MiCOM P740

Numerical Busbar Protection

P742

in 40TE

P743

in 60TE

P741

in 80TE

The MiCOM P740 numerical busbar protection scheme provides complete protection for all voltages level.

Innovative techniques, including CT supervision and saturation detection and dynamic topology processing algorithms, offer a unique combination of security, speed and sensitivity.

The substation replica processing algorithms ensure that the P740 adapts to the dynamically changing topology of the busbar which is displayed on any PC with the substation real time dynamic monitoring tool.

The MiCOM P740 busbar differential protection scheme can be engineered to provide a centralised or distributed architecture. It also supports easy maintenance, operation and future expansion of the busbar.

The optional redundant Ethernet board reduces the cost of ownership since the relay is natively embedded with the switch board. This reduces the amount of stand alone switches needed, reducing the wiring, power supply and maintenance costs. Furthermore, increasing the availability rate decreases the risk of electric outages.

APPLICATION

The MiCOM P740 numerical busbar protection scheme has been designed to protect a wide range of busbar configurations. The modular scheme utilises three relay types:
- Central Unit (CU) - P741
- Peripheral Unit (PU) - P742 / P743

These units interconnect using fibre optic cables and together with the topology configurator software, allow application to all types of busbar configuration.

The Central Unit co-ordinates the scheme, receiving signals from all the peripheral units associated with the protected busbars and acting on these signals, initiates a buszone protection trip when necessary.

A single Central Unit can accommodate up to,
- 8 Zones
- 28 Peripheral Units

One Peripheral Unit is associated with each CT location, usually one per incomer/feeder and one or two for each bus coupler/bus section, depending on the number of CTs. The Peripheral Units acquire the analogue signals from the associated CT and the binary signals from the auxiliary contacts of the circuit breakers and isolators. The Peripheral Units also incorporate the main circuit breaker failure logic together with additional protection functions (Dead zone, overcurrent, etc.).

The P743 allows for increased opto inputs, function keys and ethernet board option and is particularly useful in double busbar applications. Additionally, where single pole breakers and transfer busbars are employed, the I/O requirements are large in comparison to those required for a single busbar application, where a P742 may be more suitable.

CUSTOMER BENEFITS

- Fast fault trip (typically 11-15ms and 8ms with High Speed contacts option)
- Adaptable to any busbar configuration
- IEC61850-8.1 and IEC60870-5-103 compliant
- Can operate with different types of CT.
- Programmable function keys & hotkeys
- Flexible tri-colour LEDs
- Fibre optic intercommunication:
  - Ensures high communication speed
  - Eliminates insulation problems

