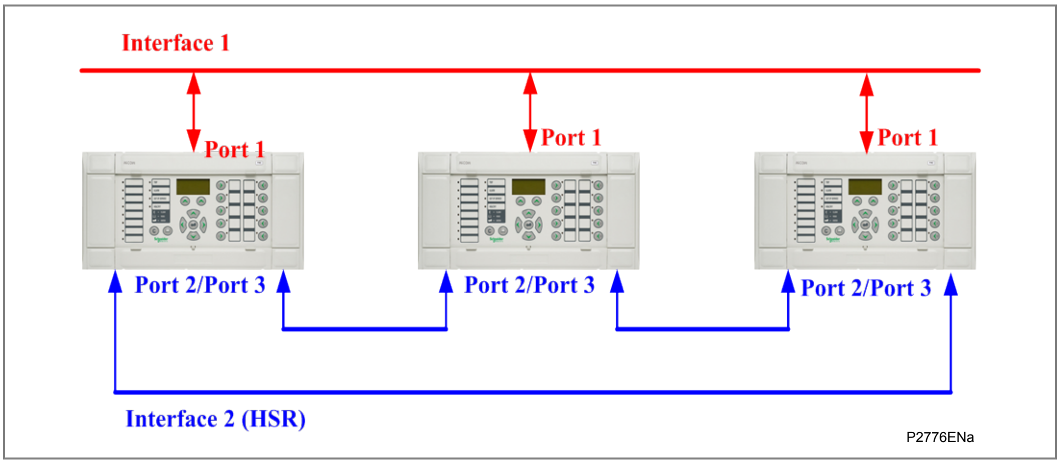


Figure 8 - HSR + Dual IP (Ethernet Mode HSR)

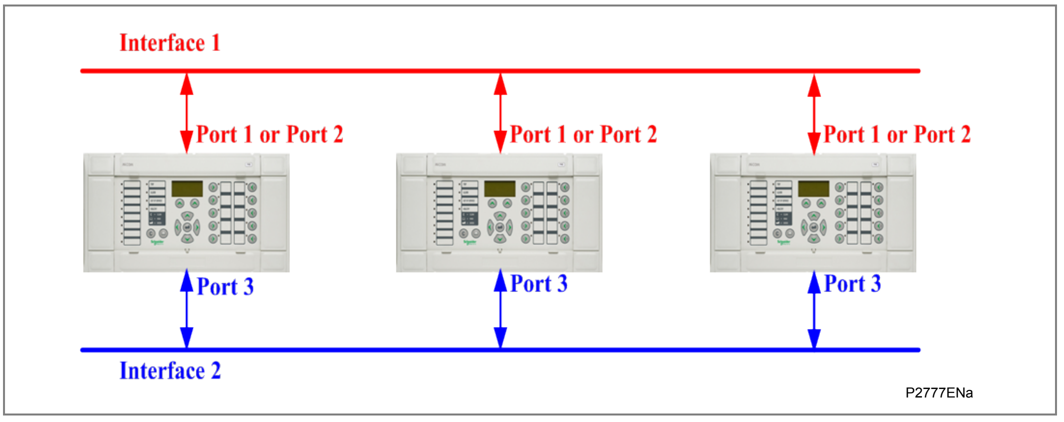


Figure 9 - Dual IP (Ethernet Mode Dual IP)

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
This setting can only be change using the HMI, and the setting change will cause the Ethernet board reboot. Restore default setting does not apply to this setting.			

Table 5 - 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.**

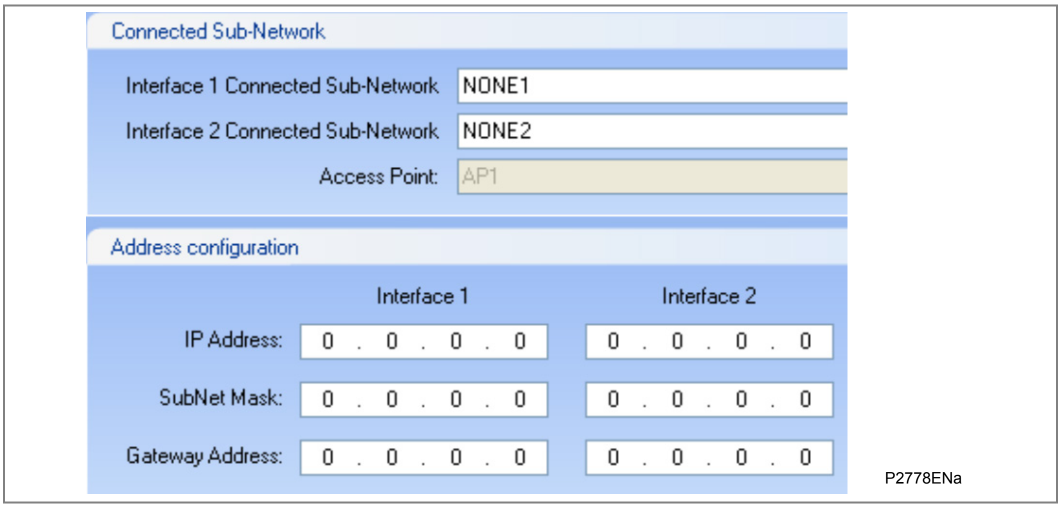


Figure 10 - Communication Parameters for two Interfaces

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 6 - 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.

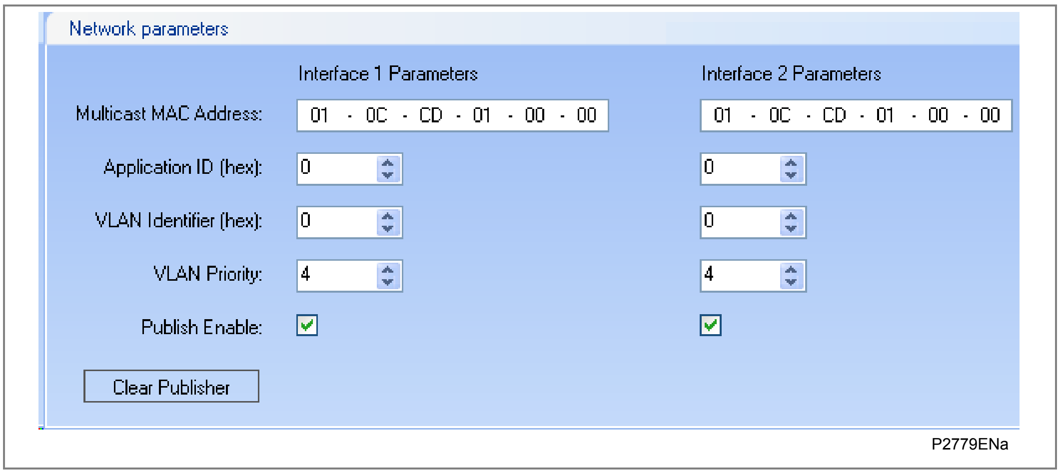


Figure 11 - Goose Publish Parameters for two Interfaces

4.4 Redundant Agency Device Configuration

The redundant agency device configuration is used by the SNMP server and only available for the device which works on PRP/HSR mode. The SNMP server can only be connected with Interface 2 (HSR/PRP port).

The following settings need to be configured in setting files:

- IP address
- Subnet Mask
- Gateway.

The MAC address is set when the device is manufactured. Also, the default IP is applied and linked to the MAC address. This default IP address can be seen in the HMI, in the Communication settings section.

The default IP address is 169.254.2.zzz.

zzz = Mod (The last byte MAC3 address, 128) + 1

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.

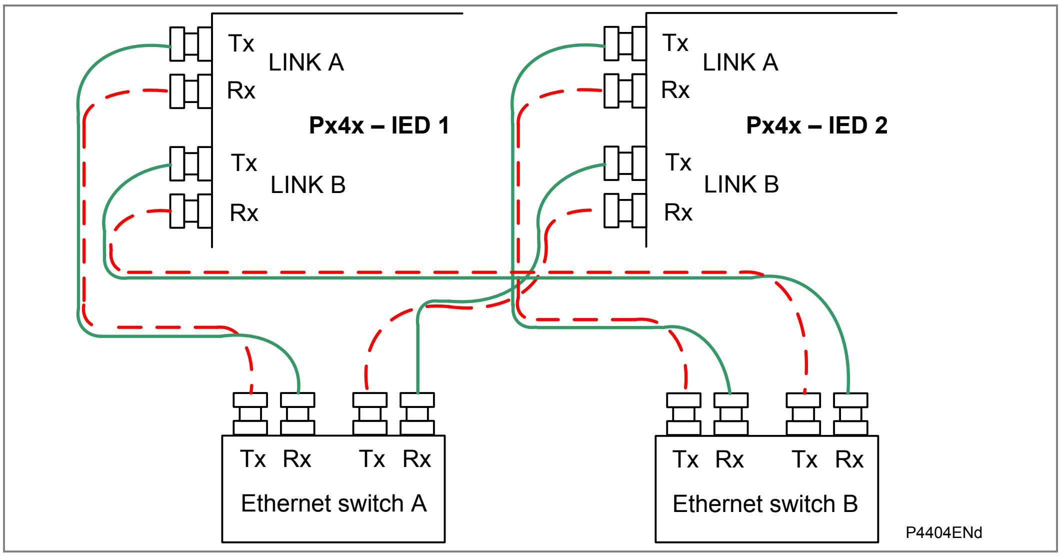


Figure 12 - PRP star connection

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.

