GE Energy Connections
Grid Solutions

MiCOM P40 Agile

P747

Technical Manual
Busbar Protection IED

Hardware version: A
Software version: 2
Publication reference: P747-TM-EN-1.1

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INTRODUCTION

CHAPTER 1

1 CHAPTER OVERVIEW

This chapter contains the following sections:

2 FOREWORD

This technical manual provides a functional and technical description of Alstom Grid's MiCOM P747, as well as a comprehensive set of instructions for using the device.

We have attempted to make this manual as accurate, comprehensive and user-friendly as possible. However we cannot guarantee that it is free from errors. Nor can we state that it cannot be improved. We would therefore be very pleased to hear from you if you discover any errors, or have any suggestions for improvement. All feedback should be sent to our contact centre via the following URL:

http://www.alstom.com/grid/contactcentre/

2.1 TARGET AUDIENCE

This manual is aimed towards all professionals charged with installing, commissioning, maintaining, troubleshooting, or operating any of the products within the specified product range. This includes installation and commissioning personnel as well as engineers who will be responsible for operating the product.

The level at which this manual is written assumes that installation and commissioning engineers have knowledge of handling electronic equipment. Also, system and protection engineers have a thorough knowledge of protection systems and associated equipment.

2.2 TYPOGRAPHICAL CONVENTIONS

The following typographical conventions are used throughout this manual.

- The names for special keys and function keys appear in capital letters.
  For example: ENTER
- When describing software applications, menu items, buttons, labels etc as they appear on the screen are written in bold type.
  For example: Select **Save** from the file menu.
- Filenames and paths use the courier font
  For example: `Example\File.text`
- Special terminology is written with leading capitals
  For example: Sensitive Earth Fault
- If reference is made to the IED's internal settings and signals database, the menu group heading (column) text is written in upper case italics
  For example: The *SYSTEM DATA* column
- If reference is made to the IED's internal settings and signals database, the setting cells and DDB signals are written in bold italics
  For example: The ***Language*** cell in the *SYSTEM DATA* column
- If reference is made to the IED's internal settings and signals database, the value of a cell's content is written in the Courier font
  For example: The ***Language*** cell in the *SYSTEM DATA* column contains the value `English`

2.3 NOMENCLATURE

Due to the technical nature of this manual, many special terms, abbreviations and acronyms are used throughout the manual. Some of these terms are well-known industry-specific terms while others may be special product-specific terms used by Alstom Grid. A glossary at the back of this manual provides a complete description of all special terms used throughout the manual.

We would like to highlight the following changes of nomenclature however:

- The word 'relay' is no longer used for the device itself. Instead, the device is referred to as an 'IED' (Intelligent Electronic Device), the 'device', the 'product', or the 'unit'. The word 'relay' is used purely to describe the electromechanical components within the device, i.e. the output relays.
- British English is used throughout this manual.
- The British term 'Earth' is used in favour of the American term 'Ground'.

2.4 PRODUCT SCOPE

This product protects busbars with up to 4 zones plus a check zone. It can be applied at any voltage level.

One device is used to protect each phase (3-box solution). A further device can be used to protect the neutral line (4-box solution). The device is suitable for applications on solidly grounded systems, or where a centralised scheme is needed.

Each device can manage a maximum of:

- 4 Voltage transformers (VTs) (1 VT per zone),
- 18 Current transformers (CTs)
- 18 Circuit breakers (CBs)
- 72 isolators
- Up to 40 Digital Inputs and 128 Virtual Inputs (128 digital inputs via communications) for each protected phase
- Up to 32 Digital Outputs and 128 Virtual Outputs (128 digital outputs via communications) for each protected phase

The P747 consists of the following main components.

Main protection

This uses low impedance biased current differential protection. The typical operating time is less than one cycle. If a fault occurs and more than one zone needs to be tripped, you might need to trip zones sequentially. You can do this by setting different time delays on each of the zone differential elements.

Backup protection

This consists of:

- phase overcurrent
- dead zone
- circuit breaker failure

Settings application software

This allows you to create a scheme and display the measured data. The scheme editor allows you to quickly draw schemes from a library of elements, then validate the scheme. It can also display the status of DDBs and measured data on the scheme in real time.

Inputs and outputs

The device has many hard-wired digital inputs and outputs. For applications that demand more, virtual inputs and outputs can be used between the products protecting the different phases. 128 virtual inputs and outputs can be shared between products using communications links. Use hard-wired inputs and outputs to connect the most time-critical signals between devices. Use Virtual inputs and outputs to communicate less time-critical information signals between devices.

3 FEATURES AND FUNCTIONS

3.1 PROTECTION FUNCTIONS

The P747 provides the following protection functions:

Protection Function	IEC 61850	ANSI
Phase segregated biased current differential high speed busbar protection	PhsPDIF	87BB/P
Check Zone segregated biased phase current differential high speed busbar protection	CzPPDIF	87CZ/P
Definite Time overcurrent protection (2 stages)	OcpPTOC	50/P
IDMT overcurrent protection (2 stages)	OcpPTOC	51/P
Dead zone phase protection (short zone between CTs and open CBs)	DzpPhsPTOC	50DZ
CB Failure (auxiliary contacts or fast undercurrent)	RBRF	50BF
CB Failure and isolator state monitoring		
Lockout	RBRF	89
Undervoltage control		27
VT blocking scheme based on V<		VTS

3.2 CONTROL FUNCTIONS

Feature	IEC 61850	ANSI
Watchdog contacts		
Read-only mode		
NERC compliant cyber-security		
Function keys (up to 10)	FnkGGIO	
Programmable LEDs (up to 18)	LedGGIO	
Programmable hotkeys (2)		
Programmable allocation of digital inputs and outputs		
Fully customizable menu texts		
Circuit breaker control, status & condition monitoring	XCBR	52
Trip circuit and coil supervision		
Control inputs	PloGGIO1	
Power-up diagnostics and continuous self-monitoring		
Dual rated 1A and 5A CT inputs		
Alternative setting groups (4)		
Graphical programmable scheme logic (PSL)		
Fault locator	RFLO	

3.3 MEASUREMENT FUNCTIONS

Measurement Function	IEC 61850	ANSI
Measurement of all instantaneous & integrated values (Exact range of measurements depend on the device model)		MET
Disturbance recorder for waveform capture – specified in samples per cycle	RDRE	DFR
Fault Records		

Measurement Function	IEC 61850	ANSI
Maintenance Records		
Event Records / Event logging		Event records
Time Stamping of Opto-inputs	Yes	Yes

3.4 COMMUNICATION FUNCTIONS

The device offers the following communication functions:

Feature	ANSI
NERC compliant cyber-security	
Front RS232 serial communication port for configuration	16S
Rear serial RS485 communication port for SCADA control	16S
2 Additional rear serial communication ports for SCADA control and teleprotection (fibre and copper) (optional)	16S
Ethernet communication (optional)	16E
Redundant Ethernet communication (optional)	16E
Courier	16S
IEC 61850 (optional)	16E
IEC 60870-5-103 (optional)	16S
DNP3.0 over serial link (optional)	16S
DNP3.0 over Ethernet (optional)	16E
IRIG-B time synchronisation (optional)	CLK

4 COMPLIANCE

The device has undergone a range of extensive testing and certification processes to ensure and prove compatibility with all target markets. Below is a list of standards with which the device is compliant. A detailed description of these criteria can be found in the Technical Specifications chapter.

Compliance Standards

Condition	Compliance
EMC compliance (compulsory)	2004/108/EC (demonstrated by EN60255-26:2009)
Product safety (compulsory)	2006/95/EC (demonstrated by EN60255-27:2005)
R&TTE Compliance (compulsory)	99/5/EC
EMC	EN50263, IEC 60255-22-1/2/3/4/5/6/7, IEC 61000-4-5/6/8/9/10/16 EN61000-4-3/18, IEEE/ANSI C37.90.1/2/3, ENV50204, EN55022
Product Safety for North America	UL/CL File No. UL/CUL E202519
Environmental conditions	IEC 60255-27:2005, IEC 60068-2-78:2001, -30:2005, -42:2003, -42:2003
Power supply interruption	IEC 60255-11, IEC 61000-4-11
Type tests for Insulation, creepage distance and clearances, high voltage dielectric withstand, and impulse voltage withstand	IEC 60255-27:2005
Enclosure protection	IEC 60529:2002 – IP10, IP30, IP52
Mechanical robustness	IEC 60255-21-1/2/3
Documentation	IEC 60255-151

5 FUNCTIONAL OVERVIEW

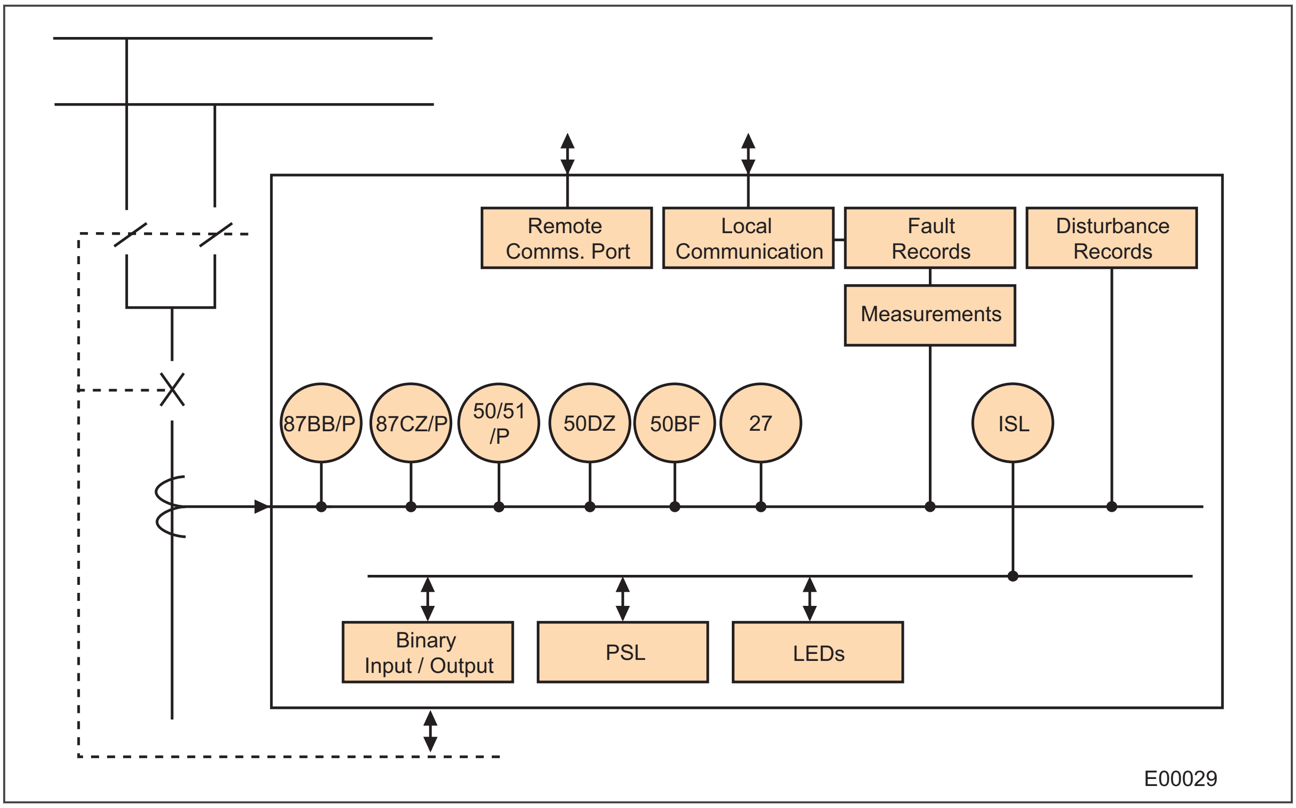


Figure 1: Functional Overview

6 ORDERING OPTIONS

Variants	Order Number
P747 Numerical Busbar Differential Protection Relay with 4-zone enhancements	**P747** _ _ _ _ _ _ _ ** _ _
Vx Aux Rating:	
New PSU 24-54 Vdc	7
New PSU 48-125 Vdc (40-100 Vac)	8
New PSU 110-250 Vdc (100-240 Vac)	9
In/Vn Rating:	
CT1 - CT18 In = 1A/5A, Vn = (100/120V) (18CT/3VT)	1
Hardware Options:	
Standard: no options	1
IRIG-B (Modulated) only	2
Fibre optic converter only	3
IRIG-B (Modulated) & fibre optic converter	4
Ethernet with 100 Mbps fibre optic port	6
2nd rear comms port	7
2nd rear comms port + IRIG-B (Modulated)	8
Ethernet (100 Mbps) + IRIG-B (Modulated)	A
Ethernet (100 Mps) + IRIG-B (Unmodulated)	B
IRIG-B (Unmodulated)	C
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 multi-mode fibre ports + Modulated IRIG-B	N
Redundant Ethernet PRP, 2 multi-mode fibre ports + Un-modulated IRIG-B	P
Product Specific Options:	
Size 16 case, 40 optos + 24 relays + coprocessor	A
Size 16 case, 32 optos + 32 relays + coprocessor	B
Size 16 case, 32 optos + 24 relays + standard coprocessor	C
Protocol Options:	
K-Bus/Courier	1
Modbus	2
IEC60870-5-103	3
DNP3.0	4
IEC 61850 over Ethernet and Courier via rear K-Bus/RS485	6
DNP3 over Ethernet with Courier rear port K-Bus/RS485 protocol	8
Mounting Options:	
Panel mounting	M
Rack mounting	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 Options:	
Unless specified the latest version will be delivered	**
Settings Files Options:	
Default	0
Customer specific	A
Design Suffix:	
Extended CPU	K

E00036

SAFETY INFORMATION

CHAPTER 2

1 CHAPTER OVERVIEW

This chapter provides information about the safe handling of the equipment. The equipment must be properly installed and handled in order to maintain it in a safe condition and to keep personnel safe at all times. You must be familiar with information contained in this chapter before unpacking, installing, commissioning, or servicing the equipment.

This chapter contains the following sections:

2 HEALTH AND SAFETY

Personnel associated with the equipment must be familiar with the contents of this Safety Information.

When electrical equipment is in operation, dangerous voltages are present in certain parts of the equipment. Improper use of the equipment and failure to observe warning notices will endanger personnel.

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 the system to which it is being connected.
- Are familiar with accepted safety engineering practises and are authorised to energise and de-energise equipment in the correct manner.
- Are trained in the care and use of safety apparatus in accordance with safety engineering practises
- Are trained in emergency procedures (first aid).

Although the documentation provides instructions for installing, commissioning and operating the equipment, it cannot cover all conceivable circumstances. In the event of questions or problems, do not take any action without proper authorisation. Please contact the appropriate technical sales office and request the necessary information.

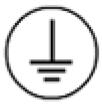
3 SYMBOLS

Throughout this manual you will come across the following symbols. You will also see these symbols on parts of the equipment.

Caution:
Refer to equipment documentation. Failure to do so could result in damage to the equipment

Warning:
Risk of electric shock

Earth terminal



Protective Earth terminal

4 INSTALLATION, COMMISSIONING AND SERVICING

4.1 LIFTING HAZARDS

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

4.2 ELECTRICAL HAZARDS

Caution:
All personnel involved in installing, commissioning, or servicing this equipment must be familiar with the correct working procedures.

Caution:
Consult the equipment documentation before installing, commissioning, or servicing the equipment.

Caution:
Always use the equipment in a manner specified by the manufacturer. Failure to do so will jeopardise the protection provided by the equipment.

Warning:
Removal of equipment panels or covers may expose hazardous live parts. Do not touch until the electrical power is removed. Take extra care when there is unlocked access to the rear of the equipment.

Warning:
Isolate the equipment before working on the terminal strips.

Warning:
Use a suitable protective barrier for areas with restricted space, where there is a risk of electric shock due to exposed terminals.

Caution:
Disconnect power before disassembling. Disassembly of the equipment may expose sensitive electronic circuitry. Take suitable precautions against electrostatic voltage discharge (ESD) to avoid damage to the equipment.

Caution:
NEVER look into optical fibres. Always use optical power meters to determine operation or signal level.

Caution:
Insulation testing may leave capacitors charged up to a hazardous voltage. At the end of each part of the test, discharge the capacitors by reducing the voltage to zero, before disconnecting the test leads.

Caution:
Operate the equipment within the specified electrical and environmental limits.

Caution:
Before cleaning the equipment, ensure that no connections are energised. Use a lint free cloth dampened with clean water.

Note:
Contact fingers of test plugs are normally protected by petroleum jelly, which should not be removed.

4.3 UL/CSA/CUL REQUIREMENTS

The information in this section is applicable only to equipment carrying UL/CSA/CUL markings.

Caution:
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).

Caution:
To maintain compliance with UL and CSA/CUL, install the equipment using UL/CSA-recognised parts for: cables, protective fuses, fuse holders and circuit breakers, insulation crimp terminals, and replacement internal batteries.

4.4 FUSING REQUIREMENTS

Caution:
Where UL/CSA listing of the equipment is required for external fuse protection, a UL or CSA Listed fuse must be used. The listed protective fuse type is: Class J time delay fuse, with a maximum current rating of 15 A and a minimum DC rating of 250 V dc (for example type AJT15).

Caution:
Where UL/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 dc rating of 250 V dc may be used (for example Red Spot type NIT or TIA).
For P60 models, use a 4A maximum T-type fuse.

Caution:
Auxiliary supply wiring and digital input circuits should be protected by a high rupture capacity NIT or TIA fuse with maximum rating of 16 A. for safety reasons, current transformer circuits must never be fused. Other circuits should be appropriately fused to protect the wire used.

4.5 EQUIPMENT CONNECTIONS

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

Caution:
Tighten M4 clamping screws of heavy duty terminal block connectors to a nominal torque of 1.3 Nm.
Tighten captive screws of terminal blocks to 0.5 Nm minimum and 0.6 Nm maximum.

Caution:
Always use insulated crimp terminations for voltage and current connections.

Caution:
Always use the correct crimp terminal and tool according to the wire size.

Caution:
Watchdog (self-monitoring) contacts are provided to indicate the health of the device on some products. We strongly recommend that you hard wire these contacts into the substation's automation system, for alarm purposes.

4.6 PROTECTION CLASS 1 EQUIPMENT REQUIREMENTS

Caution:
Earth the equipment with the supplied PCT (Protective Conductor Terminal).

Caution:
Do not remove the PCT.

Caution:
The PCT is sometimes used to terminate cable screens. Always check the PCT's integrity after adding or removing such earth connections.

Caution:
Use a locknut or similar mechanism to ensure the integrity of stud-connected PCTs.

Caution:
The recommended minimum PCT wire size is 2.5 mm^2 for countries whose mains supply is 230 V (e.g. Europe) and 3.3 mm^2 for countries whose mains supply is 110 V (e.g. North America). This may be superseded by local or country wiring regulations.
For P60 products, the recommended minimum PCT wire size is 6 mm^2. See manual for details.

Caution:
The PCT connection must have low-inductance and be as short as possible.

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

4.7 PRE-ENERGIZATION CHECKLIST

Caution:
Check voltage rating/polarity (rating label/equipment documentation).

Caution:
Check CT circuit rating (rating label) and integrity of connections.

Caution:
Check protective fuse or miniature circuit breaker (MCB) rating.

Caution:
Check integrity of the PCT connection.

Caution:
Check voltage and current rating of external wiring, ensuring it is appropriate for the application.

4.8 PERIPHERAL CIRCUITRY

Warning:
Do not open the secondary circuit of a live CT since the high voltage produced may be lethal to personnel and could damage insulation. Short the secondary of the line CT before opening any connections to it.

Note:
For most Alstom equipment with ring-terminal connections, the threaded terminal block for current transformer termination is automatically shorted when the module is removed. Therefore external shorting of the CTs may not be required. Check the equipment documentation first to see if this applies.

Caution:
Where external components such as resistors or voltage dependent resistors (VDRs) are used, these may present a risk of electric shock or burns if touched.

Warning:
Take extreme care when using external test blocks and test plugs such as the MMLG, MMLB and MiCOM ALSTOM P990, as hazardous voltages may be exposed. Ensure that CT shorting links are in place before removing MMLB test plugs, to avoid potentially lethal voltages.

4.9 UPGRADING/SERVICING

Warning:
Do not insert or withdraw modules, PCBs or expansion boards from the equipment while energised, as this may result in damage to the equipment. Hazardous live voltages would also be exposed, endangering personnel.

Caution:
Internal modules and assemblies can be heavy. Take care when inserting or removing modules into or out of the IED.

5 DECOMMISSIONING AND DISPOSAL

Caution:
Before decommissioning, completely isolate the equipment power supplies (both poles of any dc supply). The auxiliary supply input may have capacitors in parallel, which may still be charged. To avoid electric shock, discharge the capacitors using the external terminals before to decommissioning.

Caution:
Avoid incineration or disposal to water courses. Dispose of the equipment in a safe, responsible an environmentally friendly manner, and if applicable, in accordance with country-specific regulations.

HARDWARE DESIGN

CHAPTER 3

1 CHAPTER OVERVIEW

This chapter provides information about the product's hardware design.

This chapter contains the following sections:

2 HARDWARE ARCHITECTURE

The main components comprising devices based on the Px4x platform are as follows:

- The housing, consisting of a front panel and connections at the rear
- The Main processor module consisting of the main CPU (Central Processing Unit), memory and an interface to the front panel HMI (Human Machine Interface)
- A selection of plug-in boards and modules with presentation at the rear for the power supply, communication functions, digital I/O, analogue inputs, and time synchronisation connectivity

All boards and modules are connected by a parallel data and address bus, which allows the processor module to send and receive information to and from the other modules as required. There is also a separate serial data bus for conveying sampled data from the input module to the CPU. These parallel and serial databuses are shown as a single interconnection module in the following figure, which shows typical modules and the flow of data between them.

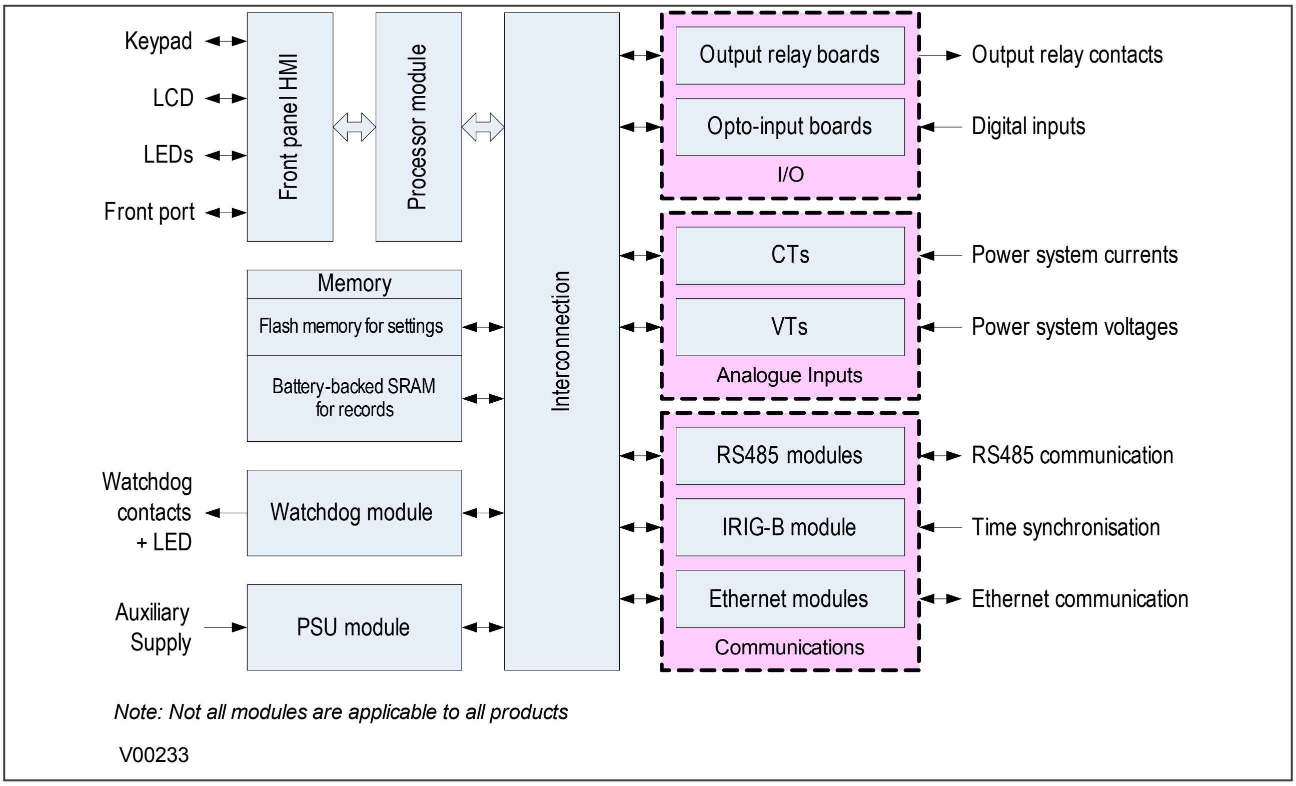


Figure 2: Hardware architecture

3 MECHANICAL IMPLEMENTATION

All products based on the Px4x platform have common hardware architecture. The hardware is modular and consists of the following main parts:

- Case and terminal blocks
- Boards and modules
- Front panel

The case comprises the housing metalwork and terminal blocks at the rear. The boards fasten into the terminal blocks and are connected together by a ribbon cable. This ribbon cable connects to the processor in the front panel.

The following diagram shows an exploded view of a typical product. The diagram shown does not necessarily represent exactly the product model described in this manual.

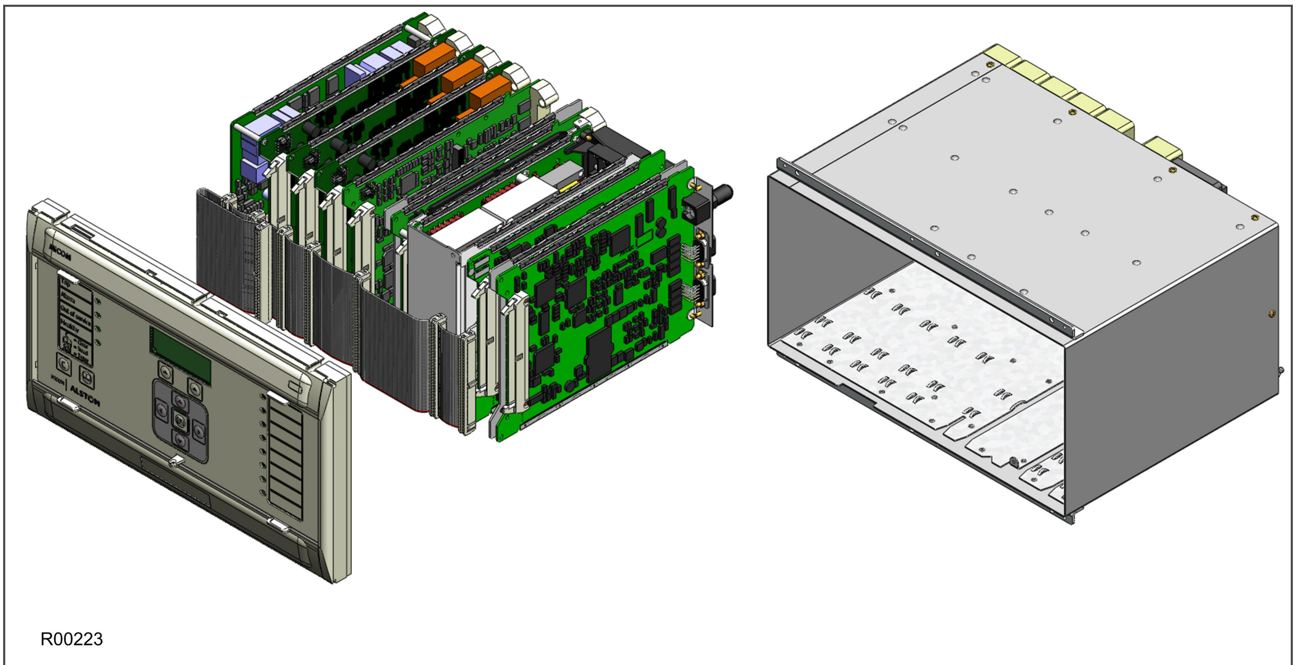


Figure 3: Exploded view of IED

3.1 HOUSING VARIANTS

The Px4x range of products are implemented in a range of case sizes. Case dimensions for industrial products usually follow modular measurement units based on rack sizes. These are: U for height and TE for width, where:

- 1U = 1.75 inches = 44.45 mm
- 1TE = 0.2 inches = 5.08 mm

The products are available in panel-mount or standalone versions. All products are nominally 4U high. This equates to 177.8 mm or 7 inches.

The cases are pre-finished steel with a conductive covering of aluminium and zinc. This provides good grounding at all joints, providing a low resistance path to earth that is essential for performance in the presence of external noise.

The case width depends on the product type and its hardware options. There are three different case widths for the described range of products: 40TE, 60TE and 80TE. The case dimensions and compatibility criteria are as follows:

Case width (TE)	Case width (mm)	Case width (inches)
40TE	203.2	8
60TE	304.8	12
80TE	406.4	16

Note:
Due to the number of required input modules, the P747 only comes in an 80TE case

3.2 LIST OF BOARDS

The product's hardware consists of several modules drawn from a standard range. The exact specification and number of hardware modules depends on the model number and variant. Depending on the exact model, the product in question will use a selection of the following boards.

Board	Use
Main Processor board	Main Processor board – with support for function keys
Power supply board 24/54V DC	Power supply input. Accepts DC voltage between 24V and 54V
Power supply board - 48/125V DC	Power supply input. Accepts DC voltage between 48V and 125V
Power supply board 110/250V DC	Power supply input. Accepts DC voltage between 110V and 125V
Transformer board	Contains the voltage and current transformers
Input board	Contains the A/D conversion circuitry
Input board with opto-inputs	Contains the A/D conversion circuitry + 8 digital opto-inputs
IRIG-B board - modulated	Interface board for modulated IRIG-B timing signal
IRIG-B - demodulated input	Interface board for demodulated IRIG-B timing signal
Fibre board	Interface board for fibre-based RS485 connection
Fibre + IRIG-B	Interface board for fibre-based RS485 connection + demodulated IRIG-B
2nd rear communications board	Interface board for RS232 / RS485 connections
2nd rear communications board with IRIG-B input	Interface board for RS232 / RS485 + IRIG-B connections
100MhZ Ethernet board	Standard 100MHz Ethernet board for LAN connection (fibre + copper)
100MhZ Ethernet board with modulated IRIG-B	Standard 100MHz Ethernet board (fibre / copper) + modulated IRIG-B
100MhZ Ethernet board with demodulated IRIG-B	Standard 100MHz Ethernet board (fibre / copper)+ demodulated IRIG-B
Redundant Ethernet SHP+ modulated IRIG-B	Redundant SHP Ethernet board (2 fibre ports) + modulated IRIG-B input
Redundant Ethernet SHP + demodulated IRIG-B	Redundant SHP Ethernet board (2 fibre ports) + demodulated IRIG-B input
Redundant Ethernet RSTP + modulated IRIG-B	Redundant RSTP Ethernet board (2 fibre ports) + modulated IRIG-B input
Redundant Ethernet RSTP+ demodulated IRIG-B	Redundant RSTP Ethernet board (2 fibre ports) + demodulated IRIG-B input
Redundant Ethernet DHP+ modulated IRIG-B	Redundant DHP Ethernet board (2 fibre ports) + modulated IRIG-B input
Redundant Ethernet DHP+ demodulated IRIG-B	Redundant DHP Ethernet board (2 fibre ports) + demodulated IRIG-B input
Redundant Ethernet PRP+ modulated IRIG-B	Redundant PRP Ethernet board (2 fibre ports) + modulated IRIG-B input
Redundant Ethernet PRP+ demodulated IRIG-B	Redundant PRP Ethernet board (2 fibre ports) + demodulated IRIG-B input
Output relay output board (8 outputs)	Standard output relay board with 8 outputs
Combined coprocessor/opto-input board	To provide extra processing power and extra opto-inputs

4 FRONT PANEL

4.1 FRONT PANEL

The following diagram shows the front panel of a typical 80TE unit. 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.

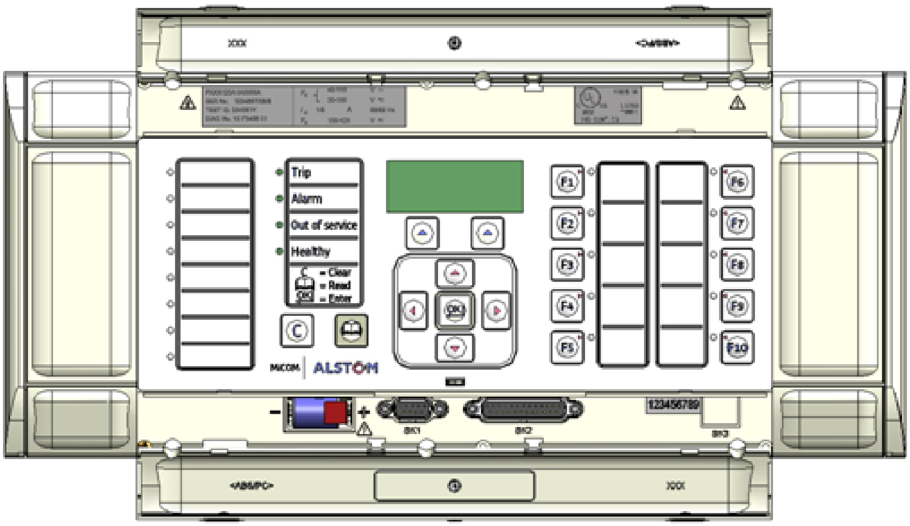


Figure 4: Front panel (80TE)

The front panel consists of:

- Top and bottom compartments with hinged cover
- LCD display
- Keypad
- Front serial port
- Front parallel port
- Fixed function LEDs
- Function keys and LEDs
- Programmable LEDs

> *Note:*
> *Due to the number of required input modules, the P747 only comes in an 80TE case*

4.1.1 TOP COMPARTMENT WITH HINGED COVER

The top compartment contains labels for the:

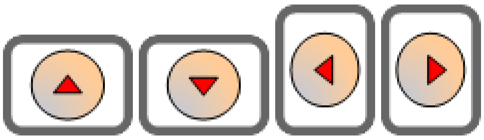
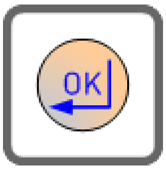
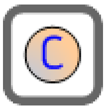
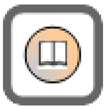
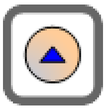
- Serial number
- Current and voltage ratings.

The bottom compartment contains:

- A compartment for a 1/2 AA size backup battery (used for the real time clock and event, fault, and disturbance records).
- A 9-pin female D-type front port for an EIA(RS)232 serial connection to a PC.
- A 25-pin female D-type parallel port for monitoring internal signals and downloading high-speed local software and language text.

4.1.2 KEYPAD

The keypad consists of the following keys:

4 arrow keys to navigate the menus	
An enter key for executing the chosen option	
A clear key for clearing the last command	
A read key for viewing larger blocks of text (arrow keys now used for scrolling)	
2 hot keys for scrolling through the default display and for control of setting groups	

4.1.3 LIQUID CRYSTAL DISPLAY

The LCD is a high resolution monochrome display with 16 characters by 3 lines and controllable back light.

4.1.4 FRONT SERIAL PORT (SK1)

The front serial port is a 9-pin female D-type connector, providing RS232 serial data communication. It is situated under the bottom hinged cover, and is used to communicate with a locally connected PC. it has two main purposes:

- To transfer settings data between the PC and the IED
- For downloading firmware updates and menu text editing

The port is intended for temporary connection during testing, installation and commissioning. It is not intended to be used for permanent SCADA communications. This port supports the Courier communication protocol only. Courier is a proprietary communication protocol to allow communication with a range of protection equipment, and between the device and the Windows-based support software package.

You can connect the unit to a PC with an EIA(RS)232 serial cable up to 15 m in length.

The inactivity timer for the front port is set to 15 minutes. This controls how long the unit maintains its level of password access on the front port. If no messages are received on the front port for 15 minutes, any password access level that has been enabled is cancelled.

Note:
The front serial port does not support automatic extraction of event and disturbance records, although this data can be accessed manually.

4.1.4.1 FRONT SERIAL PORT (SK1) CONNECTIONS

The port pin-out follows the standard for Data Communication Equipment (DCE) device with the following pin connections on a 9-pin connector.

Pin number	Description
2	Tx Transmit data
3	Rx Receive data
5	0 V Zero volts common

You must use the correct serial cable, or the communication will not work. A straight-through serial cable is required, connecting pin 2 to pin 2, pin 3 to pin 3, and pin 5 to pin 5.

Once the physical connection from the unit to the PC is made, the PC's communication settings must be set to match those of the IED. The following table shows the unit's communication settings for the front port.

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

4.1.5 FRONT PARALLEL PORT (SK2)

The front parallel port uses a 25 pin D-type connector. It is used for commissioning, downloading firmware updates and menu text editing.

4.1.6 FIXED FUNCTION LEDS

Four fixed-function LEDs on the left-hand side of the front panel indicate the following conditions.

- Trip (Red) switches ON when the IED 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 IED 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 IED's protection is unavailable.
- Healthy (Green) is ON when the IED is in correct working order, and should be ON at all times. It goes OFF if the unit's self-tests show there is an error in the hardware or software. The state of the healthy LED is reflected by the watchdog contacts at the back of the unit.

4.1.7 FUNCTION KEYS

The programmable function keys are available for custom use for devices using 30TE cases or larger.

Factory default settings associate specific functions to these keys, but by using programmable scheme logic, you can change the default functions of these keys to fit specific needs. Adjacent to these function keys are programmable tri-colour LEDs, which are set to be associated with their respective function keys.

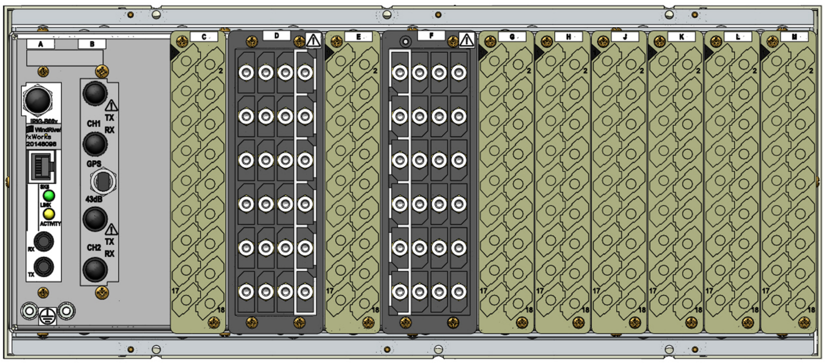
4.1.8 PROGRAMABLE LEDS

The device has a number of programmable LEDs, which can be associated with PSL-generated signals. All of the programmable LEDs are tri-colour and can be set to RED, YELLOW or GREEN.

5 REAR PANEL

The MiCOM Px40 series uses a modular construction. Most of the internal workings are on boards and modules which fit into slots. Some of the boards plug into terminal blocks, which are bolted onto the rear of the unit. However, some boards such as the communications boards have their own connectors. The rear panel consists of these terminal blocks plus the rears of the communications boards.

The back panel cut-outs and slot allocations vary. These depend on the product, the type of boards and the terminal blocks needed to populate the case. The following diagram shows a typical rear view of a case populated with various boards.



R00225

Figure 5: Rear view of populated 80TE case

> *Note:*
> *This diagram is just an example and may not show the exact product described in this manual. It also does not show the full range of available boards, just a typical arrangement.*

Not all slots are the same size. The slot width depends on the type of board or terminal block. For example, HD (heavy duty) terminal blocks, as required for the analogue inputs, require a wider slot size than MD (medium duty) terminal blocks. The board positions are not generally interchangeable. Each slot is designed to house a particular type of board. Again this is model-dependent.

The device may use one or more of the terminal block types shown in the following diagram. The terminal blocks are fastened to the rear panel with screws.

- Heavy duty (HD) terminal blocks for CT and VT circuits
- Medium duty (MD) terminal blocks for the power supply, relay outputs and rear communications port
- MiDOS terminal blocks for CT and VT circuits
- RTD/CLIO terminal block for connection to analogue transducers

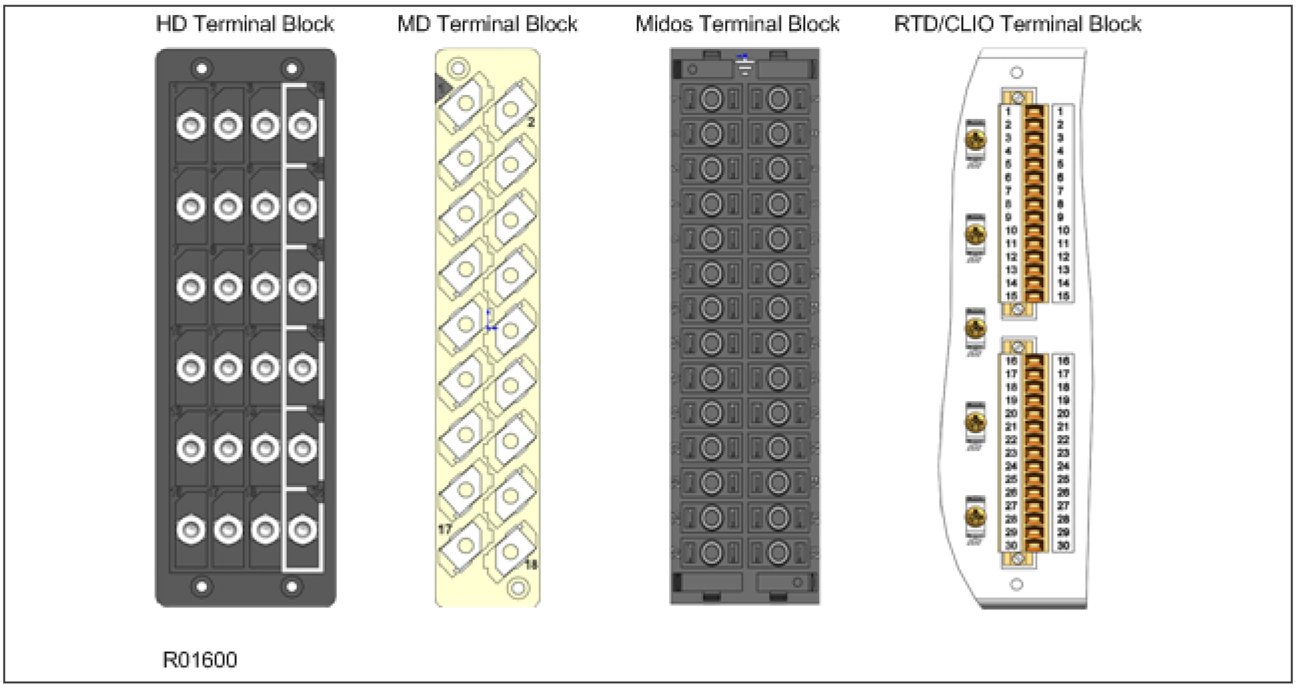


Figure 6: Terminal block types

> *Note:*
> *Not all products use all types of terminal blocks. The product described in this manual may use one or more of the above types.*

6 BOARDS AND MODULES

Each product comprises a selection of PCBs (Printed Circuit Boards) and sub-assemblies, depending on the chosen configuration.

6.1 PCBS

A PCB typically consists of the components, a front connector for connecting into the main system parallel bus via a ribbon cable, and an interface to the rear. This rear interface may be:

- Directly presented to the outside world (as is the case for communication boards such as Ethernet Boards)
- Presented to a connector, which in turn connects into a terminal block bolted onto the rear of the case (as is the case for most of the other board types)

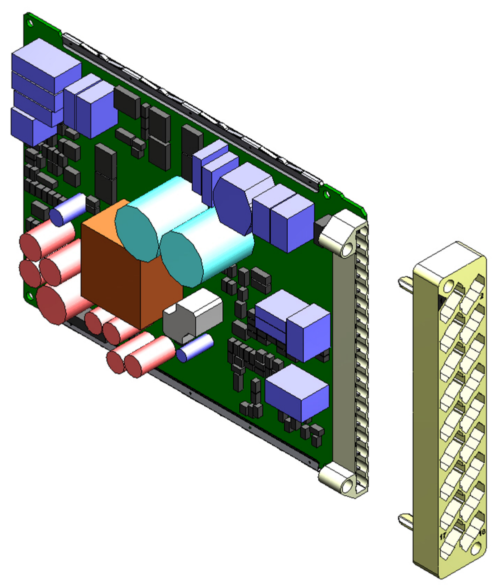


Figure 7: Rear connection to terminal block

6.2 SUBASSEMBLIES

A sub-assembly consists of two or more boards bolted together with spacers and connected with electrical connectors. It may also have other special requirements such as being encased in a metal housing for shielding against electromagnetic radiation.

Boards are designated by a part number beginning with ZN, whereas pre-assembled sub-assemblies are designated with a part number beginning with GN. Sub-assemblies, which are put together at the production stage, do not have a separate part number.

The products in the Px40 series typically contain two sub-assemblies:

- The power supply assembly comprising:
  - A power supply board
  - An output relay board
- The input module comprising:
  - One or more transformer boards, which contains the voltage and current transformers (partially or fully populated)
  - One or more input boards
  - Metal protective covers for EM (electromagnetic) shielding

The input module is pre-assembled and is therefore assigned a GN number, whereas the power supply module is assembled at production stage and does not therefore have an individual part number.

6.3 MAIN PROCESSOR BOARD

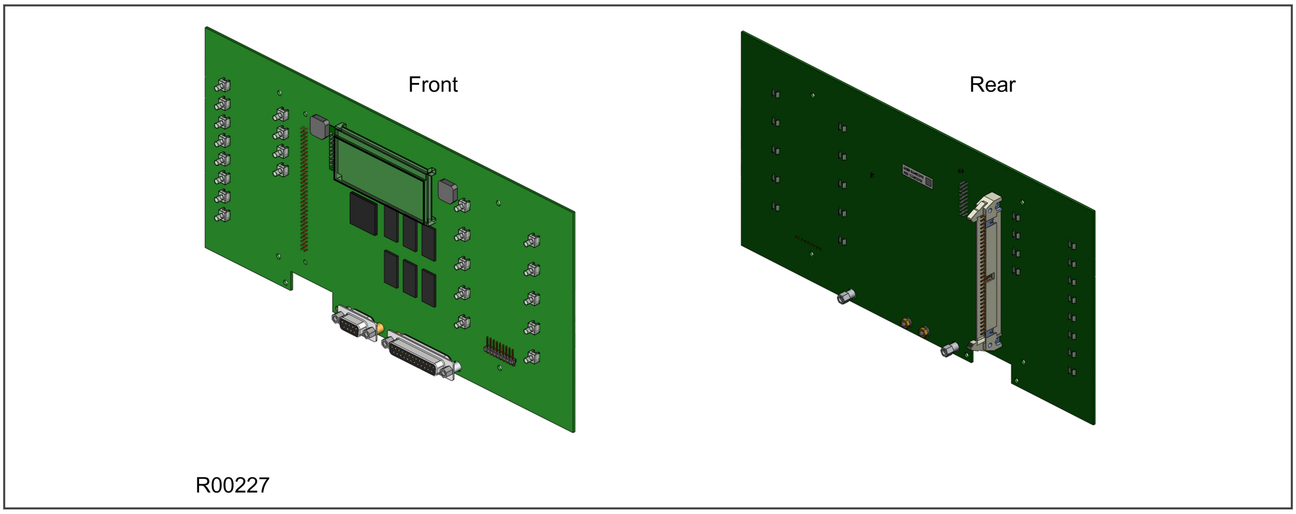


Figure 8: Main processor board

The main processor board is based around a floating point, 32-bit Digital Signal Processor (DSP). It performs all calculations and controls the operation of all other modules in the IED, including the data communication and user interfaces. This is the only board that does not fit into one of the slots. It resides in the front panel and connects to the rest of the system using an internal ribbon cable.

The LCD and LEDs are mounted on the processor board along with the front panel communication ports. All serial communication is handled using a Field Programmable Gate Array (FPGA).

The memory on the main processor board is split into two categories: volatile and non-volatile. The volatile memory is fast access SRAM, used by the processor to run the software and store data during calculations. The non-volatile memory is sub-divided into two groups:

- Flash memory to store software code, text and configuration data including the present setting values.
- Battery-backed SRAM to store disturbance, event, fault and maintenance record data.

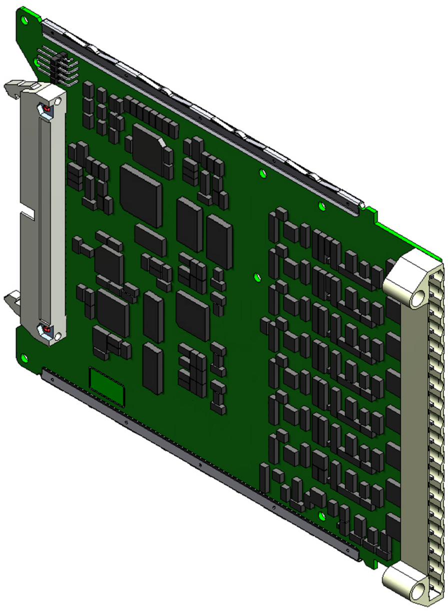
There are two board types available depending on the size of the case:

- For models in 40TE cases
- For models in 60TE cases and larger

Main Processor Board	
Sampling Rate	1200 Hz with frequency range of 46 to 54 Hz
Analogue to Digital Conversion	16 bit

Main Processor Board	
Analogue to Digital Resolution	21 bit

6.4 COMBINED COPROCESSOR AND ISOLATED INPUT BOARD



R00260

Figure 9: Combined coprocessor and isolated digital input board

This board has a coprocessor section and an isolated digital input section.

The coprocessor section is based around a floating point, 32-bit Digital Signal Processor (DSP) with 1 MB SRAM. The coprocessor is used to speed up calculations for complex algorithms.

The input section is used to convert the analogue signals delivered by the current and voltage transformers into digital quantities used by the IED. This board has eight isolated digital inputs with associated noise filtering and buffering. The terminal numbers of the isolated digital inputs are as follows.

Terminal Number	Isolated digital input
Terminal 1	Isolated digital input 1 -ve
Terminal 2	Isolated digital input 1 +ve
Terminal 3	Isolated digital input 2 -ve
Terminal 4	Isolated digital input 2 +ve
Terminal 5	Isolated digital input 3 -ve
Terminal 6	Isolated digital input 3 +ve
Terminal 7	Isolated digital input 4 -ve
Terminal 8	Isolated digital input 4 +ve
Terminal 9	Isolated digital input 5 -ve
Terminal 10	Isolated digital input 5 +ve
Terminal 11	Isolated digital input 6 -ve
Terminal 12	Isolated digital input 6 +ve
Terminal 13	Isolated digital input 7 –ve

Terminal Number	Isolated digital input
Terminal 14	Isolated digital input 7 +ve
Terminal 15	Isolated digital input 8 –ve
Terminal 16	Isolated digital input 8 +ve
Terminal 17	Common
Terminal 18	Common

6.5 POWER SUPPLY BOARD

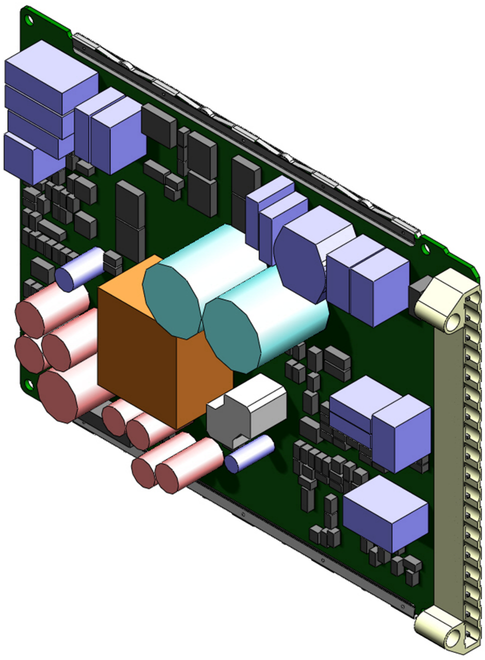


Figure 10: Power supply board

The power supply board provides power to the unit. One of three different configurations of the power supply board can be fitted to the unit. This is specified at the time of order and depends on the nature of the supply voltage that will be connected to it.

There are three board types, which support the following voltage ranges:

- 24/54 V DC
- 48/125 V DC
- 110/250 V DC

The power supply board connector plugs into a medium duty terminal block sliding in from the front of the unit to the rear. This terminal block is always positioned on the right hand side of the unit looking from the rear.

The power supply board is usually assembled together with the relay output board to form a complete sub-assembly, as shown in the following diagram.

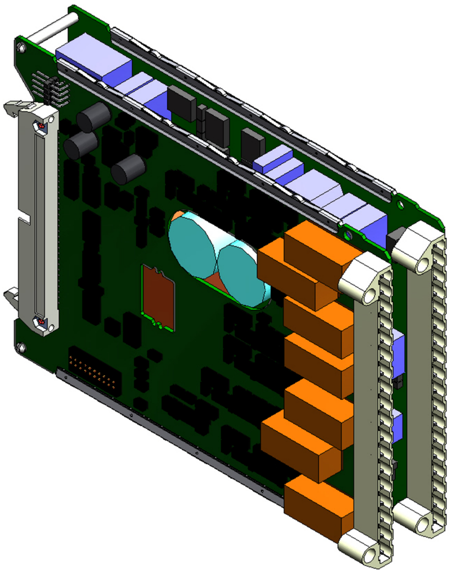


Figure 11: Power Supply Assembly

The power supply outputs are used to provide isolated power supply rails to the various modules within the unit. Three voltage levels are used by the unit's modules:

- 5.1 V for all of the digital circuits
- +/- 16 V for the analogue electronics such as on the input board
- 22 V for driving the output relay coils.

All power supply voltages, including the 0 V earth line, are distributed around the unit by the 64-way ribbon cable.

The power supply board incorporates inrush current limiting. This limits the peak inrush current to approximately 10 A.

Power is applied to pins 1 and 2 of the terminal block, where pin 1 is negative and pin 2 is positive. The pin numbers are clearly marked on the terminal block as shown in the following diagram.

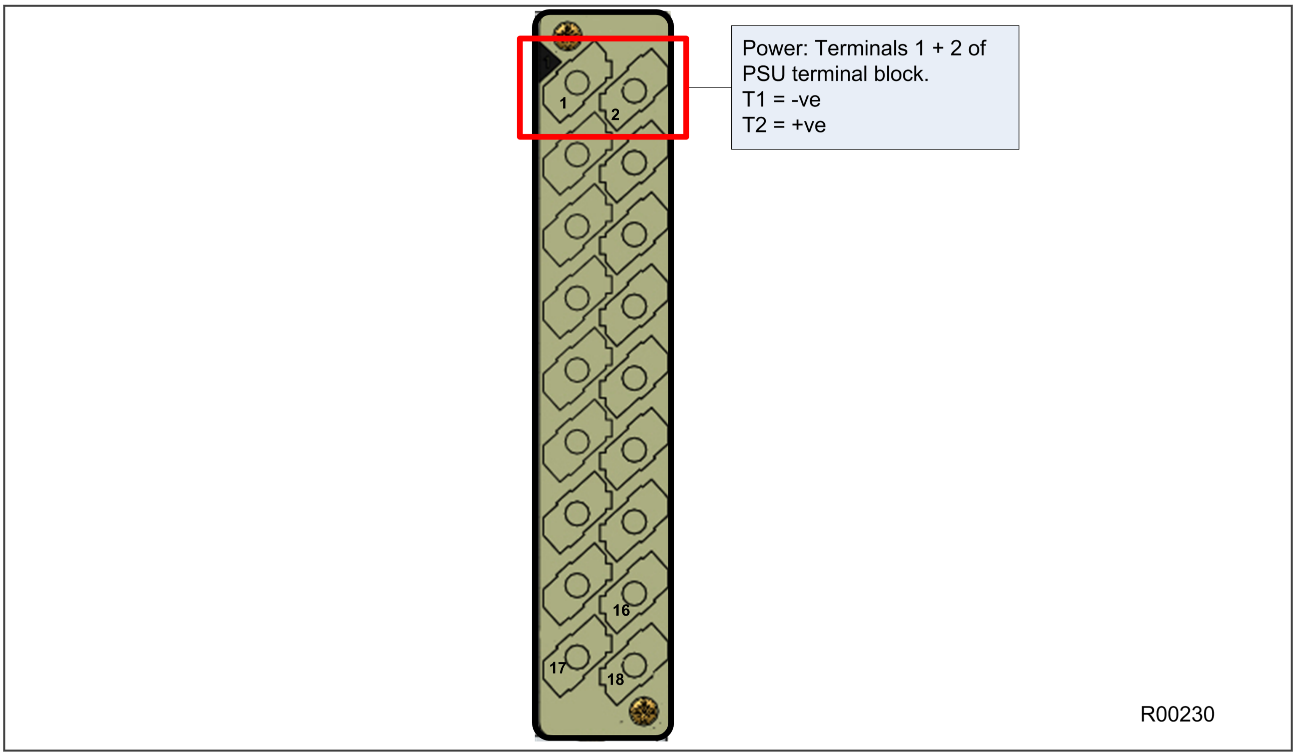


Figure 12: Power Supply Terminals

6.5.1 WATCHDOG

For space reasons, the Watchdog facility is also hosted on the power supply board. This checks the operation of the IED's hardware and software when in service. The Watchdog facility provides two output relay contacts, one normally open and one normally closed. These are used to indicate the health of the unit's processor board and are driven by the main processor board.