Schneider Electric

PROTECTION FUNCTIONS OVERVIEW

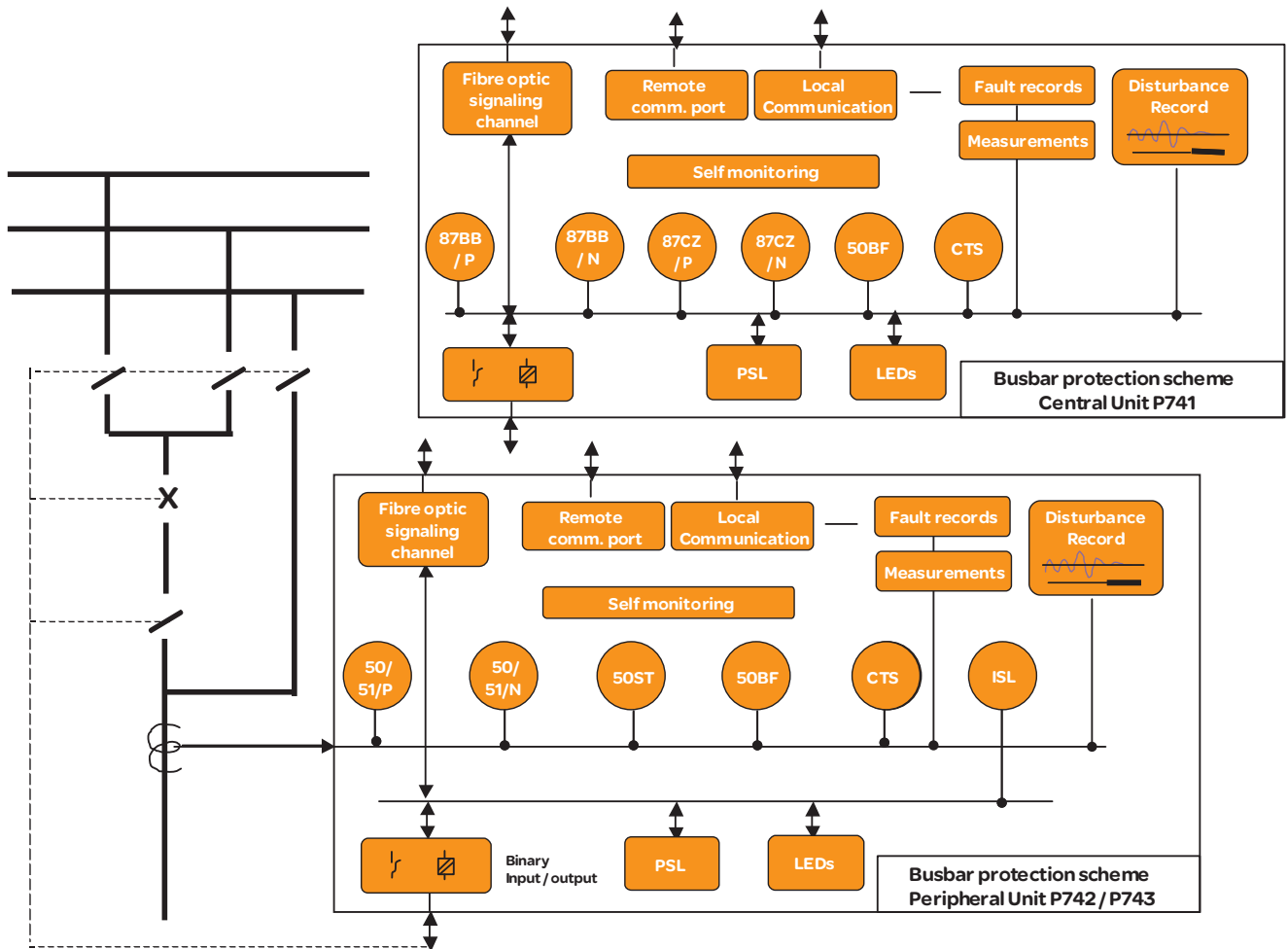| ANSI	IEC 61850	FEATURES	P741	P742	P743
87BB / P	PhsPDIF	Phase segregated biased current differential high speed busbar protection	•	-	-
87CZ / P	CzPPDIF	Check Zone segregated biased phase current differential high speed busbar protection	•	-	-
87BB / N	NeuPDIF	Sensitive earth fault bias current controlled busbar protection	•	-	-
87CZ / N	CzNPDIF	Check Zone segregated biased earth current differential high speed busbar protection	•	-	-
50/51/P	OcpPTOC	Phase overcurrent protection (2 stages)	-	•	•
50/51/N	EfmPTOC	Earth overcurrent protection (2 stages)	-	•	•
50ST / P	DzpPhsPTOC	Dead zone phase protection (short zone between CTs and open CBs)	-	•	•
50ST / N	DzpEfmPTOC	Dead zone earth protection (short zone between CTs and open CBs)	-	•	•
CTS		Current transformer supervision	•	•	•
50BF	RBRF	Breaker failure protection (LBB)	•	•	•
		ISL Isolator discrepancy alarm	-	•	•
		Fibre optic signalling channel	•	•	•
	OptGGIO	Digital inputs	8	16	24
	RlyGGIO	Output relays	8	8	16
		Virtual Digital inputs (via fibre communication)	16	16	16
		Virtual Output relays (via fibre communication)	16	16	16
		Front communication port (RS232)	•	•	•
		Rear communication port (Kbus/EIA(RS)485)	•	•	•
		Second Rear communication port (Kbus/EIA(RS)485) *	Option	-	Option
		InterMiCOM teleprotection (with second rear communication port) *	Option	-	Option
		Rear communication port (Ethernet) *	Option	-	Option
		Time synchronisation port (IRIG-B) *	Option	-	-
	FnkGGIO	Function keys	10	-	10
	LedGGIO	Programmable tri-colour LEDs	18	-	18