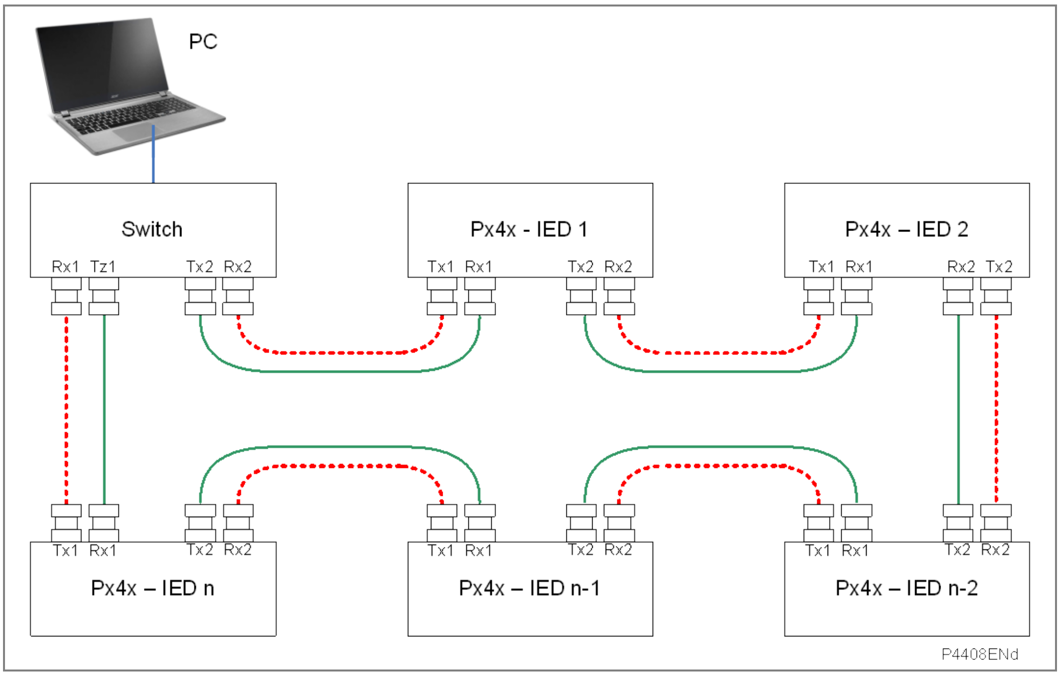


Figure 13 - HSR ring topology

The number of IEDs that can be connected in the ring can be up to 128.

6 TECHNICAL DATA

The technical data applies to a Redundant Ethernet board fitted into these MiCOM products.

- P141, P142, P143, P145
- P241, P242, P243
- P341, P342, P343, P344, P345
- P442, P443, P444, P445, P446
- P543, P544, P545, P546, P547
- P642, P643, P645
- 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 7 - 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 8 - 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 9 - 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 10 - 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):															
HV-LV (In = 1A/5A), (Vn = 100/120V) (8CT/1VT)						1									
HV-LV (In = 1A/5A), (Vn = 100/120V) (8CT/2VT)						2									
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 and Dual IP, 2 LC ports + 1 RJ45 port + Modulated/Unmodulated IRIG-B							Q								
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 3 RJ45 ports + Modulated/Unmodulated IRIG-B							R								
Ethernet (100Mbit/s), 1 RJ45 port + Modulated/Unmodulated IRIG-B							S								
Product Specific Options (these options vary depending on the model):															
Size 8 (40TE) Case, 8 Optos + 8 Relays								A							
Size 8 (40TE) Case, 8 Optos + 8 Relays + RTD								B							
Size 8 (40TE) Case, 8 Optos + 8 Relays + CLIO (mA I/O)								C							
Size 8 (40TE) Case, 12 Optos + 12 Relays								D							
Size 8 (40TE) Case, 8 Optos + 12 Relays (including 4 High Break)								E							
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 Settings	9
Design Suffix:	
Phase 3 CPU	L
Extended Phase 3 CPU	M

PRP NOTES

CHAPTER 19

Date (month/year):	12/2016			
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 P445 P44x (P442/P444) P44y (P443/P446)	L M L M L M L M M	P54x (P543/P544/P545/P546) P642 P643/P645 P741/P743 P742 P746 P841A (one circuit breaker) P841B (two circuit breakers) P849	M L M M L M M M M
Software Version:	P14x (P141/P142/P143/P145) P24x (P241/P242/P243) P341 P34x (P342/P343/P344/P345) P445 P44x (P442/P444) P44y (P443/P446)	B0/B2 D0 B1/E1 B0/B1 J4/B0/B1/E0/E1 E0/E1 H4	P54x (P543/P544/P545/P546) P64x (P642/P643/P645) P746 P74x (P741/P742/P743) P841A P841B P849	H4 B1/B2 B1/B2/B3 C1/C2/C3 B0 G4 H4 B0/B1
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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:

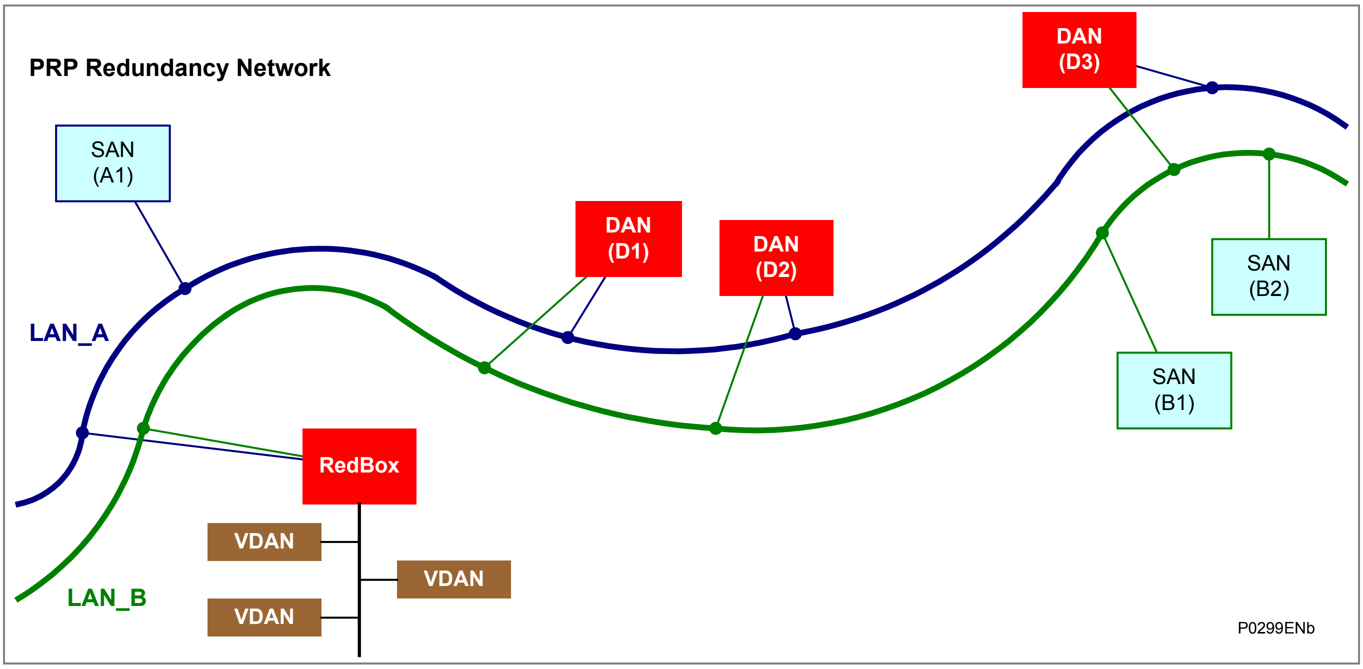

Figure 1 - PRP Redundancy Network

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.