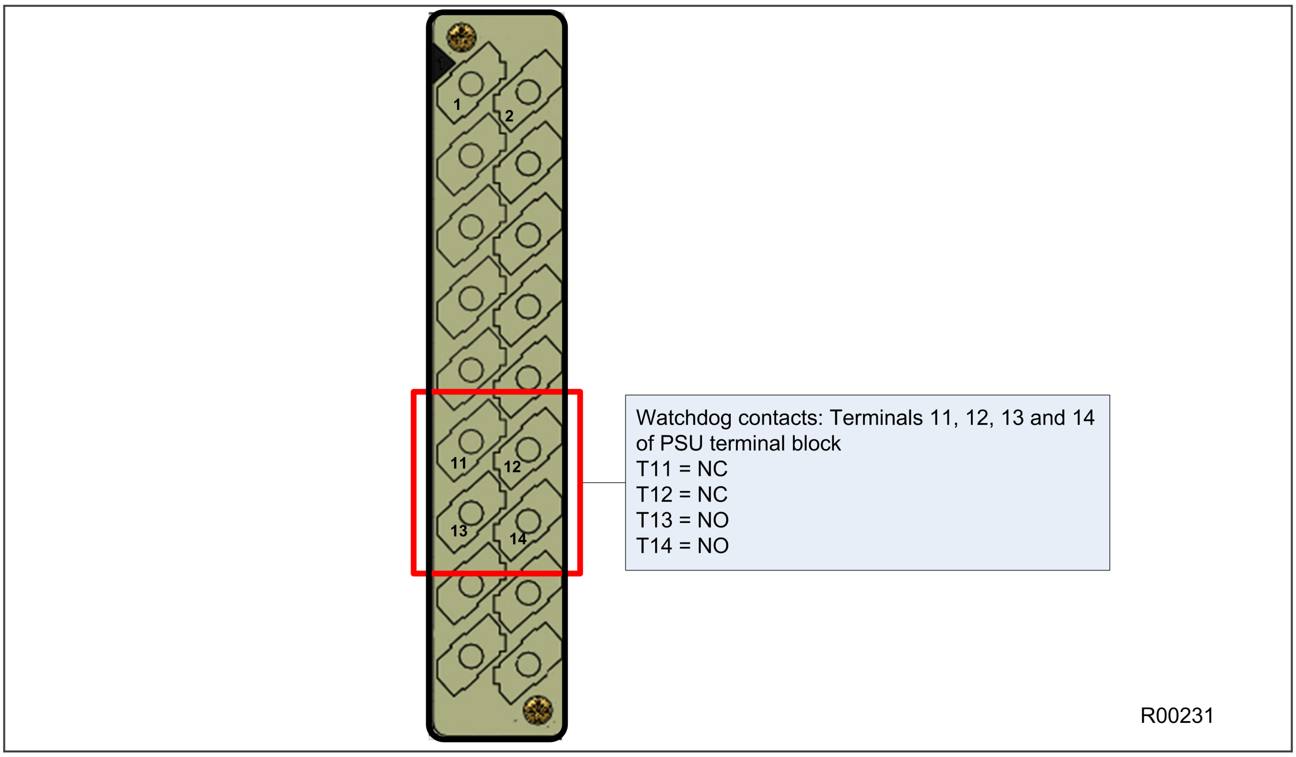


Figure 13: Watchdog contact terminals

6.5.2 REAR SERIAL PORT

For space reasons, the rear serial port (RP1) is also housed on the power supply board. This is a three-terminal serial communications port, intended for use with a permanently wired connection to a remote control centre. The physical connectivity is achieved using three screw terminals; two for the signal connection, and the third for the earth shield of the cable. These are located on pins 16, 17 and 18 of the power supply terminal block, which is on the far right looking from the rear. The interface can be selected between RS485 and K-bus. When the K-Bus option is selected, the two signal connections are not polarity conscious.

The polarity independent K-bus can only be used for the Courier data protocol. The polarity conscious MODBUS, IEC 60870-5-103 and DNP3.0 protocols need RS485.

The following diagram shows the rear serial port. The pin assignments are as follows:

- Pin 16: Ground shield
- Pin 17: Negative signal
- Pin 18: Positive signal

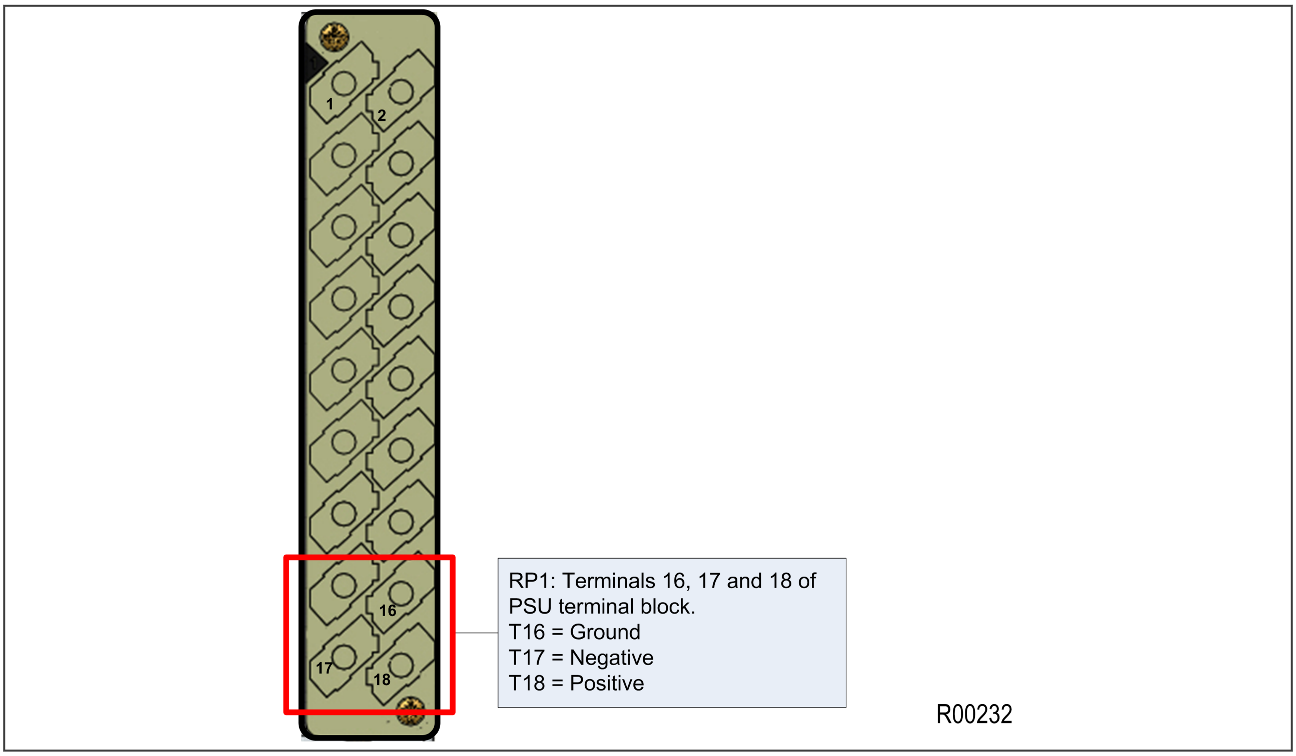


Figure 14: Rear serial port terminals

An additional serial port with D-type presentation is available as an optional board, if required.

The power supply board also provides a rear serial port. The rear serial port (RP1) is an EIA(RS)485 interface, which provides SCADA communication. The interface supports half-duplex communication and provides optical isolation for the serial data being transmitted and received.

6.6 INPUT MODULE - 2 TRANSFORMER BOARDS

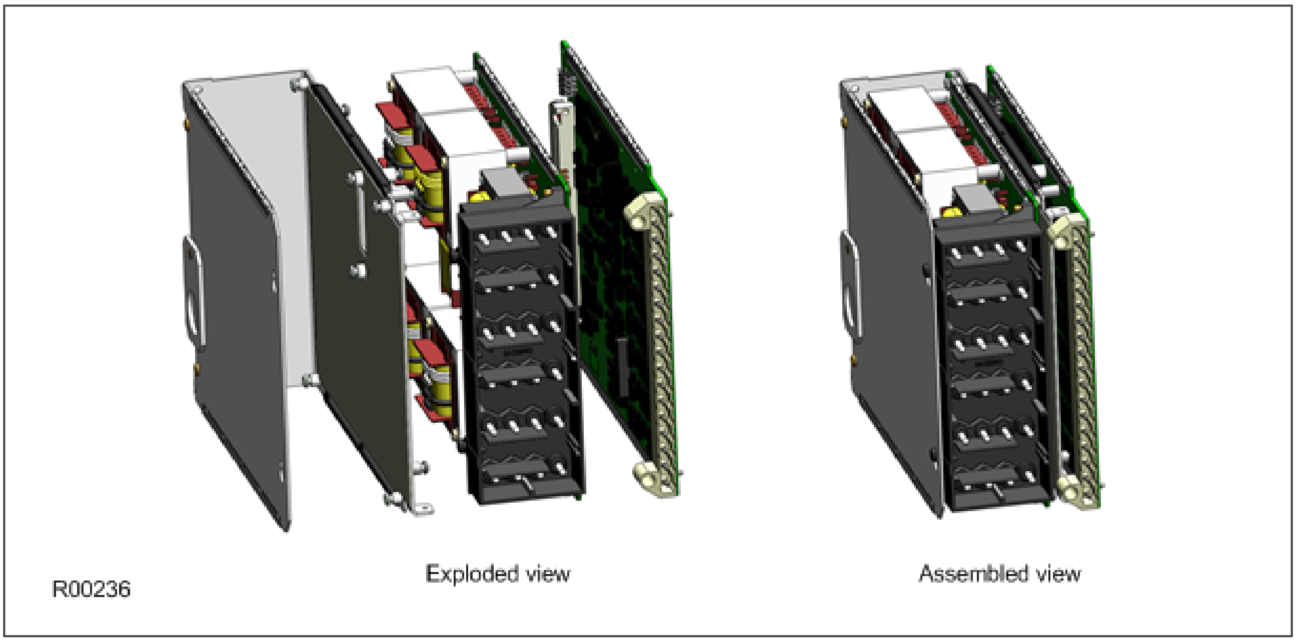


Figure 15: Input Module - 1 transformer board

The input module consists of the main input board coupled together with two transformer boards. The transformer boards contain the voltage and current transformers, which isolate and scale the analogue input signals delivered by the system transformers. The input board contains the A/D conversion and digital processing circuitry, as well as eight digital isolated inputs (opto-inputs).

The boards are connected together physically (bolted together with spacers) and electrically (via electrical connectors). The module is encased in a metal housing for shielding against electromagnet radiation.

6.6.1 SIGMA-DELTA INPUT MODULE CIRCUIT DESCRIPTION

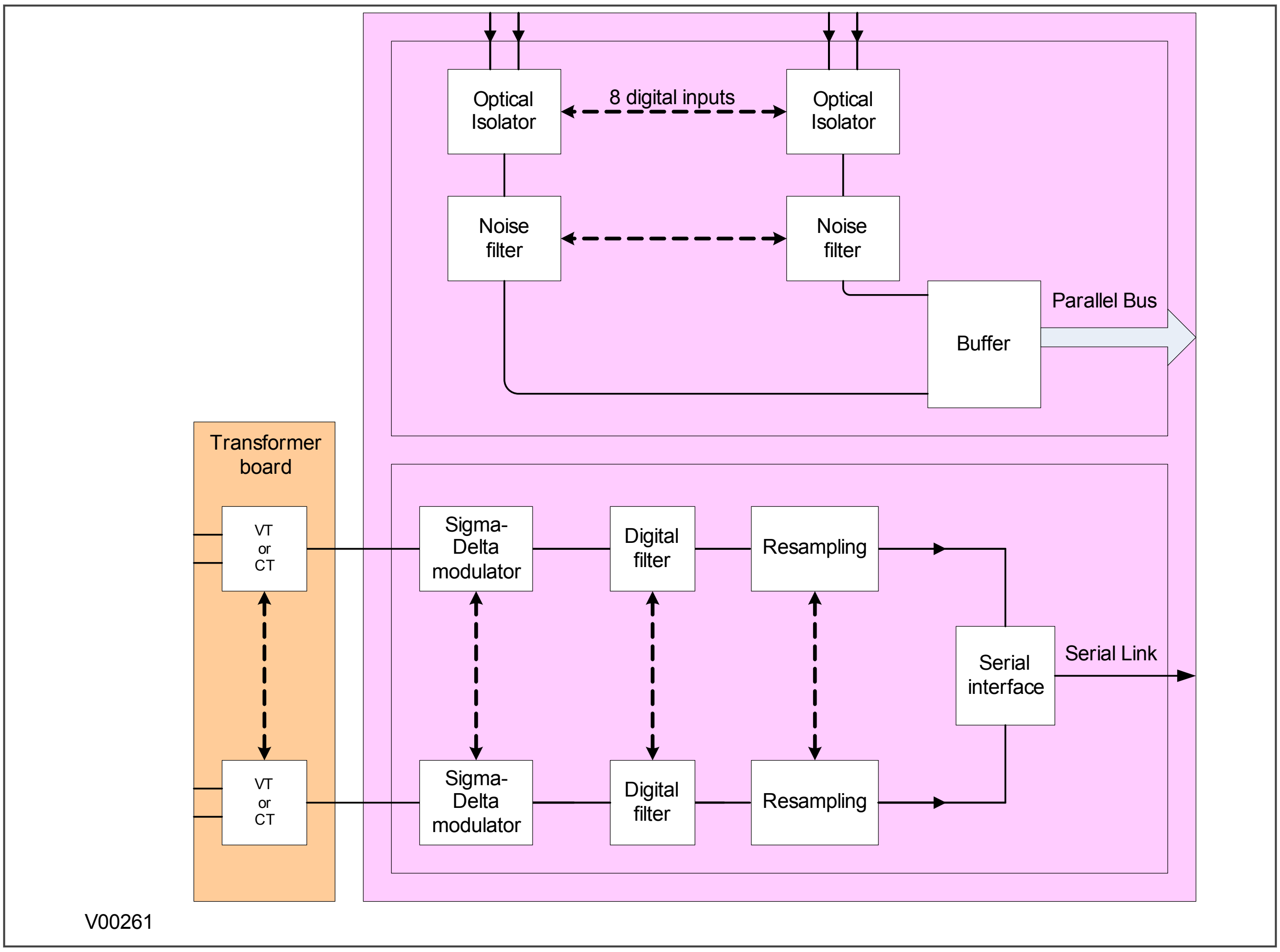


Figure 16: Input module schematic

A/D Conversion

The differential analogue inputs from the unit's CT and VT transformers are presented to the main input board as shown. Each differential input is first converted to a single input quantity referenced to the input board's ground potential.

The sigma-delta modulators convert analogue to digital using high frequency sampling. A digital filter removes several unwanted properties, then the signal is resampled to produce the required resolution digital output. These samples are passed through a serial interface module which outputs data on the serial sample data bus.

The calibration coefficients are stored in non-volatile memory. These are used by the processor board to correct for any amplitude or phase errors introduced by the transformers and analogue circuitry.

Opto-isolated inputs

The other function of the input board is to read in the digital inputs. As with the analogue inputs, the digital inputs must be electrically isolated from the power system. This is achieved by means of the 8 on-board optical isolators for connection of up to 8 digital signals. The digital signals are passed through an optional noise filter before being buffered and presented to the unit's processing boards in the form of a parallel data bus.

This selectable filtering allows the use of a pre-set filter of ½ cycle which renders the input immune to induced power-system noise on the wiring. Although this method is secure it can be slow, particularly for inter-tripping. This can be improved by switching off the ½ cycle filter in which case one of the following methods to reduce ac noise should be considered.

- Use double pole switching on the input
- Use screened twisted cable on the input circuit.

The opto-isolated logic inputs can be programmed for the nominal battery voltage of the circuit for which they are a part, allowing different voltages for different circuits such as signalling and tripping. They can also be programmed to 60% - 80% or 50% - 70% pickup to dropoff ratio of the nominal battery voltage in order to satisfy different operating constraints.

The threshold levels are as follows:

Nominal Battery voltage	Logic levels: 60-80% DO/PU	Logic Levels: 50-70% DO/PU
24/27 V	Logic 0 < 16.2 V : Logic 1 > 19.2 V	Logic 0 <12.0 V : Logic 1 > 16.8
30/34	Logic 0 < 20.4 V : Logic 1 > 24.0 V	Logic 0 < 15.0 V : Logic 1 > 21.0 V
48/54	Logic 0 < 32.4 V : Logic 1 > 38.4 V	Logic 0 < 24.0 V : Logic 1 > 33.6 V
110/125	Logic 0 < 75.0 V : Logic 1 > 88.0 V	Logic 0 < 55.0 V : Logic 1 > 77.0 V
220/250	Logic 0 < 150 V : Logic 1 > 176.0 V	Logic 0 < 110 V : Logic 1 > 154.0 V

The 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.

Note:
The opto-input circuitry can be provided without the A/D circuitry as a separate board, which can provide supplementary opto-inputs.

6.6.2 TRANSFORMER BOARD

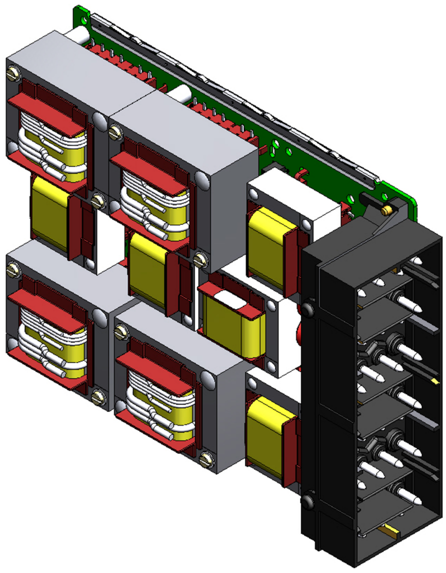

R00237

Figure 17: Instrument Transformer board

The transformer board hosts the current and voltage transformers, which are used to step down the currents and voltages originating from the power systems' current and voltage transformers to levels, which can be used by the unit's electronic circuitry. In addition to this, the on-board CT and VT transformers provide electrical isolation between the unit and the power system.

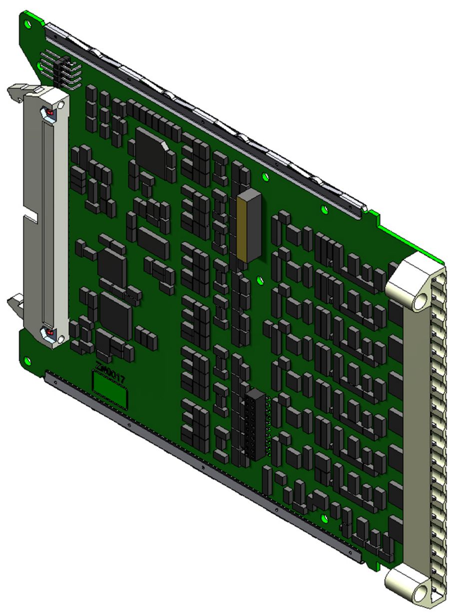
The transformer board is connected physically and electrically to the input board to form a complete input module.

The terminal numbers are as follows:

Terminal Number	Analogue Input Signal
Terminal 1	VT1, T1
Terminal 2	VT1, T2
Terminal 3	VT2, T3
Terminal 4	VT2, T4
Terminal 5	
Terminal 6	
Terminal 7	
Terminal 8	
Terminal 9	
Terminal 10	
Terminal 11	CT1
Terminal 12	CT1
Terminal 13	CT2
Terminal 14	CT2
Terminal 15	CT3

Terminal Number	Analogue Input Signal
Terminal 16	CT3
Terminal 17	CT4
Terminal 18	CT4
Terminal 19	CT5
Terminal 20	CT5
Terminal 21	CT6
Terminal 22	CT6
Terminal 23	CT7
Terminal 24	CT7
Terminal 25	CT8
Terminal 26	CT8
Terminal 27	CT9
Terminal 28	CT9

6.6.3 MAIN INPUT BOARD



R00238

Figure 18: Main input board

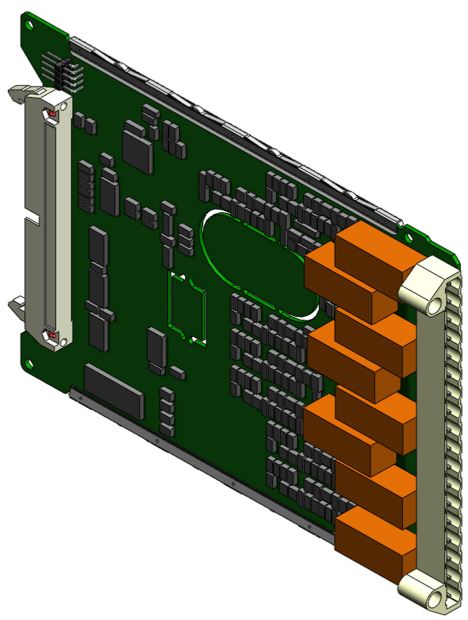
The input board is used to convert the analogue signals delivered by the current and voltage transformers into digital quantities used by the IED. This input board also has on-board opto-input circuitry, providing eight optically-isolated digital inputs and associated noise filtering and buffering. These opto-inputs are presented to the user by means of a MD terminal block, which sits adjacent to the analogue inputs terminal block.

The input board is connected physically and electrically to the transformer board to form a complete input module.

The main input board can come in several different variants depending on the exact model. The terminal numbers of the opto-inputs are as follows:

Terminal Number	Opto-input
Terminal 1	Opto 1 -ve
Terminal 2	Opto 1 +ve
Terminal 3	Opto 2 -ve
Terminal 4	Opto 2 +ve
Terminal 5	Opto 3 -ve
Terminal 6	Opto 3 +ve
Terminal 7	Opto 4 -ve
Terminal 8	Opto 4 +ve
Terminal 9	Opto 5 -ve
Terminal 10	Opto 5 +ve
Terminal 11	Opto 6 -ve
Terminal 12	Opto 6 +ve
Terminal 13	Opto 7 –ve
Terminal 14	Opto 7 +ve
Terminal 15	Opto 8 –ve
Terminal 16	Opto 8 +ve
Terminal 17	Common
Terminal 18	Common

6.7 STANDARD OUTPUT RELAY BOARD



R00234

Figure 19: Output relay board - 8 contacts

This output relay board has 8 relays with 6 Normally Open contacts and 2 Changeover contacts.

The output relays can drive any circuit requiring logical inputs such as circuit breakers, blocking signals, and PSL schemes.

The output relay board can be provided together with the power supply board as a complete assembly, or independently for the purposes of relay output expansion.

In the above figure, you can see the two cut-out locations in the board. These can be removed to allow power supply components to protrude when coupling the output relay board to the power supply board. If the output relay board is to be used independently, these cut-out locations remain intact.

The terminal numbers are as follows:

Terminal Number	Output Relay
Terminal 1	Relay 1 NO
Terminal 2	Relay 1 NO
Terminal 3	Relay 2 NO
Terminal 4	Relay 2 NO
Terminal 5	Relay 3 NO
Terminal 6	Relay 3 NO
Terminal 7	Relay 4 NO
Terminal 8	Relay 4 NO
Terminal 9	Relay 5 NO
Terminal 10	Relay 5 NO
Terminal 11	Relay 6 NO
Terminal 12	Relay 6 NO
Terminal 13	Relay 7 changeover
Terminal 14	Relay 7 common
Terminal 15	Relay 7 changeover
Terminal 16	Relay 8 changeover
Terminal 17	Relay 8 common
Terminal 18	Relay 8 changeover

6.8 IRIG-B BOARD

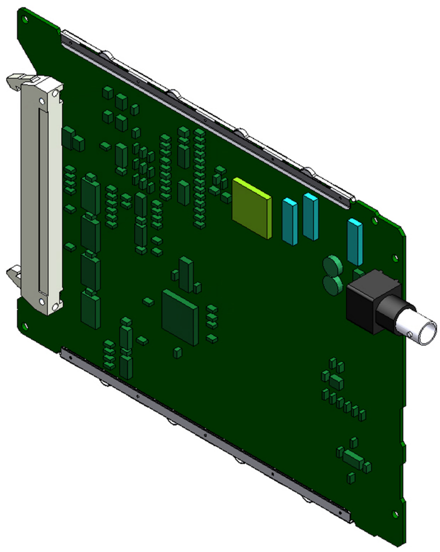


Figure 20: IRIG-B board

The IRIG-B board can be fitted to provide an accurate timing reference for the device. The IRIG-B signal is connected to the board via a BNC connector. The timing information is used to synchronise the IED's internal real-time clock to an accuracy of 1 ms. The internal clock is then used for time tagging events, fault maintenance and disturbance records.

IRIG-B interface is available in modulated or demodulated formats.

Due to slot limitations the IRIG-B facility is also provided in combination with other functionality on a number of additional boards, such as:

- Fibre board with IRIG-B
- Second rear communications board with IRIG-B
- Ethernet board with IRIG-B
- Redundant Ethernet board with IRIG-B

Each of these boards is also available with either modulated or demodulated IRIG-B.

6.9 FIBRE OPTIC BOARD

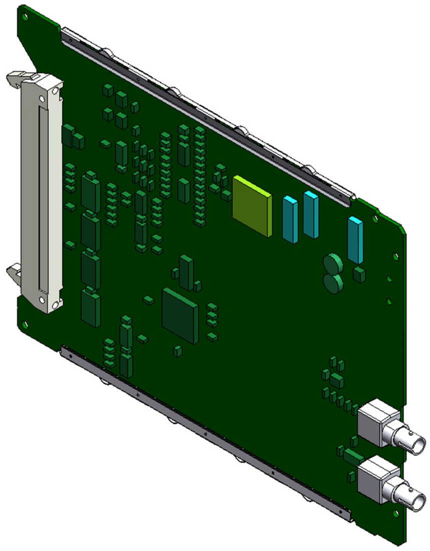


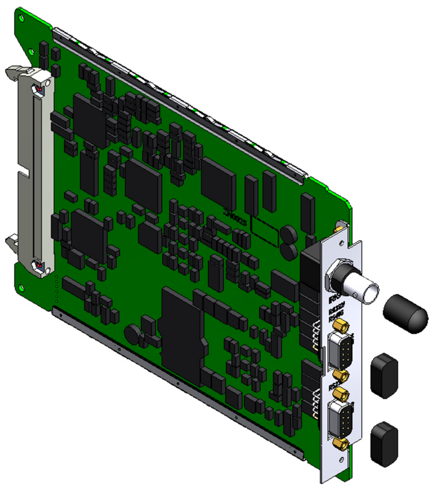
Figure 21: Fibre optic board

This board provides an interface for communicating with a master station. This communication link can use all compatible protocols (Courier, IEC 60870-5-103, MODBUS and DNP 3.0). It is a fibre-optic alternative to the metallic RS485 port presented on the power supply terminal block, and as such is mutually exclusive with it.

It uses BFOC 2.5 ST connectors

The board comes in two varieties; one with an IRIG-B input and one without:

6.10 REAR COMMUNICATION BOARD



R00243

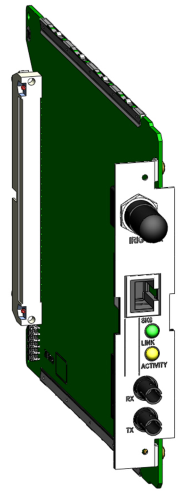
Figure 22: Rear communication board

The optional communications board containing the secondary communication ports provide two serial interfaces presented on 9 pin D-type connectors. These interfaces are known as SK4 and SK5.

SK4 can be used with RS232, RS485 and K-bus. SK5 can only be used with RS232 and is used for InterMiCOM communication.

The second rear communications board and IRIG-B board are mutually exclusive since they use the same hardware slot. The board comes in two varieties; one with an IRIG-B input and one without.

6.11 ETHERNET BOARD



R00241

Figure 23: Ethernet board

This is a communications board that provides a standard 100-Base Ethernet interface. This board supports one electrical copper connection and one fibre-pair connection.

There are several variants for this product as follows:

- 100 MHz Ethernet board
- 100 MHz Ethernet with on-board modulated IRIG-B input
- 100 MHz Ethernet with on-board demodulated IRIG-B input
- 10 MHz Ethernet board

Two of the variants provide an IRIG-B interface. IRIG-B provides a timing reference for the unit – one board for modulated IRIG-B and one for demodulated. The IRIG B signal is connected to the board with a BNC connector.

6.12 REDUNDANT ETHERNET BOARD

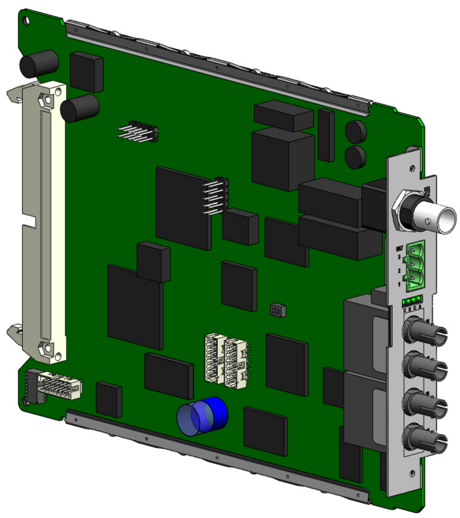


Figure 24: Redundant Ethernet board

This board provides dual redundant Ethernet (supported by two fibre pairs) together with an IRIG-B interface for timing.

We supply different board variants depending on the redundancy protocol and the type of IRIG-B signal (demodulated or modulated). The available redundancy protocols are:

- SHP (Self healing Protocol)
- RSTP (Rapid Spanning Tree Protocol)
- DHP (Dual Homing Protocol)
- PRP (Parallel Redundancy Protocol)

The variants for this product are as follows:

- 100 MHz redundant Ethernet running RSTP, with on-board modulated IRIG-B
- 100 MHz redundant Ethernet running RSTP, with on-board demodulated IRIG-B
- 100 MHz redundant Ethernet running SHP, with on-board modulated IRIG-B
- 100 MHz redundant Ethernet running SHP, with on-board demodulated IRIG-B
- 100 MHz redundant Ethernet running DHP, with on-board modulated IRIG-B
- 100 MHz redundant Ethernet running DHP, with on-board demodulated IRIG-B
- 100 MHz redundant Ethernet running PRP, with on-board modulated IRIG-B
- 100 MHz redundant Ethernet running PRP, with on-board demodulated IRIG-B

CONFIGURATION

CHAPTER 4

1 CHAPTER OVERVIEW

Each product has different configuration parameters according to the functions it has been designed to perform. There is, however, a common methodology used across the entire product series to set these parameters.

This chapter describes an overview of this common methodology, as well as providing concise instructions of how to configure the device.

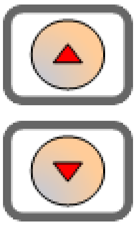
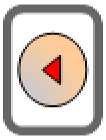
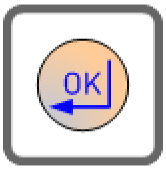
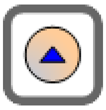
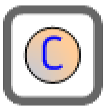
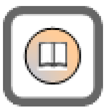
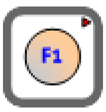
This chapter contains the following sections:

2 USING THE HMI PANEL

Using the HMI, you can:

- Display and modify settings
- View the digital I/O signal status
- Display measurements
- Display fault records
- Reset fault and alarm indications

The keypad provides full access to the device functionality using a range of menu options. The information is displayed on the LCD.

Keys	Description	Function
	Up and down cursor keys	To change the menu level or change between settings in a particular column, or changing values within a cell
	Left and right cursor keys	To change default display, change between column headings, or changing values within a cell
	ENTER key	For changing and executing settings
	Hotkeys	For executing commands and settings for which shortcuts have been defined
	Cancel key	To return to column header from any menu cell
	Read key	To read alarm messages
	Function keys (not for 20TE devices)	For executing user programmable functions

Note:
As the LCD display has a resolution of 16 characters by 3 lines, some of the information is in a condensed mnemonic form.

2.1 NAVIGATING THE HMI PANEL

The cursor keys are used to navigate the menus. These keys have an auto-repeat function if held down continuously. This can be used to speed up both setting value changes and menu navigation. The longer the key is held pressed, the faster the rate of change or movement.

The navigation map below shows how to navigate the menu items.

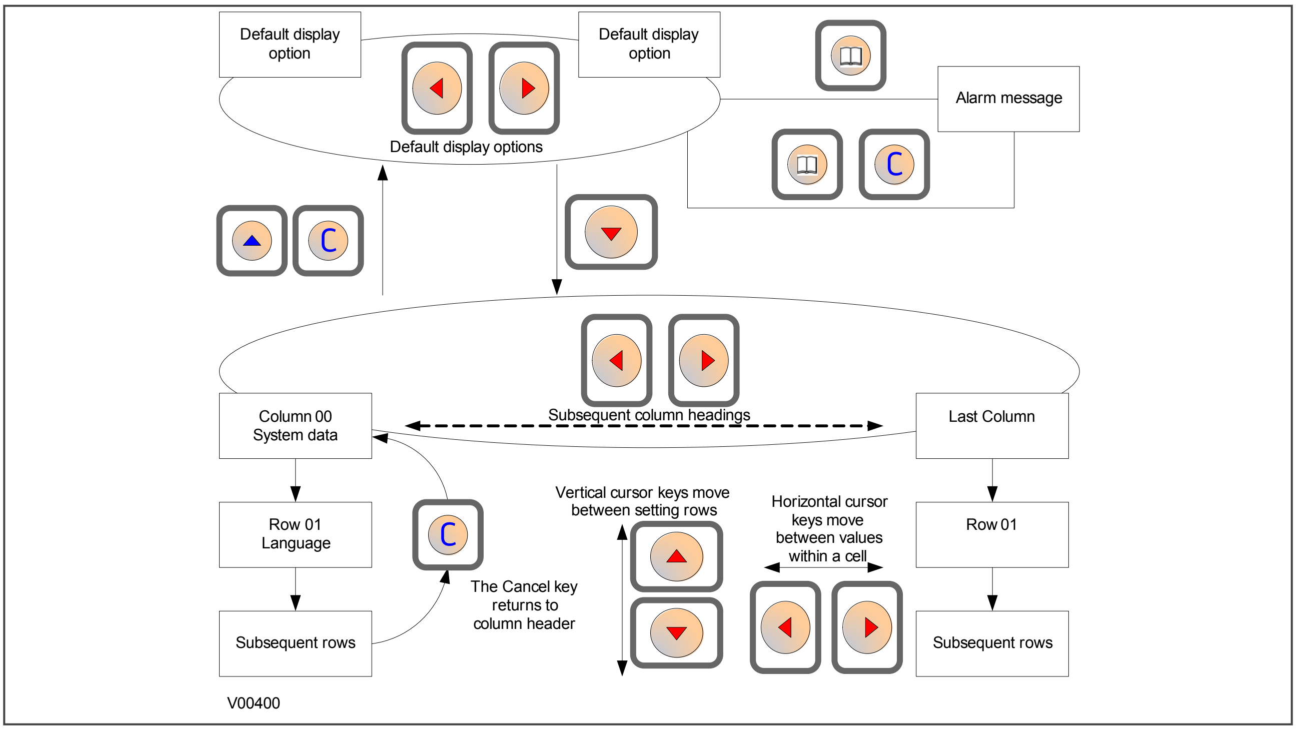


Figure 25: Menu navigation

2.2 GETTING STARTED

When you first start the IED, it will go through its power up procedure. After a few seconds it will settle down into one of the top level menus. There are two menus at this level:

- The Alarms menu for when there are alarms present
- The default display menu for when there are no alarms present.

If there are alarms present, the yellow Alarms LED will be flashing and the menu display will read as follows:

```
Alarms / Faults
Present
HOTKEY
```

Even though the device itself should be in full working order when you first start it, an alarm could still be present, for example, if there is no network connection for a device fitted with a network card. If this is the case, you can read the alarm by pressing the 'Read' key.

```
ALARMS
NIC Link Fail
```

If the device is fitted with an Ethernet card (not applicable to 20TE IEDs), the only way you will be able to completely clear this alarm will be by connecting the device into an Ethernet network. This is also the only way you will be able to get into the default display menu.

If there are other alarms present, these must also be cleared before you can get into the default display menu options.

2.3 DEFAULT DISPLAY

The default display menu contains a range of possible options that you can choose to be the default display. The options available are:

NERC Compliant banner

The IED is delivered with a NERC-compliant default display:

```
ACCESS ONLY FOR
AUTHORISED USERS
HOTKEY
```

Date and time

For example:

```
11:09:15
23 Nov 2011
HOTKEY
```

Description (user-defined)

For example:

```
Description
MiCOM P14NB
HOTKEY
```

Plant reference (user-defined)

For example:

```
Plant Reference
MiCOM
HOTKEY
```

Access Level

For example:

```
Access Level
3
HOTKEY
```

In addition to the above, there are also displays for the system voltages, currents, power and frequency etc., depending on the device model.

2.4 DEFAULT DISPLAY NAVIGATION

The default display navigation is best represented diagrammatically.

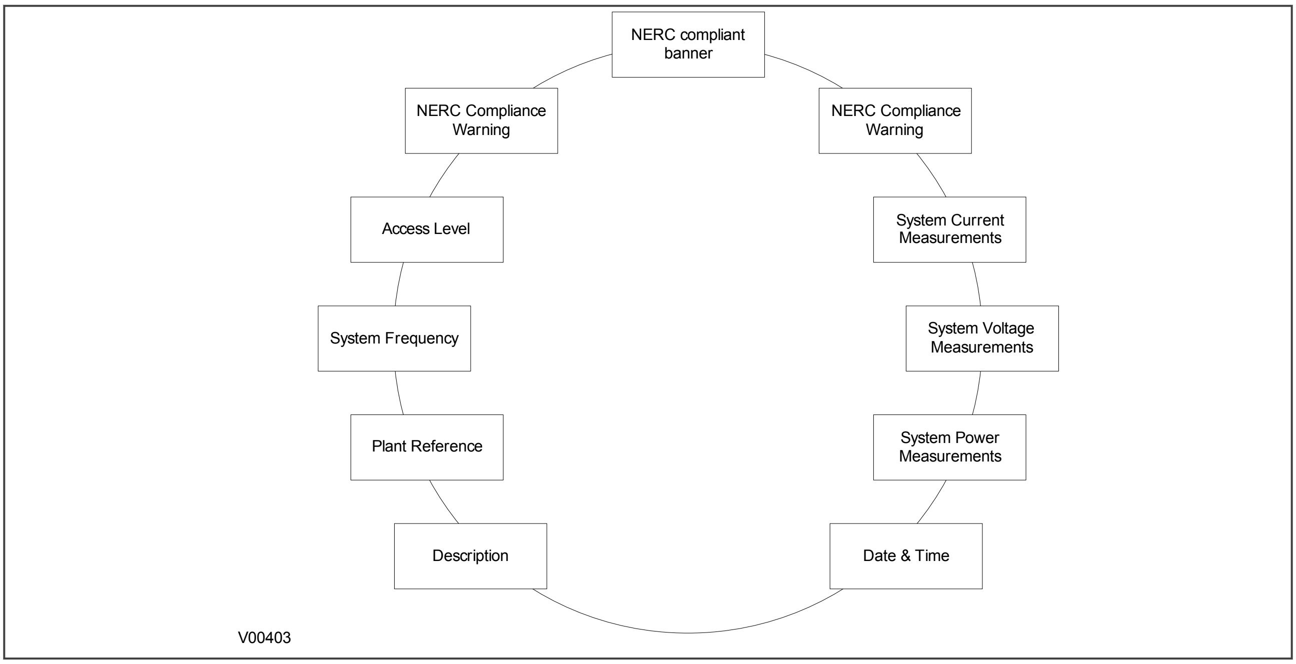


Figure 26: Default display navigation

If the device is not yet configured for NERC compliance (see Cyber-security chapter), a warning will appear when moving from the "NERC compliant" banner. The warning message is as follows:

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

You will have to confirm with the **Enter** button before you can go any further.

> *Note:*
> *Whenever the IED has an uncleared alarm the default display is replaced by the text Alarms/ Faults present. You cannot override this default display. However, you can enter the menu structure from the default display, even if the display shows the Alarms/Faults present message.*

2.5 PASSWORD ENTRY

Configuring the default display (in addition to modification of other settings) requires level 3 access. You will be prompted for a password before you can make any changes, as follows. The default level 3 password is AAAA.

```
Enter Password
```

1. A flashing cursor shows which character field of the password can be changed. Press the up or down cursor keys to change each character (tip: pressing the up arrow once will return an upper case "A" as required by the default level 3 password).
2. Use the left and right cursor keys to move between the character fields of the password.
3. Press the **Enter** keyto confirm the password. If you enter an incorrect password, an invalid password message is displayed then the display reverts to ***Enter password***. On entering a valid password a message appears indicating that the password is correct and which level of access has been unlocked. If this level is sufficient to edit the selected setting, the display returns to the setting page to allow the edit to continue. If the correct level of password has not been entered, the password prompt page appears again.
4. To escape from this prompt press the **Clear** key. Alternatively, enter the password using the ***Password*** setting in the *SYSTEM DATA* column. If the keypad is inactive for 15 minutes, the password protection of the front panel user interface reverts to the default access level.

To manually reset the password protection to the default level, select ***Password***, then press the CLEAR key instead of entering a password.

Note:
In the SECURITY CONFIG column, you can set the maximum number of attemps, the time window in which the failed attempts are counted and the time duration for which the user is blocked.

2.6 PROCESSING ALARMS AND FAULT RECORDS

If there are any alarm messages, they will appear on the default display and the yellow alarm LED flashes. The alarm messages can either be self-resetting or latched. If they are latched, 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 changes 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 cursor keys. 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 the **Clear** key. To return to the display showing alarms or faults present, and leave the alarms uncleared, press the **Read** key.
4. Depending on the password configuration settings, you may need to enter a password before the alarm messages can be cleared.
5. When all alarms are cleared, the yellow alarm LED switches off. If the red LED was on, this will also be switched off.

Note:
*To speed up the procedure, you can enter the alarm viewer using the **Read** key and subsequently pressing the **Clear** key. This goes straight to the fault record display. Press the **Clear** key again to move straight to the alarm reset prompt, then press the **Clear** key again to clear all alarms.*

2.7 MENU STRUCTURE

Settings, commands, records and measurements are stored in a local database inside the IED. When using the Human Machine Interface (HMI) it is convenient to visualise the menu navigation system as a table. Each item in the menu is known as a cell, which is accessed by reference to a column and row address. Each column and row is assigned a 2-digit hexadecimal numbers, resulting in a unique 4-digit cell address for every cell in the database. The main menu groups are allocated columns and the items within the groups are allocated rows, meaning a particular item within a particular group is a cell.

Each column contains all related items, for example all of the disturbance recorder settings and records are in the same column.

There are three types of cell:

- Settings: this is for parameters that can be set to different values
- Commands: this is for commands to be executed
- Data: this is for measurements and records to be viewed, which are not settable

Note:
Sometimes the term "Setting" is used generically to describe all of the three types.

The table below, provides an example of the menu structure:

SYSTEM DATA (Col 00)	VIEW RECORDS (Col 01)	MEASUREMENTS 1 (Col 02)	…
Language (Row 01)	"Select Event [0...n]" (Row 01)	IA Magnitude (Row 01)	…
Password (Row 02)	Menu Cell Ref (Row 02)	IA Phase Angle (Row 02)	…
Sys Fn Links Row 03)	Time & Date (Row 03)	IB Magnitude (Row 03)	…
…	…	…	…

It is convenient to specify all the settings in a single column, detailing the complete Courier address for each setting. The above table may therefore be represented as follows:

Setting	Column	Row	Description
SYSTEM DATA	**00**	**00**	**First Column definition**
Language (Row 01)	00	01	First setting within first column
Password (Row 02)	00	02	Second setting within first column
Sys Fn Links Row 03)	00	03	Third setting within first column
…	…	…	
VIEW RECORDS	**01**	**00**	**Second Column definition**
Select Event [0...n]	01	01	First setting within second column
Menu Cell Ref	01	02	Second setting within second column
Time & Date	01	03	Third setting within second column
…	…	…	
MEASUREMENTS 1	**02**	**00**	**Third Column definition**
IA Magnitude	02	01	First setting within third column

Setting	Column	Row	Description
IA Phase Angle	02	02	Second setting within third column
IB Magnitude	02	03	Third setting within third column
…	…	…	

The first three column headers are common throughout much of the product ranges. However the rows within each of these column headers may differ according to the product type. Many of the column headers are the same for all products within the series. However, there is no guarantee that the addresses will be the same for a particular column header. Therefore you should always refer to the product settings documentation and not make any assumptions.

2.8 CHANGING THE SETTINGS

1. Starting at the default display, press the Down cursor key to show the first column heading.
2. Use the horizontal cursor keys to select the required column heading.
3. Use the vertical cursor keys to view the setting data in the column.
4. To return to the column header, either press the Up cursor key for a second or so, 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 Up cursor key or the **Clear** key from any of the column headings. If you use the auto-repeat function of the Up cursor 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. 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 that the value can be changed. You may be prompted for a password first.
7. To change the setting value, press the Up and Down cursor 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 Left and Right cursor keys.
8. Press the **Enter** key to confirm the new setting value or the **Clear** key to discard it. The new setting is automatically discarded if it is not confirmed within 15 seconds.
9. For protection group settings and disturbance recorder settings, the changes must be confirmed before they are used. When all required changes have been entered, return to the column heading level and press the Down cursor key. Before returning to the default display, the following prompt appears.

```
Update settings?
ENTER or CLEAR
```

10. Press the **Enter** key to accept the new settings or press the **Clear** key 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.*

2.9 DIRECT ACCESS (THE HOTKEY MENU)

It can be quite a long process to configure settings using the HMI panel, especially for settings and commands that need to be executed quickly or on a regular basis. The IED provides a pair of keys directly below the LCD display, which can be used to execute specified settings and commands directly.

The functions available for direct access using these keys are:

- Setting group selection
- Control Inputs
- CB Control functions

The availability of these functions is controlled by the ***Direct Access*** cell in the *CONFIGURATION* column. There are four options: `Disabled`, `Enabled`, `CB Ctrl only` and `Hotkey only`.

For the Setting Group selection and Control inputs, this cell must be set to either `Enabled` or `Hotkey only`. For CB Control functions, the cell must be set to `Enabled` or `CB Ctrl only`.

2.9.1 SETTING GROUP SELECTION

By default, only Setting group 1 is enabled. Other setting groups will only be available if they are first enabled. To be able to select a different setting group, you must first enable them in the *CONFIGURATION* column.

To access the hotkey menu from the default display, you press the key directly below the HOTKEY text on the LCD. The following screen will appear.

```
←User32 STG GP→
HOTKEY MENU
              EXIT
```

Use the right cursor keys to enter the *SETTING GROUP* menu.

```
←Menu User01→
SETTING GROUP 1
Nxt Grp Select
```

Select the setting group with ***Nxt Grp*** and confirm by pressing ***Select***. If neither of the cursor keys is pressed within 20 seconds of entering a hotkey sub menu, the device reverts to the default display.

2.9.2 CONTROL INPUTS

The control inputs are user-assignable functions. You can use the *CTRL I/P CONFIG* column to configure the control inputs for the hotkey menu. In order to do this, use the first setting ***Hotkey Enabled*** cell to enable or disable any of the 32 control inputs. You can then set each control input to latched or pulsed and set its command to `On/Off`, `Set/Reset`, `In/Out`, or `Enabled/Disabled`.

By default, the hotkey is enabled for all 32 control inputs and they are set to `Set/Reset` and are `Latched`.

To access the hotkey menu from the default display, you press the key directly below the HOTKEY text on the LCD. The following screen will appear.

```
←User32 STG GP→
HOTKEY MENU
              EXIT
```

Press the right cursor key twice to get to the first control input, or the left cursor key to get to the last control input.

```
←STP GP User02→
Control Input 1
EXIT SET
```

Now you can execute the chosen function (Set/Reset in this case).

If neither of the cursor keys is pressed within 20 seconds of entering a hotkey sub menu, the device reverts to the default display.

2.9.3 CIRCUIT BREAKER CONTROL

You can open and close the controlled circuit breaker with the direct access key to the right, if enabled as described above. By default direct access to the circuit breakers is disabled.

If direct access to the circuit breakers has been enabled, the bottom right hand part of the display will read "Open or Close" depending on whether the circuit breaker is closed or open respectively:

For example:

```
Plant Reference
MiCOM
HOTKEY  CLOSE
```

To close the circuit breaker (in this case), press the key directly below CLOSE. You will be given an option to cancel or confirm.

```
Execute
CB CLOSE
Cancel Confirm
```

More detailed information on CB Control can be found in the CB Control section in the Monitoring and Control chapter.

2.10 FUNCTION KEYS

With the exception of products housed in 20TE cases, the products have a number of function keys for programming control functionality using the programmable scheme logic (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 are in the *FUNCTION KEYS* column.

The first cell down in the *FUNCTION KEYS* column is the ***Fn Key Status*** cell. This contains a 10 bit word, which represents the 10 function key commands. Their status can be read from this 10 bit word.

```
FUNCTION KEYS
Fn Key Status
0000000000
```

The next cell down (***Fn Key 1***) allows you to activate or disable the first function key (1). The ***Lock*** setting allows a function key to be locked. This allows function keys that are set to `Toggled` mode and their DDB signal active ‘high’, to be locked in their active state, 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.

```
FUNCTION KEYS
Fn Key 1
Unlocked
```

The next cell down (***Fn Key 1 Mode***) allows you to set the function key to `Normal` or `Toggled`. In the Toggle mode the function key DDB signal output stays 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 stays energised for as long as the function key is pressed then resets automatically. If required, a minimum pulse width can be programmed by adding a minimum pulse timer to the function key DDB output signal.

```
FUNCTION KEYS
Fn Key 1 Mode
Toggled
```

The next cell down (***Fn Key 1 Label***) allows you to change the label of the function. The default label is `Function key 1` in this case. To change the label you need to press the enter key and then change the text on the bottom line, character by character. This text is displayed when a function key is accessed in the function key menu, or it can be displayed in the PSL.

```
FUNCTION KEYS
Fn Key 1 Label
Function Key 1
```

Subsequent cells allow you to carry out the same procedure as above for the other function keys.

The status of the function keys is stored in non-volatile memory. If the auxiliary supply is interrupted, the status of all the function keys is restored. The IED only recognises a single function key press at a time and a minimum key press duration of approximately 200 ms is required before the key press is recognised in PSL. This feature avoids accidental double presses.

3 CONFIGURING THE DATA PROTOCOLS

Different protocols can be used with the various ports. The choice of protocol depends on the chosen model. Only one data protocol can be configured at any one time on any one IED. The range of available communication settings depend on which protocol has been chosen.

Depending on the exact model, the following choices may be available:

- Courier
- Tunneled Courier over Ethernet
- MODBUS
- DNP3
- DNP3 Over Ethernet
- IEC 60870-5-103
- IEC61850

> *Note:*
> *Not all protocols are available on all products*

You can configure the settings using the settings application software or the HMI. This section describes how to configure the device using the HMI.

3.1 COURIER CONFIGURATION

To configure the device:

1. Select the *CONFIGURATION* column and check that the ***Comms settings*** cell is set to `Visible`.
2. Select the *COMMUNICATIONS* column.
3. Move to the first cell down (***RP1 protocol***). This is a non-settable cell, which shows the chosen communication protocol – in this case `Courier`.

```
COMMUNICATIONS
RP1 Protocol
Courier
```

4. Move down to the next cell (***RP1 Address***). This cell controls the address of the IED. Up to 32 IEDs can be connected to one spur. It is therefore necessary for each IED to have a unique address so that messages from the master control station are accepted by one IED only. Courier uses an integer number between 1 and 254 for the Relay Address. It is set to 255 by default, which has to be changed. It is important that no two IEDs share the same address.

```
COMMUNICATIONS
RP1 Address
100
```

5. Move down to the next cell (***RP1 InactivTimer***). This cell controls the inactivity timer. The inactivity timer controls how long the IED 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.

```
COMMUNICATIONS
RP1 Inactivtimer
10.00 mins.
```

6. If the optional fibre optic connectors are fitted, the ***RP1 PhysicalLink*** cell is visible. This cell controls the physical media used for the communication (Copper or Fibre optic).

```
COMMUNICATIONS
RP1 PhysicalLink
Copper
```

7. Move down to the next cell (***RP1 Card Status***). This cell is not settable. It just displays the status of the chosen physical layer protocol for RP1.

```
COMMUNICATIONS
RP1 Card Status
K-Bus OK
```

8. Move down to the next cell (***RP1 Port Config***). This cell controls the type of serial connection. Select between K-Bus or RS485.

```
COMMUNICATIONS
RP1 Port Config
K-Bus
```

9. If using EIA(RS)485, the next cell (***RP1 Comms Mode***) selects the communication mode. The choice is either IEC 60870 FT1.2 for normal operation with 11-bit modems, or 10-bit no parity. If using K-Bus this cell will not appear.

```
COMMUNICATIONS
RP1 Comms Mode
IEC 60870 FT1.2
```

10. If using EIA(RS)485, the next cell down controls the baud rate. Three baud rates are supported; 9600, 19200 and 38400. If using K-Bus this cell will not appear as the baud rate is fixed at 64 kbps.

```
COMMUNICATIONS
RP1 Baud rate
19200
```

> *Note:*
> *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 Agile do not need this action for the setting changes to take effect.*

3.2 DNP3 CONFIGURATION

To configure the device:

1. Select the *CONFIGURATION* column and check that the ***Comms settings*** cell is set to `Visible`.
2. Select the *COMMUNICATIONS* column.
3. Move to the first cell down (***RP1 protocol***). This is a non-settable cell, which shows the chosen communication protocol – in this case `DNP3.0`.

```
COMMUNICATIONS
RP1 Protocol
DNP3.0
```

4. Move down to the next cell (***RP1 Address***). This cell controls the DNP3.0 address of the IED. Up to 32 IEDs can be connected to one spur, therefore it is necessary for each IED to have a unique address so that messages from the master control station are accepted by only one IED. DNP3.0 uses a decimal number between 1 and 65519 for the Relay Address. It is important that no two IEDs have the same address.

```
COMMUNICATIONS
RP1 Address
1
```

5. Move down to the next cell (***RP1 Baud Rate***). This cell controls the baud rate to be used. Six baud rates are supported by the IED 1200 bps, 2400 bps, 4800 bps, 9600 bps, 19200 bps and 38400 bps. Make sure that the baud rate selected on the IED is the same as that set on the master station.

```
COMMUNICATIONS
RP1 Baud rate
9600 bits/s
```

6. Move down to the next cell (***RP1 Parity***). This cell controls the parity format used in the data frames. The parity can be set to be one of `None`, `Odd` or `Even`. Make sure that the parity format selected on the IED is the same as that set on the master station.

```
COMMUNICATIONS
RP1 Parity
None
```

7. If the optional fibre optic connectors are fitted, the ***RP1 PhysicalLink*** cell is visible. This cell controls the physical media used for the communication (Copper or Fibre optic).

```
COMMUNICATIONS
RP1 PhysicalLink
Copper
```

8. Move down to the next cell (***RP1 Time Sync***). This cell sets the time synchronisation request from the master by the IED. It can be set to `enabled` or `disabled`. If enabled it allows the DNP3.0 master to synchronise the time.

```
COMMUNICATIONS
RP1 Time Sync
Enabled
```

3.2.1 DNP3 CONFIGURATOR

A PC support package for DNP3.0 is available as part of the supplied settings application software (MiCOM S1 Agile) to allow configuration of the device's DNP3.0 response. The configuration data is uploaded from the device to the PC in a block of compressed format data and downloaded in a similar manner after modification. The new DNP3.0 configuration takes effect after the download is complete. To restore the default configuration at any time, from the *CONFIGURATION* column, select the ***Restore Defaults*** cell then select `All Settings`.

In MiCOM S1 Agile, the DNP3.0 data is shown in three main folders, one folder each for the point configuration, integer scaling and default variation (data format). The point configuration also includes screens for binary inputs, binary outputs, counters and analogue input configuration.

3.3 IEC 60870-5-103 CONFIGURATION

To configure the device:

1. Select the *CONFIGURATION* column and check that the ***Comms settings*** cell is set to `Visible`.
2. Select the *COMMUNICATIONS* column.
3. Move to the first cell down (***RP1 protocol***). This is a non-settable cell, which shows the chosen communication protocol – in this case `IEC 60870-5-103`.

```
COMMUNICATIONS
RP1 Protocol
IEC 60870-5-103
```

4. Move down to the next cell (***RP1 Address***). This cell controls the IEC 60870-5-103 address of the IED. Up to 32 IEDs can be connected to one spur. It is therefore necessary for each IED to have a unique address so that messages from the master control station are accepted by one IED only. IEC 60870-5-103 uses an integer number between 0 and 254 for the Relay Address. It is important that no two IEDs have the same IEC 60870 5 103 address. The IEC 60870-5-103 address is then used by the master station to communicate with the IED.

```
COMMUNICATIONS
RP1 address
162
```

5. Move down to the next cell (***RP1 Baud Rate***). This cell controls the baud rate to be used. Two baud rates are supported by the IED, *9600 bits/s* and *19200 bits/s*. Make sure that the baud rate selected on the IED is the same as that set on the master station.

```
COMMUNICATIONS
RP1 Baud rate
9600 bits/s
```

6. Move down to the next cell (***RP1 Meas. period***). The next cell down controls the period between IEC 60870-5-103 measurements. The IEC 60870-5-103 protocol allows the IED to supply measurements at regular intervals. The interval between measurements is controlled by this cell, and can be set between 1 and 60 seconds.

```
COMMUNICATIONS
RP1 Meas. Period
30.00 s
```

7. If the optional fibre optic connectors are fitted, the ***RP1 PhysicalLink*** cell is visible. This cell controls the physical media used for the communication (Copper or Fibre optic).

```
COMMUNICATIONS
RP1 PhysicalLink
Copper
```

8. The next cell down (***RP1 CS103Blcking***) can be used for monitor or command blocking.

```
COMMUNICATIONS
RP1 CS103Blcking
Disabled
```

9. There are three settings associated with this cell; these are:

Setting:	Description:
Disabled	No blocking selected.
Monitor Blocking	When the monitor blocking DDB Signal is active high, either by energising an opto input or control input, reading of the status information and disturbance records is not permitted. When in this mode the device returns a "Termination of general interrogation" message to the master station.

Setting:	Description:
Command Blocking	When the command blocking DDB signal is active high, either by energising 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 device returns a "negative acknowledgement of command" message to the master station.

3.4 MODBUS CONFIGURATION

To configure the device:

1. Select the *CONFIGURATION* column and check that the ***Comms settings*** cell is set to `Visible`.
2. Select the *COMMUNICATIONS* column.
3. Move to the first cell down (***RP1 protocol***). This is a non settable cell, which shows the chosen communication protocol – in this case `Modbus`.

```
COMMUNICATIONS
RP1 Protocol
Modbus
```

4. Move down to the next cell (***RP1 Address***). This cell controls the Modbus address of the IED. Up to 32 IEDs can be connected to one spur, therefore it is necessary for each IED to have a unique address so that messages from the master control station are accepted by only one IED. Modbus uses a decimal number between 1 and 247 for the Relay Address. It is important that no two IEDs have the same address.

```
COMMUNICATIONS
RP1 Address
1
```

5. Move down to the next cell (***RP1 InactivTimer***). This cell controls the inactivity timer. The inactivity timer controls how long the IED 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.

```
COMMUNICATIONS
RP1 Inactivtimer
10.00 mins
```

6. Move down to the next cell (***RP1 Baud Rate***). This cell controls the baud rate to be used. Six baud rates are supported by the IED 1200 bits/s, 2400 bits/s, 4800 bits/s, 9600 bits/s, 19200 bits/s and 38400 bits/s. Make sure that the baud rate selected on the IED is the same as that set on the master station.

```
COMMUNICATIONS
RP1 Baud rate
9600 bits/s
```

7. Move down to the next cell (***RP1 Parity***). This cell controls the parity format used in the data frames. The parity can be set to be one of `None`, `Odd` or `Even`. Make sure that the parity format selected on the IED is the same as that set on the master station.

```
COMMUNICATIONS
RP1 Parity
None
```

8. Move down to the next cell (***Modbus IEC Time***). This cell controls the order in which the bytes of information are transmitted. There is a choice of Standard or Reverse. When `Standard` is selected the time format complies with IEC 60870-5-4 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.

```
COMMUNICATIONS
Modbus IEC Time
Standard
```

3.5 IEC 61850 CONFIGURATION

You cannot configure the device for IEC 61850 using the HMI panel on the product. For this you must use the IEC 61850 Configurator, which is part of the settings application software.