* Refer data sheet for model selection
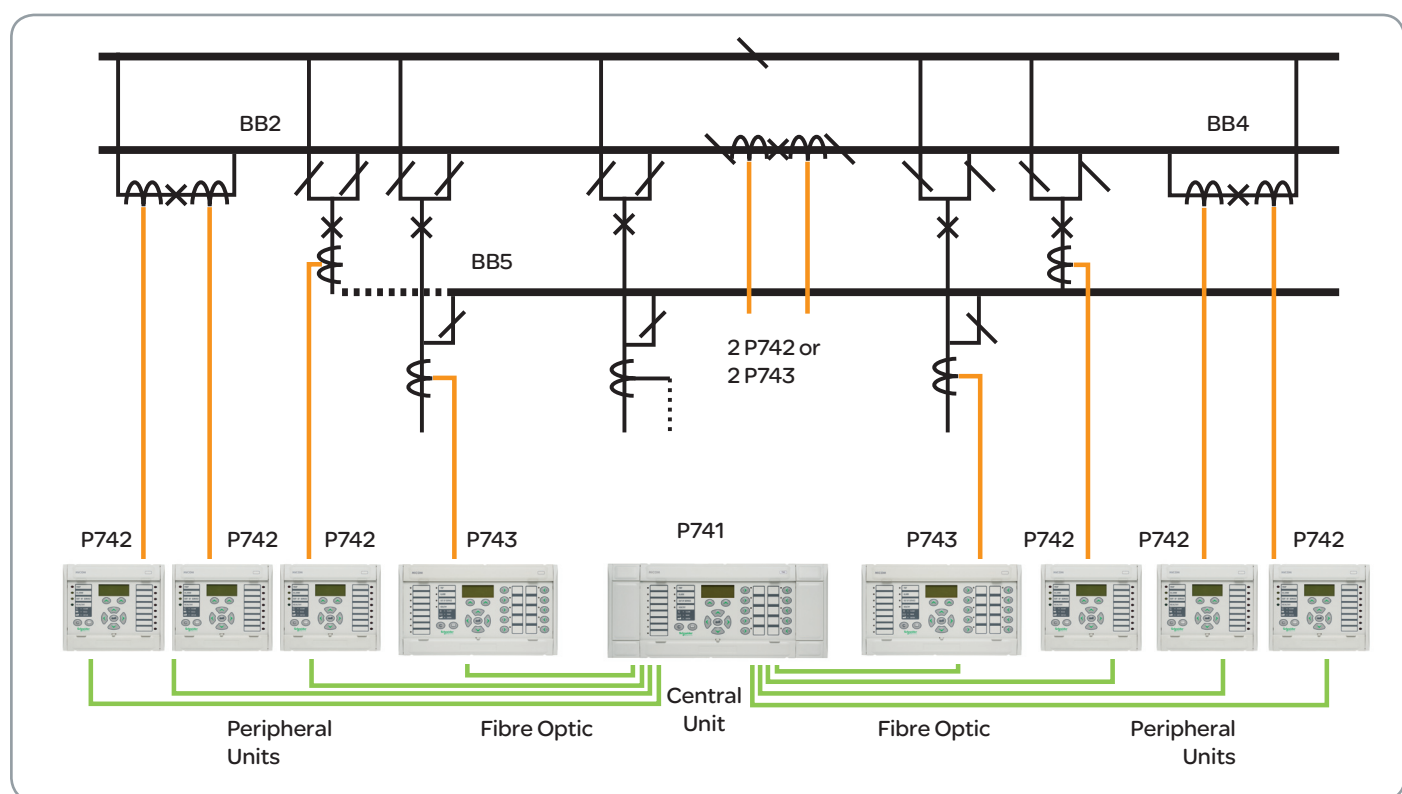
P740 scheme applied for protecting double busbar with transfer bus

Functional Overview

(Description of ANSI code nos., see Protection Function Overview)

Busbar protection scheme Central Unit P741

- Fibre optic signaling channel
- Remote comm. port
- Local Communication
- Fault records
- Measurements
- Disturbance Record
- Self monitoring
- 87BB / P
- 87BB / N
- 87CZ / P
- 87CZ / N
- 50BF
- CTS
- PSL
- LEDs

Busbar protection scheme Peripheral Unit P742 / P743

- Fibre optic signaling channel
- Remote comm. port
- Local Communication
- Fault records
- Measurements
- Disturbance Record
- Self monitoring
- 50/51/P
- 50/51/N
- 50ST
- 50BF
- CTS
- ISL
- Binary Input / output
- PSL
- LEDs

MANAGEMENT FUNCTIONS

In addition to the protection and control elements, the P740 scheme provides a wide range of measurement, monitoring, post fault analysis and self-diagnostic features:

- Circuit breaker control
- Trip circuit supervision (using PSL)
- On-line measurement
- Plant status monitoring
- 4 alternative setting groups
- Programmable scheme logic (PSL)
- Sequence of event recording (SOE)
- Comprehensive Fault record (including topology)
- Comprehensive disturbance recording (waveform capture)
- User configurable function keys & hotkeys
- User configurable tri-colour LEDs
- Local and remote communication ports
- Time synchronisation
- Fully customisable menu texts
- Multi level password protection
- Test facilities
- Power-up diagnostics and continuous self-monitoring of relay.
- User friendly setting, analysis and monitoring software

BUSBAR DIFFERENTIAL PROTECTION

The primary protection element of the P740 scheme is the phase segregated biased current differential protection. The technique is based on the numerical application of Kirchoff's Law for the selective detection and ultra high-speed isolation of a faulty section of the busbar.