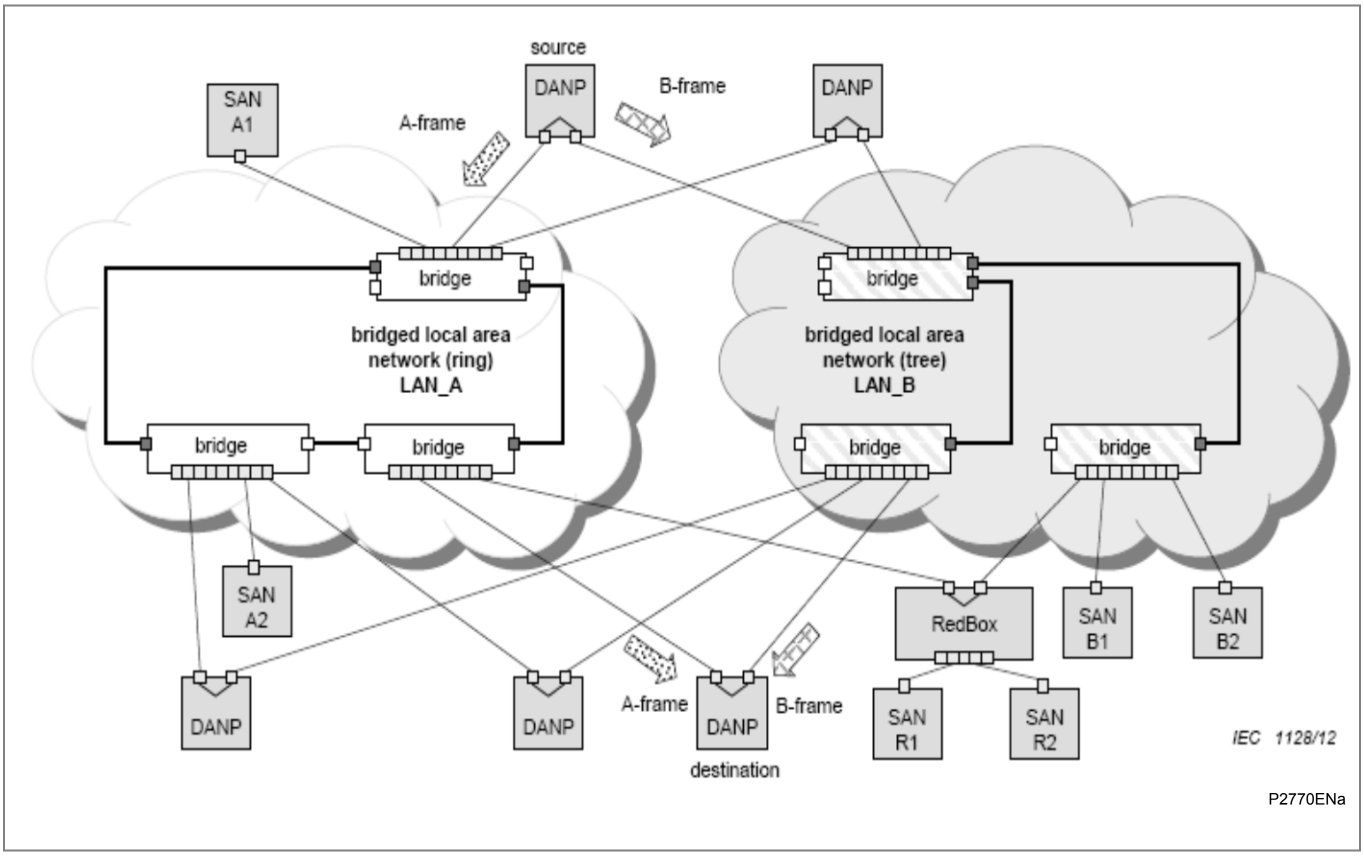

Figure 2 - PRP example of general redundant network

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:

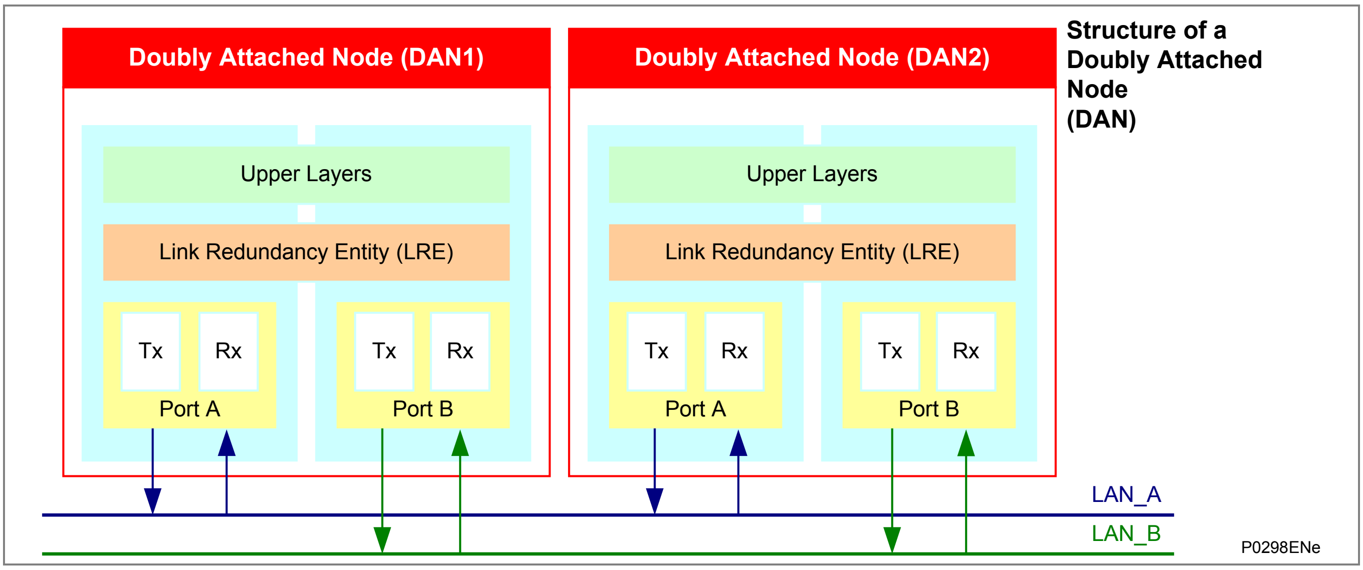

Figure 3 - Communication between two DANs (in PRP)

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.

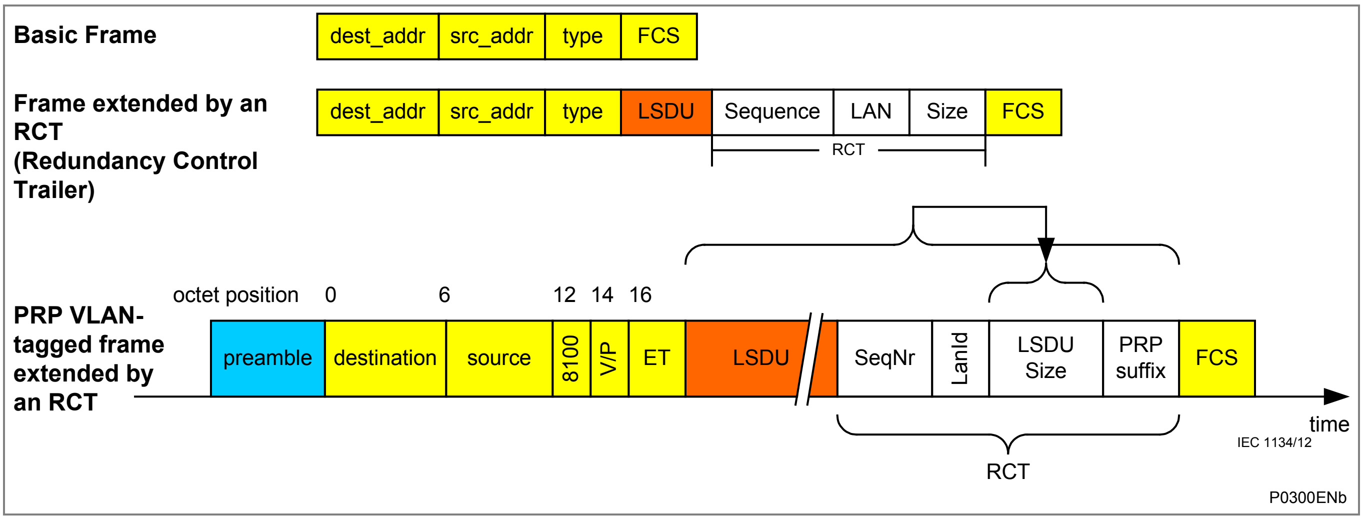

Figure 4 - Frames (basic, extended by an RCT and a VLAN tagged frame extended by RCT)

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 MiCOM S1 Studio Software and the PRP Function

The addition of this function has no impact of the MiCOM S1 Studio support files so there is no need to upgrade any MiCOM S1 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 20

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	L	P54x (P543/P544/P545/P546)	M
	P145	M	P642	L
	P241	L	P643/P645	M
	P242/P243	M	P741/P743	M
	P342	L	P742	L
	P343/P344/P345	M	P746	M
	P391	A	P74x (P741, P743)	K
	P445	L	P841A (one circuit breaker)	M
	P44x (P441/P442/P444)	K	P841B (two circuit breakers)	M
	P44x (P442/P444)	M	P849	M
	P44y (P443/P446)	M		
Software Version:	P14x (P141/P142/P143/P145)	B0/B2	P54x (P543/P544/P545/P546)	H4
	P24x (P241/P242/P243)	D0	P64x (P642/P643/P645)	B2
	P34x (P342/P343/P344/P345/P391)	B0	P746	B3/C3
	P445	J4	P74x (P741/P742/P743)	B0
	P44x (P442/P444)	E0/E1	P841A	G4
	P44y (P443/P446)	H4	P841B	H4
			P849	B0/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)		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)	
	P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01)		P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02)	
	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)		P64x (P642, P643 & P645): 10P642xx (xx = 1 to 10) 10P643xx (xx = 1 to 6) 10P645xx (xx = 1 to 9)	
	P445: 10P445xx (xx = 01 to 04)		P74x (P741, P742 & P743): 10P740xx (xx = 01 to 07)	
	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)		P746: 10P746xx (xx = 00 to 21)	
	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)		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)	

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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:

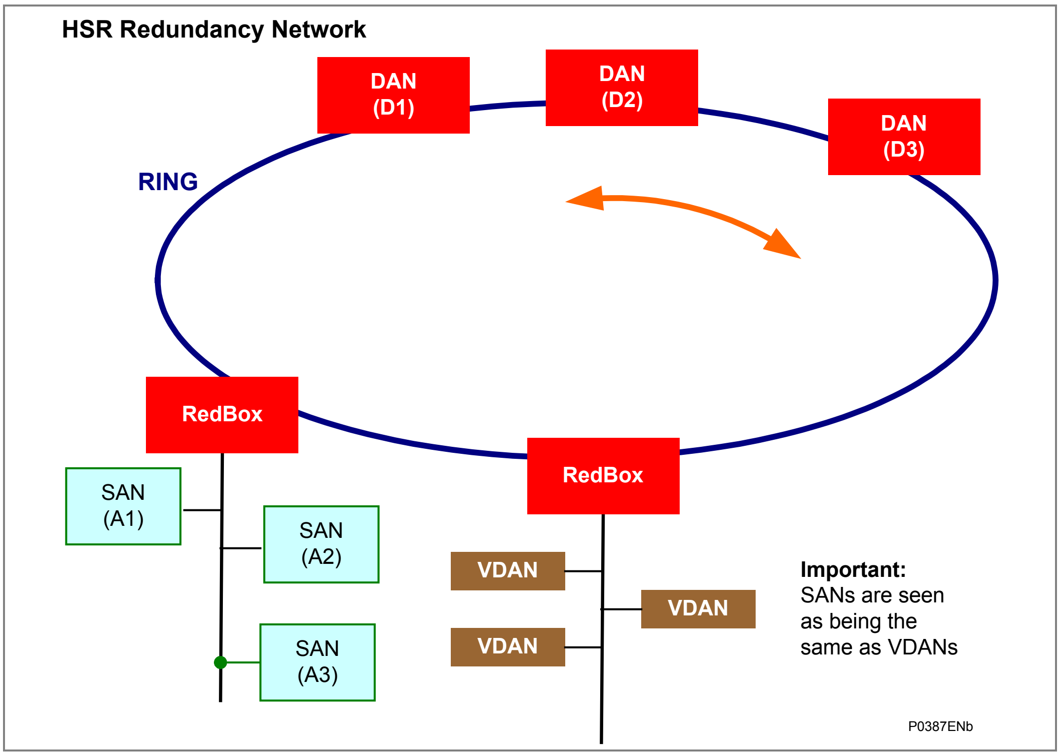


Figure 1 - HSR Redundancy Network

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 (see Note *), removes the HSR tag of the first frame before passing it to its upper layers and discards any duplicate.