IEC 61850 allows IEDs to be directly configured from a configuration file. The IED's system configuration capabilities are determined from an IED Capability Description file (ICD), supplied with the product. By using ICD files from the products to be installed, you can design, configure and test (using simulation tools), a substation's entire protection scheme before the products are installed into the substation.

To help with this process, the settings application software provides an IEC 61850 Configurator tool, which allows the pre-configured IEC 61850 configuration file to be imported and transferred to the IED. As well as this, you can manually create configuration files for all products, based on their original IED capability description (ICD file).

Other features include:

- The extraction of configuration data for viewing and editing.
- A sophisticated error checking sequence to validate the configuration data before sending to the IED.

> *Note:*
> *Some configuration data is available in the IEC61850 CONFIG. column, allowing read-only access to basic configuration data.*

3.5.1 IEC 61850 CONFIGURATION BANKS

To help version management and minimise down-time during system upgrades and maintenance, the device has incorporated a mechanism consisting of multiple configuration banks. These configuration banks fall into two categories:

- Active Configuration Bank
- Inactive Configuration Bank

Any new configuration sent to the IED is automatically stored in the inactive configuration bank, therefore not immediately affecting the current configuration.

When the upgrade or maintenance stage is complete, the IEC 61850 Configurator tool can be used to transmit a command, which authorises activation of the new configuration contained in the inactive configuration bank. This is done by switching the active and inactive configuration banks. The capability of switching the configuration banks is also available using the *IEC61850 CONFIG.* column of the HMI.

The SCL Name and Revision attributes of both configuration banks are also available in the *IEC61850 CONFIG.* column of the HMI.

3.5.2 IEC 61850 NETWORK CONNECTIVITY

Configuration of the IP parameters and SNTP (Simple Network Time Protocol) time synchronisation parameters is performed by the IEC 61850 Configurator tool. If these parameters are not available using an SCL (Substation Configuration Language) file, they must be configured manually.

Every IP address on the Local Area Network must be unique. Duplicate IP addresses result in conflict and must be avoided. Most IEDs check for a conflict on every IP configuration change and at power up and they raise an alarm if an IP conflict is detected.

The IED can be configured to accept data from other networks using the ***Gateway*** setting. If multiple networks are used, the IP addresses must be unique across networks.

4 DATE AND TIME CONFIGURATION

The Date and Time setting will normally be updated automatically by the chosen UTC (Universal Time Co-ordination) time synchronisation mechanism when the device is in service. This does not mean that you should dispense with configuring the date and time parameters during commissioning. It is desirable to have the correct date and time represented for the commissioning process, therefore this should be the first item to configure during the commissioning process.

The date and time is set in the ***Date/Time*** cell in the *DATE AND TIME* column.

4.1 TIME ZONE COMPENSATION

The UTC time standard uses Greenwich Mean Time as its standard. Without compensation, this would be the date and time that would be displayed on the device irrespective of its location.

It is obviously desirable for the device to display the local time corresponding to its geographical location. For this reason, it is possible to compensate for any difference between the local time and the UTC time. This is achieved with the settings ***LocalTime Enable*** and ***LocalTime Offset***.

The ***LocalTime Enable*** has three setting options; *Disabled*, *Fixed*, and *Flexible*.

With *Disabled*, no local time zone is maintained. Time synchronisation from any interface will be used to directly set the master clock. All times displayed on all interfaces will be based on the master clock with no adjustment.

With *Fixed*, a local time zone adjustment is defined using the ***LocalTime Offset*** setting and all non-IEC 61850 interfaces (which uses SNTP) are compensated to display the local time.

With *Flexible*, a local time zone adjustment is defined using the ***LocalTime Offset*** setting and the non-local and non-IEC 61850 interfaces can be set to either the UTC zone or the local time zone. The local interfaces are always set to the local time zone and the Ethernet interface is always set to the UTC zone.

The interfaces where you can select between UTC and Local Time are the serial interfaces RP1, RP2, DNP over Ethernet (if applicable) and Tunnelled Courier (if applicable). This is achieved by means of the following settings:

- RP1 Time Zone
- RP2 Time Zone
- DNPOE Time Zone
- Tunnel Time Zone

The ***LocalTime Offset*** setting allows you to enter the local time zone compensation from -12 to + 12 hours at 15 minute intervals.

4.2 DAYLIGHT SAVING TIME COMPENSATION

It is possible to compensate for Daylight Saving time using the following settings

- DST Enable
- DST Offset
- DST Start
- DST Start Day
- DST Start Month
- DST Start Mins
- DST End

- DST End Day
- DST End Month
- DST End Mins

These settings are described in the *DATE AND TIME* settings table in the configuration chapter.

5 CONFIGURATION SETTINGS

5.1 SYSTEM DATA

Courier Text	Col	Row	Default Setting	Available Options
Description				
SYSTEM DATA	00	00		
This column contains general system settings and records				
Language	00	01	English	English, French, German, Spanish, Russian or Chinese
This setting defines the default language used by the device for ordering option language = 0, 5 or C				
Password	00	02		ASCII text (characters 33 to 122 inclusive)
This setting defines the plain text password.				
Sys Fn Links	00	03		Bit 0 = Trip led self reset (1 = enable self reset), Bit 1 = Not Used, Bit 2 = Not Used, Bit 3 = Not Used, Bit 4 = Not Used, Bit 5 = Not Used, Bit 6 = Not Used or Bit 7 = Not Used
This setting allows the fixed function trip LED to be self resetting (set to 1 to extinguish the LED after a period of healthy restoration of load current). Only bit 0 is used.				
Description	00	04	MiCOM P	ASCII text
In this cell, you can enter and edit a 16 character IED description.				
Plant Reference	00	05	MiCOM	Extended ASCII text (characters 32 to 234 inclusive)
In this cell, you can enter and edit a 16 character plant description.				
Model Number	00	06	Model Number	<Model number>
This cell displays the IED model number. This cannot be edited.				
Serial Number	00	08	Serial Number	
This cell displays the IED serial number. This cannot be edited				
Frequency	00	09	50	50 Hz, 60 Hz
This cell sets the mains frequency to either 50 Hz or 60 Hz				
Comms Level	00	0A	2	<Conformance level>
This cell displays the Courier communications conformance level				
Relay Address	00	0B	255	0 to 255 (Courier) 0 to 247 (Modbus) 0 to 254 (CS103) 0 to 65534 (DNP3.0)
This cell sets the first rear port IED address. Available settings are dependent on the protocol. This setting can also be made in the COMMUNICATIONS column.				
Plant Status	00	0C		Binary flag (data type G4) Bit 0 = CB 1 52A state (0 = closed 1 = open) Bit 1 = CB 2 52B state (0 = open, 1 = closed)
This cell displays the circuit breaker plant status. The first two bits are used. One to indicate the 52A state and one to indicate the 52B state.				
Control Status	00	0D		Not used
This cell is not used				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Active Group	00	0E		1, 2, 3, 4
This cell displays the active settings group				
Software Ref. 1	00	11		<Software Ref. 1>
This cell displays the IED software version including the protocol and IED model.				
Software Ref 2	00	12		<Software Ref. 2>
This cell displays the software version of the Ethernet card for models equipped with IEC 61850.				
Plant Status2	00	25		
This cell displays the circuit breaker plant status. The first two bits are used. One to indicate the 52A state and one to indicate the 52B state.				
Opto I/P Status	00	30		32 bit binary flag (data type G8): 0 = energised 1 = de-energised
This cell displays the status of the first set of available opto-inputs. This information is also available in the COMMISSIONING TESTS column				
Opto I/P Status2	00	31		32 bit binary flag (data type G8): 0 = energised 1 = de-energised
This cell displays the status of the second set of available opto-inputs. This information is also available in the COMMISSIONING TESTS column				
Relay O/P Status	00	40		32 bit binary flag (data type G9): 0 = operated state 1 = non-operated state
This cell displays the status of the available output relays.				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Alarm Status 1	00	50		0=Unused 1=Unused 2=SG-optoInvalid 3=Prot'nDisabled 4=FoutofRange 5=VTFailAlarm 6=CTFailAlarm 7=CBFailAlarm 8=I^MaintAlarm 9=I^LockoutAlarm 10=CBOpsMaint 11=CBOpsLockout 12=CBOpTimeMaint 13=CBOpTimeLock 14=FaultFreqLock 15=CBStatusAlarm 16=ManCBTripFail 17=CBClsFail 18=ManCBUnhealthy 19=ManNoChecksync 20=ARLockout 21=ARCBUnhealthy 22=ARNoSysCheck 23=SystemSplit 24=UVBlock 25=SRUserAlarm1 26=SRUserAlarm2 27=SRUserAlarm3 28=SRUserAlarm4 29=SRUserAlarm5 30=SRUserAlarm6 31=SRUserAlarm7
This cell displays the status of the first set of 32 alarms as a binary string, including fixed and user settable alarms.				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Alarm Status 2	00	51		0=Unused 1=Unused 2=Unused 3=Unused 4=SR User Alarm 8 5=SR User Alarm 9 6=SR User Alarm 10 7=SR User Alarm 11 8=SR User Alarm 12 9=SR User Alarm 13 10=SR User Alarm 14 11=SR User Alarm 15 12=SR User Alarm 16 13=SR User Alarm 17 14=MR User Alarm 18 15=MR User Alarm 19 16=MR User Alarm 20 17=MR User Alarm 21 18=MR User Alarm 22 19=MR User Alarm 23 20=MR User Alarm 24 21=MR User Alarm 25 22=MR User Alarm 26 23=MR User Alarm 27 24=MR User Alarm 28 25=MR User Alarm 29 26=MR User Alarm 30 27=MR User Alarm 31 28=MR User Alarm 32 29=MR User Alarm 33 30=MR User Alarm 34 31=MR User Alarm 35
This cell displays the status of the second set of 32 alarms as a binary string, including fixed and user settable alarms.				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Alarm Status 3	00	52		0=Battery Fail 1=Field Volt Fail 2=Unused 3=GOOSE IED Absent 4=NIC Not Fitted 5=NIC No Response 6=NIC Fatal Error 7=Unused 8=Unused 9=Unused 10=NIC Link Fail 11=NIC SW Mis-Match 12=IP Addr Conflist 13=Unused 14=Unused 15=Unused 16=Unused 17=Backup Setting 18=Unused 19=Unused 20=Unused 21=Unused 22=Unused 23=Unused 24=Unused 25=Unused 26=Unused 27=Unused 28=Unused 29=Unused 30=Unused 31=Unused
This cell displays the status of the third set of 32 alarms as a binary string, including fixed and user settable alarms.				
Access Level	00	D0		0 = Read Some, 1 = Read All, 2 = Read All + Write Some, 3 = Read All + Write All
This cell displays the current access level.				
Password Level 1	00	D2	(8 spaces)	ASCII text (characters 33 to 122 inclusive)
This setting allows you to change password level 1.				
Password Level 2	00	D3	BBBB	ASCII text (characters 33 to 122 inclusive)
This setting allows you to change password level 2.				
Password Level 3	00	D4	AAAA	ASCII text (characters 33 to 122 inclusive)
This setting allows you to change password level 3.				
Security Features	00	DF	1	<cyber security level>
This setting displays the level of cyber security implemented, 1 = phase 1.				
Password	00	E1		ASCII text (characters 33 to 122 inclusive)
This cell allows you to enter the encrypted password. It is not visible via the user interfaced.				
Password Level 1	00	E2		ASCII text (characters 33 to 122 inclusive)
This setting allows you to change the encrypted password level 1. This is not visible via the user interface.				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Password Level 2	00	E3		ASCII text (characters 33 to 122 inclusive)
This setting allows you to change the encrypted password level 2. This is not visible via the user interface.				
Password Level 3	00	E4		ASCII text (characters 33 to 122 inclusive)
This setting allows you to change the encrypted password level 3. This is not visible via the user interface.				

5.2 DATE AND TIME

Courier Text	Col	Row	Default Setting	Available Options
Description				
DATE AND TIME	08	00		
This column contains Date and Time stamp configuration settings				
Date/Time	08	01		
This setting defines the IED's current date and time.				
IRIG-B Sync	08	04	Disabled	0 = Disabled or 1 = Enabled
This cell enables or disables the IRIG-B time synchronization.				
IRIG-B Status	08	05		Not Settable
This cell displays the IRIG-B status				
Battery Status	08	06		Not Settable
This cell displays whether the battery is healthy or not				
Battery Alarm	08	07	Enabled	0 = Disabled or 1 = Enabled
This cell enables or disables battery alarm. The battery alarm needs to be disabled when a battery is removed or not used				
SNTP Status	08	13		Not Settable
This cell displays the SNTP time synchronisation status for IEC61850 versions.				
LocalTime Enable	08	20	Flexibleover Eth	0 = Disabled, 1 = Fixed or 2 = Flexible
Disabled: No local time zone will be maintained Fixed - Local time zone adjustment can be defined (all interfaces) Flexible - Local time zone adjustment can be defined (non-local interfaces)				
LocalTime Offset	08	21	0	From -720m to 720m step 15m
This setting specifies the offfset for the local time zone from -12 hours to +12 hrs in 15 minute intervals. This adjustment is applied to the time based on the UTC/GMT master clock.				
DST Enable	08	22	Enabled	0 = Disabled or 1 = Enabled
This setting turns daylight saving time adjustment on or off.				
DST Offset	08	23	60	From 30m to 60m step 30m
This setting defines the daylight saving offset used for the local time adjustment.				
DST Start	08	24	Last	0 = First, 1 = Second, 2 = Third, 3 = Fourth or 4 = Last
This setting specifies the week of the month in which daylight saving time adjustment starts.				
DST Start Day	08	25	Sunday	0 = Sunday, 1 = Monday, 2 = Tuesday, 3 = Wednesday, 4 = Thursday, 5 = Friday or 6 = Saturday
This setting specifies the day of the week in which daylight saving time adjustment starts				

Courier Text	Col	Row	Default Setting	Available Options
Description				
DST Start Month	08	26	March	0 = January, 1 = February, 2 = March, 3 = April, 4 = May, 5 = June, 6 = July, 7 = August, 8 = September, 9 = October, 10 = November or 11 = December
This setting specifies the month in which daylight saving time adjustment starts				
DST Start Mins	08	27	60	From 0 mins to 1425 mins step 15 mins
Setting to specify the time of day in which daylight saving time adjustment starts. This is set relative to 00:00 hrs on the selected day when time adjustment is to start				
DST End	08	28	Last	0 = First, 1 = Second, 2 = Third, 3 = Fourth or 4 = Last
This setting specifies the week of the month in which daylight saving time adjustment ends				
DST End Day	08	29	Sunday	0 = Sunday, 1 = Monday, 2 = Tuesday, 3 = Wednesday, 4 = Thursday, 5 = Friday or 6 = Saturday
This setting specifies the day of the week in which daylight saving time adjustment ends.				
DST End Month	08	2A	October	0 = January, 1 = February, 2 = March, 3 = April, 4 = May, 5 = June, 6 = July, 7 = August, 8 = September, 9 = October, 10 = November or 11 = December
This setting specifies the month in which daylight saving time adjustment ends.				
DST End Mins	08	2B	60	From 0m to 1425m step 15m
This setting specifes the time of day in which daylight saving time adjustment ends. This is set relative to 00:00 hrs on the selected day when time adjustment is to end.				
RP1 Time Zone	08	30	UTC	0 = UTC or 1 = Local
Setting for the rear port 1 interface to specify if time synchronization received will be local or universal time co-ordinated.				
RP2 Time Zone	08	31	UTC	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				
DNPOE Time Zone	08	32	UTC	0 = UTC or 1 = Local
This setting specifies whether DNP3.0 over Ethernet time synchronisation is coordinated by local time or universal time.				
Tunnel Time Zone	08	33	UTC	0 = UTC or 1 = Local
This setting specifies whether tunnelled Courier time synchronisation is coordinated by local time or universal time.				

5.3 GENERAL CONFIGURATION

Courier Text	Col	Row	Default Setting	Available Options
Description				
CONFIGURATION	09	00		
This column contains the general configuration options				
Restore Defaults	09	01	No Operation	0 = No Operation, 1 = All Settings, 2 = Setting Group 1, 3 = Setting Group 2, 4 = Setting Group 3, 5 = Setting Group 4
This setting restores the chosen setting groups to factory default values. 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.				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Setting Group	09	02	Menu	0 = Select via Menu or 1 = Select via PSL
This setting allows you to choose whether the setting group changes are to be initiated via an Opto-input or the HMI menu.				
Active Settings	09	03	1	0 = Group 1, 1 = Group 2, 2 = Group 3, 3 = Group 4
This setting selects the active settings group.				
Save Changes	09	04	No Operation	0 = No Operation, 1 = Save, 2 = Abort
This command saves all IED settings.				
Copy From	09	05	Group 1	0 = Group 1, 1 = Group 2, 2 = Group 3, 3 = Group 4
This setting copies settings from a selected setting group.				
Copy To	09	06	No Operation	0 = No Operation, 1 = Group 1, 2 = Group 2, 3 = Group 3
This command allows the displayed settings to be copied to a selected setting group.				
Setting Group 1	09	07	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables settings Group 1.				
Setting Group 2	09	08	Disabled	0 = Disabled or 1 = Enabled
This setting enables or disables settings Group 2.				
Setting Group 3	09	09	Disabled	0 = Disabled or 1 = Enabled
This setting enables or disables settings Group 3.				
Setting Group 4	09	0A	Disabled	0 = Disabled or 1 = Enabled
This setting enables or disables settings Group 4.				
Diff Protection	09	0C	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables differential current protection				
Dead Zone OC	09	0D	Disabled	0 = Disabled or 1 = Enabled
This setting enables or disables dead zone overcurrent protection				
Over Current	09	10	Disabled	0 = Disabled or 1 = Enabled
This setting enables or disables overcurrent protection				
CB Fail	09	20	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the Circuit Breaker Fail Protection function.				
Supervision	09	21	Disabled	0 = Disabled or 1 = Enabled
This setting enables or disables the Supervision (VTS & CTS) functions.				
Input Labels	09	25	Visible	0 = Invisible or 1 = Visible
This setting hides or unhides the Input Labels menu from the IED display.				
Output Labels	09	26	Visible	0 = Invisible or 1 = Visible
This setting hides or unhides the Output Labels menu from the IED display.				
CT and VT Ratios	09	28	Visible	0 = Invisible or 1 = Visible
This setting hides or unhides the Current and Voltage Transformer ratios menu from the IED display.				
Record Control	09	29	Visible	0 = Invisible or 1 = Visible
This setting hides or unhides the Record Control menu from the IED display.				
Disturb Recorder	09	2A	Visible	0 = Invisible or 1 = Visible
This setting hides or unhides the Disturbance Recorder menu from the IED display.				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Measure't Setup	09	2B	Visible	0 = Invisible or 1 = Visible
This setting hides or unhides the Measurement Setup menu from the IED display.				
Comms Settings	09	2C	Visible	0 = Invisible or 1 = Visible
This setting hides or unhides the Communication Settings menu from the IED display.				
Commission Tests	09	2D	Visible	0 = Invisible or 1 = Visible
This setting hides or unhides the Commission Tests menu from the IED display.				
Setting Values	09	2E	Primary	0 = Primary or 1 = Secondary
This setting determines the reference for all settings dependent on the transformer ratios; either referenced to the primary or the secondary.				
Control Inputs	09	2F	Visible	0 = Invisible or 1 = Visible
Activates the Control Input status and operation menu further on in the IED setting menu.				
Control I/P Config	09	35	Visible	0 = Invisible or 1 = Visible
Sets the Control Input Configuration menu visible further on in the IED setting menu.				
Ctrl I/P Labels	09	36	Visible	0 = Invisible or 1 = Visible
Sets the Control Input Labels menu visible further on in the IED setting menu.				
Direct Access	09	39	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables direct control of the Circuit Breakers from the IED's hotkeys.				
IEC GOOSE	09	49	Visible	0 = Invisible or 1 = Visible
Hides or unhides the IEC61850 GOOSE menu from the IED display. Applies to IEC61850 versions only.				
Function Keys	09	50	Visible	0 = Invisible or 1 = Visible
This setting enables or disables the Function Key menu.				
RP1 Read Only	09	FB	Disabled	0 = Disabled or 1 = Enabled
This setting enables or disables Read Only Mode for Rear Port 1.				
RP2 Read Only	09	FC	Disabled	0 = Disabled or 1 = Enabled
This setting enables or disables Read Only Mode for Rear Port 2.				
NIC Read Only	09	FD	Disabled	0 = Disabled or 1 = Enabled
This setting enables or disables Read Only Mode of the Network Interface Card for Ethernet models.				
LCD Contrast	09	FF	11	From to step
This sets the LCD contrast.				

5.4 TRANSFORMER RATIOS

Courier Text	Col	Row	Default Setting	Available Options
Description				
CT AND VT RATIOS	0A	00		
This column contains settings for Current and Voltage Transformer ratios				
Main VT Primary	0A	03	110	From to step
This sets the main voltage transformer input primary voltage.				
Main VT Sec'y	0A	04	110	From to step
This sets the main voltage transformer input secondary voltage.				
Global Sec'y Ratio	0A	09	1000	From to step
This setting is used to align all Differential or bias currents against a common primary reference.				
Terminal 1 CT	0A	10		

Courier Text	Col	Row	Default Setting	Available Options
Description				
This sets CT main data				
Polarity	0A	11	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	12	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	13	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 2 CT	0A	14		
This sets CT main data				
Polarity	0A	15	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	16	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	17	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 3 CT	0A	18		
This sets CT main data				
Polarity	0A	19	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	1A	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	1B	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 4 CT	0A	1C		
This sets CT main data				
Polarity	0A	1D	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	1E	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	1F	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 5 CT	0A	20		
This sets CT main data				
Polarity	0A	21	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	22	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	23	1	From to step
Sets the phase Current Transformer input secondary current rating				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Terminal 6 CT	0A	24		
This sets CT main data				
Polarity	0A	25	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	26	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	27	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 7 CT	0A	28		
This sets CT main data				
Polarity	0A	29	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	2A	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	2B	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 8 CT	0A	2C		
This sets CT main data				
Polarity	0A	2D	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	2E	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	2F	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 9 CT	0A	30		
This sets CT main data				
Polarity	0A	31	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	32	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	33	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 10 CT	0A	34		
This sets CT main data				
Polarity	0A	35	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	36	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	37	1	From to step

Courier Text	Col	Row	Default Setting	Available Options
Description				
Sets the phase Current Transformer input secondary current rating				
Terminal 11 CT	0A	38		
This sets CT main data				
Polarity	0A	39	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	3A	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	3B	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 12 CT	0A	3C		
This sets CT main data				
Polarity	0A	3D	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	3E	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	3F	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 13 CT	0A	40		
This sets CT main data				
Polarity	0A	41	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	42	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	43	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 14 CT	0A	44		
This sets CT main data				
Polarity	0A	45	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	46	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	47	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 15 CT	0A	48		
This sets CT main data				
Polarity	0A	49	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	4A	1000	From to step
Sets the phase Current Transformer input primary current rating				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Secondary	0A	4B	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 16 CT	0A	4C		
This sets CT main data				
Polarity	0A	4D	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	4E	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	4F	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 17 CT	0A	50		
This sets CT main data				
Polarity	0A	51	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	52	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	53	1	From to step
Sets the phase Current Transformer input secondary current rating				
Terminal 18 CT	0A	54		
This sets CT main data				
Polarity	0A	55	Standard	0 = Standard or 1 = Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	56	1000	From to step
Sets the phase Current Transformer input primary current rating				
Secondary	0A	57	1	From to step
Sets the phase Current Transformer input secondary current rating				

5.5 SYSTEM CONFIGURATION

Courier Text	Col	Row	Default Setting	Available Options
Description				
GROUP 1 SYSTEM CONFIG	30	00		
This column contains the general configuration options				
Protected Phase	30	31	Phase A	Phase A, Phase B, Phase C
This defines the phase to be protected				
Feeder Numbers	30	33	8	From to step
This defines the feeder number				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Z1 CT Dir.	30	34	000000000001000011	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
This defines the CT connected to Zone 1 (normal polarity).				
Z1 CT. Inv Dir	30	35	000000000000000000	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
This defines the CT connected to Zone 1 (inverse polarity).				
Z2 CT Dir.	30	36	0x000000000000000011	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
This defines the CT connected to Zone 2 (normal polarity).				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Z2 CT. Inv Dir	30	37	0x000000000010000000	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
This defines the CT connected to Zone 2 (inverse polarity).				
Z3 CT Dir.	30	38	0x000000000000001100	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
Z3 CT. Inv Dir	30	39	000000000000100000	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
This defines the CT connected to Zone 3 (inverse polarity).				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Z4 CT Dir.	30	3A	000000000000011100	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
This defines the CT connected to Zone 4 (normal polarity).				
Z4 CT. Inv Dir	30	3B	000000000000000000	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
This defines the CT connected to Zone 4 (inverse polarity).				
ChZone Terminal	30	40	0x000000000000001111	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
This defines which CTs are used in the Check Zone. These are all Feeder CTs.				

Courier Text	Col	Row	Default Setting	Available Options
Description				
CB coupling 1CT	30	41	0x000000000000000000	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
Coupling 2 CT-1	30	42	0x000000000011000000	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
This defines which CTs are used for the first bus coupler with two CTs				
Coupling 2 CT-2	30	43	0x000000000000110000	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
This defines which CTs are used for the second bus coupler with two CTs				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Coupling 2 CT-3	30	44	0x000000000000000000	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
This defines which CTs are used for the third bus coupler with two CTs				
Coupling 2 CT-4	30	45	0x000000000000000000	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
This defines which CTs are used for the fourth bus coupler with two CTs				
Bus Section 1	30	48	0x1001	0x0001 Zone 1 0x0002 Zone 2 0x0004 Zone 3 0x0008 Zone 4
This define the zones connected to Bus Isolator 1				
Bus Section 2	30	49	0x0110	0x0001 Zone 1 0x0002 Zone 2 0x0004 Zone 3 0x0008 Zone 4
This define the zones connected to Bus Isolator 2				

5.6 SECURITY CONFIGURATION

Menu Text	Col	Row	Default Setting	Available Options
Description				
SECURITY CONFIG	25	00		

Menu Text	Col	Row	Default Setting	Available Options
Description				
This column contains settings for the Cyber-Security configuration				
User Banner	25	01	ACCESS ONLY FOR AUTHORISED USERS	ASCII 32 to 234
With this setting, you can enter text for the NERC compliant banner.				
Attempts Limit	25	02	3	0 to 3 step 1
This setting defines the maximum number of failed password attempts before action is taken.				
Attempts Timer	25	03	2	1 to 3 step 1
This setting defines the time window used in which the number of failed password attempts is counted.				
Blocking Timer	25	04	5	1 to 30 step 1
This setting defines the time duration for which the user is blocked, after exceeding the maximum attempts limit.				
Front Port	25	05	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the physical Front Port.				
Rear Port 1	25	06	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the primary physical rear port (RP1).				
Rear Port 2	25	07	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the secondary physical rear port (RP2).				
Ethernet Port	25	08	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the physical Ethernet Port				
Courier Tunnel	25	09	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the logical tunnelled Courier port				
IEC61850	25	0A	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the logical IEC 61850 port.				
DNP3 OE	25	0B	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the logical DNP3 over Ethernet port.				
Attempts Remain	25	11		Not Settable
This cell displays the number of password attempts remaining				
Blk Time Remain	25	12		Not Settable
This cell displays the remaining blocking time.				
Fallbck PW level	25	20		0 = Password Level 0, 1 = Password Level 1, 2 = Password Level 2, 3 = Password Level 3
This cell displays the password level adopted by the IED after an inactivity timeout, or after the user logs out. This will be either the level of the highest level password that is blank, or level 0 if no passwords are blank.				
Security Code	25	FF		Not Settable
This cell displays the 16-character security code required when requesting a recovery password.				

PROTECTION FUNCTIONS

CHAPTER 5

1 CHAPTER OVERVIEW

The MiCOM P747 provides a wide range of protection functions. This chapter describes the operation of these functions including the principles, logic diagrams and applications.

This chapter contains the following sections:

2 BUSBAR PROTECTION

A protection scheme for a power system should cover the whole system against all probable types of fault. Unrestricted forms of line protection, such as overcurrent and distance systems, meet this requirement, but clear faults in the busbar zone only after a time delay. If unit protection is applied to feeders and plant, the busbars are not inherently protected.

Busbars are often left without specific protection since the risk of a fault occurring on modern gear is considered to be small. However, the damage resulting from one uncleared fault may be extensive.

Busbar protection is needed when the system protection does not cover the busbars or when high-speed fault clearance is needed to maintain power system stability. Unit busbar protection provides this. Also if the busbars are sectionalised, only one section needs to be isolated to clear a fault.

Busbar faults generate large fault currents and must be cleared quickly, otherwise the whole substation is at risk due to both dynamic forces and thermal effects. Therefore busbar protection must provide high-speed operation. A false trip on a distribution bus can affect many customers as feeders and transmission lines are disconnected. Also a false trip on a transmission busbar can seriously affect power system stability. Therefore busbar protection must provide maximum security.

2.1 UNIT PROTECTION

In large power networks, tripping times of protection equipment can vary depending on the distance from the fault. To reduce this, power networks can be divided into protection zones. Values can be compared at zone boundaries to narrow the fault to a specific zone. Each zone can detect and isolate its own faults. The zone can cover several items of equipment such as a busbar or just one item such as a transmission line, transformer, motor or generator. This is known as Unit Protection.

2.2 CURRENT DIFFERENTIAL PROTECTION PRINCIPLES

One form of Unit Protection is called Current Differential Protection. This was first defined by Merz and Price using Kirchoff's current law. It compares currents entering and leaving a unit. If there is no fault, the current that enters is the same as the current that leaves, so the difference is zero. If there is a fault, the difference is equal to the fault current. The following diagram shows two current transformers (CTs), one at each end of a protected zone. If there is a fault between the two CTs, a current flows through the IED.

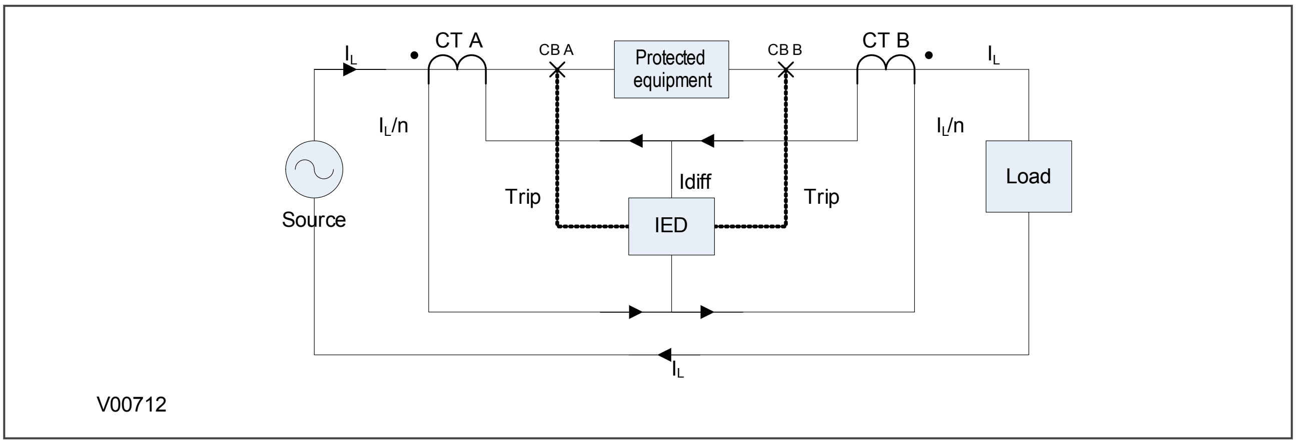


Figure 27: Current Differential Protection

The differential scheme creates a well-defined protection zone between the two CTs. Any fault in the differential protection zone is an internal fault, while any fault outside is an external fault. The protection needs to operate only for faults in the protection zone and to be sensitive to low fault currents. Theoretically a differential scheme should respond to the smallest internal faults but restrain on the largest external faults.

However, this is difficult to achieve in practice because the CTs can never have identical characteristics. A fault from another zone that causes a high current to pass through is classed as a through fault. In this case the CTs need to be able to cope without saturating. However, for very large through faults they do saturate and each saturates differently. The term used to specify the system's ability to cope with these imperfections is called Through Fault Stability.

2.3 THROUGH FAULT STABILITY

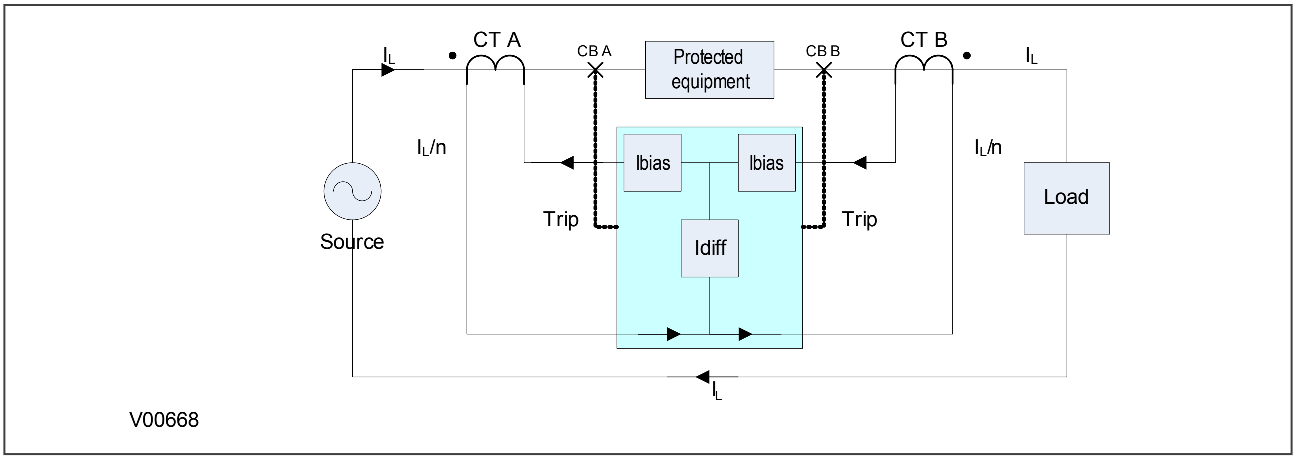
With any form of differential protection, it is important that the CTs have the same characteristics. This is to avoid unnecessarily creating a differential current. However, in reality CTs can never be identical, therefore a certain amount of differential current is inevitable. As the through-fault current in the primary increases, the discrepancies introduced by the imperfectly matched CTs is magnified, causing the differential current to build up. Eventually, the value of the differential current reaches the pickup current threshold, causing the IED to trip. In such cases, the differential scheme is said to have lost stability. To specify a differential scheme's ability to restrain from tripping on external faults, we define a parameter called 'through-fault stability limit', which is the maximum through-fault current a system can handle without losing stability.

2.4 BIAS CURRENT COMPENSATION

Any difference between CTs in a current differential scheme causes a spill current when the system is healthy. To prevent false operation under these conditions, compensation is needed to remain sensitive to real faults yet ignore through faults. This is done by applying a proportion of the scalar sum of all the currents entering and exiting the zone. This scalar sum is called bias current.

The bias characteristic changes the operating point of the IED depending on the fault current. At low through-fault currents, the CT performance is more reliable so a low bias current is needed. Less differential current is then needed to trip the breakers, allowing greater sensitivity to internal faults. At high through-fault currents, the CTs may be close to saturation so a high bias current is needed. More differential current is then needed to trip the breakers, allowing greater security from external faults and less risk of maloperation.

The IED compares the differential current with the bias current characteristic. The IED trips if the differential current exceeds the bias current at any point on the characteristic. Normally a lower threshold is set on the characteristic. This prevents tripping below normal full-load current.



The following diagram shows a typical bias characteristic, where:

Idiff is the differential current, whichis the vector sum of all the currents entering and leaving the zone.
Ibias is proportional to the scalar sum of all the currents entering and leaving the zone.

The characteristic can be defined by setting certain parameters, where:

K1 is the slope
IS1 is the minimum operating current
IS2 is the level of bias current at which the steeper slope begins

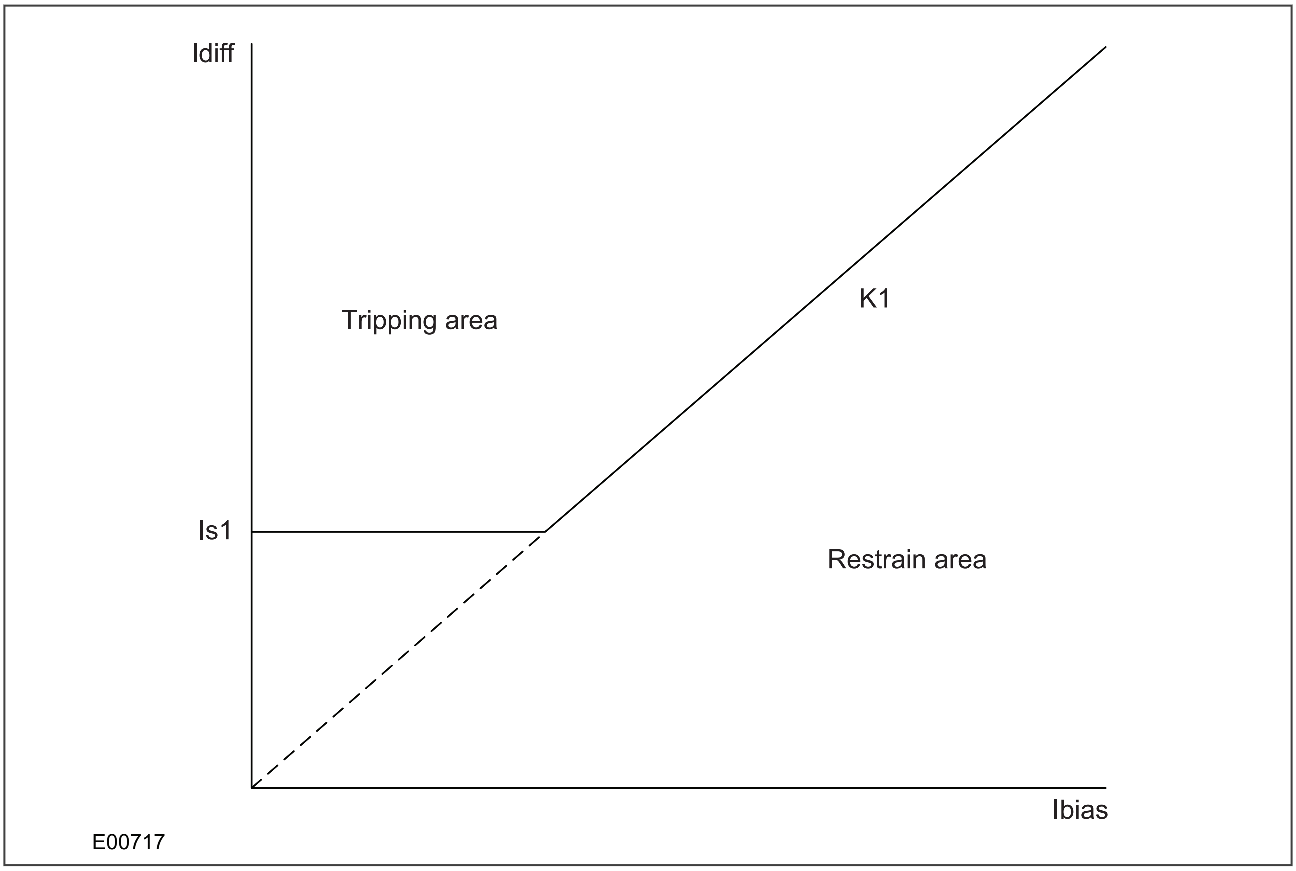


Figure 28: Compensation using biased differential characteristic

3 BUSBAR MULTIPLE TRIPPING CRITERIA

To ensure that the tripping decision is correct, the following criteria must all be satisfied. They are enabled by default, but can be disabled if required.

- The current differential element (I>2) indicates a fault on the protected zone.
- The check zone supervision element (I>CZ) agrees that there is a fault on the busbar.
- There was no indication of a CT circuitry failure before the fault.
- Comparing the phases of the currents involved confirms an internal fault.

The following criteria are optional to further qualify the tripping:

- An undervoltage element which is disabled by default because VT connections may not be available.

> *Note:*
> *If you can't apply undervoltage protection, we recommend that you set the minimum zone current differential operation threshold to greater than the highest load current expected.*

- Tripping criteria affected by signals mapped in the Programmable Scheme Logic, shown in the following diagram.

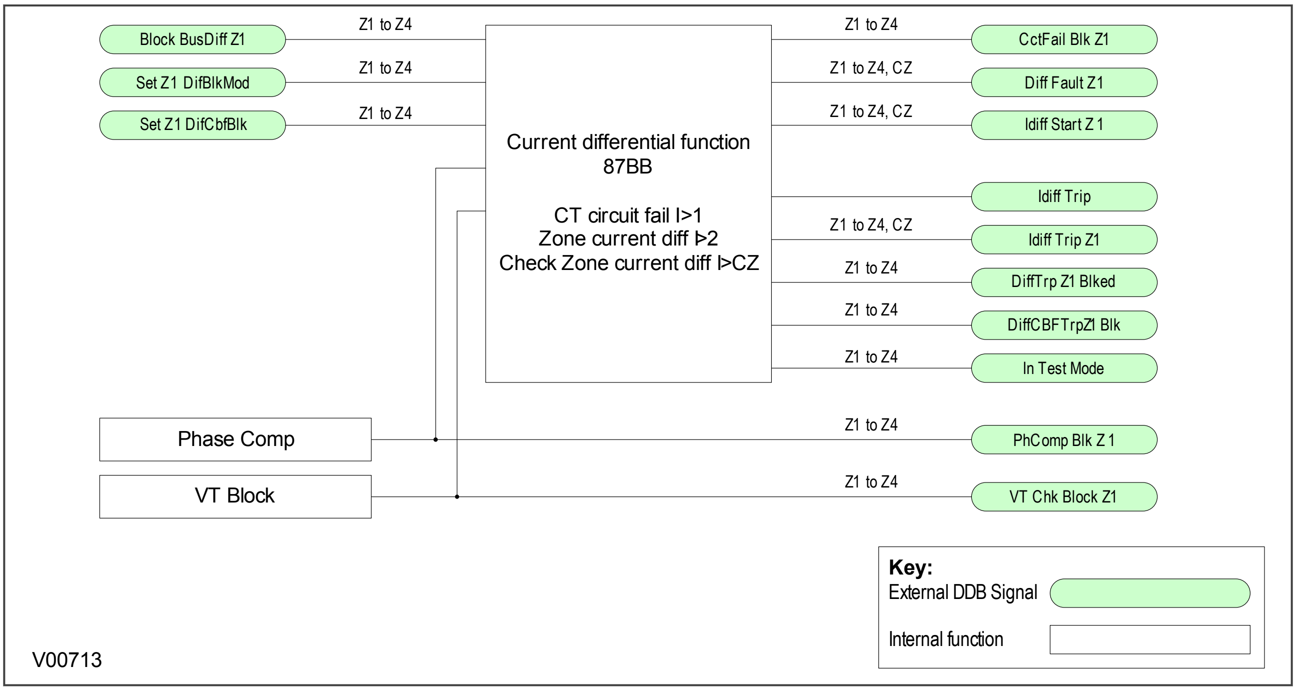


Figure 29: Multiple tripping criteria

3.1 TRIPPING CRITERIA DDBS

The following table shows the corresponding DDB signals.

Ordinal	Signal Name	Use	Unique ID
Description			
481	Block BusDiff Z1	PFSI	DDB_INHIBIT_BUSDIFF_Z1
Blocks zone 1 current differential trip			
543	Set Z1 DifBlkMod	PFSI	DDB_SET_Z1_BLOCK_DIFF_MODE

Ordinal	Signal Name	Use	Unique ID
Description			
Enables Z1 differential block mode			
547	Set Z1 DifCbfBlk	PFSI	DDB_SET_Z1_BLOCK_DIFF_CBF
Enables Z1 Diff & CBF Block Mode			
875	Idiff Trip	PFSO	DDB_IDIFF_TRIP
Differential current trip			
876	Idiff Trip Z1	PFSO	DDB_BUS_IDIFF_TRIP_Z1
Z1 Differential trip			
1053	Idiff Start Z1	PFSO	DDB_BUS_IDIFF_START_Z1
Z1 Differential start			
1080	VT Chk Block Z1	PFSO	DDB_VT_CHECK_BLOCK_ZONE1
VT Check block Z1 trip			
1084	CctFail Blk Z1	PFSO	DDB_CIR_FLT_Z1
Z1 Circuity fault			
1089	In Test Mode	PFSO	DDB_Z1_IN_TEST_MODE
Z1 in Commissioning mode			
1115	PhComp Blk Z1	PFSO	DDB_PHASE_COMP_Z1_BLOCK
Z1 Phase comparison block (OR gate of Phase A,B,C)			
1137	Diff Fault Z1	PFSO	DDB_DIFF_FAULT_Z1
Z1 Current differential has a fault			
1147	DiffTrp Z1 Blked	PFSO	DDB_DIFF_Z1_TRIP_BLOCKED
Z1 Differential trip in block status (commissioning mode active)			
1151	DiffCBFTrpZ1 Blk	PFSO	DDB_DIFF_CBF_Z1_TRIP_BLOCKED
Z1 Differential CBF trip in block status (commissioning mode active)			

3.2 TOPOLOGY REPLICA FUNCTION

This continually compares tripping commands with the status of the busbar switches in the topology. If there is a fault, the device determines optimal tripping zones to minimise disruption to the rest of the circuitry. It then issues tripping commands to selectively isolate the fault.

This also avoids errors if the actual position of an actuator or circuit breaker is different to that shown in the scheme, as this could produce a differential current.

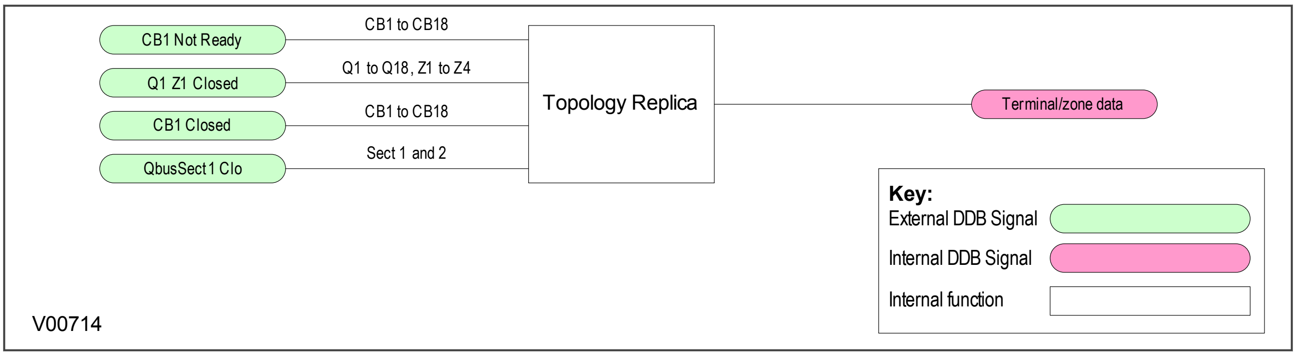


Figure 30: Topology replica function

3.3 TOPOLOGY REPLICA FUNCTION DDBS

Ordinal	English Text	Source	Element Name	Response Function
Description				
551	CB1 Alarm	PSL	DDB_CB2_AUX_3PH_ALARM	PSL
Terminal 1 CB Alarm				
552	CB1 Closed	PSL	DDB_CB1_AUX_3PH_CLOSED	PSL
Terminal 1 CB Closed				
585	CB18 Alarm	PSL	DDB_CB18_AUX_3PH_ALARM	PSL
Terminal 18 CB Alarm				
586	CB18 Closed	PSL	DDB_CB18_AUX_3PH_CLOSED	PSL
Terminal 18 CB Closed				
587	Q1 Z1 alarm	PSL	DDB_Q1_Z1_ALARM	PSL
Q1 Z1 alarm				
588	Q1 Z1 Closed	PSL	DDB_Q1_Z1_CLOSED	PSL
Q1 Z1 Closed				
593	Q1 Z4 alarm	PSL	DDB_Q1_Z4_ALARM	PSL
Q1 Z4 alarm				
594	Q1 Z4 Closed	PSL	DDB_Q1_Z4_CLOSED	PSL
Q1 Z4 Closed				
723	Q18 Z1 alarm	PSL	DDB_Q18_Z1_ALARM	PSL
Q18 Z1 alarm				
724	Q18 Z1 Closed	PSL	DDB_Q18_Z1_CLOSED	PSL
Q18 Z1 Closed				
729	Q18 Z4 alarm	PSL	DDB_Q18_Z4_ALARM	PSL
Q18 Z4 alarm				
730	Q18 Z4 Closed	PSL	DDB_Q18_Z4_CLOSED	PSL
Q18 Z4 Closed				
731	Qbus section1 alarm	PSL	DDB_QBUS_SECTION1_ALARM	PSL
Qbus section1 alarm				
732	Qbus section1 Closed	PSL	DDB_QBUS_SECTION1_CLOSE D	PSL
Qbus section1 Closed				
733	Qbus section1 alarm	PSL	DDB_QBUS_SECTION2_ALARM	PSL
Qbus section1 alarm				
734	Qbus section1 Closed	PSL	DDB_QBUS_SECTION2_CLOSE D	PSL
Qbus section1 Closed				
839	Terminal 1 CB Not Ready	PSL	DDB_CB1_NOT_READY	PSL
Terminal 1 CB Not Ready				
856	Terminal 18 CB Not Ready	PSL	DDB_CB18_NOT_READY	PSL
Terminal 18 CB Not Ready				

3.4 ZONE CURRENT DIFFERENTIAL ELEMENTS

The zone current differential element picks up if there is a fault in a zone on the busbar and the following thresholds are exceeded:

- The bias slope characteristic defined by the ***k2*** setting in the *GROUP X DIFF PROTECTION* column
- The differential current threshold defined by the ***ID>2*** setting in the *GROUP X DIFF PROTECTION* column

The following diagram shows the bias characteristic for the zone current differential, where:

Idiff is the vector sum of all the currents entering and leaving the zone.
Ibias is proportional to the scalar sum of all the currents entering and leaving the zone.

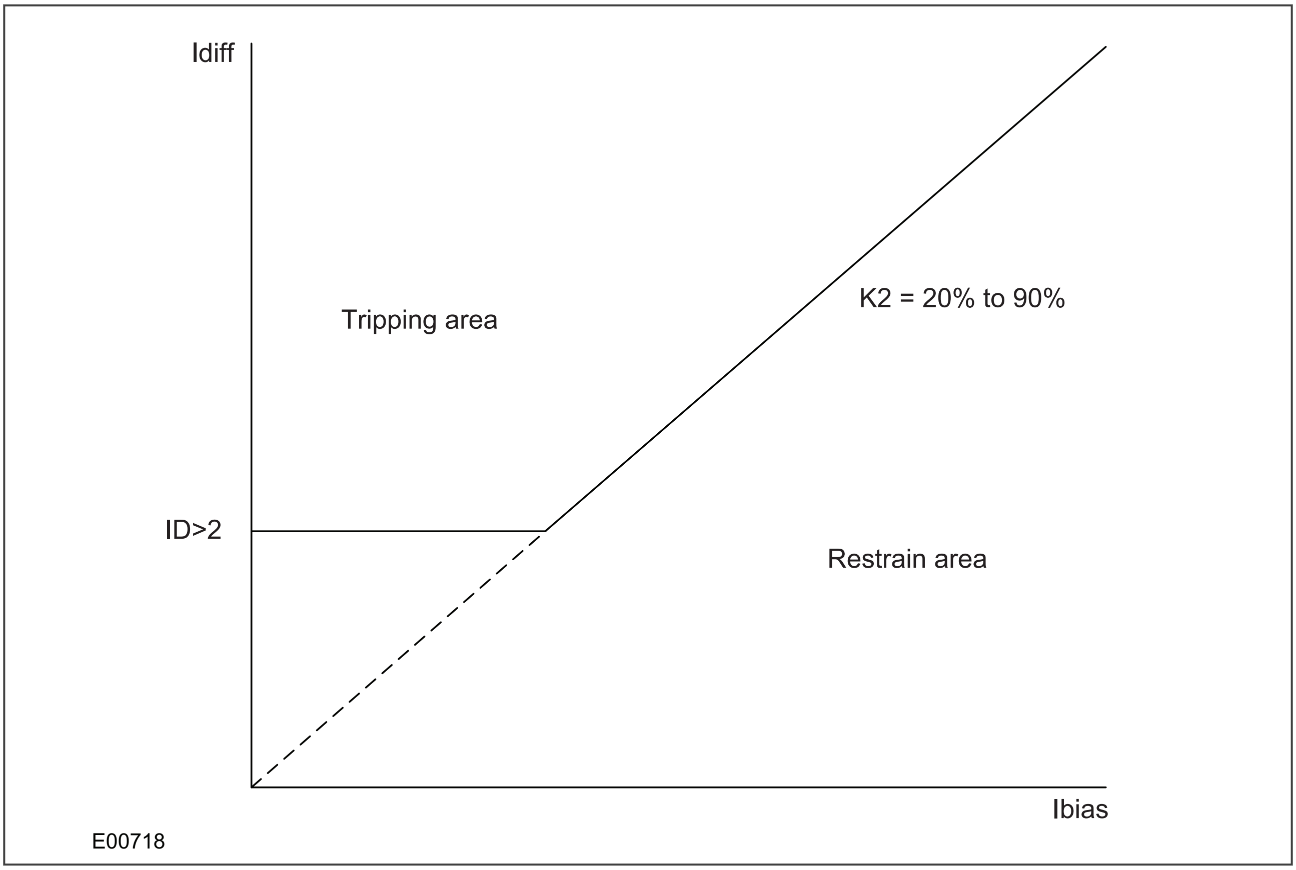


Figure 31: Zone tripping characteristic.

3.5 CHECK ZONE

The check zone element ensures that a busbar zone trip signal is correct. This avoids unnecessarily tripping a zone and affecting busbar stability. Individual zone elements compare currents entering and leaving the zone, whereas the check zone element compares all currents entering and leaving the whole busbar. Therefore the sum of zone fault currents should equal the checkzone fault current for the whole busbar. If it does not, the error may be due to a distorted zone trip signal. To trip a section of the busbar, both the current differential zone element and the check zone element must indicate a fault.

3.5.1 CHECK ZONE SUPERVISION

Just as the individual zones have a bias characteristic, so does the check zone. Therefore to confirm a trip both the zone and checkzone thresholds must be exceeded. The checkzone thresholds are:

- The bias slope characteristic defined by the ***kCZ*** setting in the *GROUP X DIFF PROTECTION* column
- The differential operating current threshold defined by the ***IDCZ>2*** setting in the *GROUP X DIFF PROTECTION* column.

The following diagram shows the bias characteristic for the check zone element, where:

Idiff is the vector sum of all the currents entering and leaving the check zone
Ibias is proportional to the scalar sum of all the currents entering and leaving the check zone.

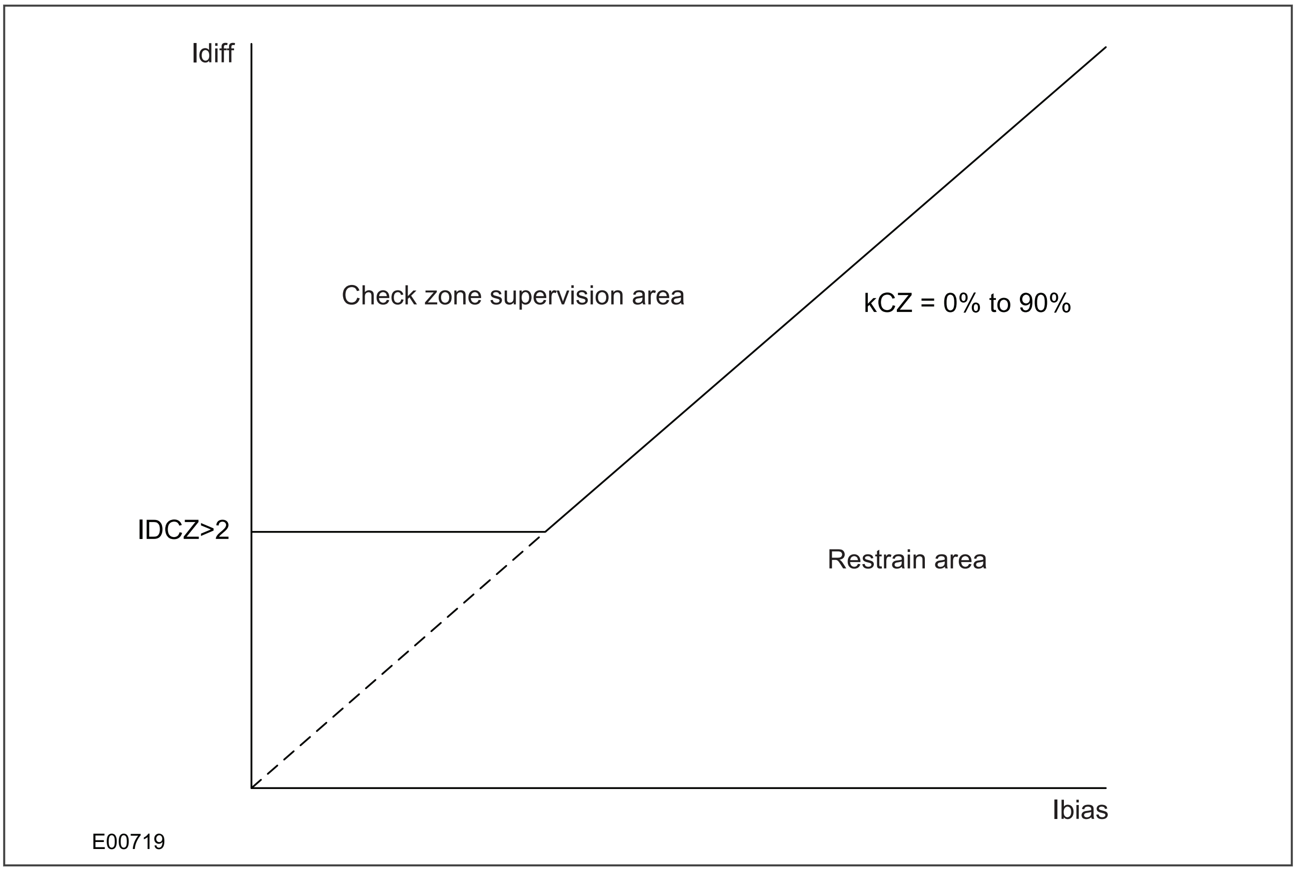


Figure 32: Check zone supervision characteristic.

3.5.2 AUXILIARY CONTACTS DISCREPANCY

If the actual position of an isolator or circuit breaker in the substation is not the same as that shown in the scheme, it can produce a differential current in one or more nodes. This is known as an auxiliary contacts discrepancy and is one of the most common causes of maloperation of differential busbar protection schemes. Therefore if a zone shows a differential current but the whole substation scheme does not, the error may be in the zone's assumption of the position of plant at that particular time.