The analysis is carried out in the Central Unit (CU) which communicates with the Peripheral Unit (PU) to gather current information from individual circuits and to implement the tripping of circuits as required This reliable, high speed communication is achieved via a direct optical connection utilising a 2.5 Mbps data rate.
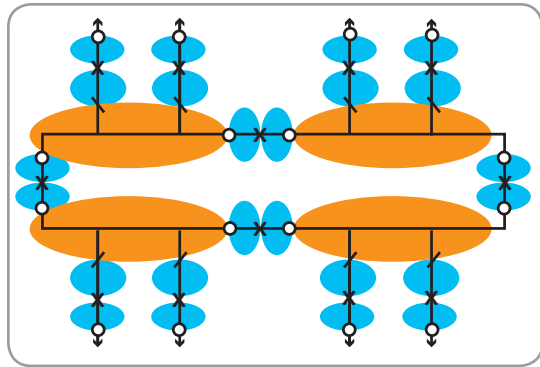
MiCOM P740:
Complete flexibility to suit any busbar configuration

To ensure adaptability of the relay to any type of busbar configuration the P740 is built with a universal topology processing algorithm. This algorithm determines the optimum tripping zone based on the current status of the plant isolators and circuit breakers.
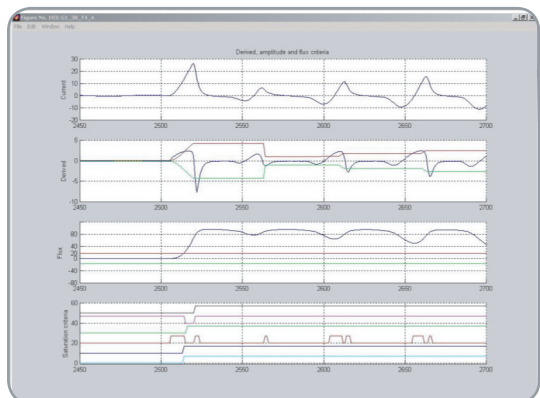
The P740 employs biased differential algorithms, in which the differential current is compared with a bias current. This characteristic ensures stability of the protection for external faults even with differing CT tolerance and errors which could lead to spurious operation.

To increase the security of the differential protection, the biased differential element is supervised by a biased global check zone element. This ensures stability even under erroneous status of the auxiliary contact of plant isolators and circuit breakers.

Bias differential characteristics

$$i_{diff\,node}(t) = i_1 + i_2 + i_3 + \dots + i_n$$

$$\text{Differential current:} \quad i_{diff\,node}(t) = i_1 + i_2 + i_3 + \dots + i_n$$

$$\text{Operating current:} \quad i_{diff}(t) = \left| i_{diff\,node}(t) \right| = \left| \Sigma_i \right|$$

$$\text{Bias current:} \quad i_{bias}(t) = \left| i_1 \right| + \left| i_2 \right| + \left| i_3 \right| + \dots + \left| i_n \right| = \Sigma \left| i_n \right|$$
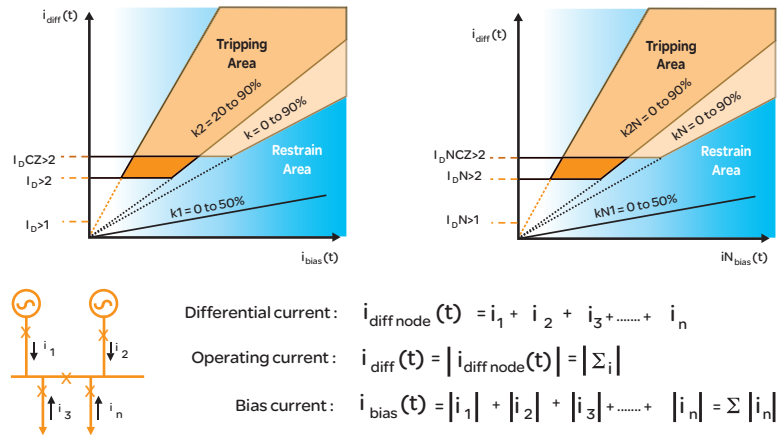
Universal on-line topology processing