*Note **	*In particular, the node will not forward a frame that it injected into the ring.*
*Note **	*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.

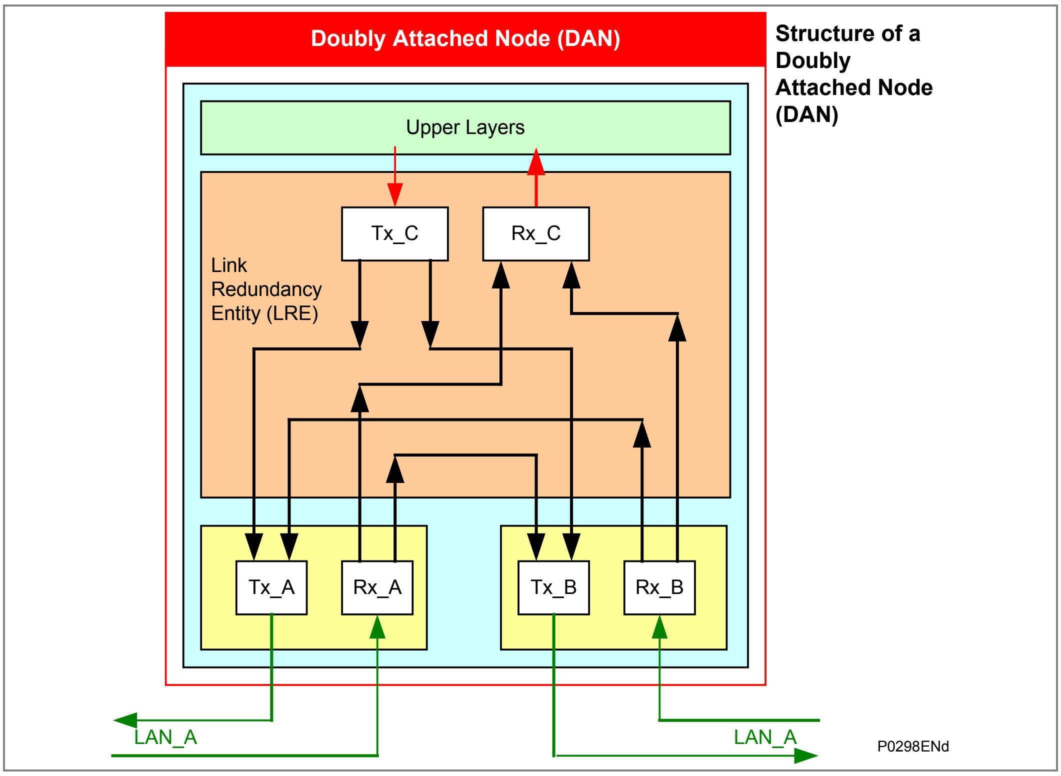


Figure 2 - DAN communication between two paths (in HSR)

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.

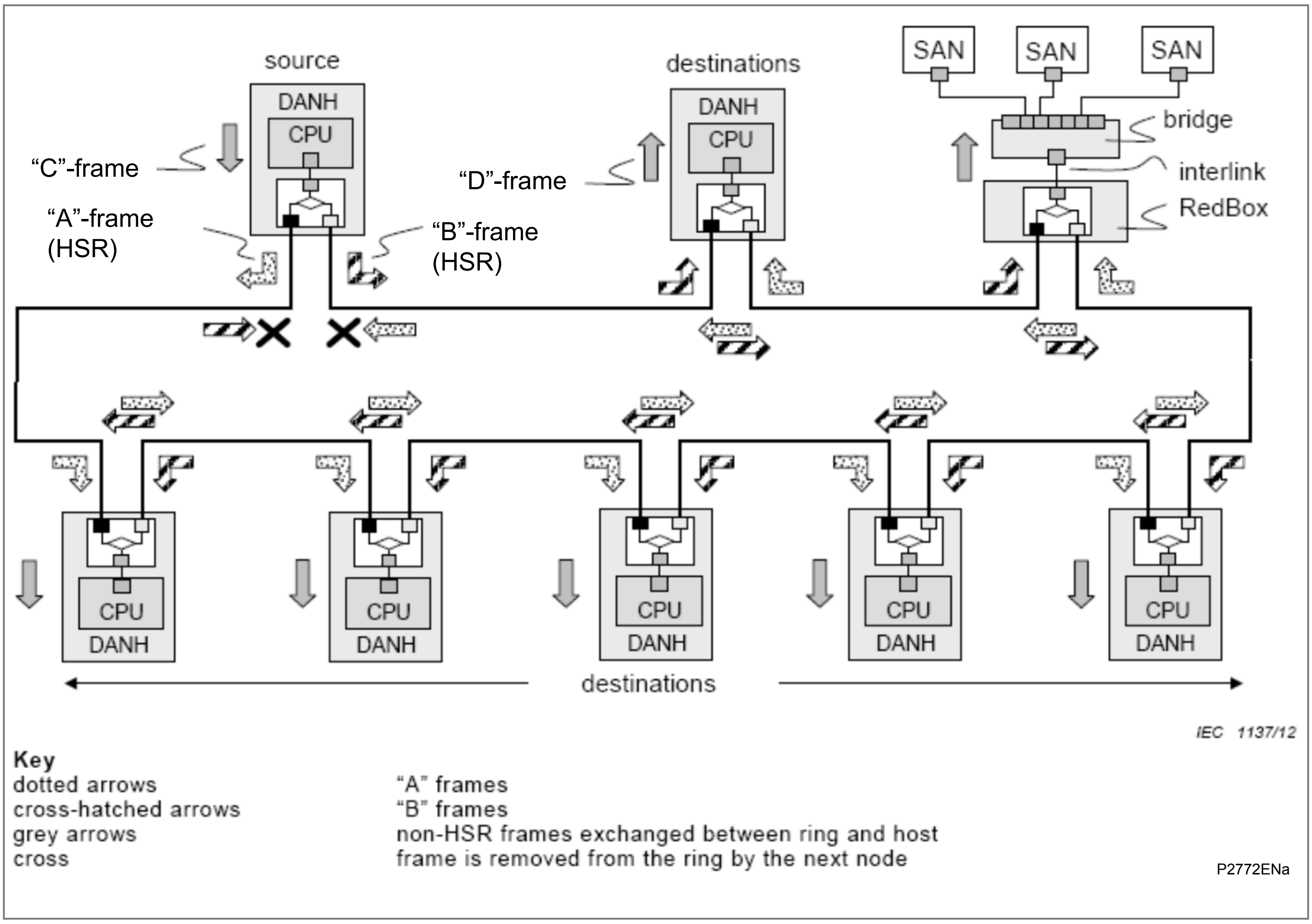


Figure 3 - HSR example of ring configuration for multicast traffic

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 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 4 and Figure 5 shows the frame types with different types of data.