3.6 CONTINUOUS SUPERVISION OF CURRENT CIRCUITS (CIRCUITRY FAIL)

Under normal operating conditions there should be no differential current, although there might be a small amount due to CT mismatch. If a CT or its circuitry fails, a differential current may be seen. This product monitors the scheme for such conditions but if you don't want to use this circuitry fail feature you can disable it.

The circuitry fail element is time delayed by default. This prevents any conflict with the tripping characteristic if there is a genuine busbar fault. If the circuitry fail element picks up, it triggers an alarm. This can be used to block tripping of the zone differential protection elements.

The circuitry fail element uses a dual slope differential characteristic. This is defined by the settings ***ID>1*** and ***k1*** in the *GROUP X DIFF PROTECTION* column. If the ratio of differential to bias current exceeds the ***ID>1*** and ***k1*** settings, but does not exceed the ***ID>2*** and ***k2*** settings, for the duration of the ***ID>1*** Alarm Timer setting, a circuitry fail alarm is raised. The ***ID>1 Alarm Timer*** delay is set to 5 seconds by default.

The following diagram shows the bias characteristic for the circuitry fail element, where:

Idiff is the vector sum of all the currents entering and leaving the zone.
Ibias is proportional to the scalar sum of all the currents entering and leaving the zone.

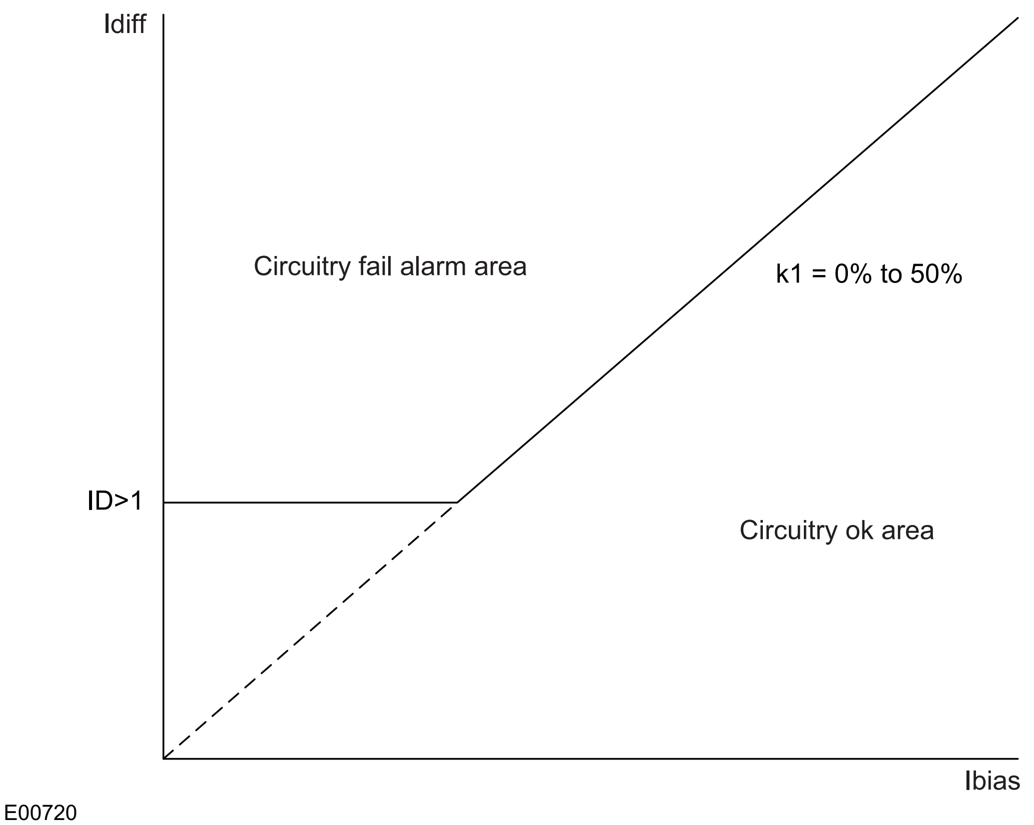


Figure 33: Circuitry check characteristic.

3.7 CURRENT PHASE COMPARISON CHECK

Unless there is a fault, the current flowing into the busbar equals the current flowing out. If an external (through) fault occurs, the busbar protection should not trip. However, if the external fault current is large enough to saturate one or more of the CTs in the scheme, differential current appears. The biased current differential characteristic provides stability for saturation of CTs for external faults. However, if the characteristic is set too high, the protection may fail to operate for internal faults.

To prevent unnecessary tripping it is necessary to detect heavy saturation of CTs for external faults. This is done using a current phase comparison function to supervise the differential decision. Tripping is blocked for faults that are considered to be external with heavy CT saturation, but the block is removed if an evolving internal fault is detected.

If a CT saturates, the relative phase angles between the currents entering and leaving the protected zone exceed 90 deg and the current exceeds the threshold ***PhComp Thresh***. These values can be used to verify that it is CT saturation and therefore is an external (through) fault which doesn't need tripping. In the *GROUP X DIFF PROTECTION* column, you can set the threshold ***PhComp Thresh***.

> *Note:*
> *This is a single-phase device and the term 'phase comparison' does not have any association with the word 'phase' normally used for single-phase and three-phase systems. However, it is closely associated with the phase comparison techniques used for unit protection of transmission lines using power line carrier.*

3.8 OPTIONAL VOLTAGE CRITERIA

If a voltage transformer connection is available, you can use an undervoltage element to supervise the current differential decision. In the *GROUP X DIFF PROTECTION* column,set ***Voltage Check*** to `Enabled`. The undervoltage settings then become visible. Set ***V< Status Zone x*** (where x is the zone number) to `Enabled` or `Disabled`.

3.9 INSTANTANEOUS OR DELAYED TRIPPING

You can set a particular zone differential element to trip as soon as a fault is detected. For example, high speed disconnection of a busbar from a transmission grid. Alternatively tripping can be delayed, for example when disconnecting generator feeders.

In the *GROUP X DIFF PROTECTION* column, set ***tDIFF*** to 0 for instantaneous tripping. Alternatively, set it to the required time delay.

3.10 DEAD ZONE (BLIND SPOT) PROTECTION

The CTs or open switches surrounding busbars normally define the limits of the main zones of protection. When a feeder switch is opened, a dead-zone or blind spot can be created between the switch and the CT.

This product can detect the condition automatically from a topology replica and protect the dead zone. This is done using one stage of definite time-delayed overcurrent protection. To use this, in the *CONFIGURATION* column, set ***Dead Zone OC*** to `Enable`, then in the *GROUP X DEAD ZONE OC* column set ***I> Status*** to `Enable`. The dead zone protection is only activated if the topology replica indicates a dead zone condition.

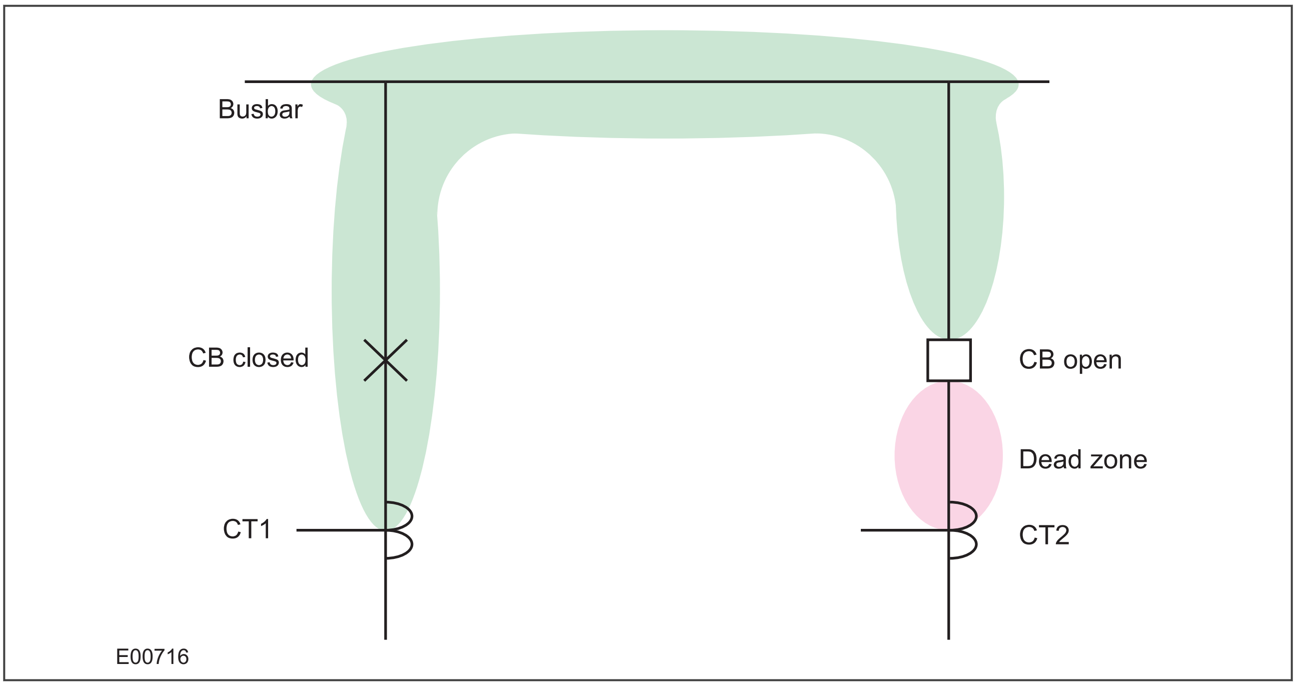


Figure 34: Example of busbar dead-zone

3.11 DEAD ZONE (BLIND SPOT) PROTECTION LOGIC

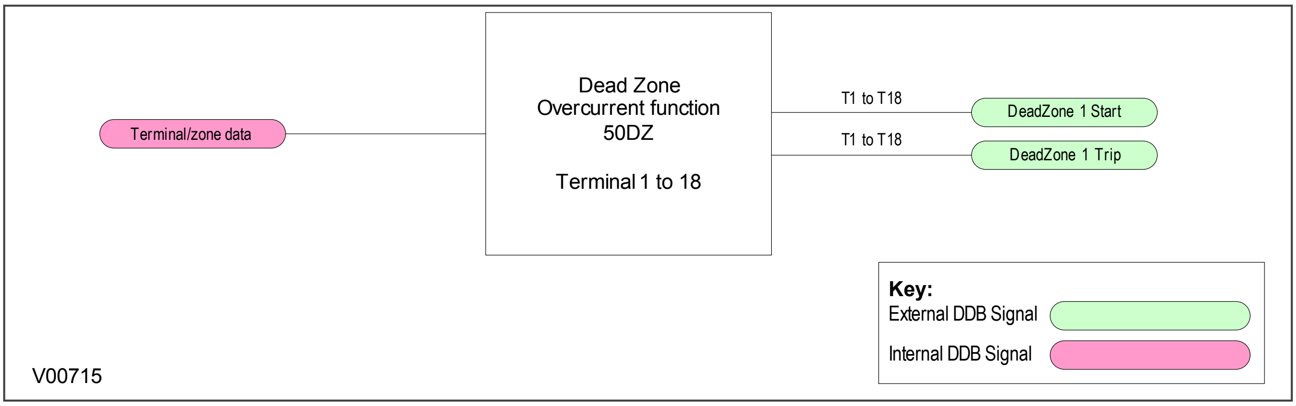


Figure 35: Dead-zone logic

3.12 DEAD ZONE (BLIND SPOT) PROTECTION DDBS

Ordinal	English Text	Source	Element Name	Response Function
Description				
898	T1 DeadZone Trip	SW	DDB_DZ1_OC_TRIP	Dead Zone
T1 DeadZone Trip				
915	T18 DeadZone Trip	SW	DDB_DZ18_OC_TRIP	Dead Zone
T18 DeadZone Trip				
1058	T1 DeadZone Over Current Start	SW	DDB_DZ1_OC_START	Dead Zone Over Current
T1 DeadZone Over Current Start				
1075	T18 DeadZone Over Current Start	SW	DDB_DZ18_OC_START	Dead Zone Over Current
T18 DeadZone Over Current Start				

4 CIRCUIT BREAKER FAIL PROTECTION

When a fault occurs, one or more protection devices will operate and issue a trip command to the relevant circuit breakers. Operation of the circuit breaker is essential to isolate the fault and prevent, or at least limit, damage to the power system. For transmission and sub-transmission systems, slow fault clearance can also threaten system stability.

For these reasons, it is common practise to install Circuit Breaker Failure protection (CBF). CBF protection monitors the circuit breaker and establishes whether it has opened within a reasonable time. If the fault current has not been interrupted following a set time delay from circuit breaker trip initiation, the CBF protection will operate, whereby the upstream circuit breakers are back-tripped to ensure that the fault is isolated.

CBF operation can also reset all start output contacts, ensuring that any blocks asserted on upstream protection are removed.

4.1 CIRCUIT BREAKER FAIL IMPLEMENTATION

Circuit Breaker Failure Protection is implemented in the *CB FAIL & I<* column of the relevant settings group.

Circuit breaker failure protection (CBF) uses logic to combine internally and externally generated trip signals with current measurements and timers. Following a fault, if a circuit breaker has not operated, signals to isolate the fault and the faulty circuit breaker are asserted.

By default, CBF is enabled. If you don’t want to use it,in the *CONFIGURATION* column set ***CB Fail*** to `Disabled`.

If CBF is set to `Enabled` and a fault occurs, the CBF sequence is initiated.

CBF is configured using a combination of:

- settings contained in the CB FAIL column of the relevant settings group
- mapping signals in the Programmable Scheme Logic (PSL).

Use ***CBF Control By*** to set the CBF reset condition. You can choose to reset if the ***I< Current Set*** threshold is satisfied, you can choose to reset if a 52a contact indicates that the circuit breaker has operated correctly, or you can use a combination of both.

The undercurrent reset element operates in less than one cycle.

The CBF has four timers. Two are used for a CBF that is initiated by internal protection. These are CB Fail 1 Timer (tBF1) and CB Fail 2 Timer (tBF2). The other two are used for a CBF that is initiated by external protection. These are CB Fail 3 Timer (tBF3) and CB Fail 4 Timer (tBF4).

There is an overcurrent element that can be enabled to provide an additional input to the CBF logic.

The settings are common to all terminals in the scheme but the CBF logic is applied individually at each terminal according to the specific terminal conditions.

Tripping for CBF conditions tries to minimise disruption to the system by monitoring the topology and adapting the tripping decision to changing configurations.

4.2 CIRCUIT BREAKER FAIL LOGIC

The following diagram shows CBF logic for internally indicated faults. The digital input and output signals (DDBs) that need mapping in the PSL are:

- Int CBF Init Tn (n=1-18)
- CBF Retrip Tn (n=1-18)
- CBF Bktrip Zn (n=1-4)

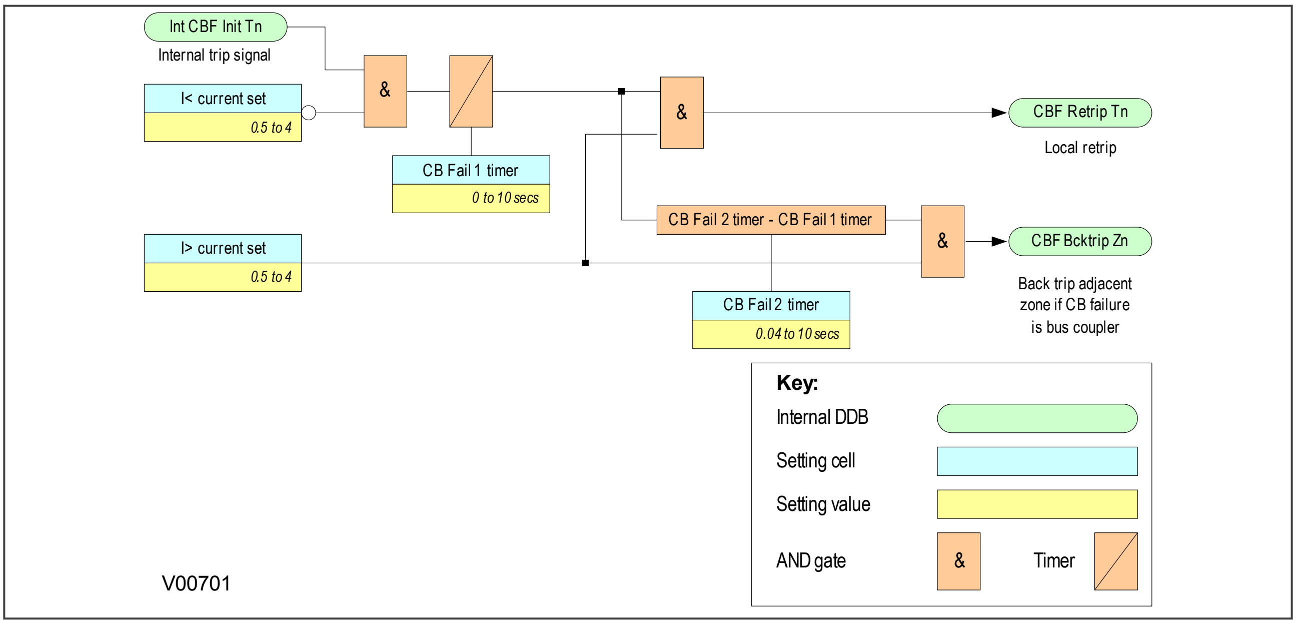


Figure 36: CBF initiated by internal signal

If the faulty circuit breaker is on a feeder, a local retrip can be issued if ***CBF Retrip Tn*** is mapped to appropriate outputs in the PSL. This may not be necessary if another protection on the feeder provides the CB Fail function.

If the fault is on a busbar coupler circuit breaker, trip all adjacent circuit breakers in the zone by mapping ***CBF Bktrip Zn*** to appropriate outputs in the PSL.

The following diagram shows CBF logic for externally indicated faults. The digital input and output signals (DDBs) that need mapping in the PSL are:

- Ext CBF INIT Tn (n=1-18)
- CBF Retrip Tn (n=1-18)
- CBF Bktrip Zn (n=1-4)
- CBF Bktrip Tn (n=1-18)
- Ext CBF Zn (n=1-4)

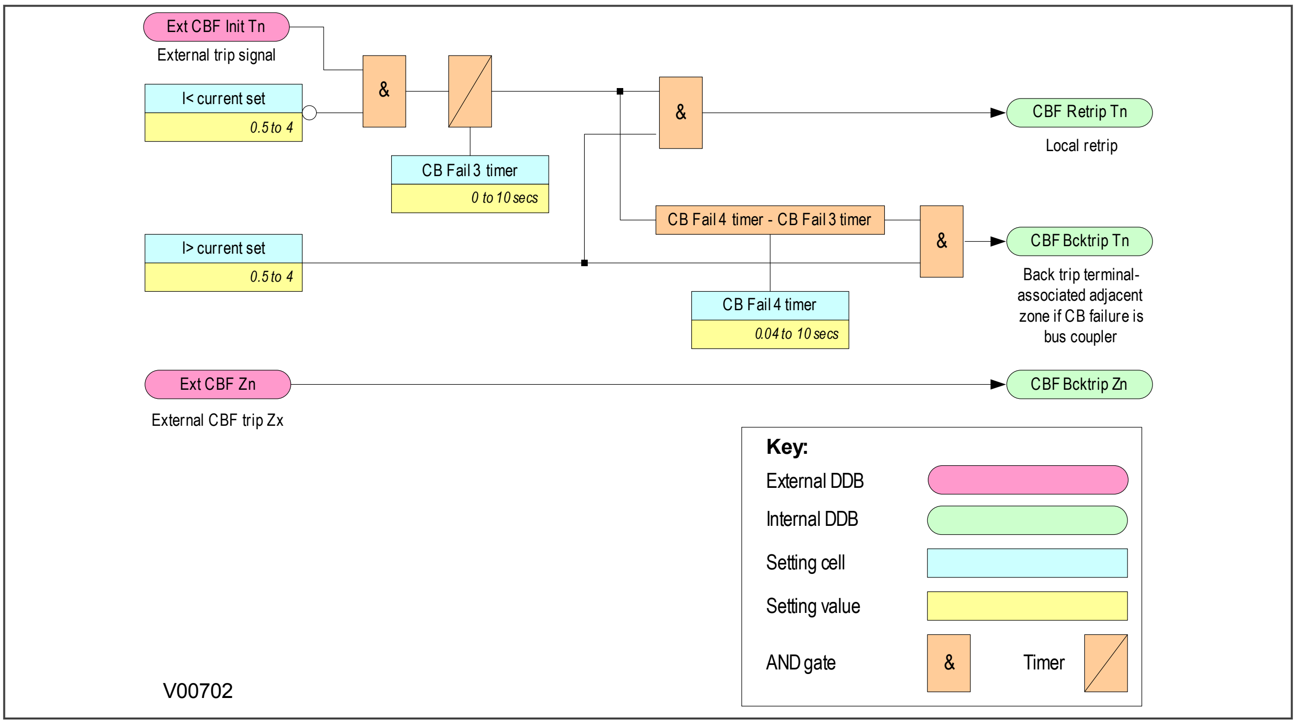


Figure 37: CBF initiated by external signal

If the faulty circuit breaker is on a feeder, a local retrip can be issued if ***CBF Retrip Tn*** is mapped to an appropriate output in the PSL. This may not be necessary if the external protection provides CBF.

If the fault is on a busbar coupler circuit breaker, the protection tries to clear the fault by asserting the ***CBF Bktrip Tn*** signals to trip all adjacent circuit breakers. If this fails to clear the fault, trip all zones by mapping the ***CBF Bktrip Zn*** DDBs to appropriate outputs in the PSL.

4.3 CB FAIL SETTINGS

Menu Text	Col	Row	Default Setting	Available Options
Description				
GROUP 1 CB FAIL & I<	45	00		
This column contains settings for Circuit Fail and Under Current.				
BREAKER FAIL	45	01		
The settings under this sub-heading relate to Circuit Breaker Fail (CB Fail) settings				
CB Fail 1 Status	45	02	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the first stage of the CB Fail protection.				
CB Fail 1 Timer	45	03	0.2	From 0s to 50s step 0.01s
This setting sets the first stage CB Fail timer in which the CB opening must be detected.				
CB Fail 2 Status	45	04	Disabled	0 = Disabled or 1 = Enabled
This setting enables or disables the second stage of the CB Fail protection.				
CB Fail 2 Timer	45	05	0.4	From 0s to 50s step 0.01s
This setting sets the second stage CB Fail timer in which the CB opening must be detected.				
Volt Prot Reset	45	06	CB Open & I<	0=I< Only 1=CB Open & I< 2=Prot Reset & I<

Menu Text	Col	Row	Default Setting	Available Options
Description				
This setting determines the elements that will reset the CB fail timer for CB Failures, which were initiated by the voltage protection function.				
Ext Prot Reset	45	07	CB Open & I<	0=I< Only 1=CB Open & I< 2=Prot Reset & I<
This setting determines the elements that will reset the CB fail timer for CB Failures initiated by external protection functions.				
UNDER CURRENT	45	08		
The settings under this sub-heading relate to Undercurrent settings				
I< Current Set	45	09	0.1	From 0.02*I1 to 3.2*I1 step 0.01*I1
This setting determines the current threshold, which will reset the CB Fail timer for Overcurrent-based protection				
IN< Current Set	45	0A	0.1	From 0.02*I2 to 3.2*I2 step 0.01*I2
This setting determines the current threshold, which will reset the CB Fail timer for Earth Fault-based protection				
ISEF< Current	45	0B	0.02	From 0.001*I3 to 0.8*I3 step 0.0005*I3
This setting determines the current threshold, which will reset the CB Fail timer for SEF-based protection				
BLOCKED O/C	45	0C		
The settings under this sub-heading relate to Blocked Overcurrent settings				
Remove I> Start	45	0D	Disabled	0 = Disabled or 1 = Enabled
This setting enables or disables the Remove I>Start signal				
Remove IN> Start	45	0E	Disabled	0 = Disabled or 1 = Enabled
This setting enables or disables the Remove IN>Start signal				

4.4 CB FAIL DDB SIGNALS

Ordinal	English Text	Source	Type	Response Function
Description				
150	CB Fail Alarm	Software	PSL Input	Alarm latched event
This DDB signal is an alarm indicating CB Failure				
227	Ext. Trip 3ph	Programmable Scheme Logic	PSL Output	No response
This DDB signal receives an external three-phase trip signal				
353	Bfail1 Trip 3ph	Software	PSL Input	Protection event
This DDB signal is the three-phase trip signal for the stage 1 CB Fail function				
354	Bfail2 Trip 3ph	Software	PSL Input	Protection event
This DDB signal is the three-phase trip signal for the stage 2 CB Fail function				
373	IA< Start	Software	PSL Input	No response
This DDB signal is the A-phase Phase Undercurrent start signal				
374	IB< Start	Software	PSL Input	No response
This DDB signal is the B-phase Phase Undercurrent start signal				
375	IC< Start	Software	PSL Input	No response
This DDB signal is the C-phase Phase Undercurrent start signal				
376	IN< Start	Software	PSL Input	No response
This DDB signal is the Earth Fault undercurrent start signal				
377	ISEF< Start	Software	PSL Input	No response
This DDB signal is the Sensitive Earth Fault undercurrent start signal				
380	All Poles Dead	Software	PSL Input	No response

Ordinal	English Text	Source	Type	Response Function
Description				
This DDB signal indicates that all poles are dead				
382	Pole Dead A	Software	PSL Input	No response
This DDB signal indicates that the A-phase pole is dead.				
383	Pole Dead B	Software	PSL Input	No response
This DDB signal indicates that the B-phase pole is dead.				
384	Pole Dead C	Software	PSL Input	No response
This DDB signal indicates that the C-phase pole is dead.				
499	External Trip A	Programmable Scheme Logic	PSL Output	No response
This DDB signal is connected to an external A-Phase trip, which initiates a CB Fail condition				
500	External Trip B	Programmable Scheme Logic	PSL Output	No response
This DDB signal is connected to an external B-Phase trip, which initiates a CB Fail condition				
501	External Trip C	Programmable Scheme Logic	PSL Output	No response
This DDB signal is connected to an external C-Phase Trip, which initiates a CB Fail condition				
502	External Trip EF	Programmable Scheme Logic	PSL Output	No response
This DDB signal is connected to an external Earth Fault trip, which initiates a CB Fail condition				
503	External TripSEF	Programmable Scheme Logic	PSL Output	No response
This DDB signal is connected to an external Sensitive Earth Fault trip, which initiates a CB Fail condition				
536	Trip Command In	Programmable Scheme Logic	PSL Output	Protection event
This DDB signal is the Trip Command In signal, which triggers the fixed trip LED and is mapped to the Trip Command Out signal in the FSL.				

5 BACKUP OVERCURRENT PROTECTION

Back-up overcurrent protection is disabled by default but can be enabled for additional protection. The product provides two stages of independent overcurrent protection for each terminal, up to the maximum of 18 terminals. For each terminal, the first stage can be programmed as definite time (DT) or inverse definite minimum time (IDMT). For IDMT protection, the product provides a choice of curves (IEC, UK, IEEE, and US). The second stage provides definite time overcurrent protection. In the *CONFIGURATION* column, set ***Overcurrent*** to `Enabled`. The overcurrent settings then appear in the *GROUP X OVERCURRENT* column (terminals 1-6), and *GROUP X OVERCURRENT 2* column (terminals 7-18).

5.1 OVERCURRENT 1 SETTINGS

Menu Text	Col	Row	Default Setting	Available Options
Description				
GROUP 1 OVERCURRENT 1	35	00		
This column contains settings for Overcurrent				
Terminal 1	35	01		
This column contains overcurrent settings for Terminal 1				
I>1 Function	35	02	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	35	04	1.0*I1	From 0.08*I1 to 4.0*I1 step 0.01*I1
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	35	05	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	35	06	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	35	07	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	35	08	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	35	09	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	35	0A	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	35	0B	Disabled	0 = Disabled 1 = DT (DT)

Menu Text	Col	Row	Default Setting	Available Options
Description				
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	35	0D	1.0*I1	From 0.08*I1 to 10.0*I1 step 0.01*I1
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	35	0E	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 2	35	21		
This column contains overcurrent settings for Terminal 2				
I>1 Function	35	22	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	35	24	1.0*I2	From 0.08*I2 to 4.0*I2 step 0.01*I2
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	35	25	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	35	26	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	35	27	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	35	28	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	35	29	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	35	2A	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	35	2B	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	35	2D	1.0*I2	From 0.08*I2 to 10.0*I2 step 0.01*I2
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	35	2E	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage overcurrent element.				
Terminal 3	35	41		
This column contains overcurrent settings for Terminal 3				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	35	42	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	35	44	1.0*I3	From 0.08*I3 to 4.0*I3 step 0.01*I3
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	35	45	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	35	46	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	35	47	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	35	48	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	35	49	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	35	4A	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	35	4B	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	35	4D	1.0*I3	From 0.08*I3 to 10.0*I3 step 0.01*I3
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	35	4E	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 4	35	61		
This column contains overcurrent settings for Terminal 4				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	35	62	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	35	64	1.0*I4	From 0.08*I4 to 4.0*I4 step 0.01*I4
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	35	65	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	35	66	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	35	67	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	35	68	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	35	69	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	35	6A	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	35	6B	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	35	6D	1.0*I4	From 0.08*I4 to 10.0*I4 step 0.01*I4
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	35	6E	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 5	35	81		
This column contains overcurrent settings for Terminal 5				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	35	82	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	35	84	1.0*I5	From 0.08*I5 to 4.0*I5 step 0.01*I5
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	35	85	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	35	86	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	35	87	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	35	88	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	35	89	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	35	8A	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	35	8B	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	35	8D	1.0*I5	From 0.08*I5 to 10.0*I5 step 0.01*I5
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	35	8E	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 6	35	A1		
This column contains overcurrent settings for Terminal 6				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	35	A2	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	35	A4	1.0*I6	From 0.08*I6 to 4.0*I6 step 0.01*I6
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	35	A5	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	35	A6	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	35	A7	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	35	A8	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	35	A9	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	35	AA	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	35	AB	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	35	AD	1.0*I6	From 0.08*I6 to 10.0*I6 step 0.01*I6
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	35	AE	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				

5.2 OVERCURRENT 2 SETTINGS

Menu Text	Col	Row	Default Setting	Available Options
Description				
GROUP 1 OVERCURRENT 2	36	00		
This column contains settings for Overcurrent				
Terminal 7	36	01		
This column contains overcurrent settings for Terminal 7				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	36	02	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	04	1.0*I7	From 0.08*I7 to 4.0*I7 step 0.01*I7
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	36	05	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	36	06	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	36	07	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	36	08	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	36	09	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	36	0A	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	36	0B	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	36	0D	1.0*I7	From 0.08*I7 to 10.0*I7 step 0.01*I7
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	36	0E	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 8	36	20		
This column contains overcurrent settings for Terminal 8				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	36	21	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	23	1.0*I8	From 0.08*I8 to 4.0*I8 step 0.01*I8
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	36	24	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	36	25	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	36	26	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	36	27	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	36	28	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	36	29	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	36	2A	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	36	2C	1.0*I8	From 0.08*I8 to 10.0*I8 step 0.01*I8
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	36	2D	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 9	36	30		
This column contains overcurrent settings for Terminal 9				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	36	31	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	33	1.0*I9	From 0.08*I9 to 4.0*I9 step 0.01*I9
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	36	34	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	36	35	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	36	36	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	36	37	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	36	38	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	36	39	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	36	3A	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	36	3C	1.0*I9	From 0.08*I9 to 10.0*I9 step 0.01*I9
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	36	3D	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 10	36	40		
This column contains overcurrent settings for Terminal 10				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	36	41	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	43	1.0*I10	From 0.08*I10 to 4.0*I10 step 0.01*I10
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	36	44	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	36	45	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	36	46	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	36	47	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	36	48	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	36	49	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	36	4A	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	36	4C	1.0*I10	From 0.08*I10 to 10.0*I10 step 0.01*I10
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	36	4D	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 11	36	50		
This column contains overcurrent settings for Terminal 11				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	36	51	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	53	1.0*I11	From 0.08*I11 to 4.0*I11 step 0.01*I11
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	36	54	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	36	55	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	36	56	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	36	57	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	36	58	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	36	59	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	36	5A	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	36	5C	1.0*I11	From 0.08*I11 to 10.0*I11 step 0.01*I11
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	36	5D	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 12	36	60		
This column contains overcurrent settings for Terminal 12				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	36	61	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	63	1.0*I12	From 0.08*I12 to 4.0*I12 step 0.01*I12
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	36	64	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	36	65	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	36	66	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	36	67	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	36	68	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	36	69	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	36	6A	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	36	6C	1.0*I12	From 0.08*I12 to 10.0*I12 step 0.01*I12
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	36	6D	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 13	36	70		
This column contains overcurrent settings for Terminal 13				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	36	71	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	73	1.0*I13	From 0.08*I13 to 4.0*I13 step 0.01*I13
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	36	74	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	36	75	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	36	76	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	36	77	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	36	78	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	36	79	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	36	7A	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	36	7C	1.0*I13	From 0.08*I13 to 10.0*I13 step 0.01*I13
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	36	7D	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 14	36	80		
This column contains overcurrent settings for Terminal 14				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	36	81	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	83	1.0*I14	From 0.08*I14 to 4.0*I14 step 0.01*I14
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	36	84	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	36	85	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	36	86	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	36	87	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	36	88	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	36	89	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	36	8A	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	36	8C	1.0*I14	From 0.08*I14 to 10.0*I14 step 0.01*I14
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	36	8D	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 15	36	90		
This column contains overcurrent settings for Terminal 15				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	36	91	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	93	1.0*I15	From 0.08*I15 to 4.0*I15 step 0.01*I15
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	36	94	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	36	95	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	36	96	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	36	97	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	36	98	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	36	99	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	36	9A	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	36	9C	1.0*I15	From 0.08*I15 to 10.0*I15 step 0.01*I15
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	36	9D	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 16	36	B0		
This column contains overcurrent settings for Terminal 16				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	36	B1	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	B3	1.0*I16	From 0.08*I16 to 4.0*I16 step 0.01*I16
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	36	B4	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	36	B5	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	36	B6	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	36	B7	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	36	B8	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	36	B9	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	36	BA	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	36	BC	1.0*I16	From 0.08*I16 to 10.0*I16 step 0.01*I16
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	36	BD	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 17	36	C0		
This column contains overcurrent settings for Terminal 17				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	36	C1	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	C3	1.0*I17	From 0.08*I17 to 4.0*I17 step 0.01*I17
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	36	C4	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	36	C5	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	36	C6	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	36	C7	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	36	C8	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	36	C9	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	36	CA	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	36	CC	1.0*I17	From 0.08*I17 to 10.0*I17 step 0.01*I17
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	36	CD	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				
Terminal 18	36	D0		
This column contains overcurrent settings for Terminal 18				

Menu Text	Col	Row	Default Setting	Available Options
Description				
I>1 Function	36	D1	IEC S Inverse	0 = Disabled 1 = DT (DT) 2 = IEC S Inverse (TMS) 3 = IEC V Inverse (TMS) 4 = IEC E Inverse (TMS) 5 = UK LT Inverse (TMS) 6 = Rectifier (TMS) 7 = RI (K) 8 = IEEE M Inverse (TD) 9 = IEEE V Inverse (TD) 10 = IEEE E Inverse (TD) 11 = US Inverse (TD) 12 = US ST Inverse (TD)
This setting determines the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	D3	1.0*I18	From 0.08*I18 to 4.0*I18 step 0.01*I18
This sets the pick-up threshold for the first stage overcurrent element.				
I>1 Time Delay	36	D4	1	From 0 to 100 step 0.01
This sets the DT time delay for the first stage overcurrent element.				
I>1 TMS	36	D5	1	From 0.025 to 1.2 step 0.025
This is the Time Multiplier Setting to adjust the operate time of IEC IDMT curves.				
I>1 Time Dial	36	D6	1	From 0.01 to 100 step 0.01
This is the Time Multiplier Setting to adjust the operate time of IEEE/US IDMT curves.				
I>1 K (RI)	36	D7	1	From 0.1 to 10 step 0.05
This setting defines the TMS constant to adjust the operate time of the RI curve.				
I>1 Reset Char	36	D8	DT	0 = DT 1 = Inverse
This setting determines the type of Reset characteristic used for the IEEE/US curves.				
I>1 tRESET	36	D9	0	From 0 to 100 step 0.01
This setting determines the Reset time for the Definite Time Reset characteristic.				
I>2 Function	36	DA	Disabled	0 = Disabled 1 = DT (DT)
This setting determines the tripping characteristic for the second stage overcurrent element.				
I>2 Current Set	36	DD	1.0*I18	From 0.08*I18 to 10.0*I18 step 0.01*I18
This sets the pick-up threshold for the second stage overcurrent element.				
I>2 Time Delay	36	DD	1	From 0 to 100 step 0.01
This sets the DT time delay for the second stage element.				

5.3 OVERCURRENT DDB SIGNALS

Ordinal	Signal Name	Source	Type	Response
Description				
203	I>1 Timer Block	Programmable Scheme Logic	PSL Output	No response
This DDB signal blocks the first stage overcurrent time delay				
204	I>2 Timer Block	Programmable Scheme Logic	PSL Output	No response
This DDB signal blocks the second stage overcurrent time delay				

Ordinal	Signal Name	Source	Type	Response
Description				
205	I>3 Timer Block	Programmable Scheme Logic	PSL Output	No response
This DDB signal blocks the third stage overcurrent time delay				
206	I>4 Timer Block	Programmable Scheme Logic	PSL Output	No response
This DDB signal blocks the fourth stage overcurrent time delay				
243	I>1 Trip	Software	PSL Input	Protection event
This DDB signal is the first stage any-phase Phase Overcurrent trip signal				
244	I>1 Trip A	Software	PSL Input	Protection event
This DDB signal is the first stage A-phase Phase Overcurrent trip signal				
245	I>1 Trip B	Software	PSL Input	Protection event
This DDB signal is the first stage B-phase Phase Overcurrent trip signal				
246	I>1 Trip C	Software	PSL Input	Protection event
This DDB signal is the first stage C-phase Phase Overcurrent trip signal				
247	I>2 Trip	Software	PSL Input	Protection event
This DDB signal is the second stage any-phase Phase Overcurrent trip signal				
248	I>2 Trip A	Software	PSL Input	Protection event
This DDB signal is the second stage A-phase Phase Overcurrent trip signal				
249	I>2 Trip B	Software	PSL Input	Protection event
This DDB signal is the second stage B-phase Phase Overcurrent trip signal				
250	I>2 Trip C	Software	PSL Input	Protection event
This DDB signal is the second stage C-phase Phase Overcurrent trip signal				
251	I>3 Trip	Software	PSL Input	Protection event
This DDB signal is the third stage any-phase Phase Overcurrent trip signal				
252	I>3 Trip A	Software	PSL Input	Protection event
This DDB signal is the third stage A-phase Phase Overcurrent trip signal				
253	I>3 Trip B	Software	PSL Input	Protection event
This DDB signal is the third stage B-phase Phase Overcurrent trip signal				
254	I>3 Trip C	Software	PSL Input	Protection event
This DDB signal is the third stage C-phase Phase Overcurrent trip signal				
255	I>4 Trip	Software	PSL Input	Protection event
This DDB signal is the fourth stage any-phase Phase Overcurrent trip signal				
256	I>4 Trip A	Software	PSL Input	Protection event
This DDB signal is the fourth stage A-phase Phase Overcurrent trip signal				
257	I>4 Trip B	Software	PSL Input	Protection event
This DDB signal is the fourth stage B-phase Phase Overcurrent trip signal				
258	I>4 Trip C	Software	PSL Input	Protection event
This DDB signal is the fourth stage C-phase Phase Overcurrent trip signal				
295	I>1 Start	Software	PSL Input	Protection event
This DDB signal is the first stage any-phase Overcurrent start signal				
296	I>1 Start A	Software	PSL Input	Protection event
This DDB signal is the first stage A-phase Overcurrent start signal				
297	I>1 Start B	Software	PSL Input	Protection event
This DDB signal is the first stage B-phase Overcurrent start signal				

Ordinal	Signal Name	Source	Type	Response
Description				
298	I>1 Start C	Software	PSL Input	Protection event
This DDB signal is the first stage C-phase Overcurrent start signal				
299	I>2 Start	Software	PSL Input	Protection event
This DDB signal is the second stage any-phase Overcurrent start signal				
300	I>2 Start A	Software	PSL Input	Protection event
This DDB signal is the second stage A-phase Overcurrent start signal				
301	I>2 Start B	Software	PSL Input	Protection event
This DDB signal is the second stage B-phase Overcurrent start signal				
302	I>2 Start C	Software	PSL Input	Protection event
This DDB signal is the second stage C-phase Overcurrent start signal				
303	I>3 Start	Software	PSL Input	Protection event
This DDB signal is the third stage any-phase Overcurrent start signal				
304	I>3 Start A	Software	PSL Input	Protection event
This DDB signal is the third stage A-phase Overcurrent start signal				
305	I>3 Start B	Software	PSL Input	Protection event
This DDB signal is the third stage B-phase Overcurrent start signal				
306	I>3 Start C	Software	PSL Input	Protection event
This DDB signal is the third stage C-phase Overcurrent start signal				
307	I>4 Start	Software	PSL Input	Protection event
This DDB signal is the fourth stage any-phase Overcurrent start signal				
308	I>4 Start A	Software	PSL Input	Protection event
This DDB signal is the fourth stage A-phase Overcurrent start signal				
309	I>4 Start B	Software	PSL Input	Protection event
This DDB signal is the fourth stage B-phase Overcurrent start signal				
310	I>4 Start C	Software	PSL Input	Protection event
This DDB signal is the fourth stage C-phase Overcurrent start signal				
351	VTS Slow Block	Software	PSL Input	No response
This DDB signal is a purposely delayed output from the VTS which can block other functions				
358	AR Blk Main Prot	Software	PSL Input	Protection event
This DDB signal, generated by the Autoreclose function, blocks the Main Protection elements (POC, EF1, EF2, NPSOC)				
567	I>5 Timer Block	Programmable Scheme Logic	PSL Output	No response
This DDB signal blocks the fifth stage overcurrent time delay				
568	I>6 Timer Block	Programmable Scheme Logic	PSL Output	No response
This DDB signal blocks the sixth stage overcurrent time delay				
570	I>5 Trip	Software	PSL Input	Protection event
This DDB signal is the fifth stage three-phase Phase Overcurrent trip signal				
571	I>5 Trip A	Software	PSL Input	Protection event
This DDB signal is the fifth stage A-phase Phase Overcurrent trip signal				
572	I>5 Trip B	Software	PSL Input	Protection event
This DDB signal is the fifth stage B-phase Phase Overcurrent trip signal				
573	I>5 Trip C	Software	PSL Input	Protection event
This DDB signal is the fifth stage C-phase Phase Overcurrent trip signal				

Ordinal	Signal Name	Source	Type	Response
Description				
574	I>6 Trip	Software	PSL Input	Protection event
This DDB signal is the sixth stage three-phase Phase Overcurrent trip signal				
575	I>6 Trip A	Software	PSL Input	Protection event
This DDB signal is the sixth stage A-phase Phase Overcurrent trip signal				
576	I>6 Trip B	Software	PSL Input	Protection event
This DDB signal is the sixth stage B-phase Phase Overcurrent trip signal				
577	I>6 Trip C	Software	PSL Input	Protection event
This DDB signal is the sixth stage C-phase Phase Overcurrent trip signal				
579	I>5 Start	Software	PSL Input	Protection event
This DDB signal is the fifth stage three-phase Phase Overcurrent start signal				
580	I>5 Start A	Software	PSL Input	Protection event
This DDB signal is the fifth stage A-phase Phase Overcurrent start signal				
581	I>5 Start B	Software	PSL Input	Protection event
This DDB signal is the fifth stage B-phase Phase Overcurrent start signal				
582	I>5 Start C	Software	PSL Input	Protection event
This DDB signal is the fifth stage C-phase Phase Overcurrent start signal				
583	I>6 Start	Software	PSL Input	Protection event
This DDB signal is the sixth stage three-phase Phase Overcurrent start signal				
584	I>6 Start A	Software	PSL Input	Protection event
This DDB signal is the sixth stage A-phase Phase Overcurrent start signal				
585	I>6 Start B	Software	PSL Input	Protection event
This DDB signal is the sixth stage B-phase Phase Overcurrent start signal				
586	I>6 Start C	Software	PSL Input	Protection event
This DDB signal is the sixth stage C-phase Phase Overcurrent start signal				
538	IA2H Start	Software	PSL Input	Protection event
This DDB signal is the A-phase 2nd Harmonic start signal				
539	IB2H Start	Software	PSL Input	Protection event
This DDB signal is the B-phase 2nd Harmonic start signal				
540	IC2H Start	Software	PSL Input	Protection event
This DDB signal is the C-phase 2nd Harmonic start signal				
541	I2H Any Start	Software	PSL Input	Protection event
This DDB signal is the 2nd Harmonic start signal for any phase				
630	A LoadBlinder	Software	PSL Input	Protection event
This DDB signal is the Phase A Load Blinder signal, either direction				
633	B LoadBlinder	Software	PSL Input	Protection event
This DDB signal is the Phase B Load Blinder signal, either direction				
636	C LoadBlinder	Software	PSL Input	Protection event
This DDB signal is the Phase C Load Blinder signal, either direction				
639	Z1 LoadBlinder	Software	PSL Input	Protection event
This DDB signal is the 3-phase Load Blinder signal, either direction				

6 CONFIGURING THE BUSBAR PROTECTION

To configure the product to the topology of the busbar, use the settings in the *GROUP X SYSTEM CONFIG* column and map the digital inputs (DDBs) in the Programmable Scheme Logic (PSL). You don't need to use special topology design software.

1. As this is a single-phase device, set the ***Protected Phase*** to the phase being protected.
2. The current input circuits are known as terminals. To configure the protection, identify the number of terminals on the busbar.
3. Using the system configuration settings, associate the terminals with the primary CT circuits to which they are connected. Use the bit-field where 1 represents a connection and 0 no connection.
4. Set the polarities of the CT terminals using 1 or 0.
5. To complete the configuration, associate the status of switches in the scheme with the digital (opto-isolated) inputs using the PSL.

6.1 EXAMPLE OF CONFIGURING THE BUSBAR PROTECTION

To guide you through setting the configuration, the following scheme is used as an example.

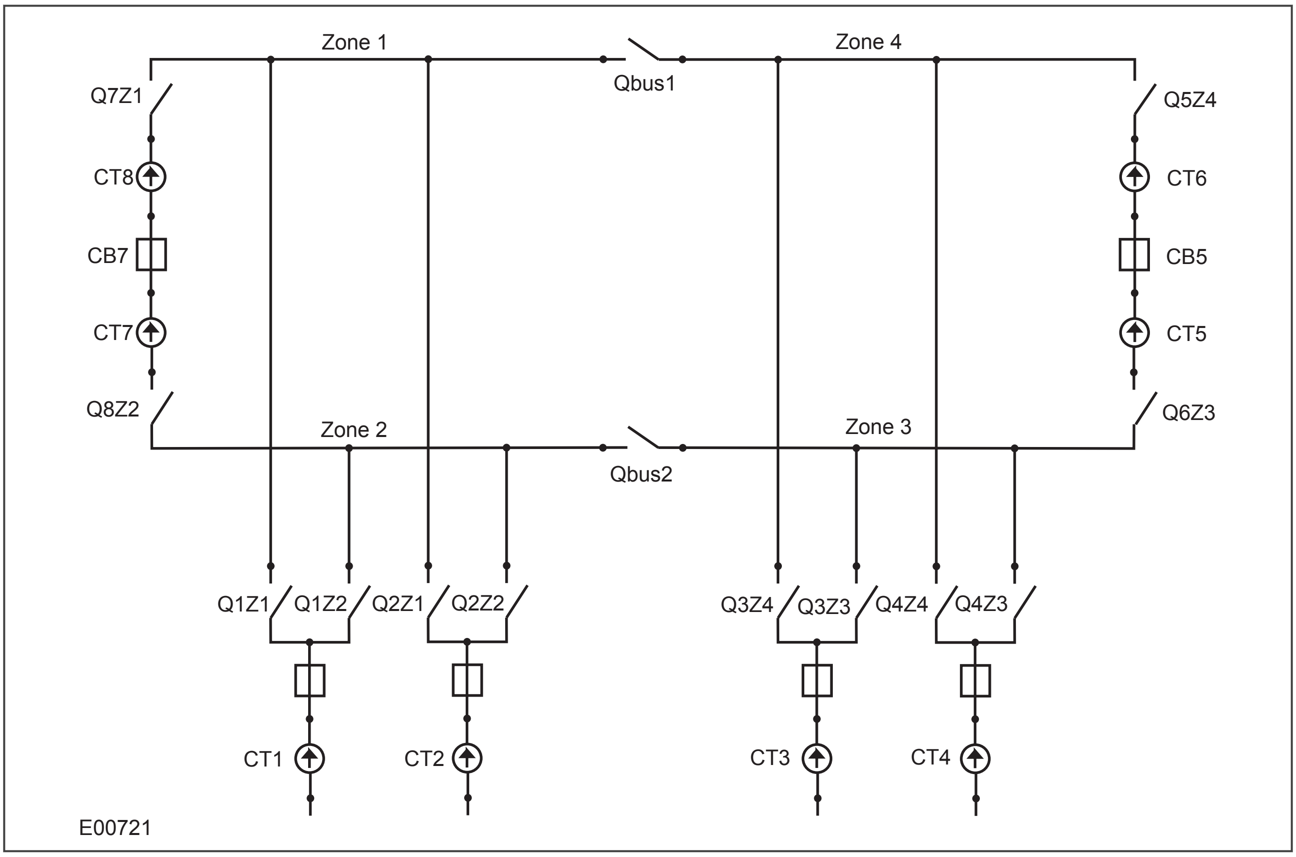


Figure 38: Busbar topology used in configuration example.

Before setting the configuration, we need to explain a few things:

- This is a double busbar scheme consisting of 4 zones.
- There are 8 current transformers and therefore 8 terminals.

- The allocation of current transformer numbers (CT1, CT2, etc.), are defined by the input circuit to which they are connected.
- The current transformers are assumed to have the polarities shown but you can invert the polarity in the settings.
- The method used to label the switches is:
  - QBusn is the bus section isolator on busbar ‘n’
  - QnZx indicates that terminal ‘n’ connects to zone ‘x’

To Set The Configuration:

1. In the ***Protected Phase*** setting, confirm which phase is protected.
2. In this scheme there are 8 current transformers so set ***Terminal Number*** to `8`.
3. Using the ***Zn CT Dir*** and ***Zn CT Inv Dir*** settings (where n = the number of the zone), map the CT connections to the zones they are protecting.
   Refer to CT directions in the diagram: if a CT looks into a zone, set the relevant bit in the ***Zn CT Dir*** setting; if a CT looks out of a zone, set the relevant bit in the ***Zn CT Inv Dir*** setting.
   The ***Zn CT Dir*** and ***Zn CT Inv Dir*** settings are 18-bit fields where the least significant bit corresponds to terminal 1 and the most significant bit corresponds to terminal 18.
   a. In this example, zone 1 is protected using terminals (CTs) 1, 2, and 7, and they all look into the zone, so you set:
      Z1 CT Dir to 000000000001000011
      Z1 CT Inv Dir to 000000000000000000
   b. In this example, zone 2 is protected using terminals (CTs) 1, 2, and 8. Terminals 1 and 2 look into the zone but terminal 8 looks out from the zone, so you set:
      Z2 CT Dir to 000000000000000011
      Z2 CT Inv Dir to 000000000010000000
4. Apply the same method to allocate the terminals for the other zones, for the check zone terminals, for the bus coupling terminals, and for the bus section terminals.
   a. The check zone for this example is defined by terminals 1, 2, 3, and 4, so you set:
      ChZONE Terminal to 000000000000001111
   b. In this example there are two bus couplers, both protected by two CTs. This is reflected in the ***Coupling 2CT-1*** and the ***Coupling 2CT-2*** settings. The ***Bus Coupler 1CT*** setting is used in applications where a single CT protects a bus coupler.
   c. The ***Bus Section 1*** and ***Bus Section 2*** settings are used to set which zones are connected to the bus section isolator.
5. Once the configuration settings are complete, map digital inputs in the Programmable Scheme Logic (PSL). Map the status of all switches on the busbar using the PSL. The following diagram shows mapped bus section isolators for this example.

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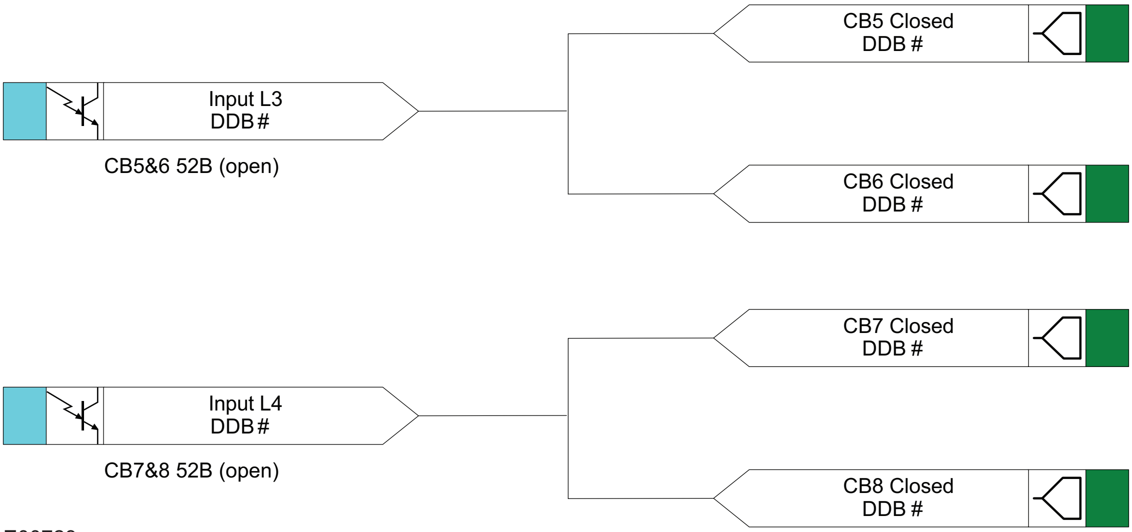
1. If a bus coupler has one circuit breaker protected by two current transformers, map the circuit breaker to both current transformers. The following diagram shows bus coupler circuit breakers for the worked example.



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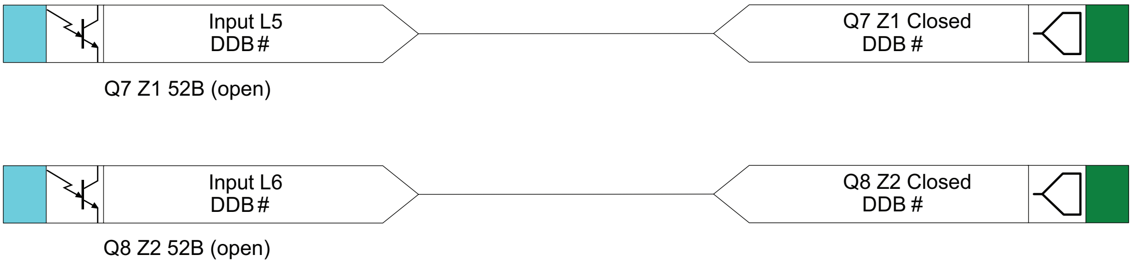
The following diagram shows bus coupler isolators for the worked example The configuration is then complete.



E00724

MONITORING AND CONTROL

CHAPTER 6

1 CHAPTER OVERVIEW

As well as providing a range of protection functions, the product includes comprehensive monitoring and control functionality.

This chapter contains the following sections:

2 EVENT RECORDS

Event records are generated when certain events happen. A change in any digital input signal or protection element output signal causes an event record to be created. These events are generated by the protection software and immediately time stamped. They are then transferred to non-volatile memory for storage.

> *Note:*
> *In extreme cases, for example under avalanche conditions it is possible for the buffer to overflow. If this occurs, a maintenance record is generated to indicate this loss of information.*

You can control which events cause an event record to be logged in the *RECORD CONTROL* column. The following table provides details of this control for all event types.

You can view the event records using the settings application software or with the front panel HMI. Select the event to be viewed on the LCD with the ***Select Event*** cell in the *VIEW RECORDS* column. A value of '0' corresponds to the latest event, '1' the next latest and so on. The following subsequent cells display details about the chosen event. Not all cells are relevant in all cases. The cells displayed depend on the type of event.

- ***Menu Cell Ref***: indicates the event type
- ***Time & Date***: indicates the time and date the event occurred
- ***Event Text***: displays the event description (2 lines of 16 characters)
- ***Event Value***: displays a 32 bit binary number representing the event
- ***Evt Iface Source***: displays the interface on which the event was logged
- ***Evt Access Level***: records the access level of the interface that initiated the event. This access level is displayed in this cell.
- ***Evt Extra Info***: provides supporting information for the event and can vary between the different event types.
- ***Evt Unique ID***: displays the unique event ID associated with the event.
- ***Reset indication***: resets the trip LED indications provided that the relevant protection element has reset.