The MiCOM P740 also employs CT supervision and an innovative, ultra high-speed, secure CT saturation detection algorithm. This ensures stability when CTs become saturated, particularly under external fault conditions. This algorithm combines a simulation of the flux built up in the core of the CTs with a recursive consistence variation control. This technique can detect CT saturation in less than 2ms.
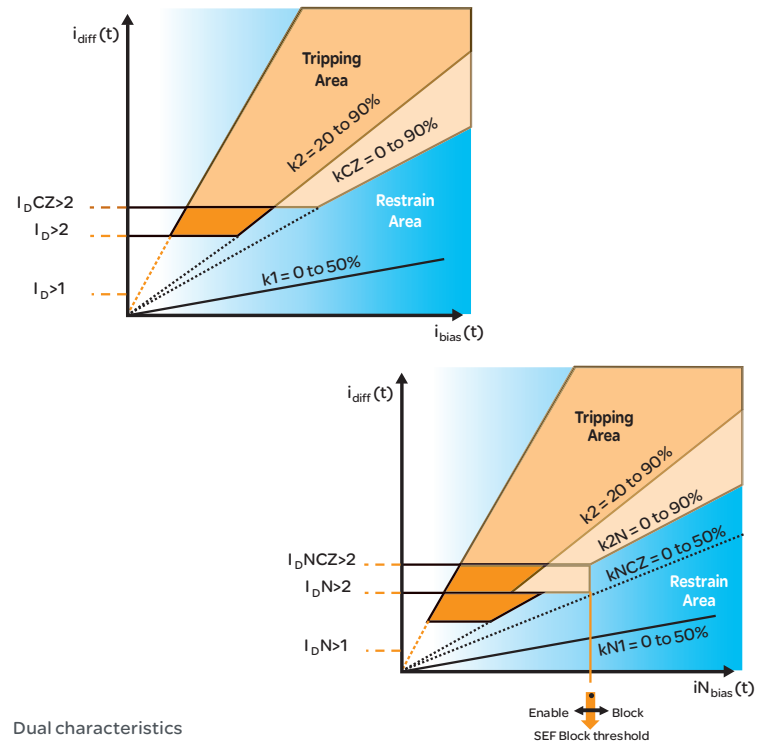
CT saturation detection

DUAL CHARACTERISTICS

To provide stability for severe through faults and at the same time detect low current internal faults, the P740 is equipped with dual characteristics. One phase segregated differential protection and another sensitive earth current differential protection.

Dual characteristics

Fast, Sensitive & Secure:
P740 the ultimate in busbar protection

MULTIPLE TRIPPING CRITERIA

The MiCOM P740 maintains the highest level of stability under all conditions including hardware failure and incoherent signals applied from external plant or generated by the power system.

Any tripping order must therefore be made conditional on the simultaneous occurrence of 7 to 9 criteria:

Magnitude Criteria: Confirmation of Two Simultaneous Thresholds per Zone

- Exceeding the bias slope characteristic (k2)
- Exceeding differential operating current threshold ($I_D>2$).

Check Zone Supervision

The zone element(s) are only permitted to trip if the order is confirmed by the check zone element:

- Exceeding the bias slope characteristic (kCZ)
- Exceeding differential operating current threshold ($I_{DCZ}>2$)

Signal Quality Criteria

- No CT saturation detected
- Current variation detected on at least two Peripheral Units (except for dead bus)

Time or Angular Criterion

The measurement elements on 2 samples taken at 1200 Hz. A first sample for the initial measurement and a second sample for trip confirmation.

Local Criteria (Optional)

The Peripheral Units can be set to only authorise tripping if there is confirmation by local overcurrent criteria or undervoltage or zero sequence overvoltage.

DEAD ZONE OR BLIND SPOT PROTECTION

The current transformers or the open breakers surrounding the busbars define the limits of the main zones. When a feeder circuit breaker is opened a dead zone or blind spot is created between the CB and the associated CT. The Peripheral Unit detects this condition automatically and provides protection for this zone also.

One stage of definite time delayed overcurrent and earth fault protection is provided in each Peripheral Unit to provide this functionality.

CONTINUOUS SUPERVISION OF CURRENT CIRCUITS

The P740 detects any abnormality in the current circuit by continuously monitoring it. Under normal operating conditions the differential current will be negligible. An anomaly is detected by a threshold, ID>1, which can be set to alarm from 10 A primary.

DIFFERENTIAL CURRENT SETTING

When switching operations are carried out in the substation, incorrect topology replicas may occur. In this case, a differential current appears. The differential elements of the MiCOM P740 are allowed to operate only if the differential current reaches a threshold ID>2 which is normally set above the highest load current.

ADDITIONAL ULTRA HIGH SPEED EXTERNAL FAULT BLOCKING

Ultra high-speed through fault detection can be carried out in each PU and can generate a control signal from the moment of the first sample (0.4 ms) to block the connected zone before CT saturation.

PHASE OVERCURRENT AND EARTH FAULT PROTECTION

Two independent stages of phase overcurrent and earth fault protection is provided in the Peripheral Units. These elements provide additional protection for the individual circuits.