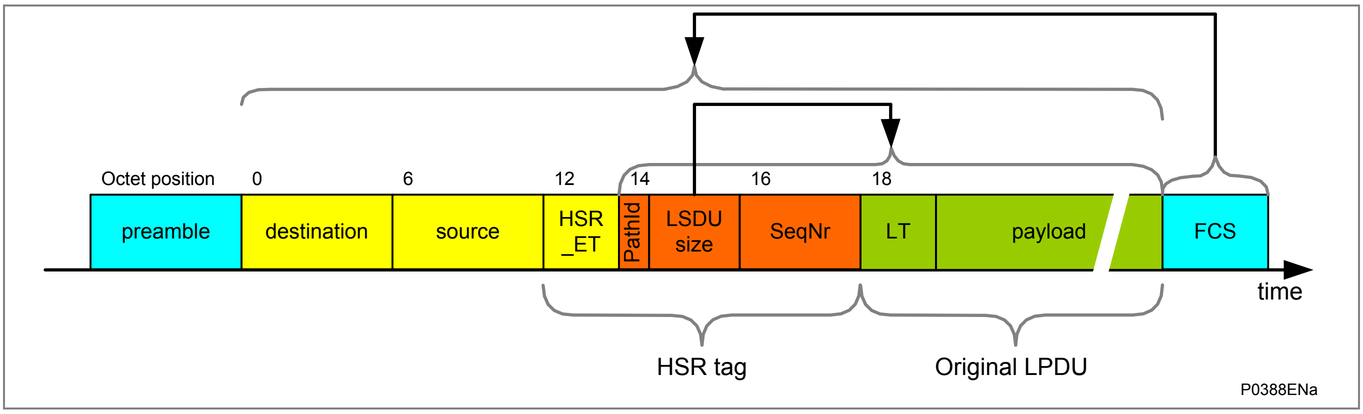


Figure 4 - HSR frame without a VLAN tag

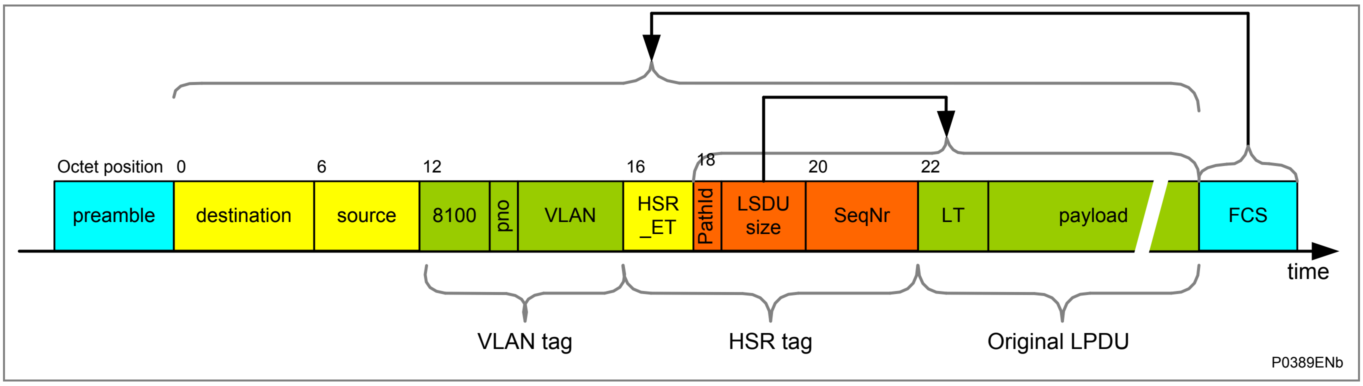


Figure 5 - HSR frame with VLAN tag

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 MiCOM S1 Studio Software and the HSR Function

The addition of this function has no impact of the MiCOM S1 Studio support files so there is no need to upgrade any MiCOM S1 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 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 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 support SNMP.
- 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 (effectively seen as a DAN)

Notes:

VERSION HISTORY

CHAPTER 21

Date:	01/2017
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:	M
Software version:	E1
Connection diagrams:	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)

CONTENTS

TABLES

Notes:

1 VERSION HISTORY

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).**

Software Version	Hardware Version	Model No	Date of Issue	Full Description of changes	S1 Compat-ibility
Branch A2.x: First Model – P441/P442 (P444 not available) – Modbus/Kbus/IEC103 – 4 languages – Optos 48Vcc (Hardware=A) Documentation: TG 1.1671-C & OG 1.1671-B					
A2.6	A	03	10/2000	VDEW-ModBus-Kbus cells/CBaux/IRIGB/WeakInfeed/Reset IDMT/SyncCheck/AR Led	V1.09
A2.6	A	04	10/2000	VDEW-ModBus-Kbus cells/CBaux/IRIGB/ WeakInfeed/Reset IDMT/ SyncCheck/AR Led New S1 version	V2.0
A2.7	A	03	04/2001	Freq out of range (major correction)- 1/3 pole AR logic - VTS	V1.10
A2.7	A	04	04/2001	Frequency out of range (major correction)- 1/3 pole AR logic New S1 version	V2.0
A2.8	A	04	07/2001	Communication improvement / Floc with 5Amp / IrigB	V2.0
A2.9	A	04	01/ 2002	3P fault in Power Swing/SOTF logic/CB Fail/Ext. Trip + 5 ms/Z1-Z2 measure for small characteristic /SOTF-TOR / U-I prim sec	V2.0
A2.10	A	04	05/2002	EEPROM correction/RCA angle/DEF correction/New general distance Trip equation (Block scheme) / Fault Locator	V2.0
A2.11	A	04	09/2003	Last A2.x branch version: Retrip CB/Ffailure/31th December for DRec/Disturbance compressed function and communication correction/Voltage memory/DEF/Ext Csync/P.Phase ref Csync/Sync live-live/2UN Vref Sync/Z1 & Arg<55°	V2.0
Note 1 For A2.x software: Software version / hardware version / model number can be found by setting in “system data” with MiCOM S1 or LCD front panel.					
Note 2 For A2.x software: Version A2.x not distributed (mandatory upgrade)					
Branch A3.x : P444 model with 24 optos/32 outputs (Omron) – Universal optos – Italian Language – DNP3					
A3.0	A or B for P441/P442 A for P444	05	05/2001	P444/DNP3/NCIT/universal input/5 languages. Italian model 4050A for P444. P441/P442 models 050A (48Vcc) or 050B (Universal optos). DDB with 1022 cells/Discrimination timer in AR/New DDB distance cells/DEFlogic/SOTF timer/Broken Conductor/Com.	V2.02 + patch
A3.1	A or B for P441/P442 A for P444	06	12/2001	SOTF-TOR/Z4 block Pswing/CB Fail/IEC103 disturbance/U-I Prim-sec / kms-Miles / 3P fault in Power Swing/Z1-Z2 measurement for a small characteristic / Ext Trip+5msec/New settings	V2.02 + patch
A3.2	A or B for P441/P442 A for P444	06	05/2002	EEPROM correction/New general distance Trip equation (Block scheme)/RCA angle/IEC 103 correction/Fault Loc/DEF P selec	V2.02 + patch
A3.3	A or B for P441/P442 A for P444	06	09/2003	Retrip CB/Ffailure/31st December for Drec/Disturbance (compressed or not compressed) and communication correction / Voltage memory / DEF/ Ext Chksync/P.Phase ref Chksync / Sync live-live / I broken Cond./ Px4X with Px3x in IEC103/2UN Vref Sync/Z1 & Ang<55°	V2.02 + patch
A3.4	A or B for P441/P442 A for P444	06	10/2003	Last A3.x branch version: Time sync cell in ModBus/ Optos tagging in event/ CB close DNP3/ Status opto with setting group/ Im displayed in Measurement mode/ IEC 103	V2.02 + patch
Note 1 For A3.x software: The software version / hardware version / model number can be found through the setting in “system data” viaMiCOM S1 or LCD front panel.					
Note 2 For A3.x software: Version A3.0, A3.1 and A3.3 not distributed (mandatory upgrade). Version A3.3: Recommended upgrade.					
Branch A4.x : Second Rear Port - more alarms - new application feature					

Software Version	Hardware Version	Model No	Date of Issue	Full Description of changes	S1 Compat-ibility
A4.0	A or B for P441/P442 A for P444	07	09/2002	Second rear port/Slip frequency/Retrip CB/VTS phase selec/PPGround phase selection/Extraction PSL/Serial Cmp Line/New DDB cells/Overlap Z/ Rev with X4 limit/Winfeed/Floc in IEC /Dead time2/I Bk conduct.	V2.05 + patch
A4.1		07	12/ 2002	Bi phase ground & phase selection/Synchro VT bus side	V2.07
A4.3		07	04/ 2003	Voltage memory improvement/compliant IEC103 with Px3x /DEF/Pswing & glitchZ	V2.07
A4.4		07	08/2003	Synchro check function improvement/Tripping time stability for Z2 fault/Problem of battery alarm when IEC103 communication resolved	V2.07
A4.5		07	09/2003	Disturbance (compressed or not compressed) and communication correction / DEF/ Ext Csync/P.Phase ref Csync / Sync live-live / I broken Cond./ Px4X with Px3x in IEC103/Battery Alarm IEC 103/31th December for Drec/2UN Vref Sync/Z1 & Arg<55°/Zn-Zn+1 with +30msec	V2.07
A4.8		07	09/2004	Timesync cell in ModBus/Synchro TP bus/Optos taging in event/Dynamic management Bus-Line for checksync /ModBus correction /DNP3/Frequency tracking/Directionnal with Deltas&Classical are computed in parallel (No delay between the algorithms)	V2.07
A4.9		07	05/2005	DNP3 with S1/ ModBus/ CB close DNP3/ Floc with evolving fault/ Status opto with setting group/ Im displayed in Measurement mode/ VTS alarm using V2	V2.07
A4.10H-S		07	2011	Last A4.x branch version: New Schneider-Electric brand	V2.7
Note 1 For A4.x Software. The software version / hardware version / model number can be found through the setting in "system data" via MiCOM S1 or LCD front panel.					
Note 2 For A4.x Software.Version A4.0, A4.1, A4.3, A4.4 and A4.5 not distributed (mandatory upgrade). Version A4.8 and A4.9 (up to A4.9H): Recommended upgrade.					
Branch B1.x : New Hardware Platform (150 MHz coprocessor Board -2nd rear port-Triptime= 1,1 Cycle - 48 samples/T) & New functions (32N & 59N)					
B1.0	C	08	12/2002	New platform/model 080C/coprocessor board at 150 MHz/PW (32N)/CVTS (59N) new functions/ Px4X with Px3x in IEC103 / Retrip CB/Ffu/31st December for Drec/I Brok.cond./DEF polar.	V2.09
B1.1		09	07/2003	Synchrocheck ext correction & PPhase ref & L-Live / 32N correction / Line angle<55° / Voltage memory / Power swing & Z glitch	V2.09 + patch*
B1.2		09	09/2003	Disturbance compressed & not compressed function and communication correction/2UN Vref Sync/Zn-Zn+1 with +30msec	V2.09 + patch*
B1.3		09	07/2004	Synchro TP bus/Optos taging in event/ZSP angle/Dynamic management Bus-Line for checksync	V2.09 + patch*
B1.4		09	09/2004	New platform /Timesync cell in ModBus /DNP3	V2.09 + patch*
B1.5		09	11/2004	CB close command is applied 2 time from DNP3 Fault location-Settings group by opto-DNP3 & model N°	V2.09 + patch*
B1.6		09	04/2005	32N corrected (5Amp) - Primary measurement & Im	V2.09 + patch*
B1.7		09	06/2005	ModBus/ VTS alarm using V2	V2.09 + patch*
B1.8-S		09	06/2005	Last B1.x branch version: (B1-8-S: New Schneider-Electric brand)	V2.09 + patch*
Note 1 For B1.x software. The software version / hardware version / model number can be found through the setting in "system data" via MiCOM S1 or LCD front panel. Patch 09 is included with MiCOM S1 version V2.11					
Note 2 For B1.x software. Version B1.0, to B1.3 not distributed (mandatory upgrade). Version B1.4 to B1.7: Recommended upgrade.					
Branch C1.x : New Hardware Platform (New CPU Board 150MHz + Coprocessor Board 150MHz-2nd rear port-Triptime= 1,1Cycle - 48 samples/T) & Functions as B1.4+ New Distance Features					