2.1 EVENT RECORDS TABLE

Courier Text	Col	Row	Default Setting	Available Options
Description				
RECORD CONTROL	0B	00		
This column contains settings for Record Controls.				
Clear Events	0B	01	No	0= No or 1 = Yes
Clears the events log				
Clear Faults	0B	02	No	0= No or 1 = Yes
Clears the fault log				
Clear Maint	0B	03	No	0= No or 1 = Yes
Clears the maintenance log				
Alarm Event	0B	04	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the generation of an event on alarm. Disabling this setting means that no event is generated for alarms.				
Relay O/P Event	0B	05	Enabled	0 = Disabled or 1 = Enabled

<table>
<tr><th>Courier Text</th><th>Col</th><th>Row</th><th>Default Setting</th><th>Available Options</th></tr>
<tr><th colspan="5">Description</th></tr>
<tr><td colspan="5">This setting enables or disables the generation of an event for a change of state of output relay contact. Disabling this setting means that no event
will be generated for any change in logic output state.</td></tr>
<tr><td>Opto Input Event</td><td>0B</td><td>06</td><td>Enabled</td><td>0 = Disabled or 1 = Enabled</td></tr>
<tr><td colspan="5">This setting enables or disables the generation of an event for a change of state of opto-input. Disabling this setting means that no event will be
generated for any change in logic input state.</td></tr>
<tr><td>General Event</td><td>0B</td><td>07</td><td>Enabled</td><td>0 = Disabled or 1 = Enabled</td></tr>
<tr><td colspan="5">This setting enables or disables the generation of general events. Disabling this setting means that no general events are generated.</td></tr>
<tr><td>Fault Rec Event</td><td>0B</td><td>08</td><td>Enabled</td><td>0 = Disabled or 1 = Enabled</td></tr>
<tr><td colspan="5">This setting enables or disables the generation of fault record events. Disabling this setting means that no event will be generated for any fault that produces a fault record.</td></tr>
<tr><td>Maint Rec Event</td><td>0B</td><td>09</td><td>Enabled</td><td>0 = Disabled or 1 = Enabled</td></tr>
<tr><td colspan="5">This setting enables or disables the generation of maintenance record events. Disabling this setting means that no event will be generated for any
occurrence that produces a maintenance record.</td></tr>
<tr><td>Protection Event</td><td>0B</td><td>0A</td><td>Enabled</td><td>0 = Disabled or 1 = Enabled</td></tr>
<tr><td colspan="5">This setting enables or disables the generation of protection events. Disabling this setting means that any operation of protection elements will not be logged as an event.</td></tr>
<tr><td>Clear Dist Recs</td><td>0B</td><td>30</td><td>No</td><td>0= No or 1 = Yes</td></tr>
<tr><td colspan="5">This allows you to clear distance records</td></tr>
<tr><td>DDB 31 - 0</td><td>0B</td><td>40</td><td>0xFFFFFFFF</td><td>32-bit binary flag (data type G27)
1 = event recording Enabled
0 = event recording Disabled</td></tr>
<tr><td colspan="5">These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)</td></tr>
<tr><td>DDB 63 - 32</td><td>0B</td><td>41</td><td>0xFFFFFFFF</td><td>32-bit binary flag (data type G27)
1 = event recording Enabled
0 = event recording Disabled</td></tr>
<tr><td colspan="5">These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)</td></tr>
<tr><td>DDB 95 - 64</td><td>0B</td><td>42</td><td>0xFFFFFFFF</td><td>32-bit binary flag (data type G27)
1 = event recording Enabled
0 = event recording Disabled</td></tr>
<tr><td colspan="5">These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)</td></tr>
<tr><td>DDB 127 - 96</td><td>0B</td><td>43</td><td>0xFFFFFFFF</td><td>32-bit binary flag (data type G27)
1 = event recording Enabled
0 = event recording Disabled</td></tr>
<tr><td colspan="5">These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)</td></tr>
<tr><td>DDB 159 - 128</td><td>0B</td><td>44</td><td>0xFFFFFFFF</td><td>32-bit binary flag (data type G27)
1 = event recording Enabled
0 = event recording Disabled</td></tr>
<tr><td colspan="5">These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)</td></tr>
<tr><td>DDB 191 - 160</td><td>0B</td><td>45</td><td>0xFFFFFFFF</td><td>32-bit binary flag (data type G27)
1 = event recording Enabled
0 = event recording Disabled</td></tr>
</table>

Courier Text	Col	Row	Default Setting	Available Options
Description				
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 223 - 192	0B	46	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 255 - 224	0B	47	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 287 - 256	0B	48	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 319 - 288	0B	49	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 351 - 320	0B	4A	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 383 - 352	0B	4B	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 415 - 384	0B	4C	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 447 - 416	0B	4D	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 479 - 448	0B	4E	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 511 - 480	0B	4F	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled

Courier Text	Col	Row	Default Setting	Available Options
Description				
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 543 - 512	0B	50	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 575 - 544	0B	51	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 607 - 576	0B	52	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 639 – 608	0B	53	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 671 – 640	0B	54	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 703 – 672	0B	55	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 735 – 704	0B	56	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 767 – 736	0B	57	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 799 – 768	0B	58	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 831 – 800	0B	59	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled

Courier Text	Col	Row	Default Setting	Available Options
Description				
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 863 – 832	0B	5A	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 895 – 864	0B	5B	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 927 – 896	0B	5C	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 959 – 928	0B	5D	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 991 – 960	0B	5E	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1023 – 992	0B	5F	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1055-1024	0B	60	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1087-1056	0B	61	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1119-1088	0B	62	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1151-1120	0B	63	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled

Courier Text	Col	Row	Default Setting	Available Options
Description				
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1183-1152	0B	64	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1215-1184	0B	65	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1247-1216	0B	66	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1279-1248	0B	67	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1311-1280	0B	68	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1343-1312	0B	69	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1375-1344	0B	6A	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1407-1376	0B	6B	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1439-1408	0B	6C	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1471-1440	0B	6D	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled

Courier Text	Col	Row	Default Setting	Available Options
Description				
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1503-1472	0B	6E	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1535-1504	0B	6F	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1567-1536	0B	70	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1599-1568	0B	71	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1631-1600	0B	72	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1663-1632	0B	73	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1695-1664	0B	74	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1727-1696	0B	75	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1759-1728	0B	76	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1791-1760	0B	77	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled

Courier Text	Col	Row	Default Setting	Available Options
Description				
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1823-1792	0B	78	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1855-1824	0B	79	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1887-1856	0B	7A	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1919-1888	0B	7B	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1951-1920	0B	7C	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 1983-1952	0B	7D	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 2015-1984	0B	7E	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				
DDB 2047-2016	0B	7F	0xFFFFFFFF	32-bit binary flag (data type G27) 1 = event recording Enabled 0 = event recording Disabled
These signals can be included or excluded from being stored as a Courier event record (assuming the DDB is capable of creating an event)				

2.2 EVENT TYPES

There are several different types of event:

- Opto-input events (Change of state of opto-input)
- Contact events (Change of state of output relay contact)
- Alarm events

- Fault record events
- Standard events
- Security Events

Standard events are further sub-categorised internally to include different pieces of information. These are:

- Protection events (starts and trips)
- Maintenance record events
- Platform Events

2.2.1 OPTO-INPUT EVENTS

If one or more of the opto-inputs has changed state since the last time the protection algorithm ran (which runs at several times per cycle), a new event is created, which logs the logic states of all opto-inputs. You can tell which opto-input has changed state by comparing the new event with the previous one.

The description of this event type, as shown in the ***Event Text*** cell is always `Logic Inputs #` where # is the batch number of the opto-inputs. This is '1', for the first batch of opto-inputs and '2' for the second batch of opto-inputs (if applicable).

The event value shown in the ***Event Value*** cell for this type of event is a binary string. This shows the logical states of the opto-inputs, where the LSB (on the right) corresponds to the first opto-input `Input L1`.

The same information is also shown in the ***Opto I/P Status*** cell in the *SYSTEM DATA* column. This information is updated continuously, whereas the information in the event log is a snapshot at the time when the event was created.

2.2.2 CONTACT EVENTS

If one or more of the output relays (also known as output contacts) has changed state since the last time the protection algorithm ran (which runs at several times per cycle), a new event is created, which logs the logic states of all output relays. You can tell which output relay has changed state by comparing the new event with the previous one.

The description of this event type, as shown in the ***Event Text*** cell is always `Output Contacts #` where # is the batch number of the output relay contacts. This is '1', for the first batch of output contacts and '2' for the second batch of output contacts (if applicable).

The event value shown in the ***Event Value*** cell for this type of event is a binary string. This shows the logical states of the output relays, where the LSB (on the right) corresponds to the first output contact `Output R1`.

The same information is also shown in the ***Relay O/P Status*** cell in the *SYSTEM DATA* column. This information is updated continuously, whereas the information in the event log is a snapshot at the time when the event was created.

2.2.3 ALARM EVENTS

The IED monitors itself on power up and continually thereafter. If it notices any problems, it will register an alarm event.

The description of this event type, as shown in the ***Event Text*** cell is cell dependent on the type of alarm and will be one of those shown in the following tables, followed by `OFF` or `ON`.

The event value shown in the ***Event Value*** cell for this type of event is a 32 bit binary string. There are one or more banks 32 bit registers, depending on the device model. These contain all the alarm types and their logic states (`ON` or `OFF`).

The same information is also shown in the ***Alarm Status (n)*** cells in the *SYSTEM DATA* column. This information is updated continuously, whereas the information in the event log is a snapshot at the time when the event was created.

Alarm Status 2

Bit no.	Bit Mask (hex)	Alarm Description
0	0x00000001	Not Used
1	0x00000002	Not Used
2	0x00000004	Setting Group selection by DDB inputs invalid
3	0x00000008	CB Status Alarm
4	0x00000010	OOS Alarm
5	0x00000020	Frequency out of range Alarm
6	0x00000040	Circuitry Fault CZ Alarm
7	0x00000080	Circuitry Fault Z1 Alarm
8	0x00000100	Circuitry Fault Z2 Alarm
9	0x00000200	Circuitry Fault Z3 Alarm
10	0x00000400	Circuitry Fault Z4 Alarm
11	0x00000800	Z1 in Diff Block Mode Alarm
12	0x00001000	Z2 in Diff Block Mode Alarm
13	0x00002000	Z3 in Diff Block Mode Alarm
14	0x00004000	Z4 in Diff Block Mode Alarm
15	0x00008000	Z1 in Diff & CBF Block Mode Alarm
16	0x00010000	Z2 in Diff & CBF Block Mode Alarm
17	0x00020000	Z3 in Diff & CBF Block Mode Alarm
18	0x00040000	Z4 in Diff & CBF Block Mode Alarm
19	0x00080000	T1 in Maintenance Mode Alarm
20	0x00100000	T2 in Maintenance Mode Alarm
21	0x00200000	T3 in Maintenance Mode Alarm
22	0x00400000	T4 in Maintenance Mode Alarm
23	0x00800000	T5 in Maintenance Mode Alarm
24	0x01000000	T6 in Maintenance Mode Alarm
25	0x02000000	T7 in Maintenance Mode Alarm
26	0x04000000	T8 in Maintenance Mode Alarm
27	0x08000000	T9 in Maintenance Mode Alarm
28	0x10000000	T10 in Maintenance Mode Alarm
29	0x20000000	T11 in Maintenance Mode Alarm
30	0x40000000	T12 in Maintenance Mode Alarm
31	0x80000000	T13 in Maintenance Mode Alarm

Alarm Status 3

Bit no.	Bit Mask (hex)	Alarm Description
0	0x00000001	T14 in Maintenance Mode Alarm
1	0x00000002	T15 in Maintenance Mode Alarm
2	0x00000004	T16 in Maintenance Mode Alarm
3	0x00000008	T17 in Maintenance Mode Alarm
4	0x00000010	T18 in Maintenance Mode Alarm
5	0x00000020	Breaker Fail Any Trip
6	0x00000040	CB Fail Alarm T1

Bit no.	Bit Mask (hex)	Alarm Description
7	0x00000080	CB Fail Alarm T2
8	0x00000100	CB Fail Alarm T3
9	0x00000200	CB Fail Alarm T4
10	0x00000400	CB Fail Alarm T5
11	0x00000800	CB Fail Alarm T6
12	0x00001000	CB Fail Alarm T7
13	0x00002000	CB Fail Alarm T8
14	0x00004000	CB Fail Alarm T9
15	0x00008000	CB Fail Alarm T10
16	0x00010000	CB Fail Alarm T11
17	0x00020000	CB Fail Alarm T12
18	0x00040000	CB Fail Alarm T13
19	0x00080000	CB Fail Alarm T14
20	0x00100000	CB Fail Alarm T15
21	0x00200000	CB Fail Alarm T16
22	0x00400000	CB Fail Alarm T17
23	0x00800000	CB Fail Alarm T18
24	0x01000000	UNUSED
25	0x02000000	UNUSED
26	0x04000000	UNUSED
27	0x08000000	UNUSED
28	0x10000000	UNUSED
29	0x20000000	UNUSED
30	0x40000000	UNUSED
31	0x80000000	UNUSED

Alarm Status 3

Bit no.	Bit Mask (hex)	Alarm Description
0	0x00000001	Battery Fail alarm indication
1	0x00000002	Field Voltage Failure
2	0x00000004	unused
3	0x00000008	Enrolled GOOSE IED absent alarm indication
4	0x00000010	Network Interface Card not fitted/failed alarm
5	0x00000020	Network Interface Card not responding alarm
6	0x00000040	Network Interface Card fatal error alarm indication
7	0x00000080	Network Interface Card software reload alarm
8	0x00000100	Bad TCP/IP Configuration Alarm
9	0x00000200	Bad OSI Configuration Alarm
10	0x00000400	Network Interface Card link fail alarm indication
11	0x00000800	Main card/NIC software mismatch alarm indication
12	0x00001000	IP address conflict alarm indication
13	0x00002000	unused
14	0x00004000	unused

Bit no.	Bit Mask (hex)	Alarm Description
15	0x00008000	unused
16	0x00010000	unused
17	0x00020000	unused
18	0x00040000	unused
19	0x00080000	unused
20	0x00100000	unused
21	0x00200000	unused
22	0x00400000	unused
23	0x00800000	unused
24	0x01000000	unused
25	0x02000000	unused
26	0x04000000	unused
27	0x08000000	unused
28	0x10000000	unused
29	0x20000000	unused
30	0x40000000	unused
31	0x80000000	unused

2.2.4 FAULT RECORD EVENTS

An event record is created for every fault the IED detects. This is also known as a fault record.

The event type description shown in the ***Event Text*** cell for this type of event is always `Fault Recorded`.

The IED contains a separate register containing the latest fault records. This provides a convenient way of viewing the latest fault records and saves searching through the event log. You access these fault records using the ***Select Fault*** setting, where fault number 0 is the latest fault.

A fault record is triggered by the ***Fault REC TRIG*** signal DDB, which is assigned in the PSL. The fault recorder records the values of all parameters associated with the fault for the duration of the fault. These parameters are stored in separate Courier cells, which become visible depending on the type of fault.

The fault recorder stops recording only when:

The Start signal is reset AND the undercurrent is ON OR the Trip signal is reset, as shown below:

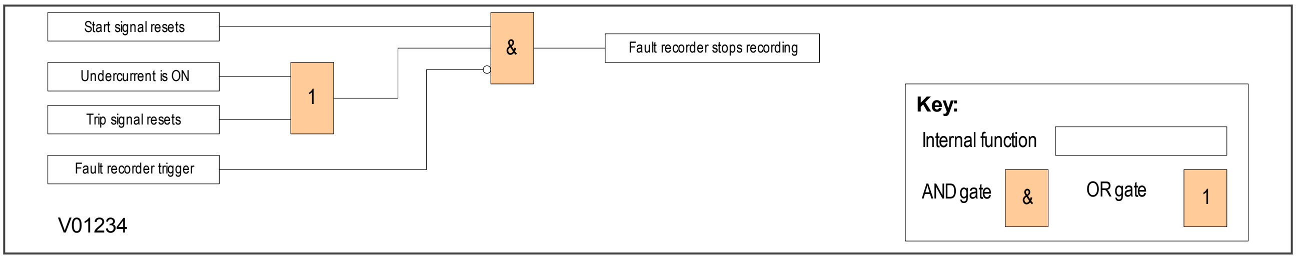


Figure 39: Fault recorder stop conditions

The event is logged as soon as the fault recorder stops. The time stamp assigned to the fault corresponds to the start of the fault. The timestamp assigned to the fault record event corresponds to the time when the fault recorder stops.

Note:
We recommend that you do not set the triggering contact to latching. This is because if you use a latching contact, the fault record would not be generated until the contact has been fully reset.

2.2.5 MAINTENANCE EVENTS

Internal failures detected by the self-test procedures are logged as maintenance records. Maintenance records are special types of standard events.

The event type description shown in the ***Event Text*** cell for this type of event is always `Maint Recorded`.

The ***Event Value*** cell also provides a unique binary code.

The IED contains a separate register containing the latest maintenance records. This provides a convenient way of viewing the latest maintenance records and saves searching through the event log. You access these fault records using the ***Select Maint*** setting.

The maintenance record has a number of extra menu cells relating to the maintenance event. These parameters are ***Maint Text***, ***Maint Type*** and ***Maint Data***. They contain details about the maintenance event selected with the ***Select Maint*** cell.

The possible maintenance records are as follows:

Event Value	Event Text	Description
6	FPGA Health Err	There is a Field Programmable Gate Array error
7	IO Card Error	There is an I/O card error
9	Code Verify Fail	There is a code verification failure
14	Software Failure	There is a general software failure
15	H/W Verify Fail	There is a hardware verification failure
16	Non Standard	There is a non-standard error
17	Ana. Sample Fail	There is a failure with the analogue signal sampling
18	NIC Soft Error	There is a Network Interface Card error
22	PSL Latch Reset	A PSL latch has been reset
23	Control IP Reset	A control input has been reset
24	Fn Keys Reset	A function key has been reset
25	SR Gates Reset	An SR gate has been reset
26	System Error	There is a system error
27	Solicited Reboot	The device has been requested to reboot
28	Unrec'ble Error	There is an unrecoverable internal error. The device will reboot after the maintenance record has been created
29	Lockout Request	A lockout has been requested. This is generated whenever maintenance access is gained through the USB port
30	IO Upgrade Fail	There has been an I/O upgrade failure. This can be caused by a faulty I/O card, or the boot loader enable bit on the micro-controller being disabled
31	Application Fail	An application has failed
32	System Restart	Not used
33	Unknown Error	There is an unknown error
34	FPGA Failure	The Field Programmable Gate Array has failed
35	Upgrade Mode Req	Upgrade mode has been requested. This is generated whenever maintenance access is gained through the USB port
36	Invalid MAC Addr	The device has an invalid MAC address

2.2.6 PROTECTION EVENTS

The IED logs protection starts and trips as individual events. Protection events are special types of standard events.

The event type description shown in the ***Event Text*** cell for this type of event is dependent on the protection event that occurred. Each time a protection event occurs, a DDB signal changes state. It is the name of this DDB signal followed by 'ON' or 'OFF' that appears in the ***Event Text*** cell.

The ***Event Value*** cell for this type of event is a 32 bit binary string representing the state of the relevant DDB signals. These binary strings can also be viewed in the *COMMISSION TESTS* column in the relevant DDB batch cells.

Not all DDB signals can generate an event. Those that can are listed in the *RECORD CONTROL* column. In this column, you can set which DDBs generate events.

2.2.7 SECURITY EVENTS

An event record is generated each time a setting that requires an access level is executed.

The event type description shown in the ***Event Text*** cell displays the type of change. These are as follows:

Event Value	Event Text	Description
0	User Logged In	A user has logged in
1	User Logged Out	A user has logged out
2	P/Word Set Blank	A blank password has been set
3	P/Word Not NERC	The password is not NERC compliant
4	Password Changed	The password has changed
5	Password Blocked	The password has been blocked
6	P/Word Unblocked	The password has been unblocked
7	P/W Ent When Blk	The password has been entered while it is blocked
8	Inval PW Entered	An invalid password has been entered
9	P/Word Timed Out	The password has timed out
10	Rcvy P/W Entered	The recovery password has been entered
11	IED Sec Code Rd	The IED security code has been read
12	IED Sec Code Exp	The IED security code timer has expired
13	Port Disabled	A port has been disabled
14	Port Enabled	A port has been enabled
15	Def Dsp Not NERC	The default display is not NERC compliant
16	PSL Stng D/Load	PSL settings have been downloaded to the IED
17	DNP Stng D/Load	DNP settings have been downloaded to the IED
18	Trace Dat D/Load	Trace Data has been downloaded to the IED
19	IED Confg D/Load	A configuration file has been downloaded to the IED
20	User Crv D/Load	A user curve has been downloaded to the IED
21	Setng Grp D/Load	A settings group has been downloaded to the IED
22	DR Settng D/Load	A Disturbance Recorder setting has been downloaded to the IED
23	PSL Stng Upload	PSL settings have been uploaded from the IED
24	DNP Stng Upload	DNP settings have been uploaded from the IED
25	Trace Dat Upload	Trace Data has been uploaded from the IED
26	IED Confg Upload	A configuration file has been uploaded from the IED
27	User Crv Upload	A user curve has been uploaded from the IED

Event Value	Event Text	Description
28	PSL Confg Upload	A PSL configuration has been uploaded from the IED
29	Settings Upload	Settings have been uploaded from the IED
30	Events Extracted	Events have been extracted
31	Actv. Grp Desel. By "Interface"	The active group has been deselected by an interface
32	Actv. Grp Select By "Interface"	The active group has been selected by an interface
33	Actv. Grp Desel. By Opto	The active group has been deselected by a digital input
34	Actv. Grp Select By Opto	The active group has been selected by a digital input
35	C & S Changed	A control and support setting has changed
36	DR Changed	A Disturbance Recorder setting has changed
37	Settings Changed	Settings have been changed
38	Def Set Restored	The default setting has been restored
39	Def Crv Restored	The default curve has been restored
40	Power On	The power has been switched on
41	App Downloaded	An application has been downloaded to the IED
42	IRIG-B Set None	IRIG-B interface has been set to "None"
43	IRIG-B Set Port1	IRIG-B interface has been set to "RP1"
44	IRIG-B Set Port2	IRIG-B interface has been set to "RP2"

2.2.8 PLATFORM EVENTS

Platform events are special types of standard events.

The event type description shown in the ***Event Text*** cell displays the type of change. These are as follows:

Event Value	Event Text	Description
0	Alarms Cleared	The alarm log has been cleared
1	Events Cleared	The events log has been cleared
2	Faults Cleared	The fault log has been cleared
3	Maint Cleared	The maintenance log has been cleared
4	IRIG-B Active	IRIG-B is active
5	IRIG-B Inactive	IRIG-B is inactive
6	Time Synch	The time has been synchronised
7	Indication Reset	The LED indications have been reset
14	NIC Link Fail	The Network Interface Card has failed
15	Dist Rec Cleared	The disturbance records have been cleared
16	IO Upgrade OK	The I/O has been upgraded successfully

2.3 VIEW RECORDS COLUMN

Courier Text	Col	Row	Default Setting	Available Options
Description				
VIEW RECORDS	01	00		
This column contains information about records. Most of these cells are not editable.				
Select Event	01	01	0	From to step
This setting selects the required event record. A value of 0 corresponds to the latest event, 1 the second latest and so on.				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Menu Cell Ref	01	02	(From Record)	<Event type>
This cell indicates the type of event				
Time & Date	01	03	(From Record)	<Date and time of the event>
This cell shows the Time & Date of the event, given by the internal Real Time Clock.				
Event Text	01	04		Not Settable
This cell shows the description of the event - up to 32 Characters over 2 lines.				
Event Value	01	05		Not Settable
This cell displays a 32 bit binary Flag representing the event.				
Select Fault	01	06		From to step
This setting selects the required fault record from those stored. A value of 0 corresponds to the latest fault and so on.				
Faulted Phase	01	07		<Faulted phase>
This cell displays the faulted phase.				
Start Elements1	01	08		<Start signal status>
This cell displays the status of the first set of 32 start signals.				
Start Elements2	01	09		Not Settable
This cell displays the status of the second set of 32 start signals.				
Start Elements3	01	0A		Not Settable
This cell displays the status of the third set of 32 start signals.				
Trip Elements1	01	10		Not Settable
This cell displays the status of the first set of 32 trip signals.				
Trip Elements2	01	11		Not Settable
This cell displays the status of the second set of 32 trip signals.				
Trip Elements3	01	12		Not Settable
This cell displays the status of the third set of 32 trip signals.				
Fault Alarms	01	50		Not Settable
This cell displays the status of the fault alarm signals.				
Fault Time	01	51	(From Record)	Not Settable
This cell displays the time and date of the fault				
Fault Type	01	52		Not Settable
This cell displays the fault type				
Active Group	01	53		Not Settable
This cell displays the active settings group				
System Frequency	01	54		Not Settable
This cell displays the system frequency				
Fault Duration	01	55		Not Settable
This cell displays the duration of the fault time				
CB Operate Time	01	56		Not Settable
This cell displays the CB operate time				
Relay Trip Time	01	60		Not Settable
This cell displays the time from protection start to protection trip				
Zone Test Mode	01	61		Not Settable
This cell displays the test mode to enter in commissioning mode by zone				

Courier Text	Col	Row	Default Setting	Available Options
Description				
IX-1 to IX-18 Magnitude	01	63 to 85		Not Settable
This cell displays the magnitude on analogue current channel 1 to 18				
VxN Magnitude Z1 to Z4	01	A0 to A3		Not Settable
This cell displays the magnitude on analogue voltage channel 1 to 4				
Ix Z1 Diff	01	B0		Not Settable
This cell displays zone 1 differential current				
Ix Z1 Bias	01	B1		Not Settable
This cell displays zone 1 bias current				
Ix Z2 Diff	01	B2		Not Settable
This cell displays zone 2 differential current				
Ix Z2 Bias	01	B3		Not Settable
This cell displays zone 2 bias current				
Ix Z3 Diff	01	B4		Not Settable
This cell displays zone 3 differential current				
Ix Z3 Bias	01	B5		Not Settable
This cell displays zone 3 bias current				
Ix Z4 Diff	01	B6		Not Settable
This cell displays zone 4 differential current				
Ix Z4 Bias	01	B7		Not Settable
This cell displays zone 4 bias current				
Ix CZ Diff	01	B8		Not Settable
This cell displays check zone differential current				
Ix CZ Bias	01	B9		Not Settable
This cell displays check zone bias current				
Evt Iface Source	01	FA		Not Settable
This cell displays the interface on which the event was logged				
Evt Access Level	01	FB		Not Settable
This cell displays the access level of the interface that initiated the event.				
Evt Extra Info	01	FC		Not Settable
This cell provides supporting information for the event and can vary between the different event types				
Evt Unique Id	01	FE		Not Settable
This cell displays the unique event ID associated with the event.				
Reset Indication	01	FF	No	
This cell resets the trip LED indications if the relevant protection element has reset				

3 DISTURBANCE RECORDER

The disturbance recorder feature allows you to record selected current and voltage inputs to the protection elements, together with selected digital signals. The digital signals may be inputs, outputs, or internal DDB signals. The disturbance records can be extracted using the disturbance record viewer in the settings application software. The disturbance record file can also be stored in the COMTRADE format. This allows the use of other packages to view the recorded data.

The integral disturbance recorder has an area of memory specifically set aside for storing disturbance records. The number of records that can be stored is dependent on the recording duration. The minimum duration is 0.1 s and the maximum duration is 10.5 s.

When the available memory is exhausted, the oldest records are overwritten by the newest ones.

Each disturbance record consists of a number of analogue data channels and digital data channels. The relevant CT and VT ratios for the analogue channels are also extracted to enable scaling to primary quantities.

The fault recording times are set by a combination of the ***Duration*** and ***Trigger Position*** cells. The ***Duration*** cell sets the overall recording time and the ***Trigger Position*** cell sets the trigger point as a percentage of the duration. For example, the default settings show that the overall recording time is set to 1.5 s with the trigger point being at 33.3% of this, giving 0.5 s pre-fault and 1 s post fault recording times.

With the ***Trigger Mode*** set to *Single*, if further triggers occurs whilst a recording is taking place, the recorder will ignore the trigger. However, with the ***Trigger Mode*** set to *Extended*, the post trigger timer will be reset to zero, extending the recording time.

You can select any of the IED's analogue inputs as analogue channels to be recorded. You can also map any of the opto-inputs output contacts to the digital channels. In addition, you may also map a number of DDB signals such as Starts and LEDs to digital channels.

You may choose any of the digital channels to trigger the disturbance recorder on either a low to high or a high to low transition, via the ***Input Trigger*** cell. The default settings are such that any dedicated trip output contacts will trigger the recorder.

It is not possible to view the disturbance records locally via the front panel LCD. You must extract these using suitable setting application software such as MiCOM S1 Agile.

4 MEASUREMENTS

4.1 MEASURED QUANTITIES

The device measures directly and calculates a number of system quantities, which are updated every second. You can view these values in the *MEASUREMENTS* columns or with the Measurement Viewer in the settings application software. Depending on the model, the device may measure and display some or more of the following quantities:

- Measured and calculated analogue current and voltage values
- Power and energy quantities
- Peak, fixed and rolling demand values
- Frequency measurements
- Others measurements

4.1.1 MEASURED AND CALCULATED CURRENTS

The device measures phase-to-phase and phase-to-neutral current values. The values are produced by sampling the analogue input quantities, converting them to digital quantities to present the magnitude and phase values. Sequence quantities are produced by processing the measured values. These are also displayed as magnitude and phase angle values. RMS values are calculated using the sum of the samples squared over a cycle of sampled data.

These measurements are contained in the *MEASUREMENTS 1* column.

4.1.2 MEASURED AND CALCULATED VOLTAGES

The device measures phase-to-phase and phase-to-neutral voltage values. The values are produced by sampling the analogue input quantities, converting them to digital quantities to present the magnitude and phase values. Sequence quantities are produced by processing the measured values. These are also displayed as magnitude and phase angle values. RMS values are calculated using the sum of the samples squared over a cycle of sampled data.

These measurements are contained in the *MEASUREMENTS 1* column.

4.1.3 POWER AND ENERGY QUANTITIES

Using the measured voltages and currents the device calculates the apparent, real and reactive power quantities. These are produced on a phase by phase basis together with three-phase values based on the sum of the three individual phase values. The signing of the real and reactive power measurements can be controlled using the measurement mode setting. The four options are defined in the table below:

Measurement Mode	Parameter	Signing
0 (Default)	Export Power Import Power Lagging Vars Leading VArs	+ – + –
1	Export Power Import Power Lagging Vars Leading VArs	– + + –
2	Export Power Import Power Lagging Vars Leading VArs	+ – – +

Measurement Mode	Parameter	Signing
3	Export Power Import Power Lagging Vars Leading VArs	– + – +

The device also calculates the per-phase and three-phase power factors.

These power values are also used to increment the total real and reactive energy measurements. Separate energy measurements are maintained for the total exported and imported energy. The energy measurements are incremented up to maximum values of 1000 GWhr or 1000 GVARhr at which point they will reset to zero, it is also possible to reset these values using the menu or remote interfaces using the Reset demand cell.

These measurements are contained in the *MEASUREMENTS 2* column.

4.1.4 DEMAND VALUES

The device produces fixed, rolling and peak demand values. It is possible to reset these quantities using the ***Reset demand*** cell.

The fixed demand value is the average value of a quantity over the specified interval. Values are produced for three phase real and reactive power. The fixed demand values displayed are those for the previous interval. The values are updated at the end of the fixed demand period according to the ***Fix Dem Period*** setting in the *MEASURE'T SETUP* column.

The rolling demand values are similar to the fixed demand values, the difference being that a sliding window is used. The rolling demand window consists of a number of smaller sub-periods. The resolution of the sliding window is the sub-period length, with the displayed values being updated at the end of each of the sub-periods according to the ***Roll Sub Period*** setting in the *MEASURE'T SETUP* column.

Peak demand values are produced for each phase current and the real and reactive power quantities. These display the maximum value of the measured quantity since the last reset of the demand values.

These measurements are contained in the *MEASUREMENTS 2* column.

4.1.5 FREQUENCY MEASUREMENTS

The device produces a range of frequency statistics and measurements relating to the Frequency Protection function. These include Check synchronisation and Slip frequency measurements found in the *MEASUREMENTS 1* column, Rate of Change of Frequency measurements found in the *MEASUREMENTS 3* column, and Frequency Protection statistics found in the *FREQ STAT* column.

The device produces the slip frequency measurement by measuring the rate of change of phase angle between the bus and line voltages, over a one-cycle period. The slip frequency measurement assumes the bus voltage to be the reference phasor.

4.1.6 OTHER MEASUREMENTS

Depending on the model, the device produces a range of other measurements such as thermal measurements.

These measurements are contained in the *MEASUREMENTS 3* column.

4.2 MEASUREMENT SETUP

You can define the way measurements are set up and displayed using the *MEASURE'T SETUP* column, as shown below:

Courier Text	Col	Row	Default Setting	Available Options
Description				
MEASURE'T SETUP	0D	00		
This column contains settings for the measurement setup				
Default Display	0D	01	User Banner	0 Banner 1 Date and Time 2 Description 3 Plant Reference 4 Frequency 5 Access Level
This setting is used to select the default display from a range of options.				
Local Values	0D	02	Primary	0 = Primary or 1 = Secondary
This setting controls whether local measured values (via HMI or front port) are displayed as primary or secondary quantities.				
Remote Values	0D	03	Primary	0 = Primary or 1 = Secondary
This setting controls whether remote measured values (via rear comms ports) are displayed as primary or secondary quantities.				
Measurement Ref	0D	04	VXN Z1	0 VxN Z1 1 VxN Z2 2 VxN Z3 3 VxN Z4 4 IX-T1 5 IX-T2 6 IX-T3 7 IX-T4 8 IX-T5 9 IX-T6 10 IX-T7 11 IX-T8 12 IX-T9 13 IX-T10 14 IX-T11 15 IX-T12 16 IX-T13 17 IX-T14 18 IX-T15 19 IX-T16 20 IX-T17 21 IX-T18
This sets the phase reference for all angular measurements (for Measurements 1 only).				

4.3 MEASUREMENT TABLES

Courier Text	Col	Row	Default Setting	Available Options
Description				
MEASUREMENTS 1	02	00		
This column contains measurement parameters				
IX-1 Magnitude	02	25		Not Settable
IX-1 Magnitude				
IX-1 Phase Angle	02	26		Not Settable
IX-1 Phase Angle				

Courier Text	Col	Row	Default Setting	Available Options
Description				
IX-2 Magnitude	02	27		Not Settable
IX-2 Magnitude				
IX-2 Phase Angle	02	28		Not Settable
IX-2 Phase Angle				
IX-3 Magnitude	02	29		Not Settable
IX-3 Magnitude				
IX-3 Phase Angle	02	2A		Not Settable
IX-3 Phase Angle				
IX-4 Magnitude	02	2B		Not Settable
IX-4 Magnitude				
IX-4 Phase Angle	02	2C		Not Settable
IX-4 Phase Angle				
IX-5 Magnitude	02	2D		Not Settable
IX-5 Magnitude				
IX-5 Phase Angle	02	2E		Not Settable
IX-5 Phase Angle				
IX-6 Magnitude	02	2F		Not Settable
IX-6 Magnitude				
IX-6 Phase Angle	02	30		Not Settable
IX-6 Phase Angle				
IX-7 Magnitude	02	31		Not Settable
IX-7 Magnitude				
IX-7 Phase Angle	02	32		Not Settable
IX-7 Phase Angle				
IX-8 Magnitude	02	33		Not Settable
IX-8 Magnitude				
IX-8 Phase Angle	02	34		Not Settable
IX-8 Phase Angle				
IX-9 Magnitude	02	35		Not Settable
IX-9 Magnitude				
IX-9 Phase Angle	02	36		Not Settable
IX-9 Phase Angle				
IX-10 Magnitude	02	37		Not Settable
IX-10 Magnitude				
IX-10 Phase Angle	02	38		Not Settable
IX-10 Phase Angle				
IX-11 Magnitude	02	39		Not Settable
IX-11 Magnitude				
IX-11 Phase Angle	02	3A		Not Settable
IX-11 Phase Angle				
IX-12 Magnitude	02	3B		Not Settable
IX-12 Magnitude				

Courier Text	Col	Row	Default Setting	Available Options
Description				
IX-12 Phase Angle	02	3C		Not Settable
IX-12 Phase Angle				
IX-13 Magnitude	02	3D		Not Settable
IX-13 Magnitude				
IX-13 Phase Angle	02	3E		Not Settable
IX-13 Phase Angle				
IX-14 Magnitude	02	3F		Not Settable
IX-14 Magnitude				
IX-14 Phase Angle	02	40		Not Settable
IX-14 Phase Angle				
IX-15 Magnitude	02	41		Not Settable
IX-15 Magnitude				
IX-15 Phase Angle	02	42		Not Settable
IX-15 Phase Angle				
IX-16 Magnitude	02	43		Not Settable
IX-16 Magnitude				
IX-16 Phase Angle	02	44		Not Settable
IX-16 Phase Angle				
IX-17 Magnitude	02	45		Not Settable
IX-17 Magnitude				
IX-17 Phase Angle	02	46		Not Settable
IX-17 Phase Angle				
IX-18 Magnitude	02	47		Not Settable
IX-18 Magnitude				
IX-18 Phase Angle	02	48		Not Settable
IX-18 Phase Angle				
VxN Magnitude Z1	02	8F		Not Settable
VxN Magnitude Z1				
VxN Phase Angle Z1	02	90		Not Settable
VxN Phase Angle Z1				
VxN Magnitude Z2	02	91		Not Settable
VxN Magnitude Z2				
VxN Phase Angle Z2	02	92		Not Settable
VxN Phase Angle Z2				
VxN Magnitude Z3	02	93		Not Settable
VxN Magnitude Z3				
VxN Phase Angle Z3	02	94		Not Settable
VxN Phase Angle Z3				
VxN Magnitude Z4	02	9A		Not Settable
VxN Magnitude Z4				

Courier Text	Col	Row	Default Setting	Available Options
Description				
VxN Phase Angle Z4	02	9B		Not Settable
VxN Phase Angle Z4				
VxN RMS Z1	02	A2		Not Settable
VxN RMS Z1				
VxN RMS Z2	02	A3		Not Settable
VxN RMS Z2				
VxN RMS Z3	02	A4		Not Settable
VxN RMS Z3				
VxN RMS Z4	02	A6		Not Settable
VxN RMS Z4				
Frequency	02	AA		Not Settable
Frequency				

4.4 MEASUREMENT TABLE 3

Courier Text	Col	Row	Default Setting	Available Options
Description				
MEASUREMENTS 2	04	00		
This column contains measurement parameters				
Ix Z1 Diff	04	01		Not Settable
Ix Z1 Diff				
Ix Z1 Bias	04	02		Not Settable
Ix Z1 Bias				
Ix Z2 Diff	04	03		Not Settable
Ix Z2 Diff				
Ix Z2 Bias	04	04		Not Settable
Ix Z2 Bias				
Ix Z3 Diff	04	05		Not Settable
Ix Z3 Diff				
Ix Z3 Bias	04	06		Not Settable
Ix Z3 Bias				
Ix Z4 Diff	04	07		Not Settable
Ix Z4 Diff				
Ix Z4 Bias	04	08		Not Settable
Ix Z4 Bias				
Ix CZ Diff	04	09		Not Settable
Ix CZ Diff				
Ix CZ Bias	04	0A		Not Settable
Ix CZ Bias				

5 I/O FUNCTIONS

5.1 FUNCTION KEYS

For many models, a number of programmable function keys are available. This allows you to assign function keys to control functionality via the programmable scheme logic (PSL). Each function key is associated with a programmable tri-colour LED, which you can program to give the desired indication on activation of the function key.

These function keys can be used to trigger any function that they are connected to as part of the PSL. The function key commands are found in the *FUNCTION KEYS* column.

Each function key is associated with a DDB signal as shown in the DDB table. You can map these DDB signals to any function available in the PSL.

The ***Fn Key Status*** cell displays the status (energised or de-energised) of the function keys by means of a binary string, where each bit represents a function key starting with bit 0 for function key 1.

Each function key has three settings associated with it, as shown:

- ***Fn Key (n)***, which enables or disables the function key
- ***Fn Key (n) Mode***, which allows you to configure the key as toggled or normal
- ***Fn Key (n) label***, which allows you to define the function key text that is displayed

The ***Fn Key (n)*** cell is used to enable (unlock) or disable the function key signals in PSL. The Lock setting has been provided to prevent further activation on subsequent 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 therefore 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 functions.

When the ***Fn Key (n) Mode*** cell is set to `Toggle`, the function key DDB signal output will remain in the set state until a reset command is given. In the `Normal` mode, the function key DDB signal will remain energised for as long as the function key is pressed and will then reset automatically. In this mode, a minimum pulse duration can be programmed by adding a minimum pulse timer to the function key DDB output signal.

The ***Fn Key Label*** 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 all function keys are recorded in non-volatile memory. In case of auxiliary supply interruption their status will be maintained.

5.1.1 FUNCTION KEY DDB SIGNALS

Ordinal	Signal Name	Source	Type	Response
Description				
320	Function Key 1	Software	Function Key	Protection event
DDB signal indicates that Function key 1 is active				
321	Function Key 2	Software	Function Key	Protection event
DDB signal indicates that Function key 2 is active				
322	Function Key 3	Software	Function Key	Protection event
DDB signal indicates that Function key 3 is active				
323	Function Key 4	Software	Function Key	Protection event
DDB signal indicates that Function key 4 is active				
324	Function Key 5	Software	Function Key	Protection event

Ordinal	Signal Name	Source	Type	Response
Description				
DDB signal indicates that Function key 5 is active				
325	Function Key 6	Software	Function Key	Protection event
DDB signal indicates that Function key 6 is active				
326	Function Key 7	Software	Function Key	Protection event
DDB signal indicates that Function key 7 is active				
327	Function Key 8	Software	Function Key	Protection event
DDB signal indicates that Function key 8 is active				
328	Function Key 9	Software	Function Key	Protection event
DDB signal indicates that Function key 9 is active				
329	Function Key 10	Software	Function Key	Protection event
DDB signal indicates that Function key 10 is active				

5.1.2 FUNCTION KEY SETTINGS

Menu Text	Col	Row	Default Setting	Available Options
Description				
FUNCTION KEYS	17	00		
This column contains the function key definitions				
Fn Key Status	17	01	0	8-bit binary string
This cell displays the status of each function key				
Fn Key 1 - 10	17	02 - 1D	Unlocked	Disable, Lock or Unlock
This setting activates function key 1. The ‘Lock’ setting allows a function key, which is in toggle mode, to be locked in its current active state.				
Fn Key 1 - 10 Mode	17	03 - 1E	Toggled	Toggle or Normal
This setting sets the function key mode. In ‘Toggle’ mode, a single key press set sand latches the function key output to ‘high’ or ‘low’ in the PSL. In ‘Normal’ mode the function key output remains high as long as key is pressed.				
Fn Key 1 - 10 Label	17	04 - 1F	Function Key 1	16-character text string
This setting lets you change the function key text to something more suitable for the application.				

5.2 LEDS

Depending on the model, different numbers of LEDs are used. Some are fixed function LEDs, some are programmable, and for devices with function keys there are LEDs associated with each function key.

5.2.1 FIXED FUNCTION LEDS

Four fixed-function LEDs on the left-hand side of the front panel indicate the following conditions.

- Trip (Red) switches ON when the IED 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 IED 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 IED's protection is unavailable.
- Healthy (Green) is ON when the IED is in correct working order, and should be ON at all times. It goes OFF if the unit’s self-tests show there is an error in the hardware or software. The state of the healthy LED is reflected by the watchdog contacts at the back of the unit.

5.2.2 PROGRAMABLE LEDS

The device has a number of programmable LEDs, which can be associated with PSL-generated signals. All of the programmable LEDs are tri-colour and can be set to RED, YELLOW or GREEN.

5.2.3 FUNCTION KEY LEDS

Adjacent to the function keys are programmable tri-colour LEDs. These should be associated with their respective function keys.

5.2.4 TRIP LED LOGIC

When a trip occurs, the trip LED is illuminated. It is possible to reset this with a number of ways:

- Directly with a reset command (by pressing the Clear Key)
- With a reset logic input
- With self-resetting logic

You enable the automatic self-resetting with the ***Sys Fn Links*** cell in the *SYSTEM DATA* column. A '0' disables self resetting and a '1' enables self resetting.

The reset occurs when the circuit is reclosed and the ***Any Pole Dead*** signal has been reset for three seconds providing the ***Any Start*** signal is inactive. The reset is prevented if the ***Any Start*** signal is active after the breaker closes.

The Trip LED logic is as follows:

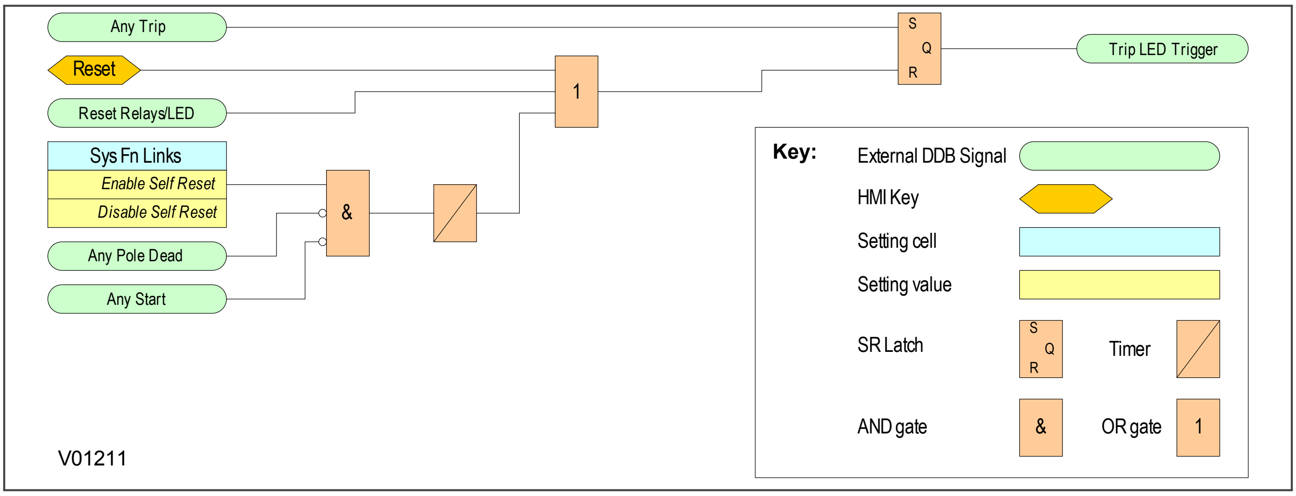


Figure 40: Trip LED logic

5.2.5 LED DDB SIGNALS

Ordinal	Signal Name	Source	Type	Response
Description				
192	LED1 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 1 - Red (Programmable LED)				
193	LED1 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 1 - Green (Programmable LED)				
194	LED2 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 2 - Red (Programmable LED)				

Ordinal	Signal Name	Source	Type	Response
Description				
195	LED2 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 2 - Green (Programmable LED)				
196	LED3 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 3 - Red (Programmable LED)				
197	LED3 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 3 - Green (Programmable LED)				
198	LED4 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 4 - Red (Programmable LED)				
199	LED4 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 4 - Green (Programmable LED)				
200	LED5 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 5 - Red (Programmable LED)				
201	LED5 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 5 - Green (Programmable LED)				
202	LED6 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 6 - Red (Programmable LED)				
203	LED6 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 6 - Green (Programmable LED)				
204	LED7 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 7 - Red (Programmable LED)				
205	LED7 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 7 - Green (Programmable LED)				
206	LED8 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 8 - Red (Programmable LED)				
207	LED8 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 8 - Green (Programmable LED)				
208	FnKey LED1 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 9 - Red (Function key LED)				
209	FnKey LED1 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 9 - Green (Function key LED)				
210	FnKey LED2 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 10 - Red (Function key LED)				
211	FnKey LED2 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 10 - Green (Function key LED)				
212	FnKey LED3 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 11 - Red (Function key LED)				
213	FnKey LED3 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 11 - Green (Function key LED)				
214	FnKey LED4 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 12 - Red (Function key LED)				
215	FnKey LED4 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 12 - Green (Function key LED)				

Ordinal	Signal Name	Source	Type	Response
Description				
216	FnKey LED5 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 13 - Red (Function key LED)				
217	FnKey LED5 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 13 - Green (Function key LED)				
218	FnKey LED6 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 14 - Red (Function key LED)				
219	FnKey LED6 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 14 - Green (Function key LED)				
220	FnKey LED7 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 15 - Red (Function key LED)				
221	FnKey LED7 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 15 - Green (Function key LED)				
222	FnKey LED8 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 16 - Red (Function key LED)				
223	FnKey LED8 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 16 - Green (Function key LED)				
224	FnKey LED9 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 17 - Red (Function key LED)				
225	FnKey LED9 Grn	Software	TRI LED	NO RESPONSE
Tri-LED - 17 - Green (Function key LED)				
226	FnKey LED10 Red	Software	TRI LED	NO RESPONSE
Tri-LED - 18 - Red (Function key LED)				
227	FnKey LED10 Grn	Software	TRI LED	NO RESPONSE

5.2.6 LED CONDITIONERS

When driving an LED, the driving signal has to first be conditioned. We need to define certain properties such as whether it should be latched or not. This is defined in the PSL Editor, which is described in the Setting Applications Software chapter.

A different set of DDB signals is provided for the purposes of connecting signals such as trips, starts and alarms, if these signals are to drive the LEDs. The names of these DDB signals are shown below.

5.3 OPTO-INPUTS

Depending on the model, different numbers of opto-inputs are available. The use of these opto-inputs depends on the application. There are a number of settings associated with the opto-inputs.

5.3.1 OPTO-INPUT CONFIGURATION

Courier Text	Col	Row	Default Setting	Available Options
Description				
OPTO CONFIG	11	00		
This column contains opto-input configuration settings				
Global Nominal V	11	01	48-54V	0 = 24-27V, 1 = 30-34V, 2 = 48-54V, 3 = 110-125V, 4 = 220-250V or 5 = Custom

Courier Text	Col	Row	Default Setting	Available Options
Description				
This setting sets the nominal DC voltage for all opto-inputs. The Custom settign allows you to set each opto-input to any voltage value individually.				
Opto Input 1	11	02	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 1				
Opto Input 2	11	03	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 2				
Opto Input 3	11	04	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 3				
Opto Input 4	11	05	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 4				
Opto Input 5	11	06	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 5				
Opto Input 6	11	07	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 6				
Opto Input 7	11	08	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 7				
Opto Input 8	11	09	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 8				
Opto Input 9	11	0A	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 9				
Opto Input 10	11	0B	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 10				
Opto Input 11	11	0C	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 11				
Opto Input 12	11	0D	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 12				
Opto Input 13	11	0E	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 13				
Opto Input 14	11	0F	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 14				
Opto Input 15	11	10	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 15				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Opto Input 16	11	11	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 16				
Opto Input 17	11	12	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 17				
Opto Input 18	11	13	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 18				
Opto Input 19	11	14	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 19				
Opto Input 20	11	15	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 20				
Opto Input 21	11	16	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 21				
Opto Input 22	11	17	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 22				
Opto Input 23	11	18	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 23				
Opto Input 24	11	19	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 24				
Opto Input 25	11	1A	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 25				
Opto Input 26	11	1B	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 26				
Opto Input 27	11	1C	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 27				
Opto Input 28	11	1D	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 28				
Opto Input 29	11	1E	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 29				
Opto Input 30	11	1F	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 30				
Opto Input 31	11	20	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V

Courier Text	Col	Row	Default Setting	Available Options
Description				
This cell sets the nominal voltage for opto-input 31				
Opto Input 32	11	21	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 32				
Opto Input 33	11	22	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 33				
Opto Input 34	11	23	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 34				
Opto Input 35	11	24	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 35				
Opto Input 36	11	25	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 36				
Opto Input 37	11	26	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 37				
Opto Input 38	11	27	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 38				
Opto Input 39	11	28	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 39				
Opto Input 40	11	29	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
This cell sets the nominal voltage for opto-input 40				
OptoFilter Ctrl1	11	50	0xFFFFFFFF	Binary flag: 0 = Off, 1 = Energised
This setting determines whether the in-built noise filter is off or on for each opto-input.				
OptoFilter Ctrl2	11	51	0x000000FF	Binary flag: 0 = Off, 1 = Energised
This setting determines whether the in-built noise filter is off or on for each opto-input.				
Characteristic	11	80	Standard 60%-80%	0 = Standard 60% to 80% or 1 = 50% to 70%
This setting selects the opto-inputs' pick-up and drop-off characteristics.				

5.3.2 OPTO-INPUT LABELS

Courier Text	Col	Row	Default Setting	Available Options
Description				
GROUP 1 INPUT LABELS	4A	00		
This column contains settings for the opto-input Labels				
Opto Input 1	4A	01	L1 Not Used	ASCII text
This setting defines the label for opto-input 1				
Opto Input 2	4A	02	L2 Not Used	ASCII text

Courier Text	Col	Row	Default Setting	Available Options
Description				
This setting defines the label for opto-input 2				
Opto Input 3	4A	03	L3 Not Used	ASCII text
This setting defines the label for opto-input 3				
Opto Input 4	4A	04	L4 Not Used	ASCII text
This setting defines the label for opto-input 4				
Opto Input 5	4A	05	L5 Not Used	ASCII text
This setting defines the label for opto-input 5				
Opto Input 6	4A	06	L6 Not Used	ASCII text
This setting defines the label for opto-input 6				
Opto Input 7	4A	07	L7 Not Used	ASCII text
This setting defines the label for opto-input 7				
Opto Input 8	4A	08	L8 Not Used	ASCII text
This setting defines the label for opto-input 8				
Opto Input 9	4A	09	L9 Not Used	ASCII text
This setting defines the label for opto-input 9				
Opto Input 10	4A	0A	L10 Not Used	ASCII text
This setting defines the label for opto-input 10				
Opto Input 11	4A	0B	L11 Not Used	ASCII text
This setting defines the label for opto-input 11				
Opto Input 12	4A	0C	L12 Not Used	ASCII text
This setting defines the label for opto-input 12				
Opto Input 13	4A	0D	L13 Not Used	ASCII text
This setting defines the label for opto-input 13				
Opto Input 14	4A	0E	L14 Not Used	ASCII text
This setting defines the label for opto-input 14				
Opto Input 15	4A	0F	L15 Not Used	ASCII text
This setting defines the label for opto-input 15				
Opto Input 16	4A	10	L16 Not Used	ASCII text
This setting defines the label for opto-input 16				
Opto Input 17	4A	11	L17 Not Used	ASCII text
This setting defines the label for opto-input 17				
Opto Input 18	4A	12	L18 Not Used	ASCII text
This setting defines the label for opto-input 18				
Opto Input 19	4A	13	L19 Not Used	ASCII text
This setting defines the label for opto-input 19				
Opto Input 20	4A	14	L20 Not Used	ASCII text
This setting defines the label for opto-input 20				
Opto Input 21	4A	15	L21 Not Used	ASCII text
This setting defines the label for opto-input 21				
Opto Input 22	4A	16	L22 Not Used	ASCII text
This setting defines the label for opto-input 22				
Opto Input 23	4A	17	L23 Not Used	ASCII text

Courier Text	Col	Row	Default Setting	Available Options
Description				
This setting defines the label for opto-input 23				
Opto Input 24	4A	18	L24 Not Used	ASCII text
This setting defines the label for opto-input 24				
Opto Input 25	4A	19	L25 Not Used	ASCII text
This setting defines the label for opto-input 25				
Opto Input 26	4A	1A	L26 Not Used	ASCII text
This setting defines the label for opto-input 26				
Opto Input 27	4A	1B	L27 Not Used	ASCII text
This setting defines the label for opto-input 27				
Opto Input 28	4A	1C	L28 Not Used	ASCII text
This setting defines the label for opto-input 28				
Opto Input 29	4A	1D	L29 Not Used	ASCII text
This setting defines the label for opto-input 29				
Opto Input 30	4A	1E	L30 Not Used	ASCII text
This setting defines the label for opto-input 30				
Opto Input 31	4A	1F	L31 Not Used	ASCII text
This setting defines the label for opto-input 31				
Opto Input 32	4A	20	L32 Not Used	ASCII text
This setting defines the label for opto-input 32				
Opto Input 33	4A	21	L33 Not Used	ASCII text
This setting defines the label for opto-input 33				
Opto Input 34	4A	22	L34 Not Used	ASCII text
This setting defines the label for opto-input 34				
Opto Input 35	4A	23	L35 Not Used	ASCII text
This setting defines the label for opto-input 35				
Opto Input 36	4A	24	L36 Not Used	ASCII text
This setting defines the label for opto-input 36				
Opto Input 37	4A	25	L37 Not Used	ASCII text
This setting defines the label for opto-input 37				
Opto Input 38	4A	26	L38 Not Used	ASCII text
This setting defines the label for opto-input 38				
Opto Input 39	4A	27	L39 Not Used	ASCII text
This setting defines the label for opto-input 39				
Opto Input 40	4A	28	L40 Not Used	ASCII text
This setting defines the label for opto-input 40				

5.3.3 OPTO-INPUT DDB SIGNALS

The number of inputs depends on the model and are connected to DDB signals as shown in the following table. The default names are provided but these can be configured in the *I/P LABELS* column.

Ordinal	Signal Name	Source	Type	Response
Description				
64 to 103	Opto-Isolator Input 1 to 40	Software	Opto	Opto Change event

Ordinal	Signal Name	Source	Type	Response
Description				
DDB signals for opto-Isolator Inputs 1 to 40				

5.3.4 ENHANCED TIME STAMPING

Each opto-input sample is time stamped within a tolerance of +/- 1 ms with respect to the Real Time Clock. These time stamps are used for the opto event logs and for the disturbance recording. The device needs to be synchronised accurately to an external clock source such as an IRIG-B signal or a master clock signal provided in the relevant data protocol.

For both the filtered and unfiltered opto-inputs, the time stamp of an opto-input change event is the sampling time at which the change of state occurred. If a mixture of filtered and unfiltered opto-inputs change state at the same sampling interval, these state changes are reported as a single event.

5.4 OUTPUT RELAYS

Depending on the model, different numbers of relay outputs are available. The use of these relay outputs depend on the application. There are a number of settings associated with the relay outputs.

5.4.1 OUTPUT RELAY LABELS

In the *O/P LABELS* column, you can define the DDB signal names for the output relays.

Courier Text	Col	Row	Default Setting	Available Options
Description				
GROUP 1 OUTPUT LABELS	4B	00		
This column contains settings for the output relay labels				
Relay 1	4B	01	R1 Not Used	ASCII text
This setting defines the label for output relay 1				
Relay 2	4B	02	R2 Not Used	ASCII text
This setting defines the label for output relay 2				
Relay 3	4B	03	R3 Not Used	ASCII text
This setting defines the label for output relay 3				
Relay 4	4B	04	R4 Not Used	ASCII text
This setting defines the label for output relay 4				
Relay 5	4B	05	R5 Not Used	ASCII text
This setting defines the label for output relay 5				
Relay 6	4B	06	R6 Not Used	ASCII text
This setting defines the label for output relay 6				
Relay 7	4B	07	R7 Not Used	ASCII text
This setting defines the label for output relay 7				
Relay 8	4B	08	R8 Not Used	ASCII text
This setting defines the label for output relay 8				
Relay 9	4B	09	R9 Not Used	ASCII text
This setting defines the label for output relay 9				
Relay 10	4B	0A	R10 Not Used	ASCII text
This setting defines the label for output relay 10				
Relay 11	4B	0B	R11 Not Used	ASCII text

Courier Text	Col	Row	Default Setting	Available Options
Description				
This setting defines the label for output relay 11				
Relay 12	4B	0C	R12 Not Used	ASCII text
This setting defines the label for output relay 12				
Relay 13	4B	0D	R13 Not Used	ASCII text
This setting defines the label for output relay 13				
Relay 14	4B	0E	R14 Not Used	ASCII text
This setting defines the label for output relay 14				
Relay 15	4B	0F	R15 Not Used	ASCII text
This setting defines the label for output relay 15				
Relay 16	4B	10	R16 Not Used	ASCII text
This setting defines the label for output relay 16				
Relay 17	4B	11	R17 Not Used	ASCII text
This setting defines the label for output relay 17				
Relay 18	4B	12	R18 Not Used	ASCII text
This setting defines the label for output relay 18				
Relay 19	4B	13	R19 Not Used	ASCII text
This setting defines the label for output relay 19				
Relay 20	4B	14	R20 Not Used	ASCII text
This setting defines the label for output relay 20				
Relay 21	4B	15	R21 Not Used	ASCII text
This setting defines the label for output relay 21				
Relay 22	4B	16	R22 Not Used	ASCII text
This setting defines the label for output relay 22				
Relay 23	4B	17	R23 Not Used	ASCII text
This setting defines the label for output relay 23				
Relay 24	4B	18	R24 Not Used	ASCII text
This setting defines the label for output relay 24				
Relay 25	4B	19	R25 Not Used	ASCII text
This setting defines the label for output relay 25				
Relay 26	4B	1A	R26 Not Used	ASCII text
This setting defines the label for output relay 26				
Relay 27	4B	1B	R27 Not Used	ASCII text
This setting defines the label for output relay 27				
Relay 28	4B	1C	R28 Not Used	ASCII text
This setting defines the label for output relay 28				
Relay 29	4B	1D	R29 Not Used	ASCII text
This setting defines the label for output relay 29				
Relay 30	4B	1E	R30 Not Used	ASCII text
This setting defines the label for output relay 30				
Relay 31	4B	1F	R31 Not Used	ASCII text
This setting defines the label for output relay 31				
Relay 32	4B	20	R32 Not Used	ASCII text

Courier Text	Col	Row	Default Setting	Available Options
Description				
This setting defines the label for output relay 32				

5.4.2 OUTPUT RELAY DDB SIGNALS

The output relays are associated with DDB signals. The default assignments are provided, but you can configure these in the *O/P LABELS* column if required.