The two stages can be programmed as:

- First stage can be programmed as definite time (DT) delay or one of the nine inverse time (IDMT) curves (IEC/UK and IEEE/US).
- Second stage can only be programmed as definite time.

CIRCUIT BREAKER FAILURE PROTECTION (LBB)

The P740 offers an in-built integrated solution for breaker failure protection. This requires all Peripheral Units to receive a duplication of the trip commands generated in their associated bay.

In general the Breaker Failure protection is executed on a per phase basis which involves the possibility of receiving tripping orders on a per pole basis.

The MiCOM P740 busbar protection scheme can also work in co-ordination with external breaker failure protection relays. In this configuration, the receipt of an external breaker failure command results in tripping of all the adjacent circuit breakers, via the topological recognition system knowing which breaker is connected to which zone.

Dead zone protection
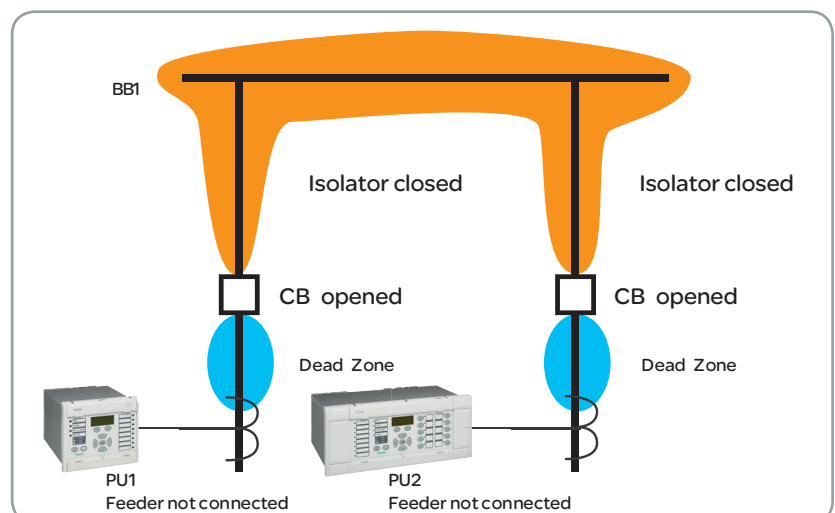
CURRENT TRANSFORMER MIXING CORRECTION

The MiCOM P740 can correct a mix between current transformer ratios over a very wide range up to 40. Its associated user interface provides a range between 1 A and 30 000 A primary.

Since the current transformer ratings in a substation may be of mixed ratios, the MiCOM P741 uses a virtual CT ratio equal to 1000/1, irrespective of the feeder section concerned.

ISOLATION AND MAINTENANCE OPERATING MODE

For ease of operation or maintenance of the busbar protection system, the Central Unit and the Peripheral Units can receive specific commands designed to allow system testing or other intervention without any danger of unwanted tripping.

In the Central Unit, a centralised command to isolate the busbars at two levels can be selectively applied per zone:

- Differential protection (87BB) blocked (measurements active and 87BB tripping deactivated). The Breaker Failure protection (50BF) remains operational.

- Differential protection (87BB) and Circuit Breaker Failure protection (50BF) blocked. The additional local protection functions (51, 51N, etc...) remain operational.

All the protections in the CU and the PUs (87BB, Dead Zone, General 50BF, Local 50BF, O/C, etc…) can be also blocked.

A selective two-level command may be applied selectively for each Peripheral Units:

- Intervention on another bay protection for maintenance and testing:
  The local Breaker Failure protection (50BF) is blocked but the busbar protection remains in service. PU in 50BF blocked mode