Software Version	Hardware Version	Model No	Date of Issue	Full Description of changes	S1 Compat-ibility
C1.0	G for P441/P442 G - H for P444	20	04/2004	New platform/model 20G or 20H/Cpu board at 150 MHz/Fast trip board/46 output-P444 model 20H/Pswing for China Distance feature: timer from Zn to Zn-1/Tilt settable in Z1Z2Zp/Output "Phaseground detection"/PAP (Winfeed for RTE France)/Drec not compressed with 24 samples by cycle/Control input/InterMicom/Tp in DEF/DEF timer from 2 to 100msec/3^{rd}&4^{th} IN>/Internal trace by Zgraph Relay-opto event log/Z4Zp indication/	V2.09 + patch* or V2.10
C1.1		20	12/2004	Last C1.x branch version:UCA2 / InterMicom with UCA2/Timesync cell in ModBus/Synchro TP bus/Optos taging in event/Dynamic management Bus-Line for checksync	V2.09 + patch* Or V2.10
Note 1 For C1.x Software. Version C1.0 and C1.1 not distributed (mandatory upgrade).					
Branch C2.x : Idem C1.x with UCA2 (Ethernet optical support) & new function (49+NCIT)					
C2.0	G - J for P441/P442 G - J - H for P444	30	08/2004	New platform- NCIT/ Thermal Overload as P540/ Synchro TP bus/ Optos tagging in event/ ZSP angle/ Dynamic management Bus-Line for checksync/ DEF Reverse sensitivity/ Time sync input/ ZSP start/ Ethernet module NCIT 61850-9-2	V2.10 + patch* Or V2.11
C2.1		30	09/2004	Timer 0/DNP3 correction	
C2.2		30	10/2004	InterMicom/ DEF primary scale/ AREVA name in UCA2	
C2.5		30	11/2004	Phase select. PPground/ Reset IN dead/ DNP3 & CB Close/ Floc/ Opto & setting group selection/ DNP3	
C2.6		30	05/2005	Primary measurement & Im - Error during flash with optical fiber/ Floc & Broken currents new cells in DNP3-E2.0 official platform with NCIT	
C2.7		30	07/2005	UCA2 no longer supported (from that version onwards)/ Add phase voltage inversion detection in Voltage Transformer Supervision (V2 presence without I0 and I2)./ Add IEC61870-5-103 Generic Services	
C2.8		30	02/2006	P0 time delay/ NCIT sampling/Extended mode with DRec/ OpticFiber with KBus model/ Tilt angle & K0/ Reset latch DDB& LEDs	V2.12 + patch
C2.9		30	03/2006	DNP3/ PreTrigger in DRec/ Tilt angle & K0/ C264 compatibility in DNP3/ Reset VTS 3phases	
C2.10c		30	05/2006	Add Chinese HMI (First implementation, will become standard in next version)	
C2.11 to C2.16		30	052007	Zone reset&overlap/ WeakInfeed Echo+DEF/ Control Inp/ Z1ext+Tilt/ Selfcheck Output board/ DRec & 5Amp/ Start D & Phase Selection/ Timer&Thermal Protec 5Amp	V2.14
C2.17-S		30	2011	Last C2.x branch version: New Schneider-Electric brand	
Note 1 For C2.x software.Software version / hardware version / model number can be found by setting in "system data" with MiCOM S1 or LCD front panel. Note 2 For C2.x software.Version C2.0 and C2.1, 2.10c – C2.11 not distributed (mandatory upgrade). Versions C2.2 to C2.8 and C2.12 to C2.15: Recommended upgrade. Note 3 For C2.x software.Patch 20 & 30 are included with MiCOM S1 version V2.11					
Branch C3.x : Idem C2.x with new communication protocol (IEC 61850-8-1) / UCA2 not supported – Model J only (Dual optos managed by default)					
C3.7	J for P441 for P442 for P444	31	12/2006	Add IEC 61850-8-1 protocol / Zone reset&overlap/ WeakInfeed Echo+DEF/ Control Inp/ 2nd Sync +NCIT/ 21-67N activated separately/ 67N&Blocking Scheme/ Floc&measurement with high harmonic/ Hysteresis at 2% for V> &V<	V2.12 + Patch
C3.8		31	02/2007	Z1ext+Tilt/ Selfcheck Output board/ NCIT acquisition	V2.14 + Patch
C3.9		31	06/2007	Start Δ & Phase Selection/ Timer&Thermal Protec 5Amp/ KEMA & Floc for 61850-8-1	
C3.10		31	02/2008	State change & Time stamping	

Software Version	Hardware Version	Model No	Date of Issue	Full Description of changes	S1 Compat-ibility
C3.11 to C3.16		31	03/2008	Last C3.x branch version: Phase select & PPGnd fault /DEF & Negative polarisation/ 61850-8-1	
Note 1 For C3.x software. Version C3.7 not distributed (mandatory upgrade). Versions C3.8 to C3.10: Recommended upgrade.					
Branch C4.x : Idem C3.x with new features (cells and DDB)					
C4.0	J for P441 for P442 for P444	35	04/2007	Start Δ & Phase Selection/ Add new DDB (Dist. Block/V>-V<)	V2.14 + Patch
C4.1		35	10/2007	Last C4.x branch version: Timer&Thermal Protec 5Amp/ KEMA & Floc for 61850-8-1	V2.14 + Patch
Note 1 For C4.x software. Version C4.0 not distributed (mandatory upgrade).					
C5.0	J for P441 for P442 for P444	36	05/2007	Phase selec & PPGnd fault/ DEF & Negative polarisation/ Conventional algo & 1PGnd fault/ Fault report/ Cont Input label/ RGuard/ IN> 2nd stage/ IDMT TMS steps/ New DDB: Internal trip+trip LED/ DRec default settings/ SOTF-TOR/ I>4&StubB/ VMemory settable/ CT polarity/ I2>/ VR>/ DNP3/ New Zone Q/ PSwing RLim/ Channel aided scheme/ I0 setting/ PSL graphic improved	V2.14 + Patch
C5.5		36	04/2008	State&time stamp/ IEC 61850-8-1/ DNP3 over Ethernet/ Courier&Group/ I2&Dist start/ WeakInfeed TAC received extented	V2.14 + Patch V3.4 (S1 Studio)
C5.6-S		36	2011	Last C5.x branch version: New Schneider-Electric brand	
Note 1 For C5.x software. Version C5.0 – C5.1 not distributed (mandatory upgrade). Versions C5.2 to C5.4: Recommended upgrade.					
Branch C7.x : Idem C5.x with Cyber security and “PSL Timers” features					
C7.A	J for P441 for P442 for P444		05/2011	The following features are added: - Cyber security features - New “PSL timers” setting allowing remote time setting of timers in the PSL using HMI. - “IN> Blocking” menu, - New technical manual	V3.4 (S1 Studio)
Branch D1.x : Idem C5.6S with new HW suffix K: extended buttons, high break contacts, tri colors LEDs…					
D1.0	K for P442 for P444	40	02/2007	HW suffix K/ Start D & Phase Selection/ New DDB cells V> &V<&independent distance scheme	V2.14 + Patch
D1.1 to D1.3		40	04/2008	Timer&Thermal Protec 5Amp/ KEMA & Floc for 61850-8-1	V2.14 + Patch
Branch D2.x : Idem D1.x with new features (cells and DDB)					