Ordinal	Signal Name	Use	Unique ID
Description			
0 - 31	Output R1 Not Used – Output R31 Not Used	Output relay	DDB_OUTPUT_RELAY_1 - DDB_OUTPUT_RELAY_31
These DDB signals are connected to their respective output relay contacts			

5.4.3 OUTPUT RELAY CONDITIONERS

When driving an output relay, the driving signal has to first be conditioned. We need to define certain properties such as, pickup time, dropoff time, dwell and whether it is a pulsed or latched output. This is all defined in the PSL Editor, which is described in the Setting Applications Software (on page 293) chapter.

A different set of DDB signals is provided for the purposes of connecting signals such as trip and start commands and alarms, if these signals are to drive the output relays. The names of these DDB signals are shown below.

Ordinal	Signal Name	Source	Type	Response
Description				
128 to 159	Relay Conditioner 1 to 32	Programmable Scheme Logic	Output Conditioner	No Response
DDB signals for relay conditioners 1 to 32				

5.5 CONTROL INPUTS

The control inputs are software switches, which can be set or reset locally or remotely. These inputs can be used to trigger any PSL function to which they are connected. There are three setting columns associated with the control inputs.

5.5.1 CONTROL INPUT SETTINGS

Courier Text	Col	Row	Default Setting	Available Options
Description				
CONTROL INPUTS	12	00		
This column contains settings for the type of control input				
Ctrl I/P Status	12	01		Binary flag: 0 = Reset, 1 = Set
This cell sets or resets the first batch of 32 Control Inputs by scrolling and changing the status of selected bits. Alternatively, each of the 32 Control inputs can be set and reset using the individual Control Input cells.				
Control Input 1	12	02	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 1				
Control Input 2	12	03	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 2				
Control Input 3	12	04	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 3				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Control Input 4	12	05	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 4				
Control Input 5	12	06	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 5				
Control Input 6	12	07	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 6				
Control Input 7	12	08	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 7				
Control Input 8	12	09	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 8				
Control Input 9	12	0A	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 9				
Control Input 10	12	0B	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 10				
Control Input 11	12	0C	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 11				
Control Input 12	12	0D	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 12				
Control Input 13	12	0E	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 13				
Control Input 14	12	0F	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 14				
Control Input 15	12	10	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 15				
Control Input 16	12	11	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 16				
Control Input 17	12	12	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 17				
Control Input 18	12	13	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 18				
Control Input 19	12	14	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 19				
Control Input 20	12	15	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 20				
Control Input 21	12	16	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 21				
Control Input 22	12	17	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 22				
Control Input 23	12	18	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 23				
Control Input 24	12	19	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 24				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Control Input 25	12	1A	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 25				
Control Input 26	12	1B	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 26				
Control Input 27	12	1C	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 27				
Control Input 28	12	1D	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 28				
Control Input 29	12	1E	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 29				
Control Input 30	12	1F	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 30				
Control Input 31	12	20	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 31				
Control Input 32	12	21	No Operation	0 = No Operation, 1 = Set , 2 = Reset
This command sets or resets Control Input 32				

5.5.2 CONTROL INPUT CONFIGURATION

Courier Text	Col	Row	Default Setting	Available Options
Description				
CTRL I/P CONFIG	13	00		
This column contains configuration settings for the control inputs.				
Hotkey Enabled	13	01	0xFFFFFFFF	Binary flag: 0 = not assigned, 1 = assigned
This setting allows the control inputs to be individually assigned to the Hotkey menu. The hotkey menu allows the control inputs to be set, reset or pulsed without the need to enter the CONTROL INPUTS column.				
Control Input 1	13	10	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 1	13	11	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 2	13	14	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 2	13	15	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 3	13	18	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 3	13	19	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 4	13	1C	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Ctrl Command 4	13	1D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 5	13	20	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 5	13	21	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 6	13	24	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 6	13	25	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 7	13	28	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 7	13	29	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 8	13	2C	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 8	13	2D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 9	13	30	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 9	13	31	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 10	13	34	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 10	13	35	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 11	13	38	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 11	13	39	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 12	13	3C	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 12	13	3D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 13	13	40	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Ctrl Command 13	13	41	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 14	13	44	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 14	13	45	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 15	13	48	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 15	13	49	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 16	13	4C	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 16	13	4D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 17	13	50	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 17	13	51	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 18	13	54	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 18	13	55	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 19	13	58	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 19	13	59	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 20	13	5C	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 20	13	5D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 21	13	60	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 21	13	61	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 22	13	64	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Ctrl Command 22	13	65	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 23	13	68	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 23	13	69	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 24	13	6C	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 24	13	6D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 25	13	70	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 25	13	71	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 26	13	74	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 26	13	75	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 27	13	78	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 27	13	79	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 28	13	7C	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 28	13	7D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 29	13	80	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 29	13	81	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 30	13	84	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 30	13	85	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 31	13	88	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Ctrl Command 31	13	89	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				
Control Input 32	13	8C	Latched	0 = Latched or 1 = Pulsed
This setting configures the control input as either 'latched' or 'pulsed'.				
Ctrl Command 32	13	8D	SET/RESET	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
This setting allows you to select the text to be displayed on the hotkey menu.				

5.5.3 CONTROL INPUT LABELS

In the *CTRL I/P LABELS* column, you can define the text identifiers for the control inputs.

Menu Text	Col	Row	Default Setting	Available Options
Description				
CTRL I/P LABELS	29	00		
This column contains settings for the Control Input Labels				
Control Inputs 1 to 32	29	01 to 20	Control Input (n)	Extended ASCII text (characters 32 to 234 inclusive)
In this cell you can enter a text label to describe the control input. This text is displayed when a control input is accessed by the hotkey menu and in the programmable scheme logic description of the control input.				

5.5.4 CONTROL INPUT DDB SIGNALS

The number of inputs depends on the model and they are connected to DDB signals as shown in the following table. The default names are provided, but note that these can be configured in the *CTRL I/P LABELS* column.

Ordinal	Signal Name	Source	Type	Response
Description				
1376 to 1407	Control Input (n)	Software	Control	Protection event
This DDB signal is a control input signal				

6 VOLTAGE TRANSFORMER SUPERVISION

The Voltage Transformer Supervision (VTS) function detects failure of the AC voltage inputs to the IED. If the IED misinterprets this as a failure of the actual phase voltages on the power system, it could result in unecessary tripping of a circuit breaker. To prevent this, the VTS detects voltage input failures which are not caused by a failure of the power system phase voltage.

The MiCOM P747 does this by looking at each zone. For each zone, if VTS detects a differential current and a voltage drop, it blocks the VT for that zone. This prevents the busbar differential element from signalling a fault for that zone and tripping a circuit breaker.

Ordinal	Signal Name	Source	Type	Response
Description				
1080	VT Chk Block Z1	Software	VT Check	Protection event
This DDB signal indicates that the VT supervision blocks tripping of the busbar differential element for Zone 1				
1081	VT Chk Block Z2	Software	VT Check	Protection event
This DDB signal indicates that the VT supervision blocks tripping of the busbar differential element for Zone 2				
1082	VT Chk Block Z3	Software	VT Check	Protection event
This DDB signal indicates that the VT supervision blocks tripping of the busbar differential element for Zone 3				
1083	VT Chk Block Z4	Software	VT Check	Protection event
This DDB signal indicates that the VT supervision blocks tripping of the busbar differential element for Zone 4				

7 TRIP CIRCUIT SUPERVISION

In most protection schemes, the trip circuit extends beyond the IED enclosure and passes through components such as links, relay contacts, auxiliary switches and other terminal boards. Such complex arrangements may require dedicated schemes for their supervision.

There are two distinctly separate parts to the trip circuit; the trip path, and the trip coil. The trip path is the path between the IED enclosure and the CB cubicle. This path contains ancillary components such as cables, fuses and connectors. A break in this path is possible, so it is desirable to supervise this trip path and to raise an alarm if a break should appear in this path.

The trip coil itself is also part of the overall trip circuit, and it is also possible for the trip coil to develop an open-circuit fault.

7.1 TRIP CIRCUIT SUPERVISION SCHEME 1

This scheme provides supervision of the trip coil with the CB open or closed, however, it does not provide supervision of the trip path whilst the breaker is open. Also, the CB status can be monitored when a self-reset trip contact is used. However, this scheme is incompatible with latched trip contacts, as a latched contact will short out the opto-input for a time exceeding the recommended Delayed Drop-off (DDO) timer setting of 400 ms, and therefore does not support CB status monitoring. If you require CB status monitoring, further opto-inputs must be used.

> *Note:*
> *A 52a CB auxiliary contact follows the CB position. A 52b auxiliary contact is the opposite.*

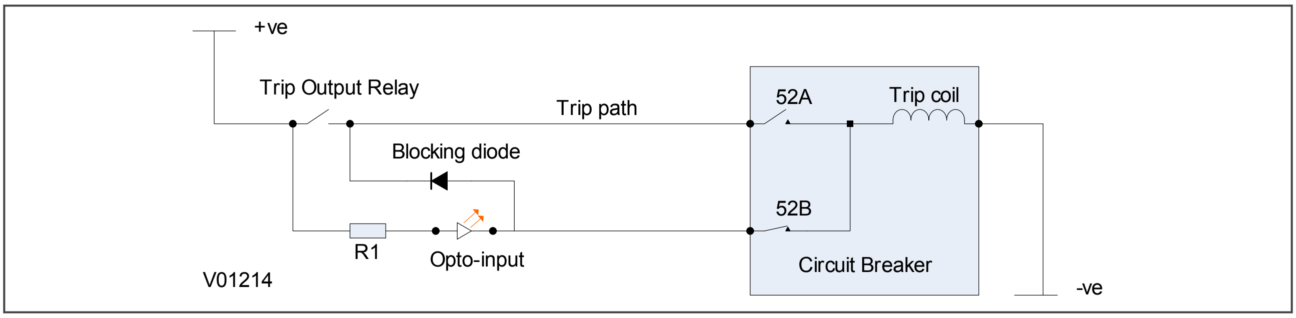


Figure 41: TCS Scheme 1

When the CB is closed, supervision current passes through the opto-input, blocking diode and trip coil. When the CB is open, supervision current flows through the opto-input and into the trip coil via the 52b auxiliary contact. This means that *Trip Coil* supervision is provided when the CB is either closed or open, however *Trip Path* supervision is only provided when the CB is closed. No supervision of the trip path is provided whilst the CB is open (pre-closing supervision). Any fault in the trip path will only be detected on CB closing, after a 400 ms delay.

7.1.1 PSL FOR TCS SCHEME 1

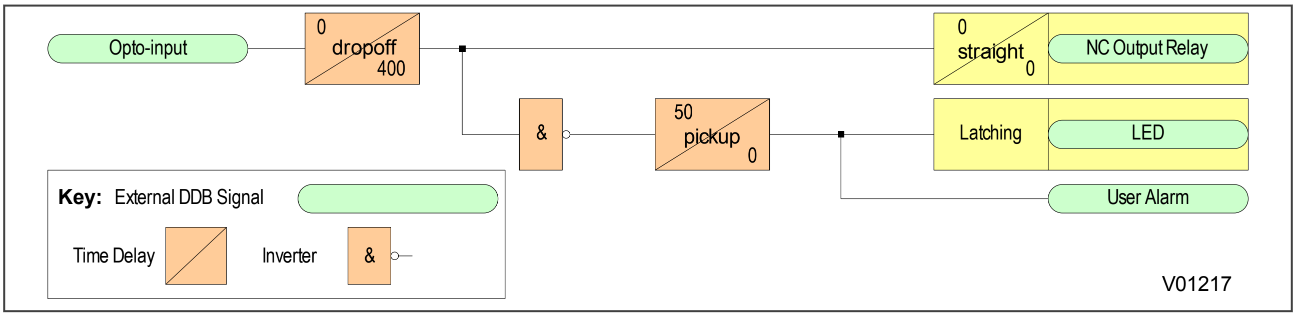


Figure 42: PSL for TCS Scheme 1

The opto-input can be used to drive a Normally Closed Output Relay, which in turn can be used to drive alarm equipment. The signal can also be inverted to drive a latching programmable LED and a user alarm DDB signal.

The DDO timer operates as soon as the opto-input is energised, but will take 400 ms to drop off/reset in the event of a trip circuit failure. The 400 ms delay prevents a false alarm due to voltage dips caused by faults in other circuits or during normal tripping operation when the opto-input is shorted by a self-reset trip contact. When the timer is operated the NC (normally closed) output relay opens and the LED and user alarms are reset.

The 50 ms delay on pick-up timer prevents false LED and user alarm indications during the power up time, following a voltage supply interruption.

7.2 TRIP CIRCUIT SUPERVISION SCHEME 2

Much like TCS scheme 1, this scheme provides supervision of the trip coil with the breaker open or closed but does not provide pre-closing supervision of the trip path. However, using two opto-inputs allows the IED to correctly monitor the circuit breaker status since they are connected in series with the CB auxiliary contacts. This is achieved by assigning Opto-input 1 to the 52a contact and Opto-input 2 to the 52b contact. Provided the ***Circuit Breaker Status*** setting in the *CB CONTROL* column is set to `52a and 52b`, the IED will correctly monitor the status of the breaker. This scheme is also fully compatible with latched contacts as the supervision current will be maintained through the 52b contact when the trip contact is closed.

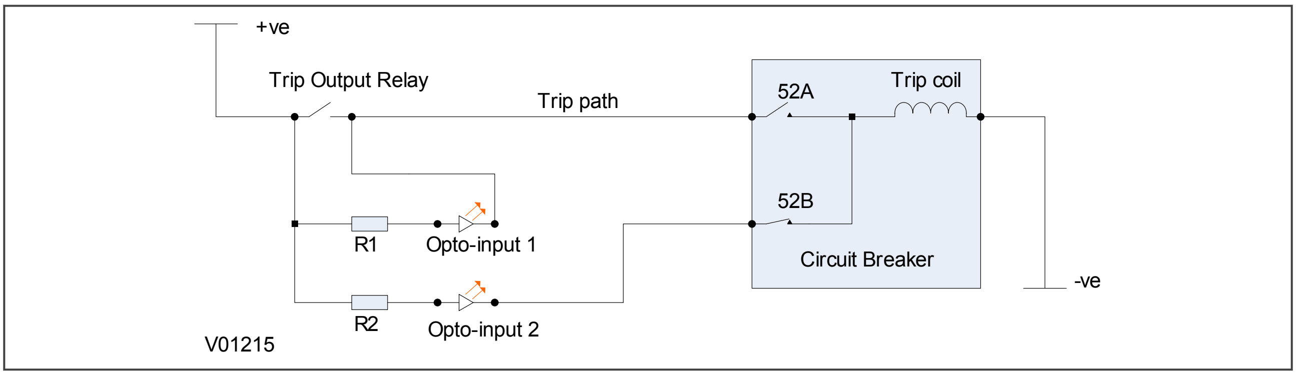


Figure 43: TCS Scheme 2

When the breaker is closed, supervision current passes through opto input 1 and the trip coil. When the breaker is open current flows through opto input 2 and the trip coil. As with scheme 1, no supervision of the trip path is provided whilst the breaker is open. Any fault in the trip path will only be detected on CB closing, after a 400 ms delay.

7.2.1 PSL FOR TCS SCHEME 2

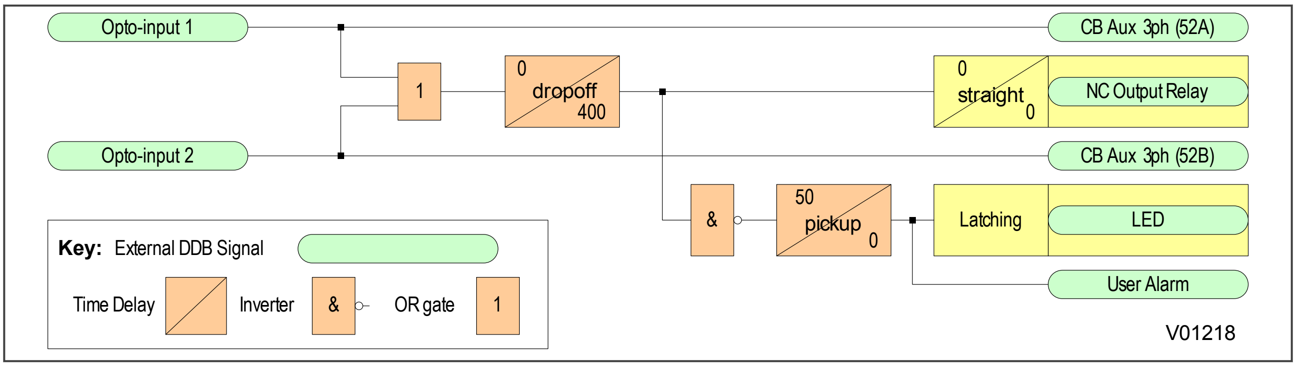


Figure 44: PSL for TCS Scheme 2

The PSL for this TCS scheme 2 is practically the same as that of TCS scheme 1. The main difference is that both opto-inputs must be low before a trip circuit fail alarm is given.

7.3 TRIP CIRCUIT SUPERVISION SCHEME 3

TCS Scheme 3 is designed to provide supervision of the trip coil with the breaker open or closed, but unlike TCS schemes 1 and 2, it also provides pre-closing supervision of the trip path. Since only one opto-input is used, this scheme is not compatible with latched trip contacts. If you require CB status monitoring, further opto-inputs must be used.

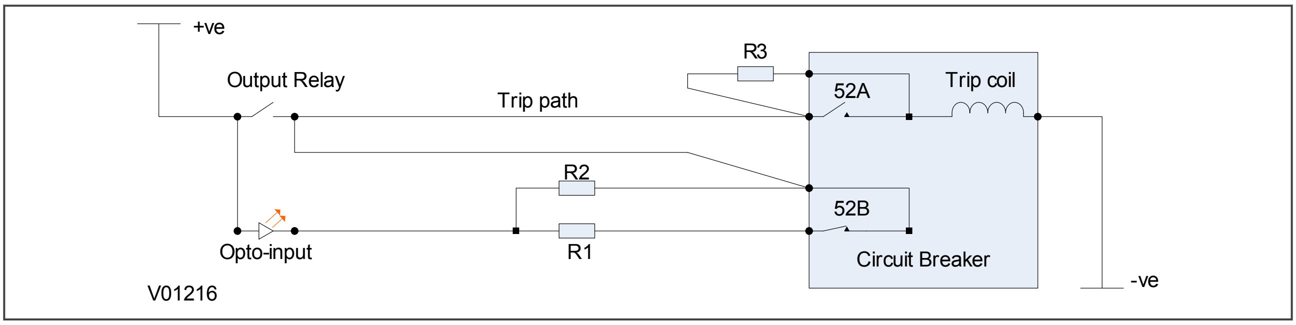


Figure 45: TCS Scheme 3

When the CB is closed, supervision current passes through the opto-input, resistor R2 and the trip coil. When the CB is open, current flows through the opto-input, resistors R1 and R2 (in parallel), resistor R3 and the trip coil. Unlike schemes 1 and 2, supervision current is maintained through the trip path with the breaker in either state, therefore providing pre-closing supervision.

7.3.1 PSL FOR TCS SCHEME 3

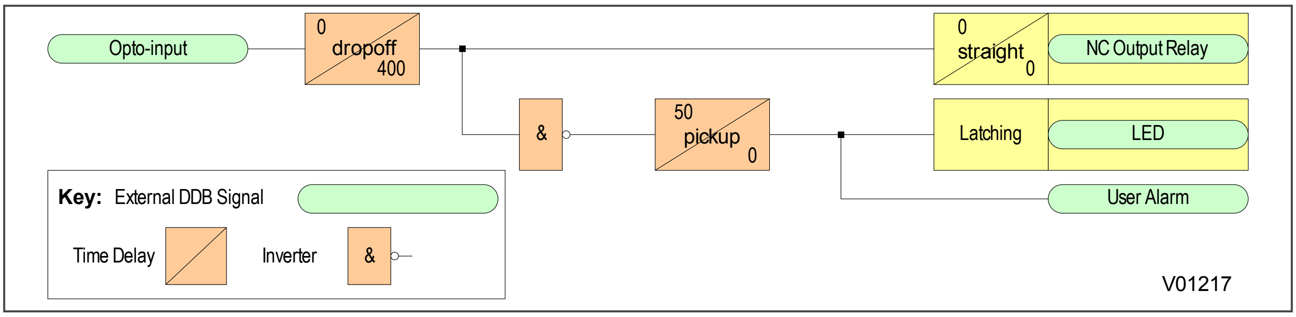


Figure 46: PSL for TCS Scheme 3

SCADA COMMUNICATIONS

CHAPTER 7

1 CHAPTER OVERVIEW

The MiCOM products support substation automation system and SCADA communications based on two communications technologies; serial and Ethernet. Serial communications has been around for a long time, and there are many substations still wired up this way. Ethernet is a more modern medium and all modern substation communications is based on this technology. Alstom Grid's MiCOM products support both of these communication technologies.

This chapter contains the following sections:

2 COMMUNICATION INTERFACES

The MiCOM Px4x products have a number of standard and optional communication interfaces. The standard and optional hardware and protocols are summarised below:

Port	Availability	Physical layer	Use	Data Protocols
Front	Standard	RS232	Local settings	Courier
Rear Port 1 (RP1 copper)	Standard	RS232 / RS485 / K-Bus	SCADA Remote settings	Courier, MODBUS, IEC60870-5-103, DNP3.0 (order option)
Rear Port 1 (RP1 fibre)	Optional	Fibre	SCADA Remote settings	Courier, MODBUS, IEC60870-5-103, DNP3.0 (order option)
Rear Port 2 (RP2)	Optional	RS232 / RS485 / K-Bus	SCADA Remote settings	SK4: Courier only SK5: InterMicom only
Ethernet	Optional	Ethernet	IEC 61850 or DNP3 Remote settings	IEC 61850, Courier (tunnelled) or DNP3.0 (order option)

Note:
Optional communications boards are always fitted into slot A and only slot A.

Note:
When optional fibre board is used for serial SCADA communication over optical fibre, the fibre port assumes designation RP1. The RP1 copper ports on power supply board are then disabled.

Note:
It is only possible to fit one optional communications board, therefore RP2 and Ethernet communications are mutually exclusive.

3 SERIAL COMMUNICATION

The physical layer standards that are used for serial communications for SCADA purposes are:

- EIA(RS)485 (often abbreviated to RS485)
- K-Bus (a proprietary customization of RS485)

EIA(RS)232 is used for local communication with the IED (for transferring settings and downloading firmware updates)

RS485 is similar to RS232 but for longer distances and it allows daisy-chaining and multi-dropping of IEDs.

K-Bus is a proprietary protocol quite similar to RS485, but it cannot be mixed on the same link as RS485. Unlike RS485, K-Bus signals applied across two terminals are not polarised.

It is important to note that these are not data protocols. They only describe the physical characteristics required for two devices to communicate with each other.

For a description of the K-Bus standard see K-Bus (on page 196) and Alstom Grid's K-Bus interface guide reference R6509.

A full description of the RS485 is available in the published standard.

3.1 EIA(RS)232 BUS

The EIA(RS)232 interface uses the IEC 60870-5 FT1.2 frame format.

The IED supports an IEC 60870-5 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 of 19200 bps, 11-bit frame (8 data bits, 1 start bit, 1 stop bit, even parity bit), and a fixed device address of '1'.

EIA(RS)232 interfaces are polarised.

3.2 EIA(RS)485 BUS

The RS485 two-wire connection provides a half-duplex, fully isolated serial connection to the IED. The connection is polarized but 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, then it is possible that the two-wire connection is reversed.

The RS485 bus must be terminated at each end with 120 Ω 0.5 W terminating resistors between the signal wires.

The RS485 standard requires that each device be directly connected to the actual bus. Stubs and tees are forbidden. Loop bus and Star topologies are not part of the RS485 standard and are also forbidden.

Two-core screened twisted pair cable should be used. The final cable specification is dependent on the application, although a multi-strand 0.5 mm^2 per core is normally adequate. The total cable length must not exceed 1000 m. It is important to avoid circulating currents, which can cause noise and interference, especially when the cable runs between buildings. For this reason, the screen should be continuous and connected to ground at one end only, normally at the master connection point.

The RS485 signal is a differential signal and there is no signal ground connection. If a signal ground connection is present in the bus cable then it must be ignored. At no stage should this be connected to the cable's screen or to the product’s chassis. This is for both safety and noise reasons.

It may 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 turn from receive mode to transmit mode. This may be because the master is waiting in receive mode, 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 consequently not responding. Symptoms of this are; poor response times (due to retries), increasing message error counts, erratic communications, and in the worst case, complete failure to communicate.

3.2.1 EIA(RS)485 BIASING REQUIREMENTS

Biasing requires that the signal lines be 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 to prevent noise being injected.

> *Note:*
> *Some devices may be able to provide the bus bias, in which case external components would not be required.*

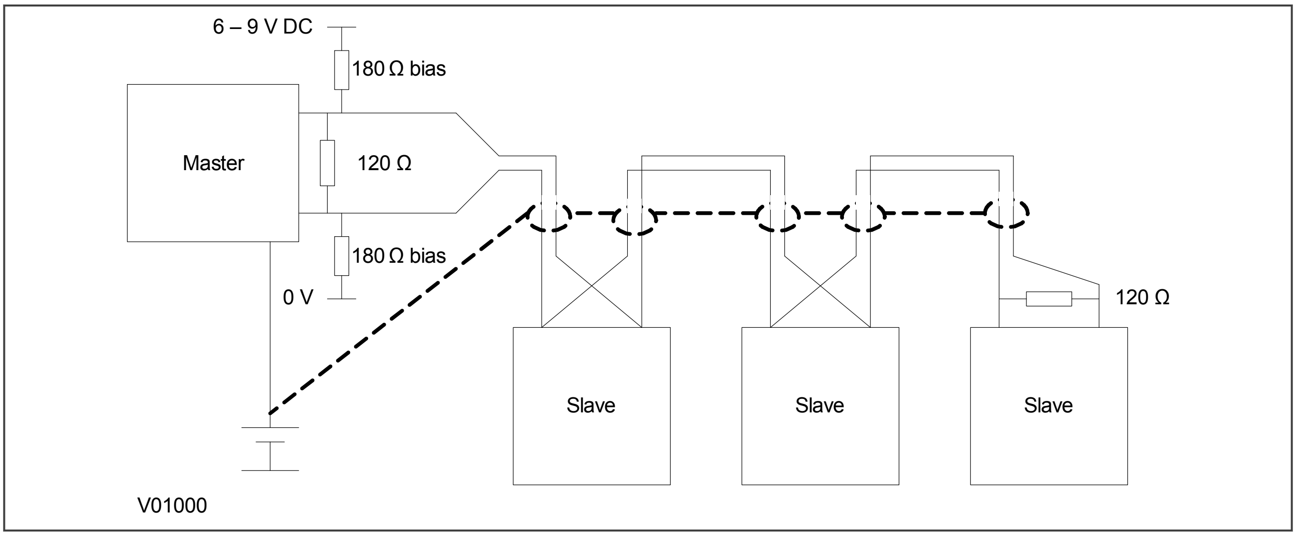


Figure 47: RS485 biasing circuit

> **Warning:**
> **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.**

It is possible to use the product's field voltage output (48 V DC) to bias the bus using values of 2.2 kΩ 0.5 W bias resistors instead of the 180 Ω resistors shown in the above diagram. If using the field voltage, please heed the following warnings.

3.3 K-BUS

K-Bus is a robust signalling method based on RS485 voltage levels. K-Bus incorporates message framing, based on a 64 kbps synchronous HDLC protocol with FM0 modulation to increase speed and security.

The rear interface is used to provide a permanent connection for K-Bus, which allows multi-drop connection.

A K-Bus spur consists of up to 32 IEDs connected together in a multi-drop arrangement using twisted pair wiring. The K-Bus twisted pair connection is non-polarised.

Two-core screened twisted pair cable should be used. The final cable specification is dependent on the application, although a multi-strand 0.5 mm^2 per core is normally adequate. The total cable length must not exceed 1000 m. It is important to avoid circulating currents, which can cause noise and interference, especially when the cable runs between buildings. For this reason, the screen should be continuous and connected to ground at one end only, normally at the master connection point.

The K-Bus signal is a differential signal and there is no signal ground connection. If a signal ground connection is present in the bus cable then it must be ignored. At no stage should this be connected to the cable's screen or to the product’s chassis. This is for both safety and noise reasons.

It is not possible to use a standard EIA(RS)232 to EIA(RS)485 converter to convert IEC 60870-5 FT1.2 frames to K-Bus. A protocol converter, namely the KITZ101, KITZ102 or KITZ201, must be used for this purpose. Please consult Alstom Grid for information regarding the specification and supply of KITZ devices. The following figure demonstrates a typical K-Bus connection.

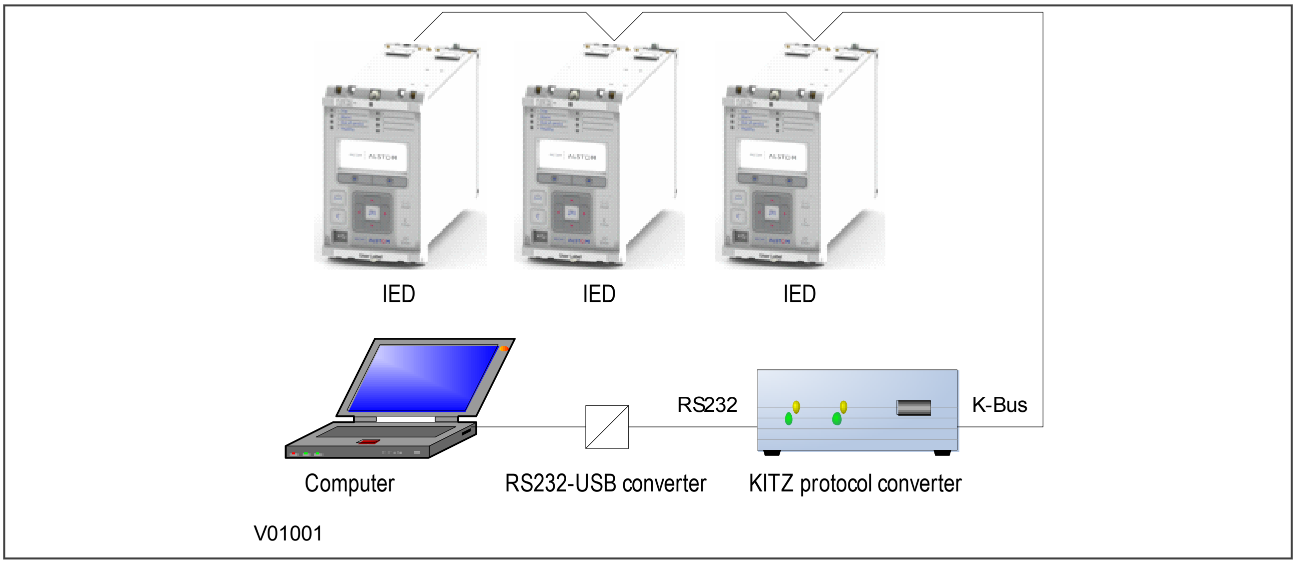


Figure 48: Remote communication using K-Bus

Note:
An RS232-USB converter is only needed if the local computer does not provide an RS232 port.

Further information about K-Bus is available in the publication R6509: K-Bus Interface Guide, which is available on request.

4 STANDARD ETHERNET COMMUNICATION

The type of Ethernet board depends on the chosen model. The available boards and their features are described in the Hardware Design chapter of this manual.

The Ethernet interface is required for either IEC 61850 or DNP3 over Ethernet (protocol must be selected at time of order). With either of these protocols, the Ethernet interface also offers communication with MiCOM S1 Studio for remote configuration and record extraction.

Fibre optic connection is recommended for use in permanent connections in a substation environment, as it offers advantages in terms of noise rejection. The fibre optic port provides 100 Mbps communication and uses type BFOC 2.5 (ST) connectors. Fibres should be suitable for 1300 nm transmission and be multimode 50/125 µm or 62.5/125 µm.

The unit can also be connected to either a 10Base-T or a 100Base-TX Ethernet hub or switch using the RJ45 port. The port automatically senses which type of hub is connected. Due to noise and interference reasons, this connection type is only recommended for short-term connections over a short distance.

The pins on the RJ45connector are as follows:

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

5 OVERVIEW OF DATA PROTOCOLS

The products supports a wide range of protocols to make them applicable to many industries and applications. The exact data protocols supported by a particular product depend on its chosen application, but the following table gives a list of the data protocols that are typically available.

SCADA data protocols

Data Protocol	Layer 1 protocol	Description
Courier	K-Bus, RS232, RS485, Ethernet	Standard for SCADA communications developed by Alstom Grid.
MODBUS	RS485	Standard for SCADA communications developed by Modicon.
IEC 60870-5-103	RS485	IEC standard for SCADA communications
DNP 3.0	RS485, Ethernet	Standard for SCADA communications developed by Harris. Used mainly in North America.
IEC 61850	Ethernet	IEC standard for substation automation. Facilitates interoperability.

The relationship of these protocols to the lower level physical layer protocols are as follows:

Data Protocols	IEC 60870-5-103 MODBUS DNP3.0 Courier	IEC 61850 DNP3.0 Courier	Courier	Courier
Data Link Layer	EIA(RS)485	Ethernet	EIA(RS)232	K-Bus
Physical Layer	Copper or Optical Fibre			

6 COURIER

This section should provide sufficient detail to enable understanding of the Courier protocol at a level required by most users. For situations where the level of information contained in this manual is insufficient, further publications (R6511 and R6512) containing in-depth details about the protocol and its use, are available on request.

Courier is an Alstom Grid proprietary communication protocol. Courier uses a standard set of commands to access a database of settings and data in the IED. This allows a master to communicate with a number of slave devices. The application-specific elements are contained in the database rather than in the commands used to interrogate it, meaning that the master station does not need to be preconfigured. Courier also provides a sequence of event (SOE) and disturbance record extraction mechanism.

6.1 PHYSICAL CONNECTION AND LINK LAYER

Courier can be used with three physical layer protocols: K-Bus, EIA(RS)232 or EIA(RS)485.

Several connection options are available for Courier

- The front serial RS232 port (for connection to Settings application software on, for example, a laptop
- Rear Port 1 (RP1) - for permanent SCADA connection via RS485 or K-Bus
- Optional fibre port (RP1 in slot A) - for permanent SCADA connection via optical fibre
- Optional Rear Port 2 (RP2) - for permanent SCADA connection via RS485, K-Bus, or RS232

For either of the rear ports, both the IED address and baud rate can be selected using the front panel menu or by the settings application software.

6.2 COURIER DATABASE

The Courier database is two-dimensional and resembles a table. 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 (0000 to FFFF Hexadecimal. Addresses in the database are specified as hexadecimal values, for example, 0A02 is column 0A 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 product-specific menu databases contain the complete database definition. This information is also presented in the Settings chapter.

6.3 SETTINGS CATEGORIES

There are two main categories of settings in protection IEDs:

- Control and support settings
- Protection settings

With the exception of the Disturbance Recorder settings, changes made to the control and support settings are implemented immediately and stored in non-volatile memory. Changes made to the Protection settings and the Disturbance Recorder settings are stored in ‘scratchpad’ memory and are not immediately implemented. These need to be committed by writing to the ***Save Changes*** cell in the *CONFIGURATION* column.

6.4 SETTING CHANGES

Courier provides two mechanisms for making setting changes. Either method can be used for editing any of the settings in the database.

Method 1

This uses a combination of three commands to perform a settings change:

First, enter Setting mode: This checks that the cell is settable and returns the limits.

1. Preload Setting: This places a new value into 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.
2. Execute Setting: This confirms the setting change. If the change is valid, a positive response is returned. If the setting change fails, an error response is returned.
3. 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 extracted 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.

Method 2

The Set Value command can be used to change a setting directly. 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. This method is therefore most suitable for off-line setting editors such as MiCOM S1 Agile, or for issuing preconfigured control commands.

6.5 SETTINGS TRANSFER

To transfer the settings to or from the IED, use the settings application software.

6.6 EVENT EXTRACTION

You can extract events either automatically (rear serial port only) or manually (either serial port). For automatic extraction, all events are extracted in sequential order using the standard Courier event mechanism. This includes fault and maintenance data if appropriate. The manual approach allows you to select events, faults, or maintenance data as desired.

6.6.1 AUTOMATIC EVENT RECORD EXTRACTION

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, non-extracted event can be extracted from the IED using the ***Send Event*** command. The IED responds with the event data.

Once an event has been extracted, the ***Accept Event*** command can be used to confirm that the event has been successfully extracted. When 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.

6.6.2 MANUAL EVENT RECORD EXTRACTION

The *VIEW RECORDS* column (location 01) is used for manual viewing of event, fault, and maintenance records. The contents of this column depend on the nature of the record selected. You can select events by event number and directly select a fault or maintenance record by number.

Event Record Selection ('Select Event' cell: 0101)

This cell can be set the number of stored events. 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 ('Select Fault' cell: 0105)

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 ('Select Maint' cell: 01F0)

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, the number associated with a particular record changes when a new event or fault occurs.

Event Types

The IED generates events under certain circumstances such as:

- Change of state of output contact
- Change of state of opto-input
- Protection element operation
- Alarm condition
- Setting change
- Password entered/timed-out

Event Record Format

The IED returns the following fields when the Send Event command is invoked:

- Cell reference
- Time stamp
- Cell text
- Cell value

The Menu Database contains tables of possible events, and shows how the contents of the above fields are interpreted. Fault and Maintenance records return a Courier Type 3 event, which contains the above fields plus two additional fields:

- Event extraction column
- Event number

These events contain additional information, which is extracted from the IED using the *RECORDER EXTRACTION* column B4. Row 01 of the *RECORDER EXTRACTION* column contains a ***Select Record*** setting that allows the fault or 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 IED by uploading the text and data from the column.

6.7 DISTURBANCE RECORD EXTRACTION

The stored disturbance records are accessible through the Courier interface. The records are extracted using the *RECORDER EXTRACTION* column (B4).

The ***Select Record*** cell can be used to select the record to be extracted. Record 0 is the oldest non-extracted record. Older records which have been already been extracted are assigned positive values, while younger records are assigned negative values. To help automatic extraction through the rear port, the IED sets the ***Disturbance*** bit of the ***Status*** byte, whenever there are non-extracted disturbance records.

Once a record has been selected, using the above cell, the time and date of the record can be read from the ***Trigger Time*** cell (B402). The disturbance record can be extracted using the block transfer mechanism from cell B40B and saved in the COMTRADE format. The settings application software software automatically does this.

6.8 PROGRAMMABLE SCHEME LOGIC SETTINGS

The programmable scheme logic (PSL) settings can be uploaded from and downloaded to the IED using the block transfer mechanism.

The following cells are used to perform the extraction:

- ***Domain*** cell (B204): Used to select either PSL settings (upload or download) or PSL configuration data (upload only)
- ***Sub-Domain*** cell (B208): Used to select the Protection Setting Group to be uploaded or downloaded.
- ***Version*** cell (B20C): Used on a download to check the compatibility of the file to be downloaded.
- ***Transfer Mode*** cell (B21C): Used to set up the transfer process.
- ***Data Transfer*** cell (B120): Used to perform upload or download.

The PSL settings can be uploaded and downloaded to and from the IED using this mechanism. The settings application software MiCOM S1 Agile must be used to edit the settings. It also performs checks on the validity of the settings before they are transferred to the IED.

6.9 TIME SYNCHRONISATION

The time and date can be set using the time synchronization feature of the Courier protocol. The device will correct for the transmission delay. The time synchronization message may be sent as either a global command or to any individual IED address. If the time synchronization message is sent to an individual address, then the device will respond with a confirm message. If sent as a global command, the (same) command must be sent twice. A time synchronization Courier event will be generated/produced whether the time-synchronization message is sent as a global command or to any individual IED address.

If the clock is being synchronized using the IRIG-B input then it will not be possible to set the device time using the Courier interface. An attempt to set the time using the interface will cause the device to create an event with the current date and time taken from the IRIG-B synchronized internal clock.

6.10 CONFIGURATION

To configure the IED for this protocol, please see the Configuration (on page 55) chapter.

7 IEC 60870-5-103

The specification IEC 60870-5-103 (Telecontrol Equipment and Systems Part 5 Section 103: Transmission Protocols), defines the use of standards IEC 60870-5-1 to IEC 60870-5-5, which were designed for communication with protection equipment

This section describes how the IEC 60870-5-103 standard is applied to the Px40 platform. It is not a description of the standard itself. The level at which this section is written assumes that the reader is already familiar with the IEC 60870-5-103 standard.

This section should provide sufficient detail to enable understanding of the standard at a level required by most users.

The IEC 60870-5-103 interface is a master/slave interface with the device as the slave device. The device conforms to compatibility level 2, as defined in the IEC 60870-5-103.standard.

The following IEC 60870-5-103 facilities are supported by this interface:

- Initialization (reset)
- Time synchronization
- Event record extraction
- General interrogation
- Cyclic measurements
- General commands
- Disturbance record extraction
- Private codes

7.1 PHYSICAL CONNECTION AND LINK LAYER

Two connection options are available for IEC 60870-5-103:

- Rear Port 1 (RP1) - for permanent SCADA connection via RS485
- Optional fibre port (RP1 in slot A) - for permanent SCADA connection via optical fibre

If the optional fibre optic port is fitted, a menu item appears in which the active port can be selected. However the selection is only effective following the next power up.

The IED address and baud rate can be selected using the front panel menu or by the settings application software.

7.2 INITIALISATION

Whenever the device has been powered up, or if the communication parameters have been changed a reset command is required to initialize the communications. The device will respond to either of the two reset commands; Reset CU or Reset FCB (Communication Unit or Frame Count Bit). The difference between the two commands is that the Reset CU command will clear any unsent messages in the transmit buffer, whereas the Reset FCB command does not delete any messages.

The device will respond to the reset command with an identification message ASDU 5. The Cause of Transmission (COT) of this response will be either Reset CU or Reset FCB depending on the nature of the reset command. The content of ASDU 5 is described in the IEC 60870-5-103 section of the Menu Database, available from Alstom Grid separately if required.

In addition to the above identification message, it will also produce a power up event.

7.3 TIME SYNCHRONISATION

The time and date can be set using the time synchronization feature of the IEC 60870-5-103 protocol. The device will correct for the transmission delay as specified in IEC 60870-5-103. If the time synchronization message is sent as a send/confirm message then the device will respond with a confirm message. A time synchronization Class 1 event will be generated/produced whether the time-synchronization message is sent as a send confirm or a broadcast (send/no reply) message.

If the clock is being synchronized using the IRIG-B input then it will not be possible to set the device time using the IEC 60870-5-103 interface. An attempt to set the time via the interface will cause the device to create an event with the current date and time taken from the IRIG-B synchronized internal clock.

7.4 SPONTANEOUS EVENTS

Events are categorized using the following information:

- Function type
- Information Number

The IEC 60870-5-103 profile in the Menu Database contains a complete listing of all events produced by the device.

7.5 GENERAL INTERROGATION (GI)

The GI request can be used to read the status of the device, the function numbers, and information numbers that will be returned during the GI cycle. These are shown in the IEC 60870-5-103 profile in the Menu Database.

7.6 CYCLIC MEASUREMENTS

The device will produce measured values using ASDU 9 on a cyclical basis, this can be read from the device using a Class 2 poll (note ADSU 3 is not used). The rate at which the device produces new measured values can be controlled using the measurement period setting. This setting can be edited from the front panel menu or using MiCOM S1 Agile. It is active immediately following a change.

The device transmits its measurands at 2.4 times the rated value of the analogue value.

7.7 COMMANDS

A list of the supported commands is contained in the Menu Database. The device will respond to other commands with an ASDU 1, with a cause of transmission (COT) indicating ‘negative acknowledgement’.

7.8 TEST MODE

It is possible to disable the device output contacts to allow secondary injection testing to be performed using either the front panel menu or the front serial port. The IEC 60870-5-103 standard interprets this as ‘test mode’. An event will be produced to indicate both entry to and exit from test mode. Spontaneous events and cyclic measured data transmitted whilst the device is in test mode will have a COT of ‘test mode’.

7.9 DISTURBANCE RECORDS

The disturbance records are stored in uncompressed format and can be extracted using the standard mechanisms described in IEC 60870-5-103.

> *Note:*
> *IEC 60870-5-103 only supports up to 8 records.*

7.10 COMMAND/MONITOR BLOCKING

The device supports a facility to block messages in the monitor direction (data from the device) and also in the command direction (data to the device). Messages can be blocked in the monitor and command directions using one of the two following methods

- The menu command ***RP1 CS103Blocking*** in the *COMMUNICATIONS* column
- The DDB signals Monitor Blocked and Command Blocked

7.11 CONFIGURATION

To configure the IED for this protocol, please see the Configuration (on page 55) chapter.

8 DNP 3.0

This section describes how the DNP 3.0 standard is applied to the Px40 platform. It is not a description of the standard itself. The level at which this section is written assumes that the reader is already familiar with the DNP 3.0 standard.

The descriptions given here are intended to accompany the device profile document that is included in the Menu Database document. The DNP 3.0 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 DNP 3.0 implementation. This is the standard format DNP 3.0 document that specifies which objects; variations and qualifiers are supported. The device profile document also specifies what data is available from the device using DNP 3.0. The IED operates as a DNP 3.0 slave and supports subset level 2, as described in the DNP 3.0 standard, plus some of the features from level 3.

The DNP 3.0 protocol is defined and administered by the DNP Users Group. For further information on DNP 3.0 and the protocol specifications, please see the DNP website (www.dnp.org).

8.1 PHYSICAL CONNECTION AND LINK LAYER

DNP 3.0 can be used with three physical layer protocols: EIA(RS)232, EIA(RS)485, or Ethernet.

Several connection options are available for DNP 3.0

- Rear Port 1 (RP1) - for permanent SCADA connection via RS485
- Optional fibre port (RP1 in slot A) - for permanent SCADA connection via optical fibre
- Optional Rear Port 2 (RP2) - for permanent SCADA connection via RS485 or RS232
- An RJ45 connection on an optional Ethernet board - for permanent SCADA Ethernet connection
- A fibre connection on an optional Ethernet board - for permanent SCADA Ethernet connection

The IED address and baud rate can be selected using the front panel menu or by the settings application software.

When using a serial interface, the data format is: 1 start bit, 8 data bits, 1 stop bit and optional configurable parity bit.

8.2 OBJECT 1 BINARY INPUTS

Object 1, binary inputs, contains information describing the state of signals in the IED, which mostly form part of the digital data bus (DDB). In general these include the state of the output contacts and opto-inputs, alarm signals, and protection start and trip signals. The ‘DDB number’ column in the device profile document provides the DDB numbers for the DNP 3.0 point data. These can be used to cross-reference to the DDB definition list. See the relevant 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.

8.3 OBJECT 10 BINARY OUTPUTS

Object 10, binary outputs, contains commands that can be operated using DNP 3.0. Therefore the points accept commands of type pulse on (null, trip, close) and latch on/off as detailed in the device profile in the relevant Menu Database document, and execute the command once for either command. The other fields are ignored (queue, clear, trip/close, in time and off time).

There is an additional image of the Control Inputs. Described as Alias Control Inputs, they reflect the state of the Control Input, but with a dynamic nature.

- If the Control Input DDB signal is already SET and a new DNP SET command is sent to the Control Input, the Control Input DDB signal goes momentarily to RESET and then back to SET.
- If the Control Input DDB signal is already RESET and a new DNP RESET command is sent to the Control Input, the Control Input DDB signal goes momentarily to SET and then back to RESET.

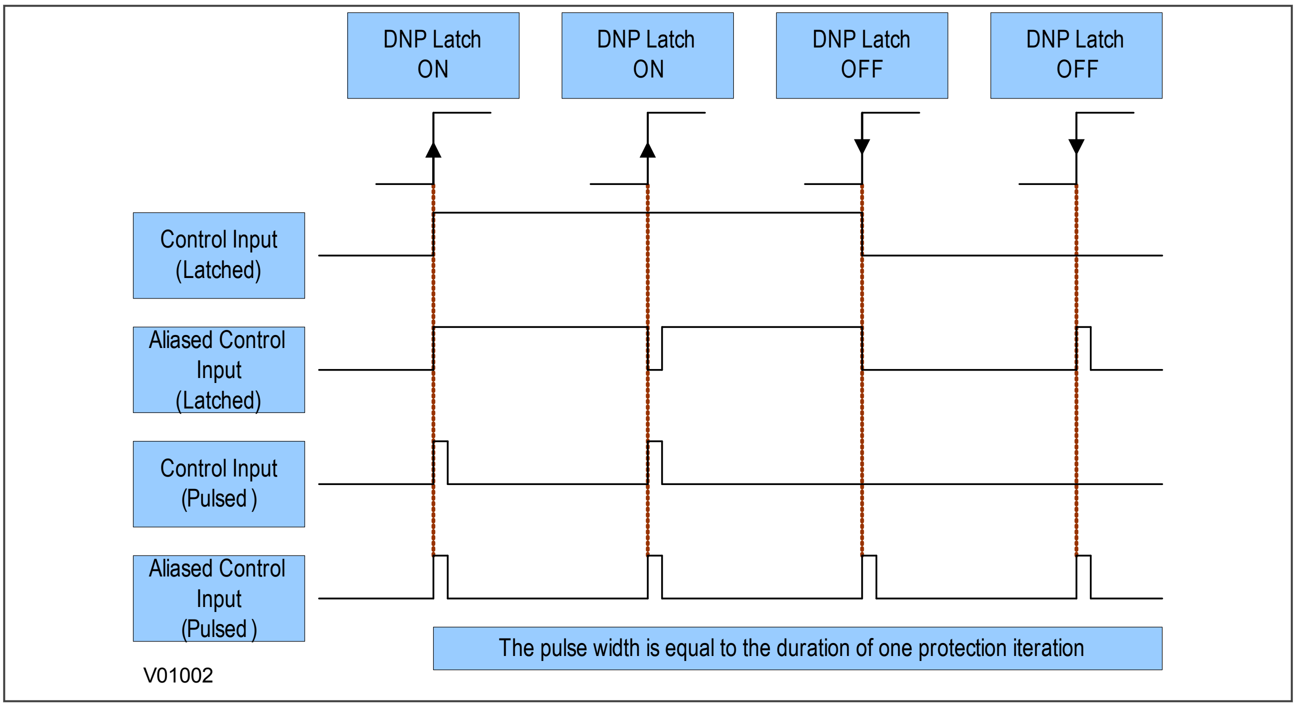


Figure 49: Control input behaviour

Many of the IED'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

8.4 OBJECT 20 BINARY COUNTERS

Object 20, binary counters, contains cumulative counters and measurements. The binary counters can be read as their present 'running' value from Object 20, or as a 'frozen' value from Object 21. The running counters of object 20 accept the read, freeze and clear functions. The freeze function takes the current value of the object 20 running counter and stores it in the corresponding Object 21 frozen counter. The freeze and clear function resets the Object 20 running counter to zero after freezing its value.

Binary counter and frozen counter change event values are available for reporting from Object 22 and Object 23 respectively. Counter change events (Object 22) only report the most recent change, so the maximum number of events supported is the same as the total number of counters. Frozen counter change events (Object 23) are generated whenever a freeze operation is performed and a change has occurred since the previous freeze command. The frozen counter event queues store the points for up to two freeze operations.

8.5 OBJECT 30 ANALOGUE INPUT

Object 30, analogue inputs, contains information from the IED's measurements columns in the menu. All object 30 points can be reported as 16 or 32-bit integer values with flag, 16 or 32-bit integer values without flag, as well as short floating point values.

Analogue values can be reported to the master station as primary, secondary or normalized values (which takes into account the IED's CT and VT ratios), and this is settable in the *COMMUNICATIONS* column in the IED. Corresponding deadband settings can be displayed in terms of a primary, secondary or normalized value. Deadband point values can be reported and written using Object 34 variations.

The deadband is the setting used to determine whether a change event should be generated for each point. The change events can be read using Object 32 or Object 60. These events are generated for any point which has a value changed by more than the deadband setting since the last time the data value was reported.

Any analogue measurement that is unavailable when it is read is reported as offline. For example, the frequency would be offline if the current and voltage frequency is outside the tracking range of the IED. All Object 30 points are reported as secondary values in DNP 3.0 (with respect to CT and VT ratios).

8.6 OBJECT 40 ANALOGUE OUTPUT

The conversion to fixed-point format requires the use of a scaling factor, which is configurable for the various types of data within the IED such as current, voltage, and phase angle. All Object 40 points report the integer scaling values and Object 41 is available to configure integer scaling quantities.

8.7 OBJECT 50 TIME SYNCHRONISATION

Function codes 1 (read) and 2 (write) are supported for Object 50 (time and date) variation 1. The DNP Need Time function (the duration of time waited before requesting another time sync from the master) is supported, and is configurable in the range 1 - 30 minutes.

If the clock is being synchronized using the IRIG-B input then it will not be possible to set the device time using the Courier interface. An attempt to set the time using the interface will cause the device to create an event with the current date and time taken from the IRIG-B synchronized internal clock.

8.8 CONFIGURATION

To configure the IED for this protocol, please see the Configuration (on page 55) chapter.

9 MODBUS

This section describes how the MODBUS standard is applied to the Px40 platform. It is not a description of the standard itself. The level at which this section is written assumes that the reader is already familiar with the MODBUS standard.

The MODBUS protocol is a master/slave protocol, defined and administered by the MODBUS Organization For further information on MODBUS and the protocol specifications, please seethe Modbus web site (www.modbus.org).

9.1 PHYSICAL CONNECTION AND LINK LAYER

Two connection options are available for MODBUS

- Rear Port 1 (RP1) - for permanent SCADA connection via RS485
- Optional fibre port (RP1 in slot A) - for permanent SCADA connection via optical fibre

The MODBUS interface uses ‘RTU’ mode communication rather than ‘ASCII’ mode as this provides more efficient use of the communication bandwidth. This mode of communication is defined by the MODBUS standard.

The IED address and baud rate can be selected using the front panel menu or by the settings application software.

When using a serial interface, the data format is: 1 start bit, 8 data bits, 1 parity bit with 1 stop bit, or 2 stop bits (a total of 11 bits per character).

9.2 MODBUS FUNCTIONS

The following MODBUS function codes are supported:

- 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

These are interpreted by the MiCOM IED in the following way:

- 01: Read status of output contacts (0xxxx addresses)
- 02: Read status of opto inputs (1xxxx addresses)
- 03: Read setting values (4xxxx addresses)
- 04: Read measured values (3xxxx addresses
- 06: Write single setting value (4xxxx addresses)
- 16: Write multiple setting values (4xxxx addresses)

9.3 RESPONSE CODES

MCode	MODBUS Description	MiCOM Interpretation
01	Illegal Function Code	The function code transmitted is not supported by the slave.

MCode	MODBUS Description	MiCOM Interpretation
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 then all changes within the request are discarded and this error response will be 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 within range. Other values transmitted within the same packet will be executed if inside range.
06	Slave Device Busy	The write command cannot be implemented due to the database being locked by another interface. This response is also produced if the software is busy executing a previous request.

9.4 REGISTER MAPPING

The device supports the following memory page references:

- 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

where xxxx represents the addresses available in the page (0 to 9999).

A complete map of the MODBUS addresses supported by the device is contained in the relevant menu database, which is available on request.

Note:
The "extended memory file" (6xxxx) is not supported.

Note:
MODBUS convention is to document register addresses as ordinal values whereas the actual protocol addresses are literal values. The MiCOM relays begin their register addresses at zero. Therefore, the first register in a memory page is register address zero. The second register is register address 1 and so on.

Note:
The page number notation is not part of the address.

9.5 EVENT EXTRACTION

The device supports two methods of event extraction providing either automatic or manual extraction of the stored event, fault, and maintenance records.

9.5.1 AUTOMATIC EVENT RECORD EXTRACTION

The automatic extraction facilities allow all types of record to be extracted as they occur. Event records are extracted in sequential order including any fault or maintenance data that may be associated with the event.

The MODBUS master can determine whether the device has any events stored that have not yet been extracted. This is performed by reading the status register 30001 (G26 data type). If the event bit of this register is set then the device has non-extracted events available. 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.

9.5.2 MANUAL EVENT RECORD EXTRACTION

There are three registers available to manually select stored records and three read-only registers allowing the number of stored records to be determined.

- 40100: Select Event
- 40101: Select Fault
- 40102: Select Maintenance Record

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. If this event record is selected, the additional registers allowing the fault or maintenance record details will also become populated.

9.5.3 RECORD DATA

The location and format of the registers used to access the record data is the same whether they have been selected using either automatic or manual extraction.

Event Description	MODBUS Address	Length	Comments
Time and Date	30103	4	See G12 data type description
Event Type	30107	1	See G13 data type description
Event Value	30108	2	Nature of value depends on event type. This will contain the status as a binary flag for contact, opto-input, 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.

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 independently clear the stored relay event/fault and maintenance records. This register also provides an option to reset the device indications, which has the same effect on the relay as pressing the clear key within the alarm viewer using the HMI panel menu.

9.6 DISTURBANCE RECORD EXTRACTION

The IED provides facilities for both manual and automatic extraction of disturbance records.

Records extracted over MODBUS from Px40 devices are presented in COMTRADE format. This involves extracting an ASCII text configuration file and then extracting a binary data file.

Each file is extracted by reading a series of data pages from the IED The data page is made up of 127 registers, giving a maximum transfer of 254 bytes per page.

The following set of registers is presented to the master station to support the extraction of uncompressed disturbance records:

MODBUS registers

MODBUS Register	Name	Description
3x00001	Status register	Provides the status of the relay 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' on b4 indicates the presence of a disturbance
3x00800	No of stored disturbances	Indicates the total number of disturbance records currently stored in the relay, both extracted and non-extracted.
3x00801	Unique identifier of the oldest disturbance record	Indicates the unique identifier value for the oldest disturbance record stored in the relay. 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 Number 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 - 3x00933	Record time stamp	These registers return the timestamp of the disturbance record.
3x00802	No of registers in data page	This register informs the master station of the number of registers in the data page that are populated.
3x00803 - 3x00929	Data page registers	These 127 registers are used to transfer data from the relay to the master station. They are 16-bit unsigned integers.
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.