- Intervention on the PU for maintenance and testing: PU in Overhaul mode

PROGRAMMABLE SCHEME LOGIC

Powerful programmable scheme logic (PSL) allows the user to customize the protection and control functions. It is also used to programme the functionality of the optically isolated inputs, relay outputs and LED indications (red or tri-colour). The programmable scheme logic comprises of gate logic and general purpose timers. The gate logic includes OR, AND and majority gate functions, with the ability to invert the inputs and outputs, and provide feedback. The programmable scheme logic is configured using the graphical MiCOM S1 Studio PC based support software.
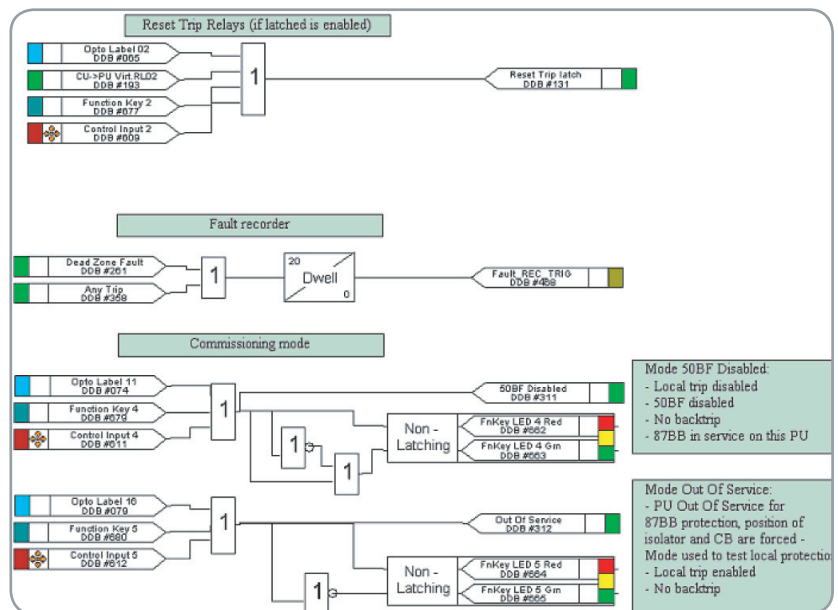

Programmable scheme logic (MiCOM S1 Studio– PSL Editor)

PLANT STATUS AND MONITORING

Checks and monitoring of the plant status can be made and an alarm raised for any discrepancy condition between the open and closed auxiliary contacts of the isolators and circuit breakers.
The Dynamic Synoptic software allows the user to monitor the position of CBs and isolators in the busbar scheme, as well as currents, alarms, etc..
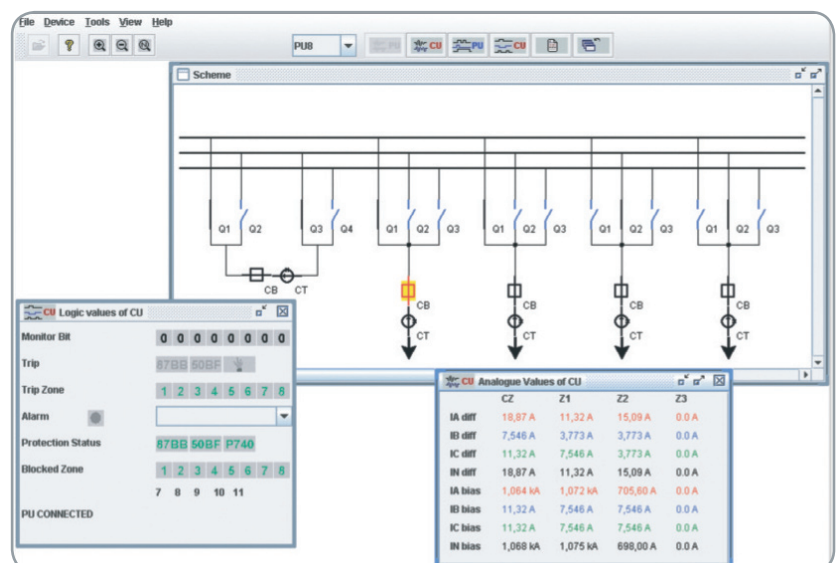
MEASUREMENT AND RECORDING FACILITIES

The P740 series relays are capable of measuring and storing the values associated with a fault. All the events, faults records and disturbance records are time tagged to 1 ms using an internal real time clock. An optional IRIG-B port is also provided for accurate time synchronization. A lithium battery provides a back up for the real time clock and all records in the event of supply failure.

MEASUREMENTS

The measurements provided, which may be viewed in primary or secondary values, can be accessed via the back lit liquid crystal display. They are also accessible via the communication ports. The following instantaneous parameters can be viewed:
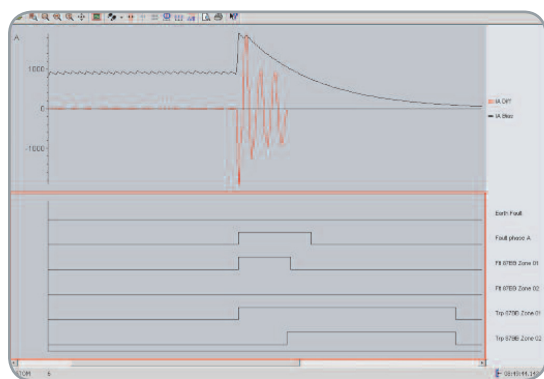
Central Unit (P741)
• Differential current Idiff / phase / zone
• Bias current Ibias / phase / zone
• Check zone Idiff / phase

Peripheral Units (P742 & P743)
• Phase currents IA IB IC
• Neutral current IN
• Sequence currents
• Frequency

EVENT RECORDER

Up to 512 time tagged event records are stored in battery backed memory, and can be extracted via the communication port or be viewed on the front panel display.