Software Version	Hardware Version	Model No	Date of Issue	Full Description of changes	S1 Compat-ibility
D2.0 to D2.6	K for P442 for P444	40 45	11/2008	The following features are added: - reverse guard detection - Second stage of IN> earth overcurrent with DT or IDMT, - IDMT step size for TMS from 0.025 to 0.005 - Extension from 4 In to 10 In the maximum setting range for the 2 first stages - Labels for disturbance records modified, - “SOFT I>3 Enabled” TOR/SOTF mode creation, - “Trip LED” menu added in DDB - voltage memory validity settable from 0s to 10s (step 0.01s) - CT connection can be modified by software - Negative sequence overcurrent protection enhanced, - Residual overvoltage enhanced - DNP3 serial added - Zone Q added - resistance limits for power swing = R1, R2, RP, RQ, R3/R4) - Channel aided trip modification - Channel-aided distance schemes: trip after receipt of signal from remote end protection and Tp instead of T1. - New settings for I0 threshold - InterMiCom Interrupt integration	V2.14 + Patch S1 Studio
Branch D3.x : Idem D2.6 with new features (cells and DDB)					
D3.0 D3.1 D3.2	K for P442 for P444	50	06/2009	The following features are added: - New undercurrent protection features, - New Frequency protection features, - DDB with 2047 cells - Undervoltage protection: stages 3&4 (V<3, V<4) added, - Overvoltage protection: stages 3&4 (V>3, V>4) added, - new autoreclose blocking parameters	V2.14 + Patch V3.0 (S1 Studio)
D3.3-S	K for P442 for P444	50	06/2009	Last D3.x branch version: New Schneider-Electric brand	V2.14 + Patch V3.0 (S1 Studio)
Branch D1.x : Idem D3.x with modified or new features (cells and DDB)					
D4.0	K for P442 for P444	55	2011	The following features are modified: - addition of trip reset for Zero sequence power (IDMT/DT) - I0 threshold and DEF algorithm operation, - delta direction decision during delta phase selection, - forward zone decision during reverse phase operation, - zone decision when a double fault occurs, - phase selection, zone decision and global convergence after a double fault, - thermal overload deactivation, - Current measurement offset with NCIT module, - synchro check calculation (with IEC61850-9-2 module) - LED reset after 1P A/R or 3P A/R, - PAP when distance protection is disabled, - improvement of phase selection with fast decision, - bit transmission in the IEC61850 model, The following features are added: - Read Only Mode compliant with the Px4x range, - Set/Reset latch gate logic compliant with the Px4x range - DNP for SSE integration note compliant with the Px4x range - IEC61850 compliance with the Px4x range - Select-Before-Operate control function interlocking facilities in the IEC 60870-5-103 protocol, - new setting time-delay in the DEF protection, - IEC61850 and RS 485 IEC60870-5-103 comms - Control input, relays and LEDs state stored in the RAM.	V3.1 (S1 Studio)

Software Version	Hardware Version	Model No	Date of Issue	Full Description of changes	S1 Compat-ibility
D4.1		55	2011	The following features are modified: - IEC61850-8-1 phase 2.1 comms reports issues - SBO support for CS103 protocol.	
D4.2		55	2011	The following features are modified: - "Latched alarm" reset DDB for IEC61850, - DNP3 group change command	
D4.3	K for P442 for P444	55	2011	The following features are modified: - V3<, V4<, V3> or V4> fault display (front panel), - V3<, V4<,n V3> and V4> added in DNP files, - hysteresis of the first threshold of residual overvoltage = 98%, - Block A/R2 address in Modbus tab, - assignation of some Logical Nodes data source - BBRAM use - New brand	V3.1 (S1 Studio)
D4.3-S	K for P442 for P444	55	2011	Last D4.x branch version: New Schneider-Electric brand	V3.1 (S1 Studio)
Branch D5.x : Idem D4.3-S with IEC61850-9-2 communication protocol					
D5.A	K for P442 for P444	55	2011	Last D5.x branch version : The following features are modified: - Compatibility with IEC61850-9-2 Ethernet communication protocol, - modification of "Ethernet NCIT" synchronization alarms - new NCIT alarm statuses - Logical nodes arrangements modified - New technical manual	V3.4 (S1 Studio)
Branch D6.x : Idem D5.x with new functions					
D6.A	K for P442 for P444	D6	2012	Last D6.x branch version : The following features are modified: - Busbar isolation added (under "distance" element setting), - New VTS I> inhibition setting, - Addition of disturbance records full memory alarm, - new display of impedance values and margin (in %) to start/tripping characteristic- - VTS reset - DIST Start In reset - ZSP activation reset	V3.4 (S1 Studio)
D6.A	K for P442 for P444	D6	2013	- New PSU, opto-isolated input, output relay boards & Sigma input modules,	V3.4 (S1 Studio)
D6.B	K for P442 for P444	D6	2013	- Add PRP support and GOOSE performance enhancements	V3.4 (S1 Studio)
D6.D	K for P442 for P444	D6	2015	- Earth fault detect minimum value = 0.01.In - DR Full Memory Alarm reset - Huge step change of frequency filtering	V3.4 (S1 Studio)
E0	M for P442 for P444		05/2015	**Hardware:** 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). Parallel Redundancy Protocol (PRP) Dual Ethernet communications (Dual IP).	V5.0.1 (S1 Studio) or later

Software Version	Hardware Version	Model No	Date of Issue	Full Description of changes	S1 Compat-ibility
E1	M for P442 for P444		11/2015	New protocol IEC61850 Edition 1 / 2 and DNPoE and DNP3 Serial. 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. Courier Tunneling via Secured Communication. Latest Fault Record via DNPoE and IEC61850. 32 User Alarms. Virtual I/O Naming. New DDB: Logic 0 and IRIGB Valid. Restore Record Clear Functions. Bug fixes.	V7.0.0 or later versions
Note *This table includes versions released and supplied to customers only.*					

Table 1 - Hardware and Software Version History

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).**

2 RELAY AND SETTING FILE SOFTWARE VERSION

Setting File Software Version	Relay Software Version																		
	A2.x	A3.x	A4.x	B1.x	C1.x	C2.x	C3.x	C4.x	C5.x	C6.x	C7.x	D1.x	D2.x	D3.x	D4.x	D5.x	D6.x	E0	E1
A2.x	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
A3.x	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
A4.x	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
B1.x	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
C1.x	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×
C2.x	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×
C3.x	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×
C4.x	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×
C5.x	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×
C6.x	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×
C7.x	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×
D1.x	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×
D2.x	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×
D3.x	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×
D4.x	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×
D5.x	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×
D6.x	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×
E0	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×
E1	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓

Table 2 - Relay and Setting File Software Version

3 RELAY AND PSL FILE SOFTWARE VERSION

PSL File Software Version	Relay Software Version																		
	A2.x	**A3.x**	**A4.x**	**B1.x**	**C1.x**	**C2.x**	**C3.x**	**C4.x**	**C5.x**	**C6.x**	**C7.x**	**D1.x**	**D2.x**	**D3.x**	**D4.x**	**D5.x**	**D6.x**	**E0**	**E1**
A2.x	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
A3.x	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
A4.x	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
B1.x	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
C1.x	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×
C2.x	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×
C3.x	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×
C4.x	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×
C5.x	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×
C6.x	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×
C7.x	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×
D1.x	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×
D2.x	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×
D3.x	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×
D4.x	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×
D5.x	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×
D6.x	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×
E0	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×
E1	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓

Table 3 - Relay and PSL File Software Version

4 RELAY AND MENU TEXT FILE SOFTWARE VERSION

Menu Text File Software Version	Relay Software Version																		
	A2.x	A3.x	A4.x	B1.x	C1.x	C2.x	C3.x	C4.x	C5.x	C6.x	C7.x	D1.x	D2.x	D3.x	D4.x	D5.x	D6.x	E0	E1
A2.x	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
A3.x	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
A4.x	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
B1.x	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
C1.x	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×
C2.x	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×
C3.x	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×
C4.x	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×
C5.x	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×
C6.x	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×
C7.x	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×
D1.x	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×
D2.x	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×
D3.x	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	×
D4.x	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×
D5.x	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×
D6.x	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×
E0	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×
E1	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓

Table 4 - Relay and Menu Text File Software Version

SYMBOLS AND GLOSSARY

CHAPTER SG

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

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

Term	Description
Check Synch	Check Synchronizing function
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

Term	Description
DC / dc	Direct Current
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

Term	Description
ELR	Environmental Lapse Rate
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

Term	Description
I	Current
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.
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.
PICS	Protocol Implementation Conformance Statement
PIP	Policy Information Point. Software entity acting as an information source for the PDP.
PKI	Public Key infrastructure

Term	Description
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.
RTCS	Real Time Certificate Status. Facility. An IETF draft for online certificates validation.
RTD	Resistance Temperature Device
RTU	Remote Terminal Unit

Term	Description
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
SOTF	Switch on to Fault
SP	Single pole.
SPAR	Single pole auto-reclose.

Term	Description
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
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.
UDP	User Datagram Protocol
UL	Underwriters Laboratory
UPCT	User Programmable Curve Tool
UTC	Universal Time Coordinated
V	Voltage

Term	Description
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	

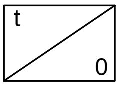
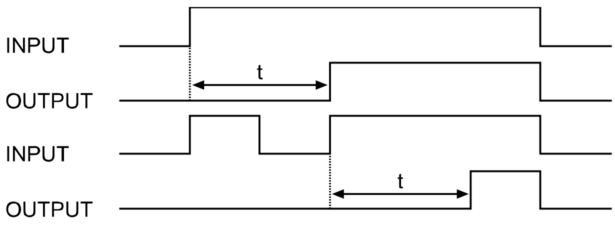
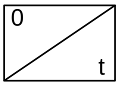
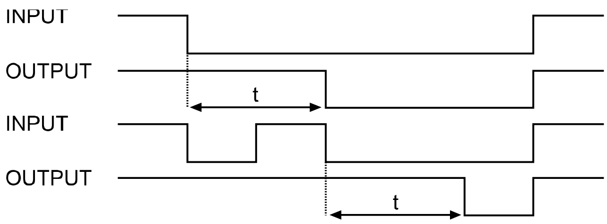
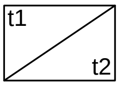
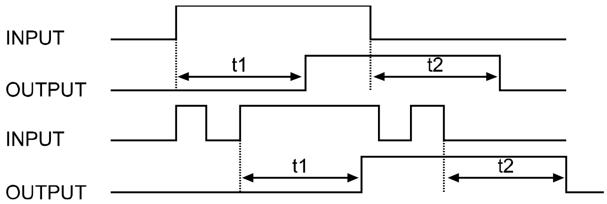
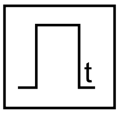
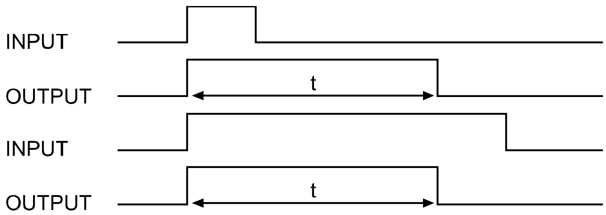
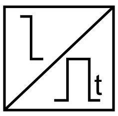
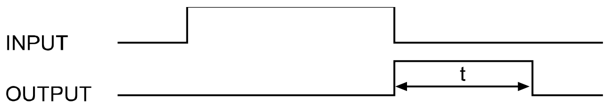
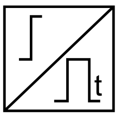
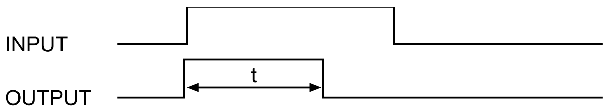
Symbol	Description	Units
K_1	Lower bias slope setting of biased differential element	%
K_2	Higher bias slope setting of biased differential element	%
KCZ	Slope of the differential phase element for the Check Zone.	
K_e	Dimensioning factor for earth fault	
km	Distance in kilometers	
K_{max}	Maximum dimensioning 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	