Note:
Register addresses are provided in reference code + address format. E.g. 4x00001 is reference code 4x, address 1 (which is specified as function code 03, address 0x0000 in the MODBUS specification).

The disturbance record status register will report one of the following values:

Disturbance record states

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 relay is currently processing data.
Page ready	The data page has been populated and the master station can now safely read the data.
Configuration complete	All of the configuration data has been read without error.
Record complete	All of the disturbance data has been extracted.
Disturbance overwritten	An error occurred during the extraction process where the disturbance being extracted was overwritten by a new record.
No non-extracted disturbances	An attempt was made by the master station to automatically select the next oldest non-extracted disturbance when all records have been extracted.
Not a valid disturbance	An attempt was made by the master station to manually select a record that did not exist in the relay.
Command out of sequence	The master station issued a command to the relay that was not expected during the extraction process.

9.6.1 MANUAL EXTRACTION PROCEDURE

The procedure used to extract a disturbance manually is shown below. The manual method of extraction does not allow for the acceptance of disturbance records.

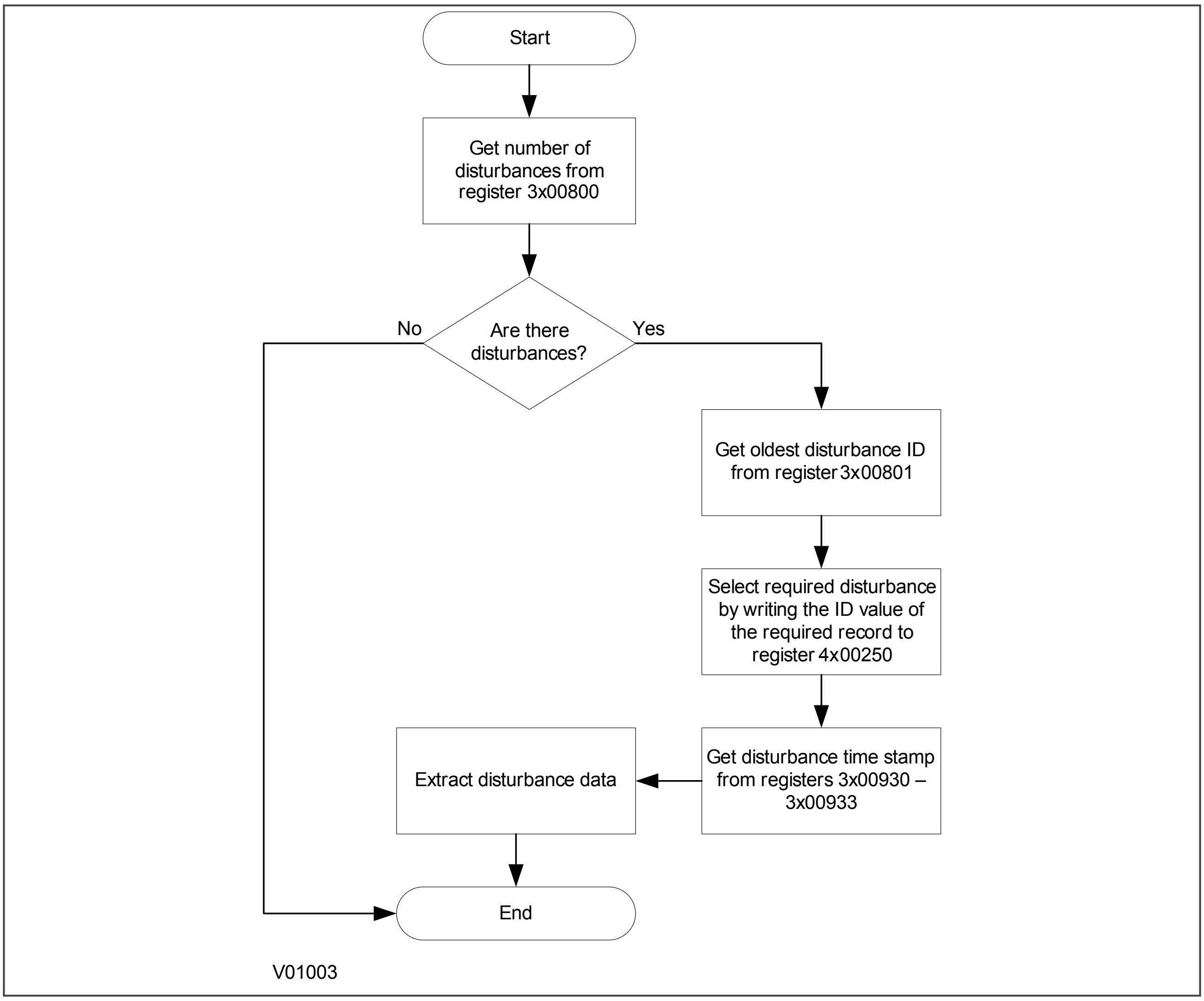


Figure 50: Manual selection of a disturbance record

9.6.2 AUTOMATIC EXTRACTION PROCEDURE

There are two methods that can be used for automatically extracting disturbances:

Method 1

Method 1 is simpler and is better at extracting single disturbance records (when the disturbance recorder is polled regularly).

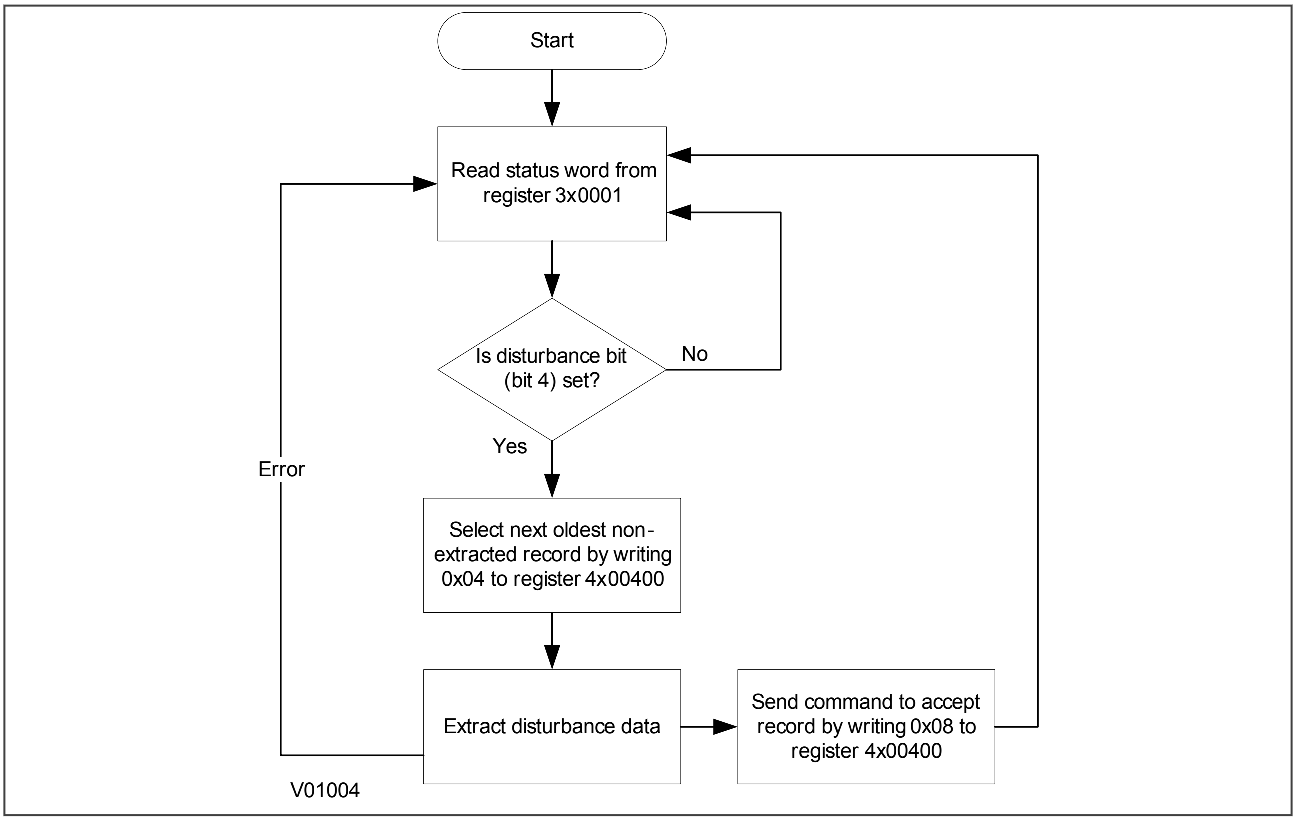


Figure 51: Automatic selection of disturbance record - method 1

Method 2

Method 2 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 therefore may have many stored records.

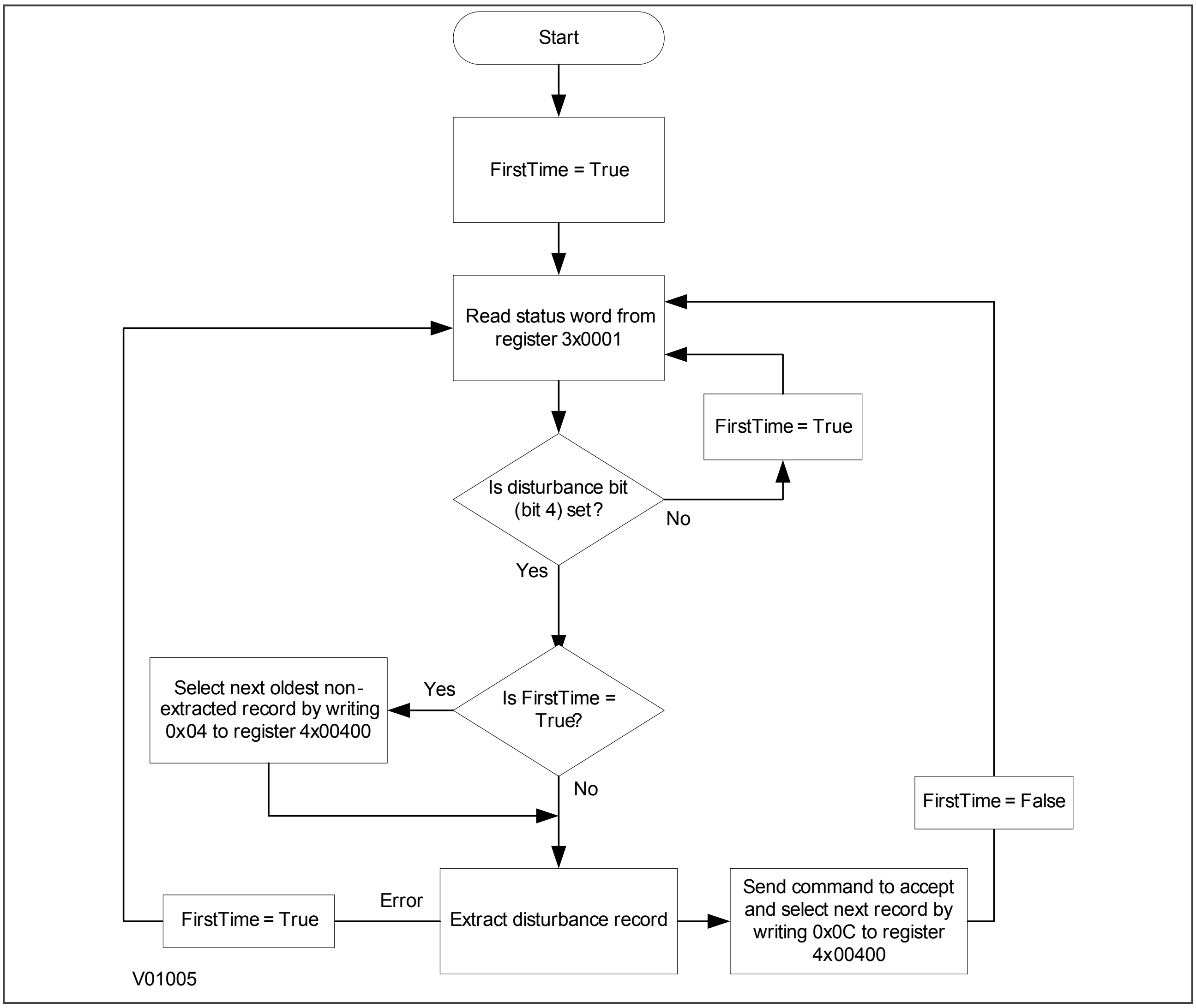


Figure 52: Automatic selection of disturbance record - method 2

9.6.3 EXTRACTING THE DISTURBANCE DATA

The extraction of the disturbance record is a two-stage process that involves extracting the configuration file first and then the data file. first the configuration file must be extracted, followed by the data file:

Extracting the Comtrade configuration file

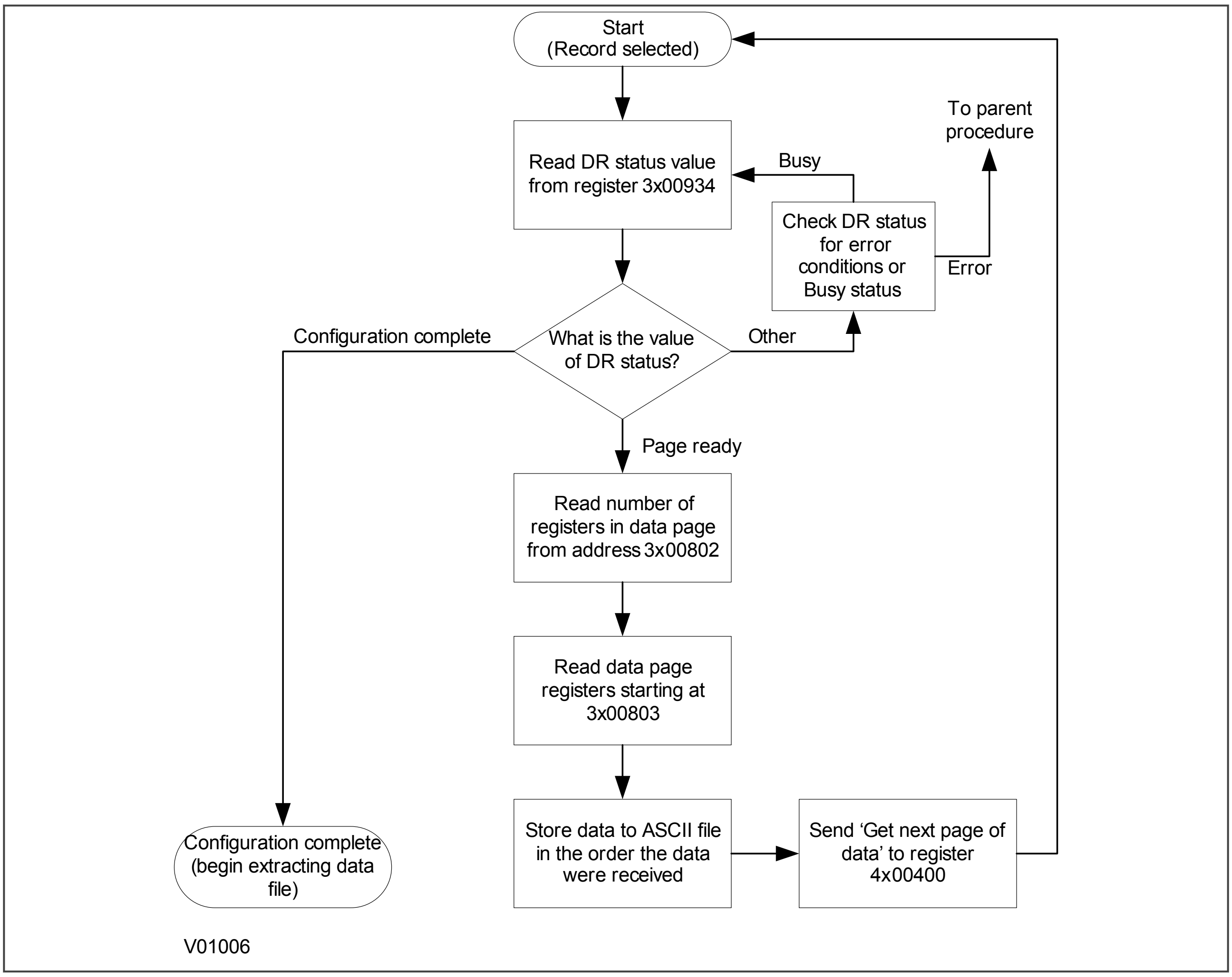


Figure 53: Configuration file extraction

Extracting the comtrade data file

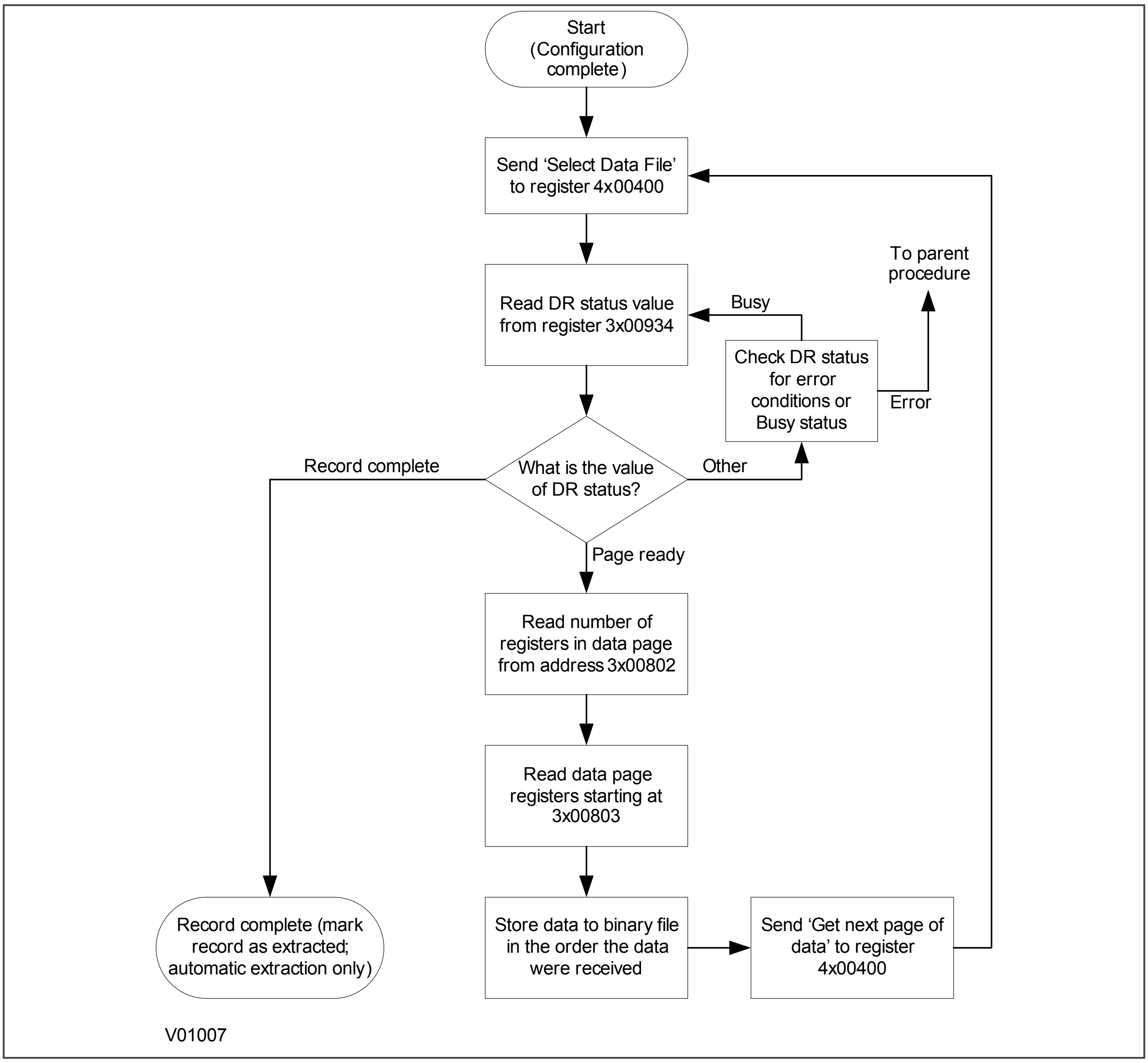


Figure 54: Data file extraction

During the extraction of the COMTRADE files, an error may occur, which will be reported on the DR Status register 3x00934. In this case, you must take action to re-start the record extraction or to abort according to the table below.

Value	State	Description
0	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.
1	Busy	The relay is currently processing data.
2	Page ready	The data page has been populated and the master station can now safely read the data.
3	Configuration complete	All of the configuration data has been read without error.
4	Record complete	All of the disturbance data has been extracted.
5	Disturbance overwritten	An error occurred during the extraction process where the disturbance being extracted was overwritten by a new record.

Value	State	Description
6	No unextracted disturbances	An attempt was made by the master station to automatically select the next oldest unextracted disturbance when all records have been extracted.
7	Not a valid disturbance	An attempt was made by the master station to manually select a record that did not exist in the relay.
8	Command out of sequence	The master station issued a command to the relay that was not expected during the extraction process.

9.7 SETTING CHANGES

All the IED settings are 4xxxx page addresses. 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 first address for a multi-register write must be a valid address. If there are unmapped addresses within the range being written to, the data associated with these addresses will be discarded.
- If a write operation is performed with values that are out of range, the illegal data response will be produced. Valid setting values within the same write operation will be executed.
- If a write operation is performed, which attempts to change registers requiring a higher level of password access than is currently enabled then all setting changes in the write operation will be discarded.

9.8 PASSWORD PROTECTION

The following registers are available to control password protection:

Function	MODBUS Registers
Password entry	4x00001 to 4x00002 and 4x20000 to 4x20003
Setting to change password level 1 (4 character)	4x00023 to 4x00024
Setting to change password level 1 (8 character)	4x20008 to 4x20011
Setting to change password level 2	4x20016 to 4x20019
Setting to change password level 3	4x20024 to 4x20027
Can be read to indicate current access level	3x00010

9.9 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 IED unless confirmed. Register 40405 can be used either to confirm or abort the setting changes within the scratchpad area.

The IED supports four groups of protection settings. The MODBUS addresses for each of the four groups are repeated within the following address ranges.

- Group 1: 4x1000 - 4x2999
- Group 2: 4x3000 - 4x4999
- Group 3: 4x5000 - 4x6999
- Group 4: 4x7000 - 4x8999

In addition to the basic editing of the protection setting groups, the following functions are provided:

- Default values can be restored to a setting group or to all of the relay settings by writing to register 4x0402.
- It is possible to copy the contents of one setting group to another by writing the source group to register 40406 and the target group to 4x0407.

The setting changes performed by either of the two operations defined above are made to the scratchpad area. These changes must be confirmed by writing to register 4x0405.

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.

9.10 TIME SYNCHRONISATION

The date-time data type G12 allows *real* date and time information to be conveyed to a resolution of 1 ms. The structure of the data type is compliant with the IEC 60870-5-4 **Binary Time 2a** format.

The seven bytes of the date/time frame are packed into four 16-bit registers and are transmitted in sequence starting from byte 1. This is followed by a null byte, making eight bytes in total.

Register data is usually transmitted starting with the highest-order byte. Therefore 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.

G12 date & time data type structure

	Bit Position							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
1	m7	m6	m5	m4	m3	m2	m1	m0
2	m15	m14	m13	m12	m11	m10	m9	m8
3	IV	R	I5	I4	I3	I2	I1	I0
4	SU	R	R	H4	H3	H2	H1	H0
5	W2	W1	W0	D4	D3	D2	D1	D0
6	R	R	R	R	M3	M2	M1	M0
7	R	Y6	Y5	Y4	Y3	Y2	Y1	Y0

Key to table:

- m = milliseconds: 0 to 59,999
- I = minutes: 0 to 59
- H = hours: 0 to 23
- W = day of the week: 1 to 7 starting from Monday
- D = day of the month: 1 to 31
- M = month of the year: 1 to 12 starting from January
- Y = year of the century: 0 to 99
- R = reserved: 0
- SU = summertime: 0 = GMT, 1 = summertime
- IV = invalid: 0 = invalid value, 1 = valid value

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 date.

The invalid bit has two applications:

- It can indicate that the date-time information is considered inaccurate, but is the best information available.
- It can indicate that the 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.

The day of the week field is optional and if not calculated will be set to zero.

The concept of time zone is not catered for by this data type and hence by the relay. It is up to the end user to determine the time zone. Normal practice is to use UTC (universal co-ordinated time).

9.11 POWER AND ENERGY MEASUREMENT DATA FORMATS

The power and energy measurements are available in the Data Type G31 format. This uses two registers and is listed in the *DISTURBANCE RECORDER* column of the Courier database.

Data Type G31

Two Register	Analogue Channel Assignment Selector
Related to Number	
0x00000001	VxN Z1
0x00000002	VxN Z2
0x00000004	VxN Z3
0x00000008	VxN Z4
0x00000010	IX-T1
0x00000020	IX-T2
0x00000040	IX-T3
0x00000080	IX-T4
0x00000100	IX-T5
0x00000200	IX-T6
0x00000400	IX-T7
0x00000800	IX-T8
0x00001000	IX-T9
0x00002000	IX-T10
0x00004000	IX-T11
0x00008000	IX-T12
0x00010000	IX-T13
0x00020000	IX-T14
0x00040000	IX-T15
0x00080000	IX-T16
0x00100000	IX-T17
0x00200000	IX-T18

10 IEC 61850

This section describes how the IEC 61850 standard is applied to Alstom Grid products. It is not a description of the standard itself. The level at which this section is written assumes that the reader is already familiar with the IEC 61850 standard.

IEC 61850 is the international standard for Ethernet-based communication in substations. It enables integration of all protection, control, measurement and monitoring functions within a substation, and additionally provides the means for interlocking and inter-tripping. It combines the convenience of Ethernet with the security that is so essential in substations today.

10.1 BENEFITS OF IEC 61850

The standard provides:

- Standardized models for IEDs and other equipment within the substation
- Standardized communication services (the methods used to access and exchange data)
- Standardized formats for configuration files
- Peer-to-peer communication

The standard adheres to the requirements laid out by the ISO OSI model and therefore provides complete vendor interoperability and flexibility on the transmission types and protocols used. This includes mapping of data onto Ethernet, which is becoming more and more widely used in substations, in favour of RS485. Using Ethernet in the substation offers many advantages, most significantly including:

- Ethernet allows high-speed data rates (currently 100 Mbps, rather than tens of kbps or less used by most serial protocols)
- Ethernet provides the possibility to have multiple clients
- Ethernet is an open standard in every-day use
- There is a wide range of Ethernet-compatible products that may be used to supplement the LAN installation (hubs, bridges, switches)

10.2 IEC 61850 INTEROPERABILITY

A major benefit of IEC 61850 is interoperability. IEC 61850 standardizes the data model of substation IEDs, which allows interoperability between products from multiple vendors.

An IEC 61850-compliant device may be interoperable, but this does not mean it is interchangeable. You cannot simply replace a product from one vendor with that of another without reconfiguration. However the terminology is pre-defined and anyone with prior knowledge of IEC 61850 should be able to integrate a new device very quickly without having to map all of the new data. IEC 61850 brings improved substation communications and interoperability to the end user, at a lower cost.

10.3 THE IEC 61850 DATA MODEL

The data model of any IEC 61850 IED can be viewed as a hierarchy of information, whose nomenclature and categorization is defined and standardized in the IEC 61850 specification.

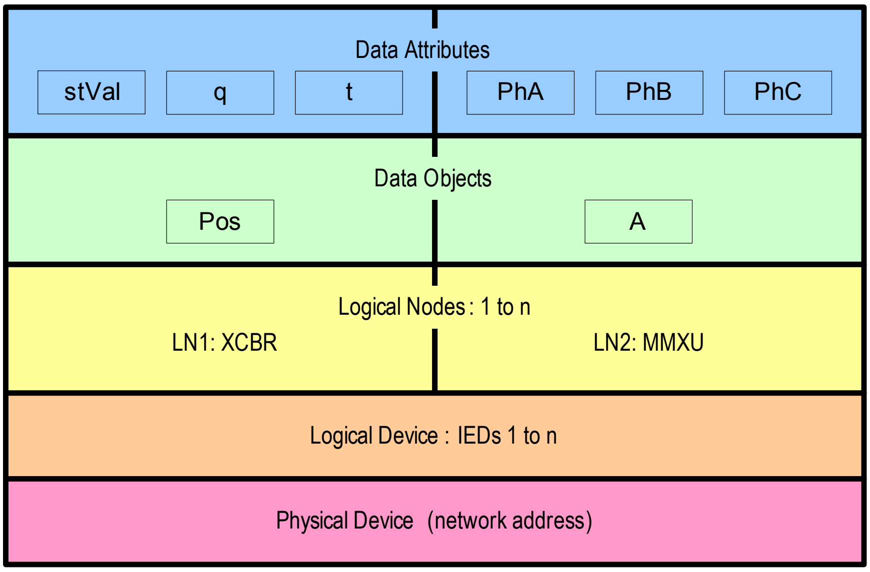


Figure 55: Data model layers in IEC 61850

The levels of this hierarchy can be described as follows:

Data Frame format

Layer	Description
Physical Device	Identifies the actual IED within 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 within the Physical Device. For the MiCOM IEDs, 5 Logical Devices exist: Control, Measurements, Protection, Records, System
Wrapper/Logical Node Instance	Identifies the major functional areas within 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 you will be presented with. For example, Pos (position) of Logical Node type XCBR
Data Attribute	This is the actual data (measurement value, status, description, etc.). For example, stVal (status value) indicating actual position of circuit breaker for Data Object type Pos of Logical Node type XCBR

10.4 IEC 61850 IN MICOM IEDS

IEC 61850 is implemented by use of a separate Ethernet card. This Ethernet card manages the majority of the IEC 61850 implementation and data transfer to avoid any impact on the performance of the protection functions.

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 bay computer (MiCOM C264)
- An HMI
- An MMS browser, with which the full data model can be retrieved from the IED, without any prior knowledge of the IED

The IEC 61850 compatible interface standard provides capability for the following:

- Read access to measurements
- Refresh of all measurements at the rate of once per second.
- Generation of non-buffered reports on change of status or measurement
- SNTP time synchronization over an Ethernet link. (This is used to synchronize the IED's internal real time clock.
- GOOSE peer-to-peer communication
- Disturbance record extraction by file transfer. The record is extracted as an ASCII format COMTRADE file
- Controls (Direct and Select Before Operate)

> *Note:*
> *Setting changes are not supported in the current IEC 61850 implementation. Currently these setting changes are carried out using MiCOM S1 Agile.*

10.5 IEC 61850 DATA MODEL IMPLEMENTATION

The data model naming adopted in the IEDs has been standardised for consistency. Therefore the Logical Nodes are allocated to one of the five Logical Devices, as appropriate.

The data model is described in the Model Implementation Conformance Statement (MICS) document, which is available as a separate document.

10.6 IEC 61850 COMMUNICATION SERVICES IMPLEMENTATION

The IEC 61850 communication services which are implemented in the IEDs are described in the Protocol Implementation Conformance Statement (PICS) document, which is available as a separate document.

10.7 IEC 61850 PEER-TO-PEER (GSSE) COMMUNICATIONS

The implementation of IEC 61850 Generic Object Oriented Substation Event (GOOSE) enables faster communication between IEDs offering the possibility for a fast and reliable system-wide distribution of input and output data values. The GOOSE model uses multicast services to deliver event information. Multicast messaging means that messages are sent to all the devices on the network, but only those devices that have been appropriately configured will receive the frames. In addition, the receiving devices can specifically accept frames from certain devices and discard frames from the other devices. It is also known as a publisher-subscriber system. When a device detects a change in one of its monitored status points it publishes a new message. Any device that is interested in the information subscribes to the data it contains.

> *Note:*
> *Multicast messages cannot be routed across networks without special equipment.*

Each new message is re-transmitted at configurable intervals, to counter for possible corruption due to interference, and collisions, therefore ensuring delivery. In practice, the parameters controlling 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.

10.8 MAPPING GOOSE MESSAGES TO VIRTUAL INPUTS

Each GOOSE signal contained in a subscribed GOOSE message can be mapped to any of the 32 virtual inputs within the PSL. The virtual inputs allow the mapping to internal logic functions for protection control, directly to output contacts or LEDs for monitoring.

An IED can subscribe to all GOOSE messages but only the following data types can be decoded and mapped to a virtual input:

- BOOLEAN
- BSTR2
- INT16
- INT32
- INT8
- UINT16
- UINT32
- UINT8

10.8.1 IEC 61850 GOOSE CONFIGURATION

All GOOSE configuration is performed using the IEC 61850 Configurator tool available in the MiCOM S1 Agile software application.

All GOOSE publishing configuration can be found under the **GOOSE Publishing** tab in the configuration editor window. All GOOSE subscription configuration parameters are under the **External Binding** tab in the configuration editor window.

Settings to enable GOOSE signalling and to apply Test Mode are available using the HMI.

10.9 ETHERNET FUNCTIONALITY

Settings relating to a failed Ethernet link are available in the *COMMUNICATIONS* column of the IED's HMI.

10.9.1 ETHERNET DISCONNECTION

IEC 61850 **Associations** are unique and made between the client and server. If Ethernet connectivity is lost for any reason, the associations are lost, and will need to be re-established by the client. The IED has a **TCP_KEEPALIVE** function to monitor each association, and terminate any which are no longer active.

10.9.2 LOSS OF POWER

The IED allows the re-establishment of associations without disruption of its operation, even after its power has been removed. As the IED acts as a server in this process, the client must request the association. Uncommitted settings are cancelled when power is lost, and reports requested by connected clients are reset. The client must re-enable these when it next creates the new association to the IED.

10.10 IEC 61850 CONFIGURATOR SETTINGS

This section contains the table for setting up the IEC 61850 Configurator.

Courier Text	Col	Row	Default Setting	Available Options
Description				
IED CONFIGURATOR	19	00		
This column contains settings for the IEC 61850 IED Configurator				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Switch Conf.Bank	19	05	No Action	0 = No Action or 1 = Switch banks
This command allows you to switch between the current configuration, held in the Active Memory Bank to the configuration held in the Inactive Memory Bank.				
Restore MCL	19	0A	No Action (0)	0 = No Action or 1 = Restore MCL
This command lets you restore the MCL (MiCOM Control Language).				
Active Conf.Name	19	10	Not Available	Not Settable
This cell displays the name of the configuration in the Active Memory Bank (usually taken from the SCL file).				
Active Conf.Rev	19	11	Not Available	Not Settable
This cell displays the configuration revision number of the configuration in the Active Memory Bank (usually taken from the SCL file).				
Inact.Conf.Name	19	20	Not Available	Not Settable
This cell displays the name of the configuration in the Inactive Memory Bank (usually taken from the SCL file).				
Inact.Conf.Rev	19	21	Not Available	Not Settable
This cell displays the configuration revision number of the configuration in the Inactive Memory Bank (usually taken from the SCL file).				
IP PARAMETERS	19	30		
The data in this sub-heading relates to the IEC61850 IP parameters				
IP Address	19	31	0.0.0.0	Not Settable
This cell displays the IED's IP address.				
Subnet Address	19	32	0.0.0.0	Not Settable
Ths cell displays the subnet mask, which defines the subnet on which the IED is located.				
Gateway	19	33	0.0.0.0	Not Settable
Ths cell displays the gateway address of the LAN on which the IED is located.				
SNTP PARAMETERS	19	40		
The data and settings under this sub-heading relate to the IEC61850 SNTP parameters				
SNTP Server 1	19	41	0.0.0.0	Not Settable
This cell displays the IP address of the primary SNTP server.				
SNTP Server 2	19	42	0.0.0.0	Not Settable
This cell displays the IP address of the secondary SNTP server.				
IEC 61850 SCL	19	50		
IEC61850 versions only.				
IED Name	19	51	Not Available	Not Settable
This setting displays the unique IED name used on the IEC 61850 network (usually taken from the SCL file).				
IEC 61850 GOOSE	19	60		
IEC61850 versions only.				
GoEna	19	70	00000000(bin)	Bit 0=gcb01 GoEna Bit 1=gcb02 GoEna Bit 2=gcb03 GoEna Bit 3=gcb04 GoEna Bit 4=gcb05 GoEna Bit 5=gcb06 GoEna Bit 6=gcb07 GoEna Bit 7=gcb08 GoEna
This setting enables the GOOSE publisher settings.				
Test Mode	19	71	00000000(bin)	0 = Disabled, 1 = Pass Through, 2 = Forced

Courier Text	Col	Row	Default Setting	Available Options
Description				
This setting allows the test pattern to be sent in the GOOSE message. With ‘Pass Through’, the data in the GOOSE message is sent as normal. With ‘Forced’, the data sent in the GOOSE message follows the ‘VOP Test Pattern’ setting.				
Ignore Test Flag	19	73	No	0 = No or 1 = Yes
This cell allows you to ignore the test flag, if set.				

11 READ ONLY MODE

With IEC 61850 and Ethernet/Internet communication capabilities, security has become an important issue. In view of this, all MiCOM devices comply with the latest Cyber-Security (on page 273) standards. In addition to this, the device provides a facility to allow the user to enable or disable the physical interfaces. This feature is available for products using Courier, IEC 60870-5-103, or IEC 61850.

Note:
For IEC 60870-5-103, Read Only Mode function is different from the existing Command block feature.

11.1 IEC 60870-5-103 PROTOCOL

If Read-Only Mode is enabled for RP1 or RP2 with IEC 60870-5-103, the following commands are blocked at the interface:

- Write parameters (=change setting) (private ASDUs)
- General Commands (ASDU20), namely:
  - INF16 auto-recloser on/off
  - INF19 LED reset
  - Private INFs (for example: CB open/close, Control Inputs)

The following commands are still allowed:

- Poll Class 1 (Read spontaneous events)
- Poll Class 2 (Read measurands)
- GI sequence (ASDU7 'Start GI', Poll Class 1)
- Transmission of Disturbance Records sequence (ASDU24, ASDU25, Poll Class 1)
- Time Synchronisation (ASDU6)
- General Commands (ASDU20), namely:
  - INF23 activate characteristic 1
  - INF24 activate characteristic 2
  - INF25 activate characteristic 3
  - INF26 activate characteristic 4

11.2 COURIER PROTOCOL

If Read-Only Mode is enabled for RP1 or RP2 with Courier, the following commands are blocked at the interface:

- Write settings
- All controls, including:
  - Reset Indication (Trip LED)
  - Operate Control Inputs
  - CB operations
  - Auto-reclose operations
  - Reset demands
  - Clear event/fault/maintenance/disturbance records
  - Test LEDs & contacts

The following commands are still allowed:

• Read settings, statuses, measurands

• Read records (event, fault, disturbance)

• Time Synchronisation

• Change active setting group

11.3 IEC 61850 PROTOCOL

If Read-Only Mode is enabled for the Ethernet interfacing with IEC 61850, the following commands are blocked at the interface:

- All controls, including:
  - Enable/disable protection
  - Operate Control Inputs
  - CB operations (Close/Trip, Lock)
  - Reset LEDs

The following commands are still allowed:

- Read statuses, measurands
- Generate reports
- Extract disturbance records
- Time synchronisation
- Change active setting group

11.4 READ-ONLY SETTINGS

The following settings are available for enabling or disabling Read Only Mode.

- RP1 Read Only
- RP2 Read Only
- NIC Read Only (where Ethernet is available)

These settings are not available for MODBUS and DNP3.

11.5 READ-ONLY DDB SIGNALS

The remote read only mode is also available in the PSL using three dedicated DDB signals:

- RP1 Read Only
- RP2 Read Only
- NIC Read Only (where Ethernet is available)

Using the PSL, these signals can be activated by opto-inputs, Control Inputs and function keys if required.

12 TIME SYNCHRONISATION

In modern protection schemes it is necessary to synchronise the IED's real time clock so that events from different devices can be time stamped and placed in chronological order. This is achieved in various ways depending on the chosen options and communication protocols.

- Using the IRIG-B input (if fitted)
- Using the SNTP time protocol (for Ethernet IEC 61850 versions + DNP3 OE)
- By using the time synchronisation functionality inherent in the data protocols

13 DEMODULATED IRIG-B

IRIG stands for Inter Range instrumentation Group, which is a standards body responsible for standardising different time code formats. There are several different formats starting with IRIG-A, followed by IRIG-B and so on. The letter after the "IRIG" specifies the resolution of the time signal in pulses per second (PPS). IRIG-B, the one which we use has a resolution of 100 PPS. IRIG-B is used when accurate time-stamping is required.

The following diagram shows a typical GPS time-synchronised substation application. The satellite RF signal is picked up by a satellite dish and passed on to receiver. The receiver receives the signal and converts it into time signal suitable for the substation network. IEDs in the substation use this signal to govern their internal clocks and event recorders.

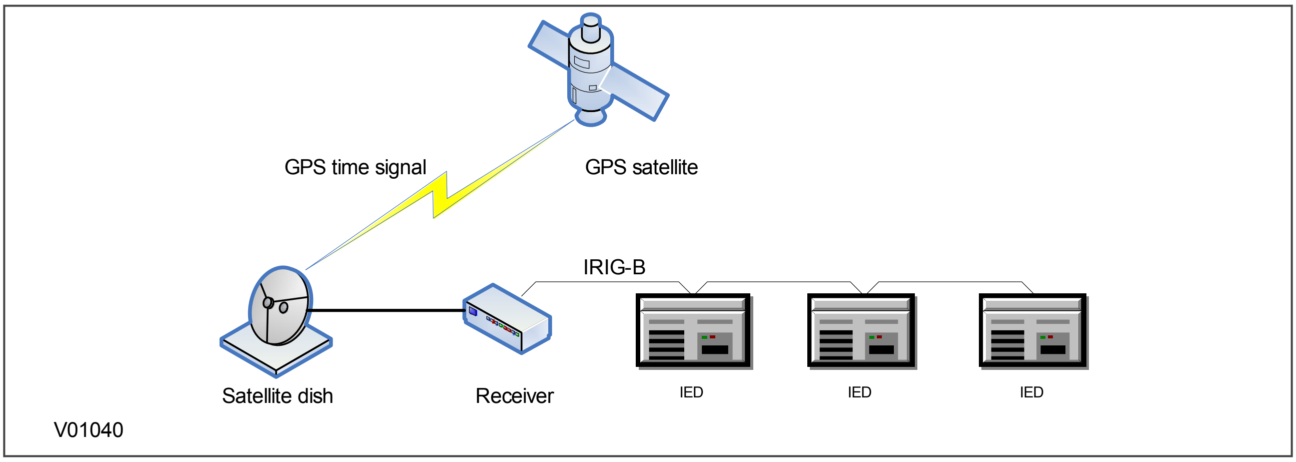


Figure 56: GPS Satellite timing signal

The IRIG-B time code signal is a sequence of one second time frames. Each frame is split up into ten 100 mS slots as follows:

- Time-slot 1: Seconds
- Time-slot 2: Minutes
- Time-slot 3: Hours
- Time-slot 4: Days
- Time-slot 5 and 6: Control functions
- Time-slots 7 to 10: Straight binary time of day

The first four time-slots define the time in BCD (Binary Coded Decimal). Time-slots 5 and 6 are used for control functions, which control deletion commands and allow different data groupings within the synchronisation strings. Time-slots 7-10 define the time in SBS (Straight Binary Second of day).

13.1 IRIG-B IMPLEMENTATION

Depending on the chosen hardware options, the product can be equipped with an IRIG-B input for time synchronisation purposes. The IRIG-B interface is implemented either on a dedicated card, or together with other communication functionality such as Ethernet. The IRIG-B connection is presented by a connector is a BNC connector. IRIG-B signals are usually presented as an RF-modulated signal. There are two types of input to our IRIG-B boards: demodulated or modulated. A board that accepts a demodulated input is used where the IRIG-B signal has already been demodulated by another device before being fed to the IED. A board that accepts a modulated input has an on-board demodulator.

To set the device to use IRIG-B, use the setting ***IRIG-B Sync*** cell in the *DATE AND TIME* column.

The IRIG-B status can be viewed in the ***IRIG-B Status*** cell in the *DATE AND TIME* column.

14 SNTP

SNTP is used to synchronise the clocks of computer systems over packet-switched, variable-latency data networks, such as IP. SNTP can be used as the time synchronisation method for models using IEC 61850 over Ethernet.

The device is synchronised by the main SNTP server. This is achieved by entering the IP address of the SNTP server into the IED using the IEC 61850 Configurator software described in the S1 Agile chapter. A second server is also configured with a different IP address for backup purposes.

The HMI menu does not contain any configurable settings relating to SNTP, as the only way to configure it is using the IEC 61850 Configurator. However it is possible to view some parameters in the *COMMUNICATIONS* column under the sub-heading SNTP parameters. Here you can view the SNTP server addresses and the SNTP poll rate in the cells ***SNTP Server 1***, ***SNTP Server 2*** and ***SNTP Poll rate*** respectively.

The SNTP time synchronisation status is displayed in the ***SNTP Status*** cell in the *DATE AND TIME* column.

15 TIME SYNCHRONSIATION USING THE COMMUNICATION PROTOCOLS

All communication protocols have in-built time synchronisation mechanisms. If neither IRIG-B nor SNTP is used to synchronise the devices, the time synchronisation mechanism within the relevant serial protocol is used. The real time is usually defined in the master station and communicated to the relevant IEDs via one of the rear serial ports using the chosen protocol. It is also possible to define the time locally using settings in the *DATE AND TIME* column.

The time synchronisation for each protocol is described in the relevant protocol description sections as follows:

- Courier Time Synchronisation (on page 203)
- IEC 60870-5-103 Time synchronisation (on page 205)
- DNP 3 Time Synchronisation (on page 209)
- Modbus time Synchronisation (on page 221)

16 COMMUNICATION SETTINGS

This section contains a complete table of the settings required to set up the device communication.

Courier Text	Col	Row	Default Setting	Available Options
Description				
COMMUNICATIONS	0E	00		
This column contains settings for configuring the communications				
RP1 Protocol	0E	01		0 = Courier, 1 = IEC870-5-103, 2 = Modbus, 3 = DNP3.0
This cell displays the communications protocol that is used on RP1.				
RP1 Address	0E	02	255	0 to 255 (Courier)
This sets the Rear Port 1 Courier Protocol device address				
RP1 Address	0E	02	1	0 to 247 (Modbus)
This sets the Rear Port 1 Modbus Protocol device address				
RP1 Address	0E	02	1	0 to 254 (CS103)
This sets the Rear Port 1 IEC60870-5-103 Protocol device address				
RP1 Address	0E	02	1	0 to 65534 (DNP3.0)
This sets the Rear Port 1 DNP 3.0 Protocol device address				
RP1 InactivTimer	0E	03	15	From 1 min to 30 min step 1m
This sets the Rear Port 1 Courier Protocol inactivity timer				
RP1 InactivTimer	0E	03	15	From 1 min to 30 min step 1m
This sets the Rear Port 1 Modbus Protocol inactivity timer				
RP1 InactivTimer	0E	03	15	From 1 min to 30 min step 1m
This sets the Rear Port 1 IEC60870-5-103 Protocol inactivity timer				
RP1 Baud Rate	0E	04	19200 bits/s	1200, 2400, 4800 9600, 19200, 38400 (dependent on protocol)
This sets the Rear Port 1 Modbus Protcol serial bit/baud rate				
RP1 Baud Rate	0E	04	19200 bits/s	1200, 2400, 4800 9600, 19200, 38400 (dependent on protocol)
This sets the Rear Port 1 IEC60870-5-103 Protcol serial bit/baud rate				
RP1 Baud Rate	0E	04	19200 bits/s	1200, 2400, 4800 9600, 19200, 38400 (dependent on protocol)
This sets the Rear Port 1 DNP 3.0 Protcol serial bit/baud rate				
RP1 Parity	0E	05	None	0 = Odd, 1 = Even, 2 = None
This sets the Rear Port 1 Modbus Protocol parity				
RP1 Parity	0E	05	None	0 = Odd, 1 = Even, 2 = None
This sets the Rear Port 1 DNP 3.0 Protocol parity				
RP1 Meas Period	0E	06	15	From 1s to 60s step 1s
This sets the Rear Port 1 IEC60870-5-103 Protocol measurment period				
RP1 PhysicalLink	0E	07	Copper	0 = Copper or 1 = Fibre Optic
This sets the Rear Port 1 Physical link selector. Available when Fibre Optic Comms card is specified by model number				
RP1 Time Sync	0E	08	Disabled	0 = Disabled or 1 = Enabled
This sets the Rear Port 1 DNP 3.0 Protocol time sync configuration. NB Not available when IRIG-B option fitted and enabled.				

Courier Text	Col	Row	Default Setting	Available Options
Description				
Modbus IEC Time	0E	09	Standard	0=Standard IEC (Existing format) 1=Reverse IEC (Company agreed format)
This controls the format of the time-date G12 data type. Modbus Only.				
RP1 CS103Blcking	0E	0A	Disabled	0 = Disabled, 1 = Monitor Blocking or 2 = Command Blocking
This sets the Rear Port 1 IEC60870-5-103 Protocol blocking configuration				
RP1 Card Status	0E	0B		0 = K Bus OK 1 = EIA485 OK 2 = IRIG-B
This sets the Rear Port 1 Courier Protocol Status				
RP1 Port Config	0E	0C	K-Bus	0 = K-Bus 1 = EIA485 (RS485)
This sets the Rear Port 1 Courier Protocol copper port configuration; K-Bus or EIA485				
RP1 Comms Mode	0E	0D	IEC60870 FT1.2	0 = IEC60870 FT1.2 Frame or 1 = 10-bit no parity
This sets the Rear Port 1 Courier Protocol EIA485 mode				
RP1 Baud Rate	0E	0E	19200 bits/s	0 = 9600 bps 1 = 19200 bps 2 = 38400 bps Courier protocol only
This sets the Rear Port 1 Courier Protocol EIA485 bit/baud rate				
RP1 Meas scaling	0E	0F	Primary	0 = Normalised, 1 = Primary, 2 = Secondary
This setting determines the scaling type of analogue quantities - in terms of primary, secondary or normalised, for DNP3 models.				
DNP Need Time	0E	11	10	From 1m to 30m step 1m
This sets the duration of time waited before requesting another time sync from the master. DNP 3.0 versions only.				
DNP App Fragment	0E	12	2048	100 to 2048 step 1
This sets the maximum message length (application fragment size) transmitted by the IED for DNP 3.0 versions.				
DNP App Timeout	0E	13	2	From 1s to 120s step 1s
This sets the maximum waiting time between sending a message fragment and reciving confirmation from the master. DNP 3.0 versions only.				
DNP SBO Timeout	0E	14	10	From 1s to 10s step 1s
This sets the maximum waiting time between receiving (sending?) a select command and awaiting an operate confirmation from the master. DNP 3.0 versions only.				
DNP Link Timeout	0E	15	0	From 0s to 120s step 1s
This sets the maximum waiting time for a Data Link Confirm from the master. A value of 0 means data link support disabled. DNP 3.0 versions only.				
NIC Protocol	0E	1F	IEC61850	IEC61850 or DNP3.0
This cell indicates whether IEC 61850 or DNP 3.0 over Ethernet are used on the rear Ethernet port.				
NIC MAC Address	0E	22	Ethernet MAC Addr	Not Settable
This cell displays the MAC address of the rear Ethernet port, if applicable.				
NIC Tunl Timeout	0E	64	5.00 min	From 1ms to 30ms step 1ms
This sets the maximum waiting time before an inactive tunnel to the application software is reset. DNP 3.0 over Ethernet versions only.				
NIC Link Report	0E	6A	Alarm	0 = Alarm, 1 = Event, 2 = None
This setting defines how a failed or unfitted network link is reported. DNP 3.0 over Ethernet versions only.				

Courier Text	Col	Row	Default Setting	Available Options
Description				
REAR PORT2 (RP2)	0E	80		
This column contains configuration settings and information for RP2				
RP2 Protocol	0E	81	Courier	Not Settable
This cell indicates which protocol is used on RP2				
RP2 Card Status	0E	84		0 = Unsupported, 1 = Card Not Fitted, 2 = EIA232 OK, 3 = EIA485 OK, 4 = K Bus OK
This setting displays the communication type and status of RP2				
RP2 Port Config	0E	88	EIA232 (RS232)	0 = EIA232 (RS232), 1 = EIA485 (RS485), 2 = K-Bus
This seting selects the type of physical protocol for RP2				
RP2 Comms Mode	0E	8A	IEC60870 FT1.2	0 = IEC60870 FT1.2 Frame or 1 = 10-bit no parity
This setting determines the serial communication mode.				
RP2 Address	0E	90	255	0 to 255 step 1
This setting sets the address of RP2.				
RP2 InactivTimer	0E	92	15	From 1m to 30m step 1m
This setting defines the period of inactivity on RP2 before the IED reverts to its default state.				
RP2 Baud Rate	0E	94	19200 bits/s	0 = 9600 bits/s, 1 = 19200 bits/s, 2 = 38400 bits/s
This setting sets the communication speed between the IED RP2 port and the master station. It is important that both IED and master station are set at the same speed setting.				
NIC Protocol	0E	A0	DNP3	Not Settable
This cell indicates whether IEC 61850 or DNP 3.0 over Ethernet are used on the rear Ethernet port.				
IP Address	0E	A1	0.0.0.0	Not Settable
This cell displays the IED's IP address. DNP over Ethernet versions only.				
Subnet mask	0E	A2	0.0.0.0	Not Settable
This cell displays the the LAN's subnet address on which the IED is located. DNP 3.0 over Ethernet versions only.				
NIC MAC Address	0E	A3	Ethernet MAC Addr	Not Settable
This setting displays the MAC address of the rear Ethernet port, if applicable.				
Gateway	0E	A4	0.0.0.0	Not Settable
This cell displays the LAN's gateway address on which the IED is located. DNP 3.0 over Ethernet versions only.				
DNP Time Sync	0E	A5	Disabled	0 = Disabled or 1 = Enabled
If set to ‘Enabled’ the DNP3.0 master station can be used to synchronise the IED's time clock. If set to ‘Disabled’ either the internal free running clock, or IRIG-B input are used. DNP 3.0 over Ethernet versions only.				
DNP Meas scaling	0E	A6	Primary	0 = Normalised, 1 = Primary, 2 = Secondary
This setting determines the scaling type of analogue quantities - in terms of primary, secondary or normalised, for DNP3 OE models.				
NIC Tunl Timeout	0E	A7	5.00 min	From 1ms to 30ms step 1ms
This sets the maximum waiting time before an inactive tunnel to the application software is reset. DNP 3.0 over Ethernet versions only.				
NIC Link Report	0E	A8	Alarm	0 = Alarm, 1 = Event, 2 = None

Courier Text	Col	Row	Default Setting	Available Options
Description				
This setting defines how a failed or unfitted network link is reported. DNP3.0 over Ethernet versions only.				
SNTP PARAMETERS	0E	AA		
The settings in this sub-menu are for models using DNP3 over Ethernet.				
SNTP Server 1	0E	AB	0.0.0.0	Not Settable
This cell indicates the SNTP Server 1 address. DNP 3.0 over Ethernet versions only.				
SNTP Server 2	0E	AC	0.0.0.0	Not Settable
This cell indicates the SNTP Server 2 address. DNP 3.0 over Ethernet versions only.				
SNTP Poll Rate	0E	AD	64	Not Settable
This cell displays the SNTP poll rate interval in seconds. DNP 3.0 over Ethernet versions only.				
DNP Need Time	0E	B1	10	From 1 to 30 step 1
This sets the duration of time waited before requesting another time sync from the master. DNP 3.0 versions only.				
DNP App Fragment	0E	B2	2048	From 100 to 2048 step 1
This sets the maximum message length (application fragment size) transmitted by the IED for DNP 3.0 versions.				
DNP App Timeout	0E	B3	2	From 1s to 120s step 1s
This sets the maximum waiting time between sending a message fragment and reciving confirmation from the master. DNP 3.0 versions only.				
DNP SBO Timeout	0E	B4	10	From 1s to 10s step 1s
This sets the maximum waiting time between receiving (sending?) a select command and awaiting an operate confirmation from the master. DNP 3.0 versions only.				

REDUNDANT ETHERNET

CHAPTER 8

1 CHAPTER OVERVIEW

Redundancy is transparent backup. It is required where a single point of failure cannot be tolerated, so is required in critical applications such as substation automation. Redundancy acts as an insurance policy, providing an alternative route if one route fails.

The Redundant Ethernet Board (REB) assures "bumpless" redundancy at the intelligent electronic device (IED) level. "Bumpless" in this context means the transfer from one communication path to another without noticeable consequences.

This chapter contains the following sections:

2 BOARD VERSIONS

Each board combines Ethernet communications, with IRIG-B timing functionality. There is a choice of embedded protocols for the Ethernet communications, and two types of IRIG-B.

Board options

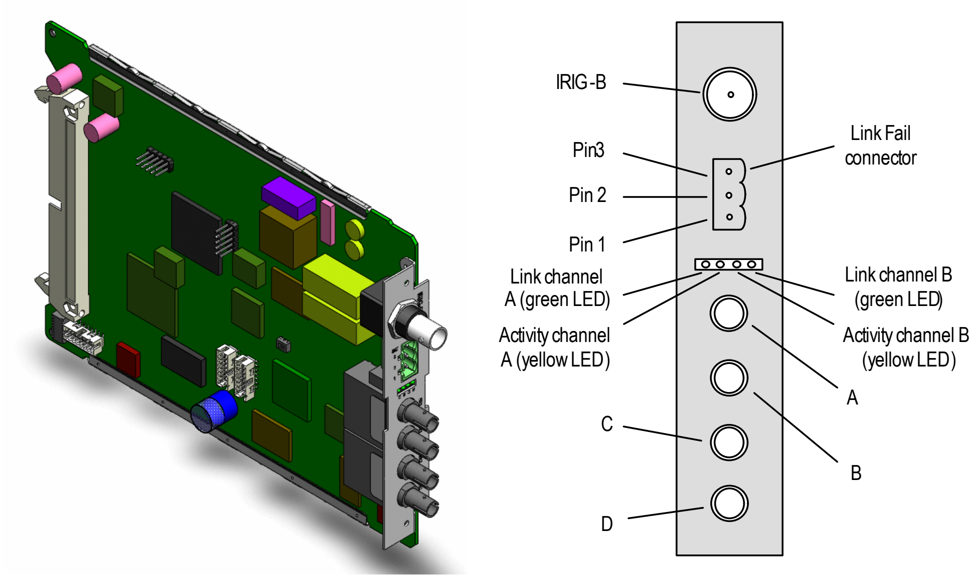
<table>
<tr><th>Board</th><th>Part No.</th><th>Compatible With</th></tr>
<tr><td>Redundant Ethernet SHP, 2 multi-mode fibre ports + modulated IRIG-B</td><td>ZN0071 001</td><td rowspan="2">C264-SWR212 and MiCOM H35x multi-mode switches</td></tr>
<tr><td>Redundant Ethernet SHP, 2 multi-mode fibre ports + demodulated IRIG-B</td><td>ZN0071 002</td></tr>
<tr><td>Redundant Ethernet RSTP, 2 multi-mode fibre ports + modulated IRIG-B</td><td>ZN0071 005</td><td rowspan="2">Any RSTP device</td></tr>
<tr><td>Redundant Ethernet RSTP, 2 multi-mode fibre ports + demodulated IRIG-B</td><td>ZN0071 006</td></tr>
<tr><td>Redundant Ethernet DHP, 2 multi-mode fibre ports + modulated IRIG-B</td><td>ZN0071 007</td><td rowspan="2">C264-SWD212 and MiCOM H36x multi-mode switches</td></tr>
<tr><td>Redundant Ethernet DHP, 2 multi-mode fibre ports + demodulated IRIG-B</td><td>ZN0071 008</td></tr>
<tr><td>Redundant Ethernet PRP, 2 multi-mode fibre ports + modulated IRIG-B</td><td>ZN0071 009</td><td rowspan="2">Any PRP device</td></tr>
<tr><td>Redundant Ethernet PRP, 2 multi-mode fibre ports + demodulated IRIG-B</td><td>ZN0071 010</td></tr>
</table>

Each board has two MAC addresses, one for the managed embedded switch and one for the IED. The MAC address of the embedded switch is printed on the board. The MAC address of the IED is printed on the rear panel of the IED. The redundant Ethernet board is fitted into Slot A of the IED, which is the optional communications slot.