Disturbance record viewed in MiCOM S1 Studio

FAULT RECORDER

Records of the last 5 faults are stored in the battery-backed memory of both the Central and Peripheral Units.

Each fault record includes:

• Indication of the faulty zone (CU + PU)
• Protection element operated
• Active setting group
• Fault duration
• Currents and frequency (PU)
• Faulty zone differential and bias current (CU)
• Topology at the fault occurence

DISTURBANCE RECORDER

The Central and Peripheral units of the P740 have independent disturbance recording facility. The Peripheral Units can record 4 analogue and 32 digital channels, whereas the Central unit stores 8 analogue and 32 digital channels in addition to 1 time channel.

Specific Analogue Channels
• Check zone Ibias / Idiff (CU)
• IA, IB, IC, IN (PU)

Maximum Duration of One Record and Number of Records
• 1.2s per record and 8 records (CU)
• Up to 10.5s per record and minimum of 50 records 1.5s (PU)

Disturbance records can be extracted from the relay via the remote communications and saved in the COMTRADE format. These records may be examined using MiCOM S1 Studio or any other standard COMTRADE viewer.

LOCAL AND REMOTE COMMUNICATIONS

Two communication ports are available as standard; a rear port providing remote communications and a front port providing local communications. As option an Ethernet board can be added in the P741 and P743s to use the IEC61850-8.1 protocol.

The front RS232 port has been designed for use with MiCOM S1 Studio, which fully supports functions within the relay by providing the ability to programme the settings off-line, configure the programmable scheme logic, extract and view event, disturbance and fault records, view the measurement information dynamically and perform control functions (using Courier protocol).

The default remote communications is Courier / RS 485 or K-bus and can be converted to IEC60870-5-103.

An optional second rear courier communications port is available which may be configured as RS232, RS485 or K-Bus.

IEC 61850 is available when the optional Ethernet port is ordered. IEC 61850 offers high-speed data exchange, peer-to-peer communication, reporting, disturbance record extraction and time synchronization.

InterMiCOM (Optional)

InterMiCOM allows transfer of any digital status information between relays. Intertripping is supported too, with channel health monitoring and cyclic redundancy checks (CRC) on the received data for maximum message security.

InterMiCOM provides eight end-end signals, assignable to any function within a MiCOM relay's programmable logic. Default failsafe states can be set in case of channel outage.

The physical format for InterMiCOM is:

• EIA (RS) 232 for MODEM links

DIAGNOSTICS

Automatic tests performed including power-on diagnostics and continuous self-monitoring ensures a high degree of reliability. The results of the self-test functions are stored in battery backed memory. Test features available on the user interface provide examination of input quantities, states of the digital inputs and relay outputs. A local monitor port provides digital outputs, selected from a prescribed list of signals, including the status of protection elements.

DEVICE TRACK RECORD

• Over 200 **DIFB**, medium impedance biased differential busbar protection scheme delivered since its launch in 1992.
• Medium impedance biased differential busbar protection with linear current combination, **DIFB CL,** launched in 1996. Over 70 cubicles delivered.
• Since the launch of the **P740**, over 800 systems have been delivered.

HARDWARE

All models within the MiCOM P740 series relays include:

• A back-lit liquid crystal display
• LEDs (12 for the P742 and 18 tri-color for the P741 and P743)
• Function keys (P741 and P743)
• Hotkeys
• Optional IRIG-B port (CU)
• RS232 (front port) & RS485 / K-bus (rear port)
• Fibre optic connection from the CU to the PUs
• Download/monitor port
• Battery (supervised)
• N/O and C/O watchdog contacts
• Supervised +48 V field voltage
• Dual rated CT inputs 1A/5A
• Universal opto inputs with programmable voltage threshold
• Optional Ethernet rear communication board (P741 & P743)
• Optional Redundant Ethernet ports (IEC61850)
  Px4x devices can be enhanced with an optional redundant Ethernet board. The redundancy is managed by the market's fastest recovery time protocols: Self Healing Protocol and Dual Homing Protocol allowing bumpless redundancy. Furthermore, the RSTP (Rapid Spanning Tree) protocol is also available. The redundant Ethernet board supports either modulated or demodulated IRIG-B and the SNTP protocol for time synchronization. The redundant Ethernet board also has a watchdog relay contact to alarm in case of a failure.
• Depending on the relay model, up to eight High Speed-High Break contacts are available as an option. This will protect against burnt contacts due to a stuck breaker or defective breaker auxiliary contact conditions.

The optically isolated inputs are independent and may be powered from the +48V field voltage.