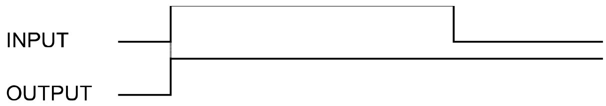
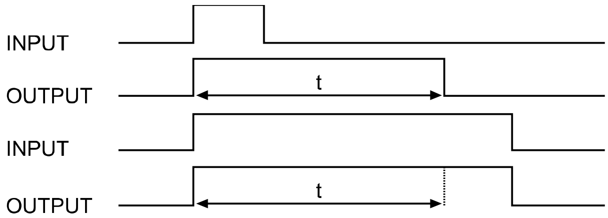
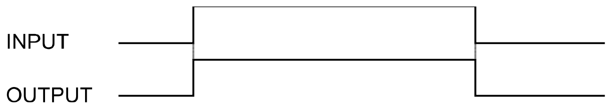
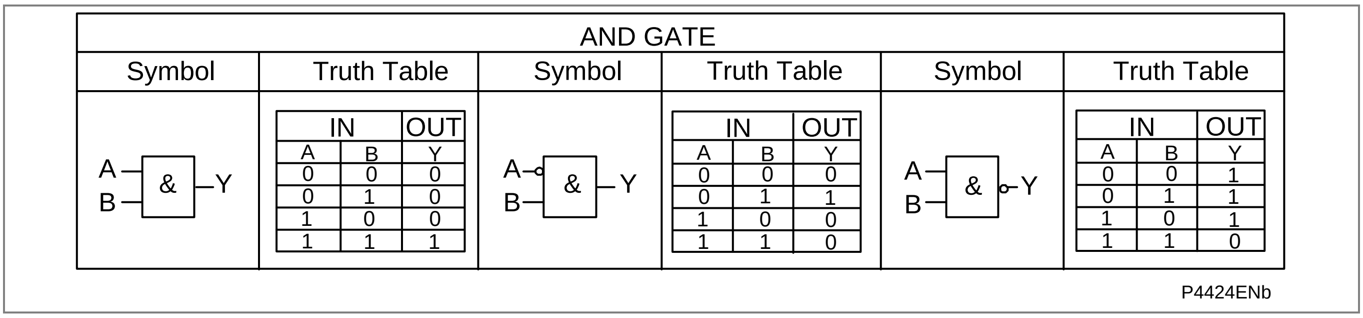
Logic symbols	Explanation	Time chart
Latching	Latch	
Dwell / Timer	Dwell timer	
Straight	Straight (non latching): Hold value until input reset signal	

Table 9 - Logic Timers

9 LOGIC GATES

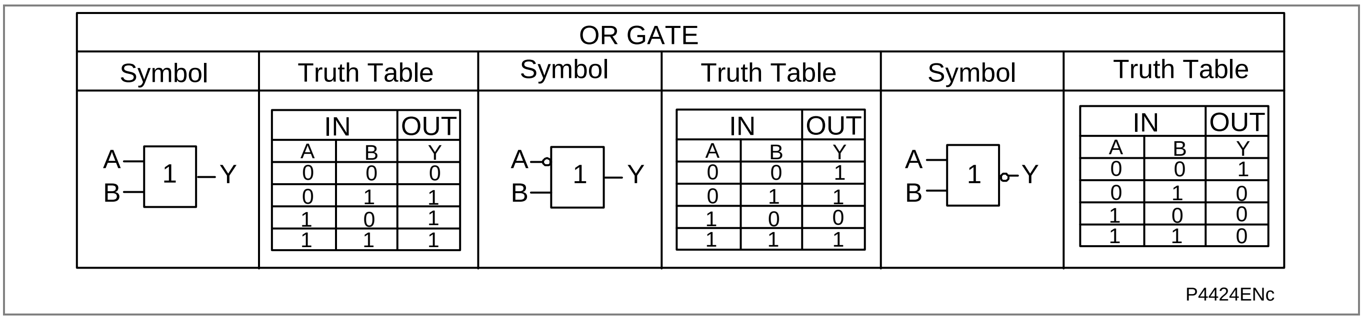


IN		OUT
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

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

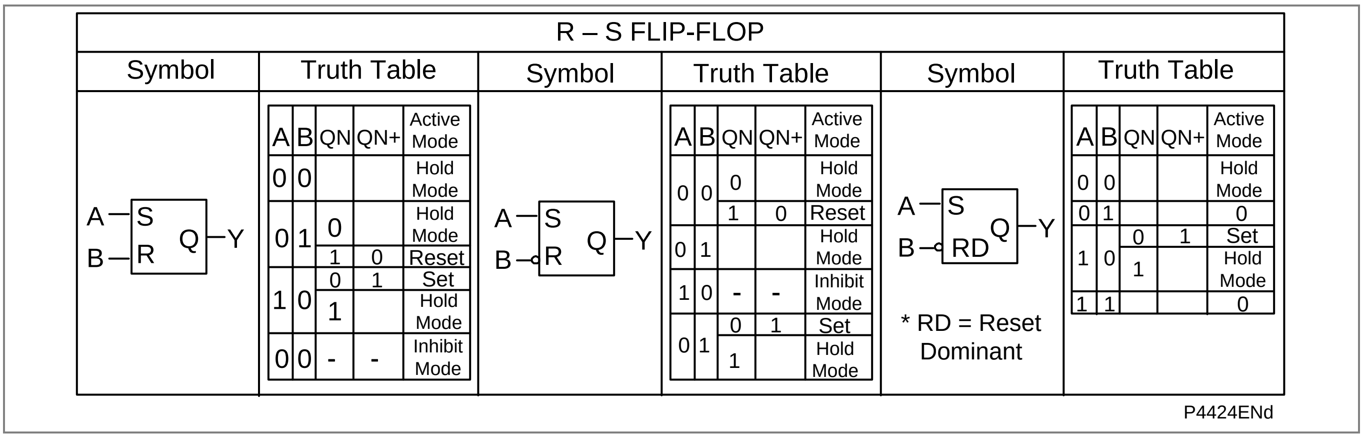


IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

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

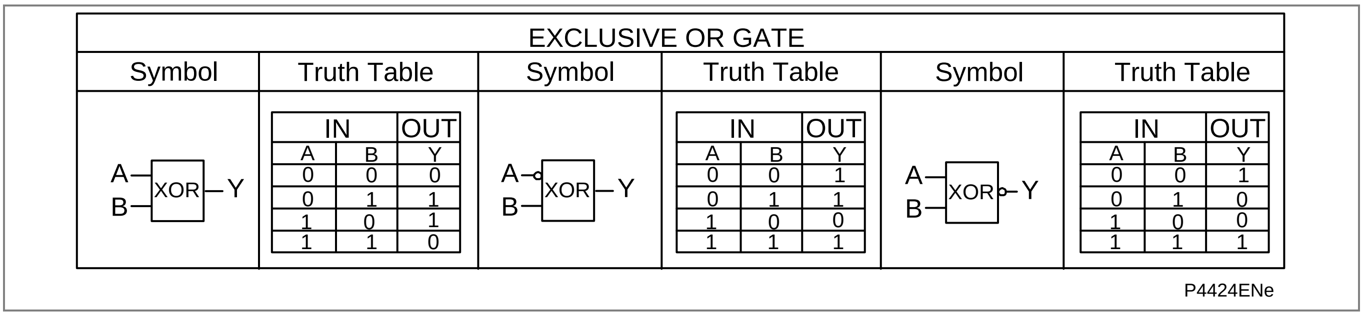


A	B	QN	QN+	Active Mode
0	0			Hold Mode
0	1	0		Hold Mode
		1	0	Reset
1	0	0	1	Set
		1		Hold Mode
0	0	-	-	Inhibit Mode

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

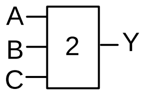
IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	0
1	1	1

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

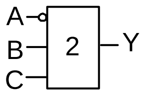
Symbol



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

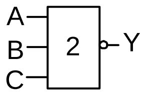
Symbol



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

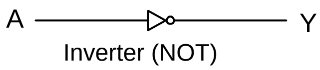
IN			OUT
A	B	C	Y
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

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:

Customer Care Centre

http://www.schneider-electric.com/ccc

Schneider Electric

35 rue Joseph Monier
92506 Rueil-Malmaison
FRANCE

Phone: +33 (0) 1 41 29 70 00
Fax: +33 (0) 1 41 29 71 00

www.schneider-electric.com

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