All Ethernet connections are made with 1300 nm multi mode 100BaseFx fiber optic Ethernet ports (ST® connector). The boards support both IEC 61850 and DNP3.0 over Ethernet.

Note:
SHP and DHP are proprietary protocols providing extremely fast recovery time. These boards offer compatibility with C264-SWR212/SWD212 and MiCOM H35x/H36x multi-mode switches.

3 BOARD CONNECTIONS



V01009

Figure 57: Board connectors

IRIG-B Connector

Available as a modulated or demodulated input. Centre connection, signal. Outer connection, Earth.

Link Fail Connector (Watchdog Relay)

Pin	Closed	Open
1-2	Link fail Channel 1 (A)	Link ok Channel 1 (A)
2-3	Link fail Channel 2 (B)	Link ok Channel 2 (B)

LEDs

LED	Function	On	Off	Flashing
Green	Link	Link ok	Link broken	
Yellow	Activity	SHP running		PRP, RSTP or DHP traffic

Optical Fibre Connectors

Uses 1300 nm multi mode 100BaseFx and ST connectors.

Connector	DHP	RSTP	SHP	PRP
A	RXA	RX1	RS	RXA
B	TXA	TX1	ES	TXA
C	RXB	RX2	RP	RXB
D	TXB	TX2	EP	TXB

4 REDUNDANCY PROTOCOLS

The following redundancy protocols are available:

- PRP (Parallel Redundancy Protocol)
- RSTP (Rapid Spanning Tree Protocol)
- SHP (Self-Healing Protocol)
- DHP (Dual Homing Protocol)

The protocol must be selected at the time of ordering.

4.1 PARALLEL REDUNDANCY PROTOCOL (PRP)

Power system companies have traditionally used proprietary protocols for redundant communications. This is because standardized protocols could not meet the requirements for real-time systems. Even a short loss of connectivity may result in loss of functionality.

However, Parallel Redundancy Protocol (PRP) uses the IEC 62439 standard in Dual Homing Star Topology networks, designed for IEDs from different manufacturers to operate with each other in a substation redundant-Ethernet network. PRP provides bumpless redundancy for real-time systems and is the standard for double Star-topology networks in substations.

4.1.1 PRP NETWORKS

Redundant networks usually rely on the network’s ability to reconfigure if there is a failure. However, PRP uses two independent networks in parallel.

PRP implements the redundancy functions in the end nodes rather than in network elements. This is one major difference to RSTP. An end node is attached to two similar LANs of any topology which operate in parallel.

The sending node replicates each frame and transmits them over both networks. The receiving node processes the frame that arrives first and discards the duplicate. Therefore there is no distinction between the working and backup path. The receiving node checks that all frames arrive in sequence and that frames are correctly received on both ports.

The PRP layer manages this replicate and discard function, and hides the two networks from the upper layers. This scheme works without reconfiguration and switchover, so it stays available ensuring no data loss.

There should be no common point of failure between the two LANs. Therefore they are not powered by the same source and cannot be connected directly together. They are identical in protocol at the MAC level but may differ in performance and topology. Both LANs must be on the same subnet so all IP addresses must be unique.

4.1.2 NETWORK ELEMENTS

A PRP compatible device has two ports that operate in parallel. Each port is connected to a separate LAN. In the IEC 62439 standard, these devices are called DANP (Doubly Attached Node running PRP). A DAN has two ports, one MAC address and one IP address.

A Single Attached Node (SAN) is a non-critical node attached to only one LAN. SANs that need to communicate with each other must be on the same LAN.

The following diagram shows an example of a PRP network. The Doubly Attached Nodes DANP 1 and DANP 2 have full node redundancy. The Singly Attached Nodes SAN 1 and SAN 4 do not have any redundancy. Singly attached nodes can be connected to both LANs using a Redundancy Box (RedBox). The RedBox converts a singly attached node into a doubly attached node. Devices such as PCs with one network card, printers, and IEDs with one network card are singly attached nodes. A SAN behind a RedBox appears like a DAN so is called a Virtual DAN (VDAN).

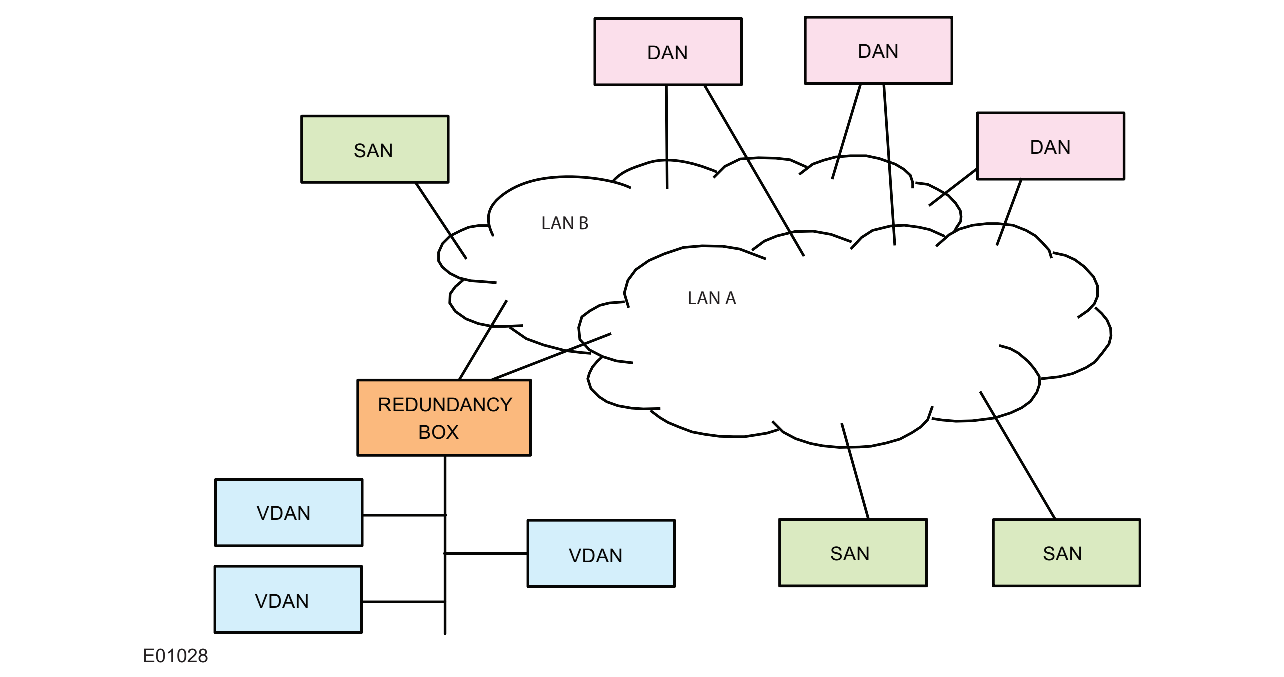


Figure 58: Example PRP redundant network

In a DAN, both ports share the same MAC address so it does not affect the way devices talk to each other in an Ethernet network (Address Resolution Protocol at layer 2). Every data frame is seen by both ports.

When a DAN sends a frame of data, the frame is duplicated on both ports and therefore on both LAN segments. This provides a redundant path for the data frame if one of the segments fails. Under normal conditions, both LAN segments are working and each port receives identical frames. There are two ways of handling this: Duplicate Accept and Duplicate Discard.

The Alstom Grid RedBox is the H382 switch. This is compatible with any other vendor's PRP device.

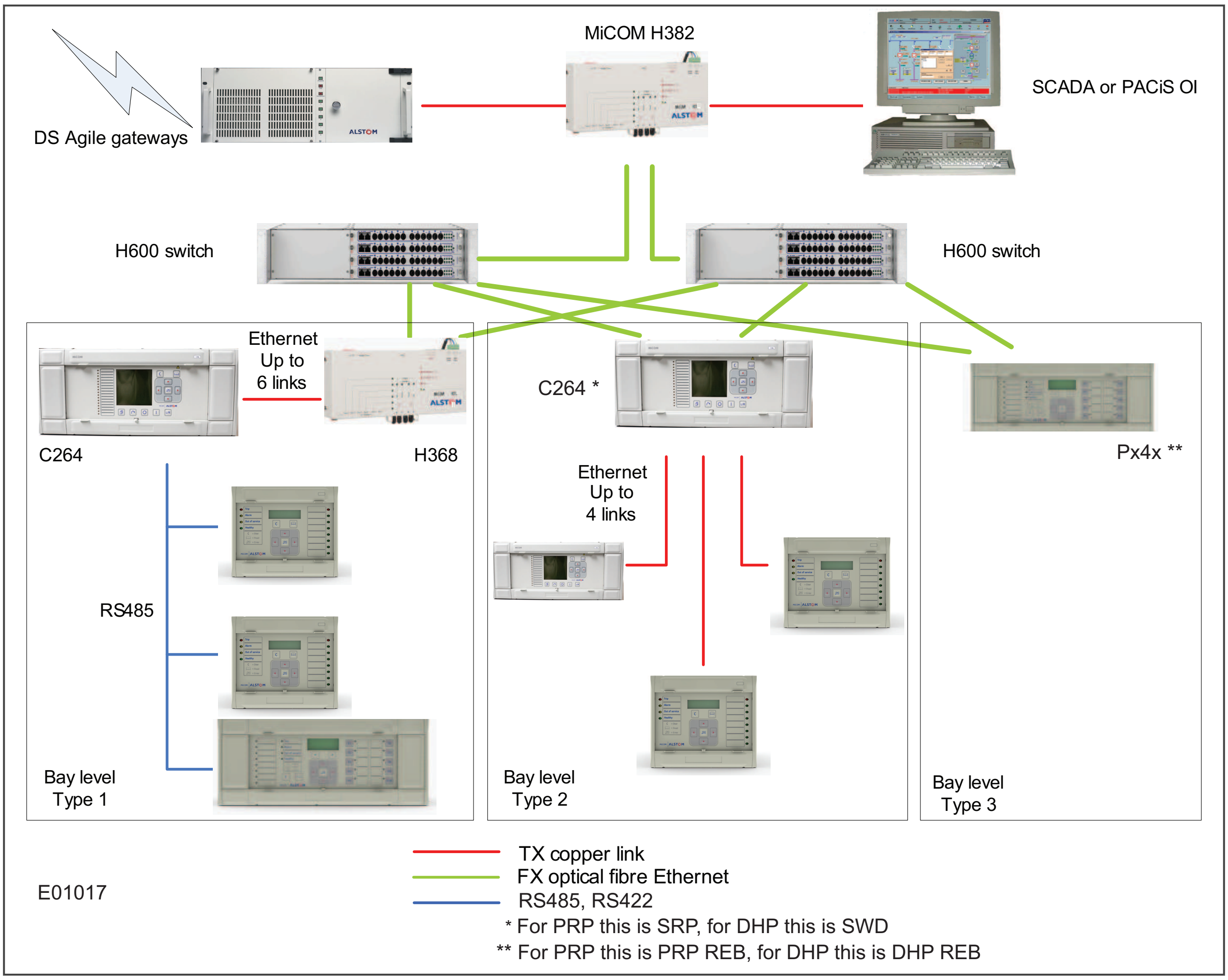


Figure 59: Application of PRP at substation level

4.2 RAPID SPANNING TREE PROTOCOL (RSTP)

RSTP is a standard used to quickly reconnect a network fault by finding an alternative path, allowing loop-free network topology. Although RSTP can recover network faults quickly, the fault recovery time depends on the number of devices and the topology. The recovery time also depends on the time taken by the devices to determine the root bridge and compute the port roles (discarding, learning, forwarding). The devices do this by exchanging Bridge Protocol Data Units (BPDUs) containing information about bridge IDs and root path costs. See the IEEE 802.1D 2004 standard for further information.

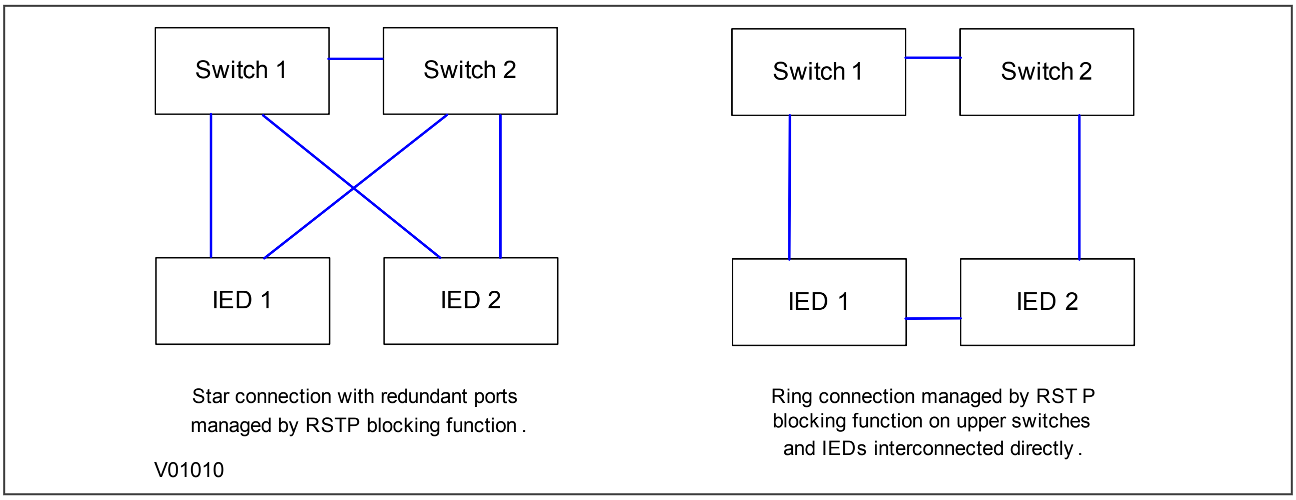


Figure 60: IED attached to redundant Ethernet star or ring circuit

The RSTP solution is based on open standards. It is therefore compatible with other Manufacturers' IEDs that use the RSTP protocol. The RSTP recovery time is typically 300 ms but it increases with network size, therefore cannot achieve the desired bumpless redundancy.

4.3 SELF-HEALING PROTOCOL (SHP)

Unlike RSTP, the Alstom Grid SHP solution responds to the constraints of critical time applications such as the GOOSE messaging of IEC 61850. SHP in MiCOM Px4x is fully compatible with SHP used in the MiCOM C264 and MiCOM H series of switches that are components of the PACiS Substation Automation System.

SHP is applied to double-ring network topologies. When a fibre is broken, both end stations detect the break. Using both the primary and redundant networks the ring is automatically reclosed.

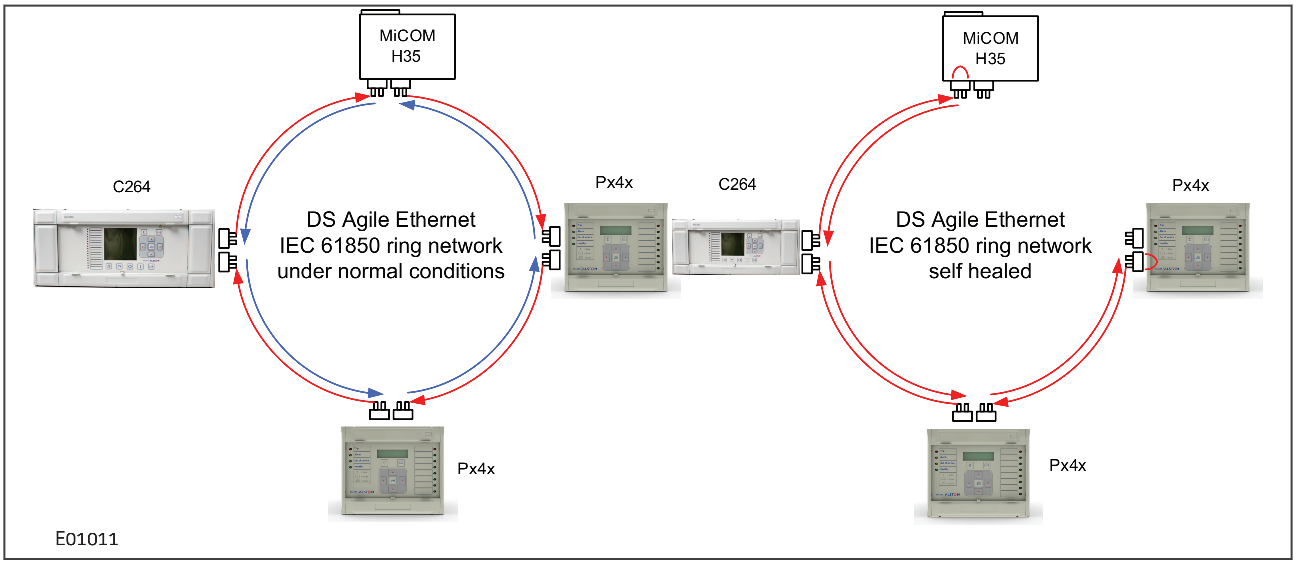


Figure 61: IED, bay computer and Ethernet switch with self healing ring facilities

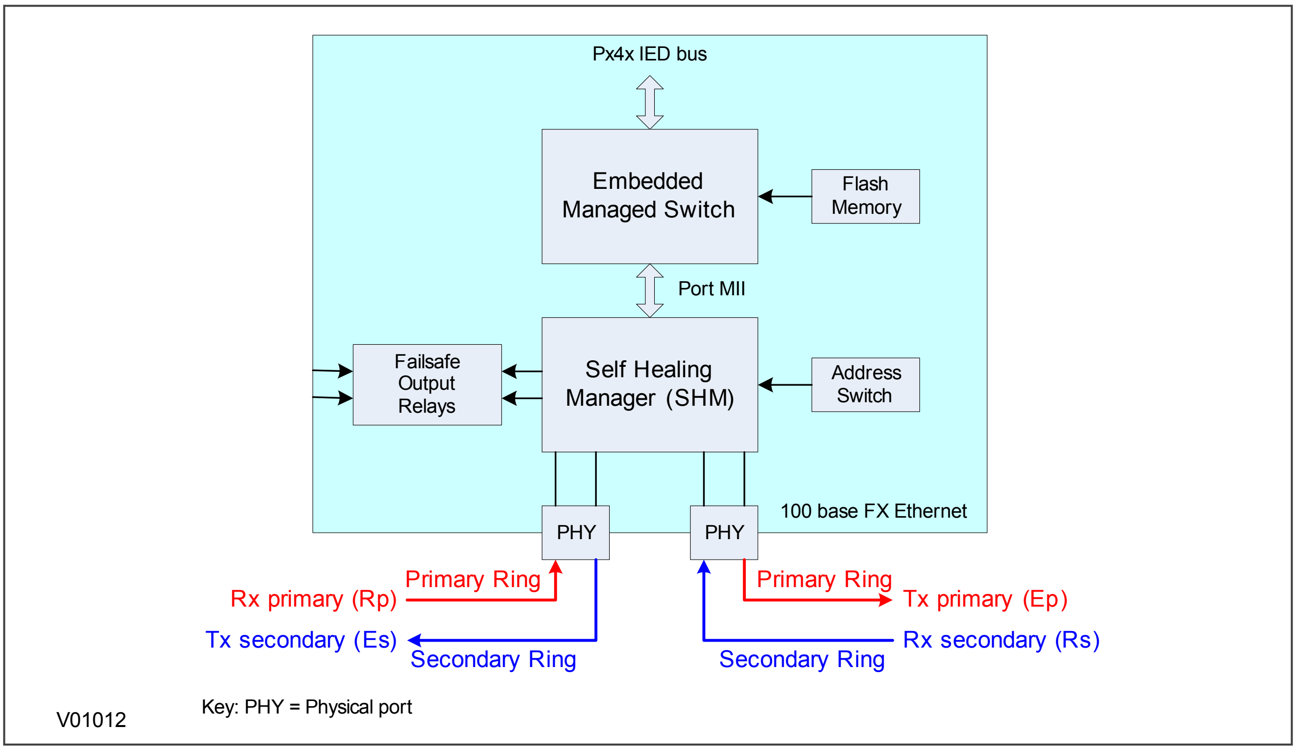


Figure 62: Internal architecture of IED, C264 bay computer and H36x Ethernet switch

The SHM functions manage the ring. If the fibre optic connection between two devices is broken, the network continues to run correctly.

Normally the Ethernet packets travel on the primary fibre in the same direction, and only a checking frame (4 octets) is sent every 5 µs on the secondary fibre in the opposite direction.

If the link goes down, both SHMs immediately start the network self-healing. At one side of the break, received messages are no longer sent to the primary fibre but are sent to the secondary fibre. On the other side of the break, messages received on the secondary fibre are sent to the primary fibre and the new topological loop is closed in less than 1 ms.

As well as providing bumpless redundancy for unintentional network failure, this system can also be used to extend the number of devices, or the size of a sub-station network, without having to disable the network.

First, the loop is opened intentionally and it immediately self heals. Then the new equipment is connected and it immediately self heals again, closing the loop.

To increase the reliability some additional mechanisms are used:

- The quality of transmission is monitored. Each frame (Ethernet packet or checking frame) is controlled by the SHM. Even if the link is not broken, but a larger than normal error rate is detected, the redundancy mechanism is initiated.
- Even if there is no traffic in the primary link, the secondary link is still supervised by sending out checking frames every 5 µs.

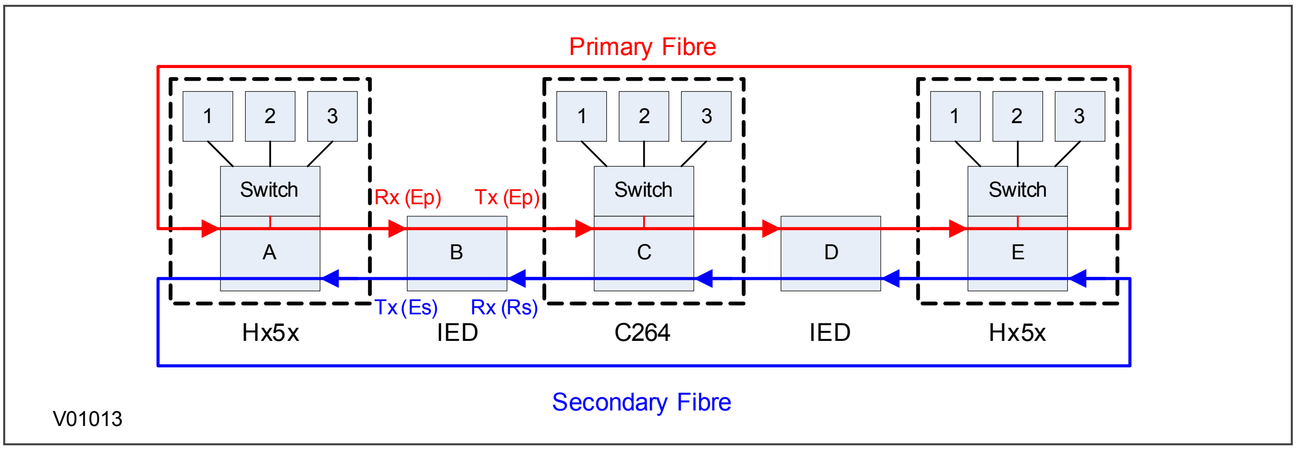


Figure 63: Redundant Ethernet ring architecture with IED, bay computer and Ethernet switches

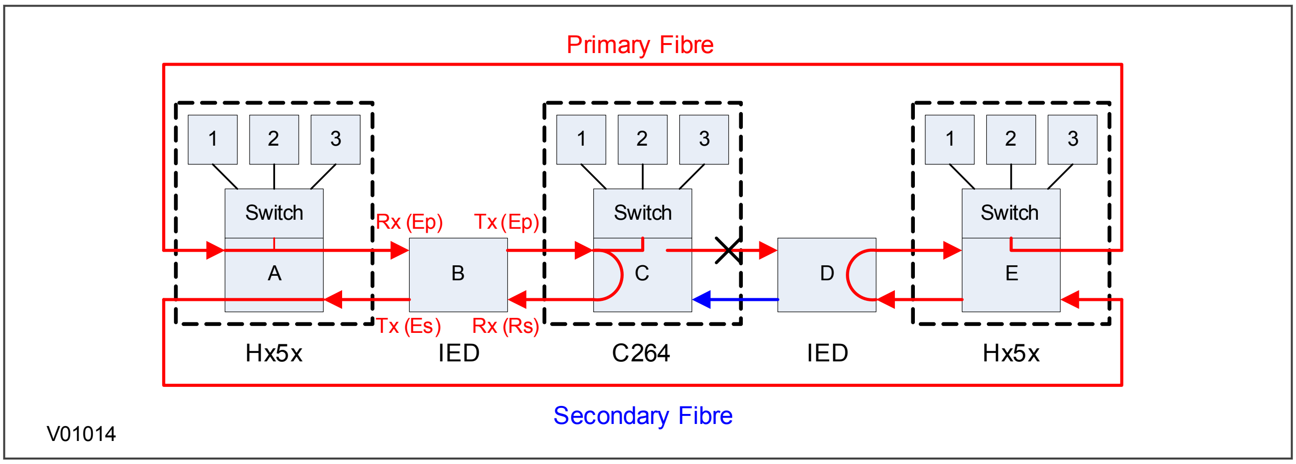


Figure 64: Redundant Ethernet ring architecture with IED, bay computer and Ethernet switches after failure

4.4 DUAL-HOMING PROTOCOL (DHP)

Unlike RSTP, the Alstom Grid DHP solution responds to the constraints of critical time applications such as the GOOSE messaging of IEC 61850.

DHP is applied to double-star network topologies. If the optical fibre connection between two devices is broken, the network continues to operate correctly.

The Dual Homing Manager (DHM) handles topologies where a device is connected to two independent networks, one being the "main" path, the other being the "backup" path. Both are active at the same time.

In sending mode, packets from the device are sent by the DHM to the two networks. In receive mode, the duplicate discard principle is used. This means that when both links are up, the MiCOM Alstom H16x switch receives the same Ethernet frame twice. The DHM transmits the first frame received to upper layers for processing, and the second frame is discarded. If one link is down, the frame is sent through the link, received by the device, and passed to upper layers for processing.

Alstom Grid's DHM fulfils automation requirements by delivering a very fast recovery time for the entire network (less than 1 ms).

To increase reliability some specific mechanisms are used:

- Each frame carries a sequence number which is incremented and inserted into both frames.
- Specific frames are used to synchronize the discard mechanism.

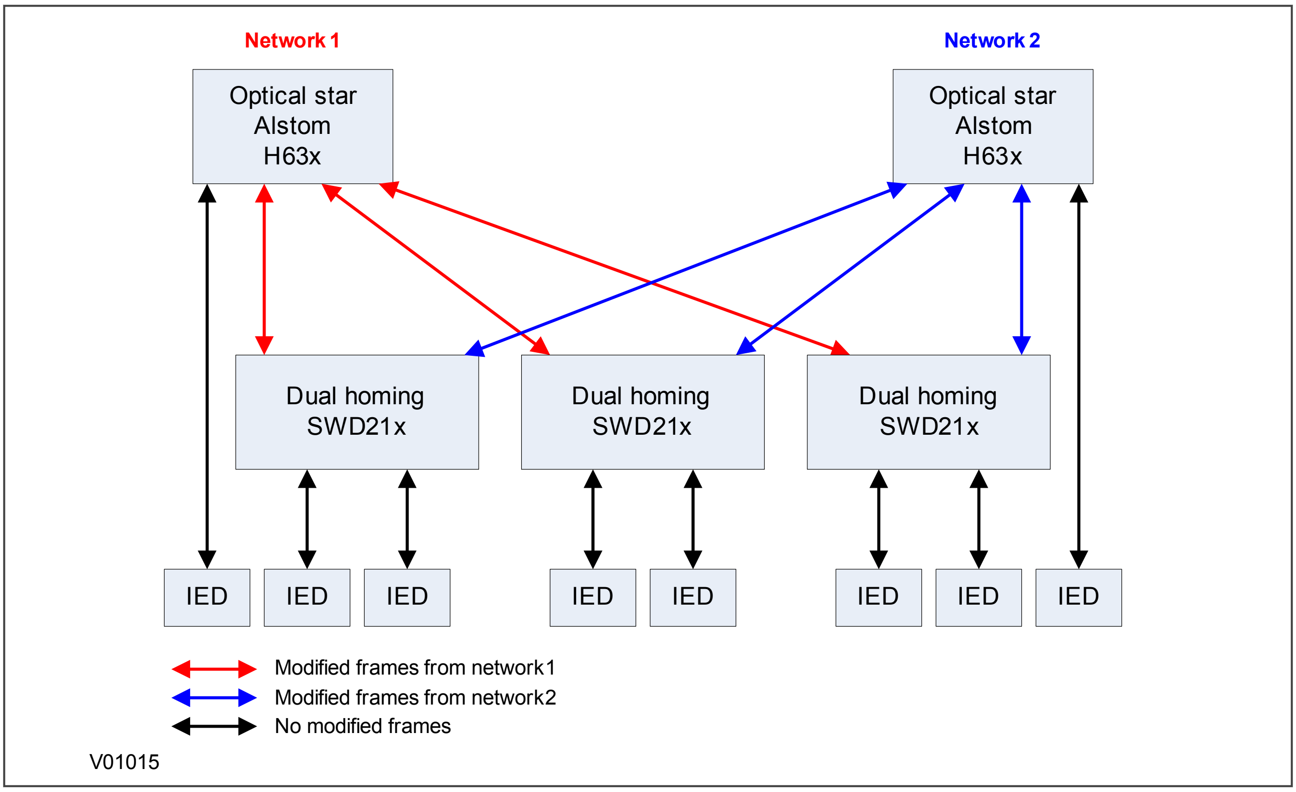


Figure 65: Dual homing mechanism

The H36x is a repeater with a standard 802.3 Ethernet switch, plus the DHM.

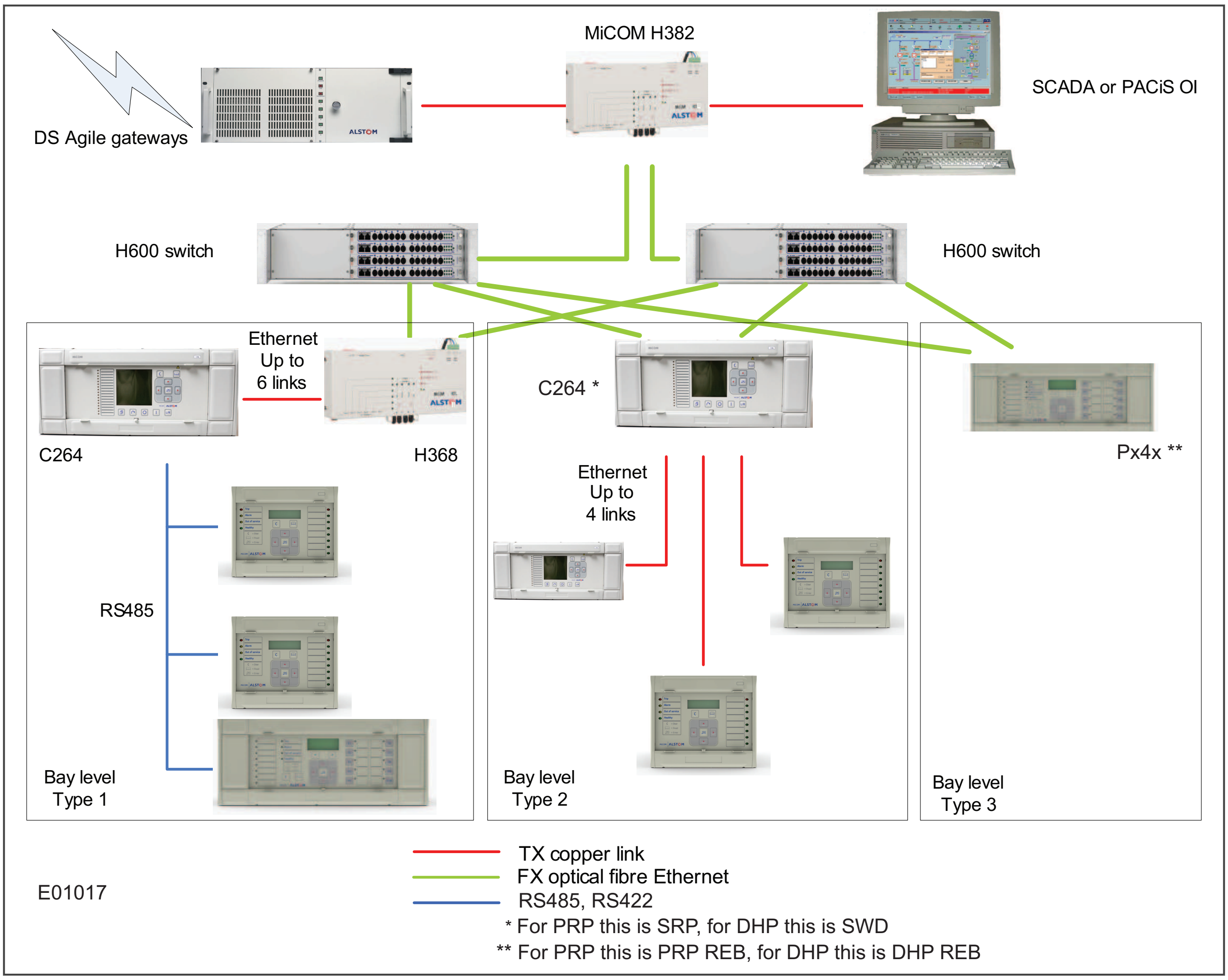


Figure 66: Application of Dual Homing Star at substation level

5 GENERIC FUNCTIONS FOR REDUNDANT ETHERNET BOARDS

The following functions apply to all redundant Ethernet protocols.

5.1 FORWARDING

The MiCOM ALSTOM Ethernet switch products support store and forward mode. The switch forwards messages with known addresses to the appropriate port. The messages with unknown addresses, the broadcast messages and the multicast messages are forwarded out to all ports except the source port. MiCOM ALSTOM switches do not forward error packets, 802.3x pause frames, or local packets.

5.1.1 PRIORITY TAGGING

802.1p priority tagging is enabled on all ports.

5.2 SIMPLE NETWORK MANAGEMENT PROTOCOL (SNMP)

Simple Network Management Protocol (SNMP) is a network protocol designed to manage devices in an IP network. SNMP uses 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 MIB is standardized.

Each system in a network (workstation, server, router, bridge, etc.) maintains a MIB that reflects the status of the managed resources on that system, such as the version of the software running on the device, the IP address assigned to a port or interface, the amount of free hard drive space, or the number of open files. The MIB does not contain static data, but is instead an object-oriented, dynamic database that provides a logical collection of managed object definitions. The MIB defines the data type of each managed object and describes the object.

The SNMP-related branches of the MIB tree are located in the internet branch, which contains two main types of branches:

- Public branches (mgmt=2), which are defined by the Internet Engineering Task Force (IETF).
- Private branches (private=4), which are assigned by the Internet Assigned Numbers Authority (IANA). These are defined by the companies and organizations to which these branches are assigned.

The following figure shows the structure of the SNMP MIB tree. There are no limits on the width and depth of the MIB tree.

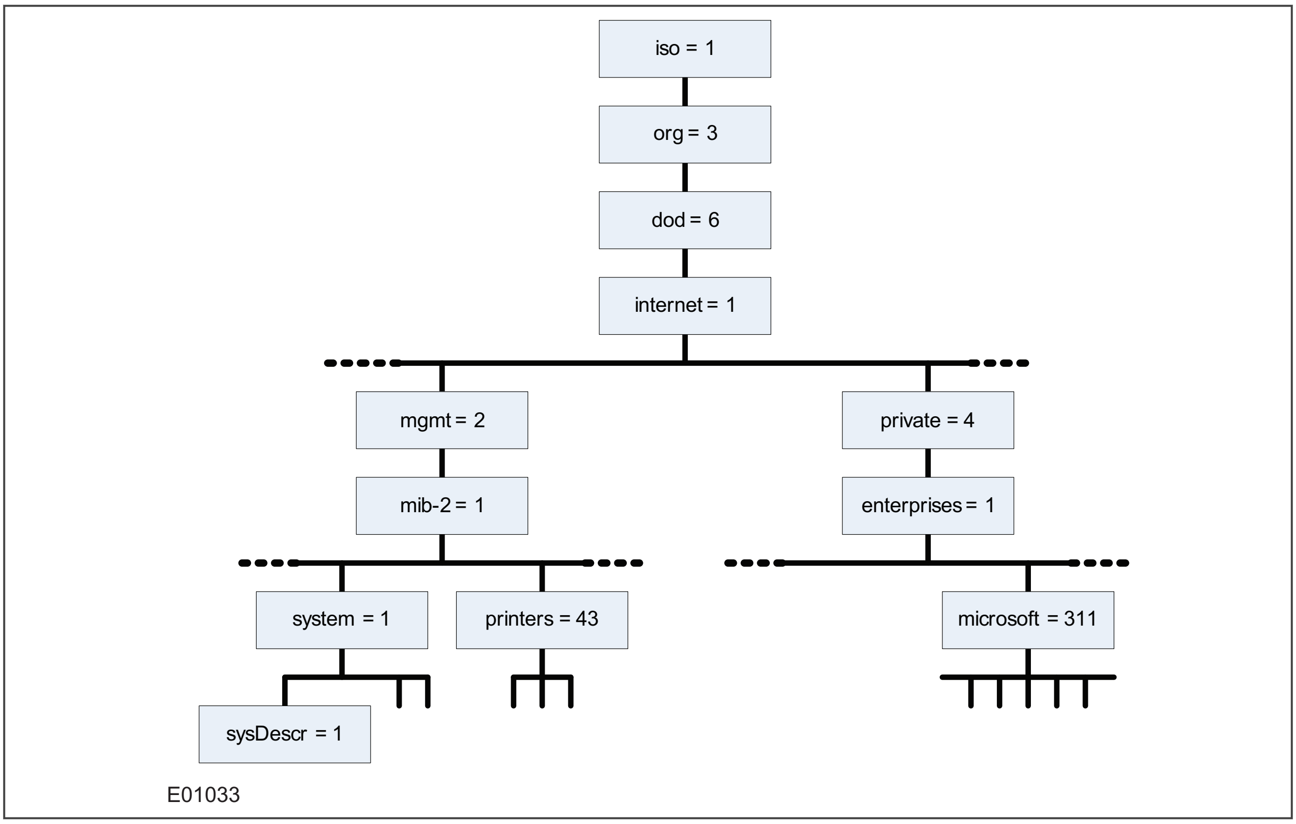


Figure 67: SNMP MIB tree

The top four levels of the hierarchy are fixed. These are:

- International Standards Organization (iso)
- Organization (org)
- Department of Defence (dod)
- Internet

Management (mgmt) is the main public branch. It defines network management parameters common to devices from all vendors. Underneath the Management branch is MIB-II (mib-2), and beneath this are branches for common management functions such as system management, printers, host resources, and interfaces.

The private branch of the MIB tree contains branches for large organizations, organized under the enterprises branch. This is not applicable to Alstom Grid.

5.3 SNMP MIB STRUCTURE FOR RSTP, DHP AND SHP

The Alstom Grid MIB uses three types of OID:

- sysDescr
- sysUpTime
- sysName

Address												Name
0												CCITT
	1											ISO
		3										Org

Address												Name
			6									DOD
				1								Internet
					2							mgmt
						1						Mib-2
							1					sys
								1				sysDescr
								3				sysUpTime
								4				sysName
Remote Monitoring												
							16					RMON
								1				statistics
									1			etherstat
										1		etherStatsEntry
											9	etherStatsUndersizePkts
											10	etherStatsOversizePkts
											12	etherStatsJabbers
											13	etherStatsCollisions
											14	etherStatsPkts64Octets
											15	etherStatsPkts65to127Octets
											16	etherStatsPkts128to255Octets
											17	etherStatsPkts256to511Octets
											18	etherStatsPkts512to1023Octets

Redundant Ethernet Board MIB Structurearious SNMP client software tools can be used. Alstom Grid recommends using an SNMP MIB browser, which can perform the basic SNMP operations such as GET, GETNEXT and RESPONSE.

> *Note:*
> *When communicating with the Redundant Ethernet Card, there are two IP addresses visible: one for the IED and one for the Ethernet switch on the redundant Ethernet board. To access the network using SNMP, use the IP address of the redundant Ethernet board switch and not that of the IED. See the Configuration chapter for further information.*

5.4 SNMP MIB STRUCTURE FOR PRP

Address												Name
0												ITU
	1											ISO
		0										Standard
			62439									IECHighavailibility
				3								PRP
					1							linkRedundancyEntityObjects
						0						lreConfiguration
							0					lreConfigurationGeneralGroup
								1				lreManufacturerName
								2				lreInterfaceCount

Address												Name
							1					lreConfigurationInterfaceGroup
								0				lreConfigurationInterfaces
									1			lreInterfaceConfigTable
										1		lreInterfaceConfigEntry
											1	lreInterfaceConfigIndex
											2	lreRowStatus
											3	lreNodeType
											4	lreNodeName
											5	lreVersionName
											6	lreMacAddressA
											7	lreMacAddressB
											8	lreAdapterAdminStateA
											9	lreAdapterAdminStateB
											10	lreLinkStatusA
											11	lreLinkStatusB
											12	lreDuplicateDiscard
											13	lreTransparentReception
											14	lreHsrLREMode
											15	lreSwitchingEndNode
											16	lreRedBoxIdentity
											17	lreSanA
											18	lreSanB
											19	lreEvaluateSupervision
											20	lreNodesTableClear
											21	lreProxyNodeTableClear
						1						lreStatistics
							1					lreStatisticsInterfaceGroup
								0				lreStatisticsInterfaces
									1			lreInterfaceStatsTable
											1	lreInterfaceStatsIndex
											2	lreCntTotalSentA
											3	lreCntTotalSentB
											4	lreCntErrWrongLANA
											5	lreCntErrWrongLANB
											6	lreCntReceivedA
											7	lreCntReceivedB
											8	lreCntErrorsA
											9	lreCntErrorsB
											10	lreCntNodes
									3			lreProxyNodeTable
										1		lreProxyNodeEntry
											1	reProxyNodeIndex
											2	reProxyNodeMacAddress

Address												Name
		3										Org
			6									Dod
				1								Internet
					2							mgmt
						1						mib-2
							1					System
								1				sysDescr
								3				sysUpTime
								5				sysName
								7				sysServices
							2					interfaces
								2				ifTable
									1			ifEntry
										1		ifIndex
										2		ifDescr
										3		ifType
										4		ifMtu
										5		ifSpeed
										6		ifPhysAddress
										7		ifAdminStatus
										8		ifOpenStatus
										9		ifLastChange
										10		ifInOctets
										11		ifInUcastPkts
										12		ifInNUcastPkts
										13		ifInDiscards
										14		ifInErrors
										15		ifInUnknownProtos
										16		ifOutOctets
										17		ifOutUcastPkts
										18		ifOutNUcastPkts
										19		ifOutDiscards
										20		ifOutErrors
										21		ifOutQLen
										22		ifSpecific
							16					rmon
								1				statistics
									1			etherStatsTable
										1		etherStatsEntry
											1	etherStatsIndex
											2	etherStatsDataSource
											3	etherStatsDropEvents
											4	etherStatsOctets

Address												Name
											5	etherStatsPkts
											6	etherStatsBroadcastPkts
											7	etherStatsMulticastPkts
											8	etherStatsCRCAlignErrors
											9	etherStatsUndersizePkts
											10	etherStatsOversizePkts
											11	etherStatsFragments
											12	etherStatsJabbers
											13	etherStatsCollisions
											14	etherStatsPkts64Octets
											15	etherStatsPkts65to127Octets
											16	etherStatsPkts128to255Octets
											17	etherStatsPkts256to511Octets
											18	etherStatsPkts512to1023Octets
											19	etherStatsPkts1024to1518Octets
											20	etherStatsOwner
											21	etherStatsStatus

Various SNMP client software tools can be used. Alstom Grid recommends using an SNMP MIB browser, which can perform the basic SNMP operations such as GET, GETNEXT and RESPONSE.

Note:
When communicating with the Redundant Ethernet Card, there are two IP addresses visible: one for the IED and one for the Ethernet switch on the redundant Ethernet board. To access the network using SNMP, use the IP address of the redundant Ethernet board switch and not that of the IED. See the Configuration chapter for further information.

5.5 SIMPLE NETWORK TIME PROTOCOL (SNTP)

Simple Network Time Protocol (SNTP) is used to synchronize the clocks of computer systems over packet-switched, variable-latency data networks, such as IP. A jitter buffer is used to reduce the effects of variable latency introduced by queuing, ensuring a continuous data stream over the network.

SNTP is supported by both the IED and the switch in the redundant Ethernet board. Both the IED and the redundant Ethernet board have their own IP address. Using the IP address of each device it can be synchronised to the SNTP server.

For the IED this is done by entering the IP address of the SNTP server into the IED using the IEC 61850 Configurator software.

For the redundant Ethernet board, this is done depending on the redundant Ethernet protocol being used. For PRP use the PRP Configurator. For RSTP use the RSTP Configurator. For SHP and DHP use Switch Manager.

6 CONFIGURING IP ADDRESSES

An IP address is a logical address assigned to devices in a computer network that uses the Internet Protocol (IP) for communication between nodes. IP addresses are stored as binary numbers but they are represented using Decimal Dot Notation, where four sets of decimal numbers are separated by dots as follows:

XXX.XXX.XXX.XXX

For example:

10.86.254.85

An IP address in a network is usually associated with a subnet mask. The subnet mask defines which network the device belongs to. A subnet mask has the same form as an IP address.

For example:

255.255.255.0

Both the IED and the REB each have their own IP address. The following diagram shows the IED as IP1 and the REB as IP2.

Note:
IP1 and IP2 are different but use the same subnet mask.

The switch IP address must be configured through the Ethernet network.

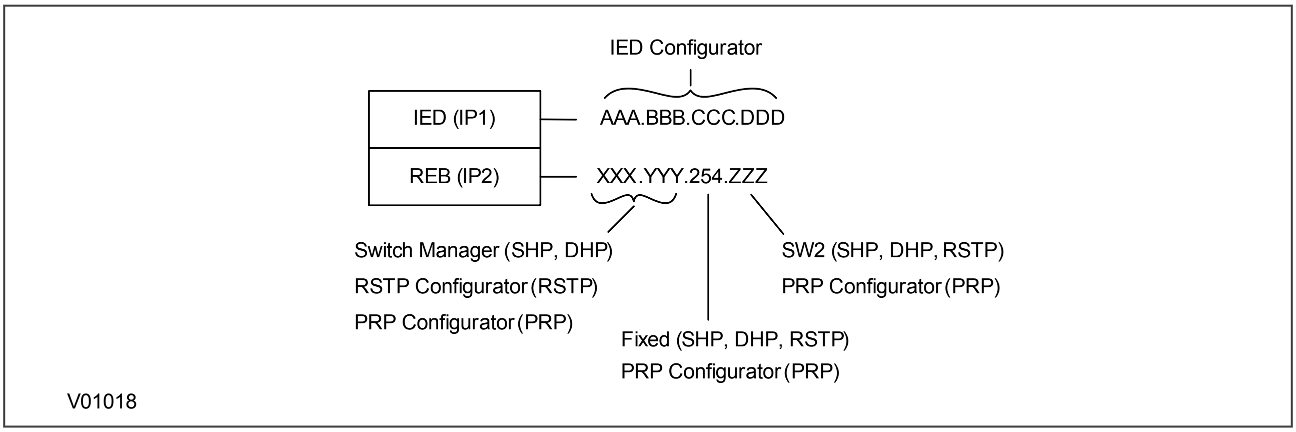


Figure 68: IED and REB IP address configuration

6.1 CONFIGURING THE IED IP ADDRESS

If you are using IEC 61850, set the IED IP address using the IEC 61850 Configurator software. In the IEC 61850 Configurator, set **Media** to **Single Copper or Redundant Fibre**.

If you are using DNP3 over Ethernet, set the IED IP address by editing the DNP3 file, using the DNP3 Configurator software. In the DNP3 Configurator, set **Ethernet Media** to **Copper**, even though the redundant Ethernet network uses fibre optic cables.

6.2 CONFIGURING THE BOARD IP ADDRESS

The board IP address must be configured before connecting the IED to the network to avoid an IP address conflict.

PRP

If using PRP, configure the IP address of the redundant Ethernet board using the PRP Configurator software.

RSTP

If using RSTP, configure the IP address of the redundant Ethernet board using the RSTP Configurator software and DIP switches on the board.

SHP or DHP

If using SHP or DHP configure the IP address of the redundant Ethernet board using the Switch Manager software and DIP switches on the board.

6.2.1 CONFIGURING THE FIRST TWO OCTETS OF THE BOARD IP ADDRESS

If using PRP, the first two octets are configured using the PRP Configurator software tool.

If using SHP or DHP, the first two octets are configured using the Switch Manager software tool or an SNMP MIB browser. An H35 (SHP) or H36 (DHP) network device is needed in the network to configure the Px40 redundant Ethernet board IP address using SNMP.

If using RSTP, the first two octets are configured using the RSTP Configurator software tool or using an SNMP MIB browser.

6.2.2 CONFIGURING THE THIRD OCTET OF THE BOARD IP ADDRESS

The third octet is fixed at 254 (FE hex, 11111110 binary) for SHP, DHP and RSTP. However, for PRP it is set using the PRP Configurator.

6.2.3 CONFIGURING THE LAST OCTET OF THE BOARD IP ADDRESS

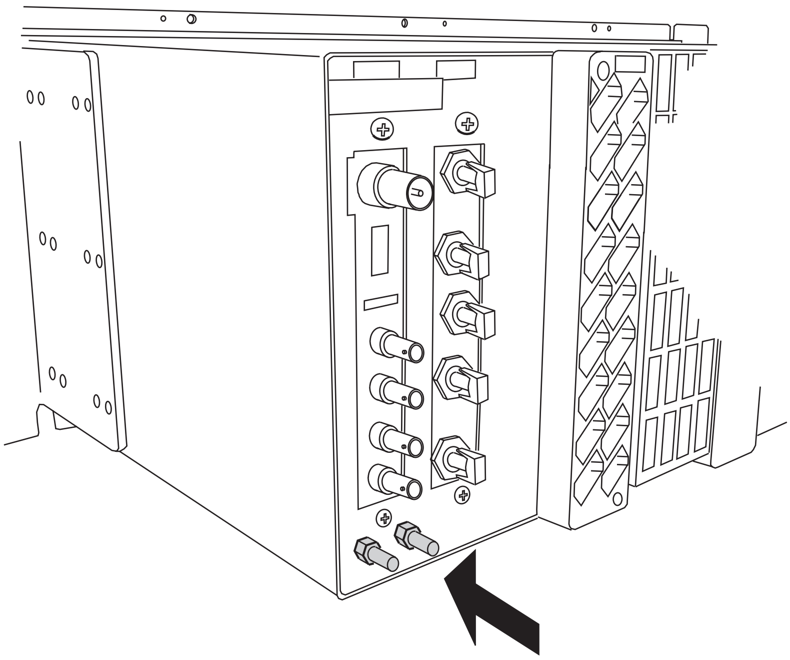
If using PRP, the last octet is configured using the PRP Configurator software tool.

If using SHP, DHP or RSTP, the last octet is configured using board address switch SW2 on the board. Remove the IED front cover to gain access to the board address switch.

Warning:
Configure the hardware settings before the unit is installed.

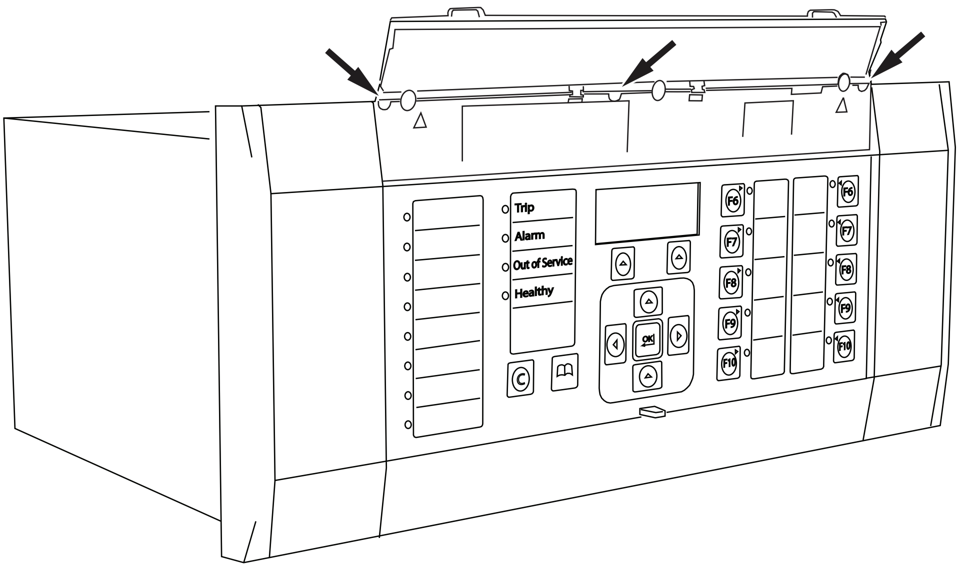
1. Refer to the safety section of the IED.
2. Switch off the IED. Disconnect the power and all connections.
3. Before removing the front cover, take precautions to prevent electrostatic discharge damage according to the ANSI/ESD-20.20 -2007 standard.

4. Wear a 1 MΩ earth strap and connect it to the earth (ground) point on the back of the IED.



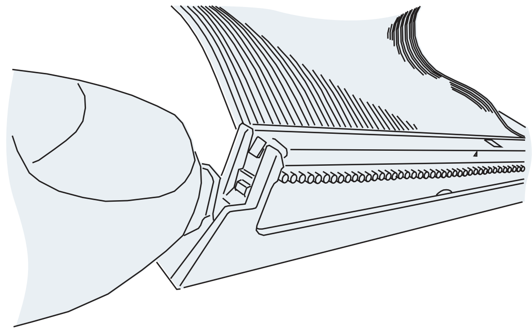
E01019

5. Lift the upper and lower flaps. Remove the six screws securing the front panel and pull the front panel outwards.



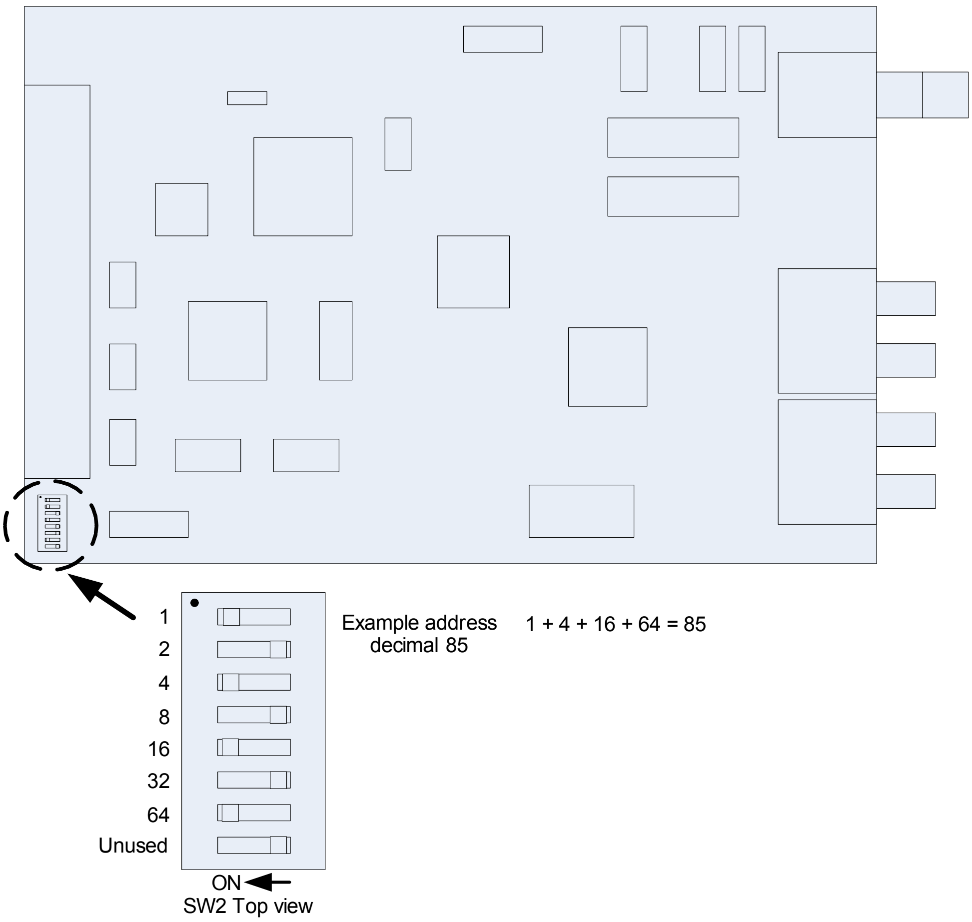
E01020

6. Press the levers either side of the connector to disconnect the ribbon cable from the front panel.



E01021

7. Remove the redundant Ethernet board. Set the last octet of IP address using the DIP switches. The available range is 1 to 127.



V01022

8. Once you have set the IP address, reassemble the IED, following theses instructions in the reverse order.

Warning:
Take care not to damage the pins of the ribbon cable connector on the front panel when reinserting the ribbon cable.

7 PRP CONFIGURATOR

The PRP Configurator tool is intended for MiCOM Px4x IEDs with redundant Ethernet using PRP (Parallel Redundancy Protocol). This tool is used to identify IEDs, configure the redundancy IP address, configure the SNTP IP address and configure the PRP parameters.

7.1 CONNECTING THE IED TO A PC

Connect the IED to the PC on which the Configurator tool is used. This connection is done through an Ethernet switch or through a media converter.

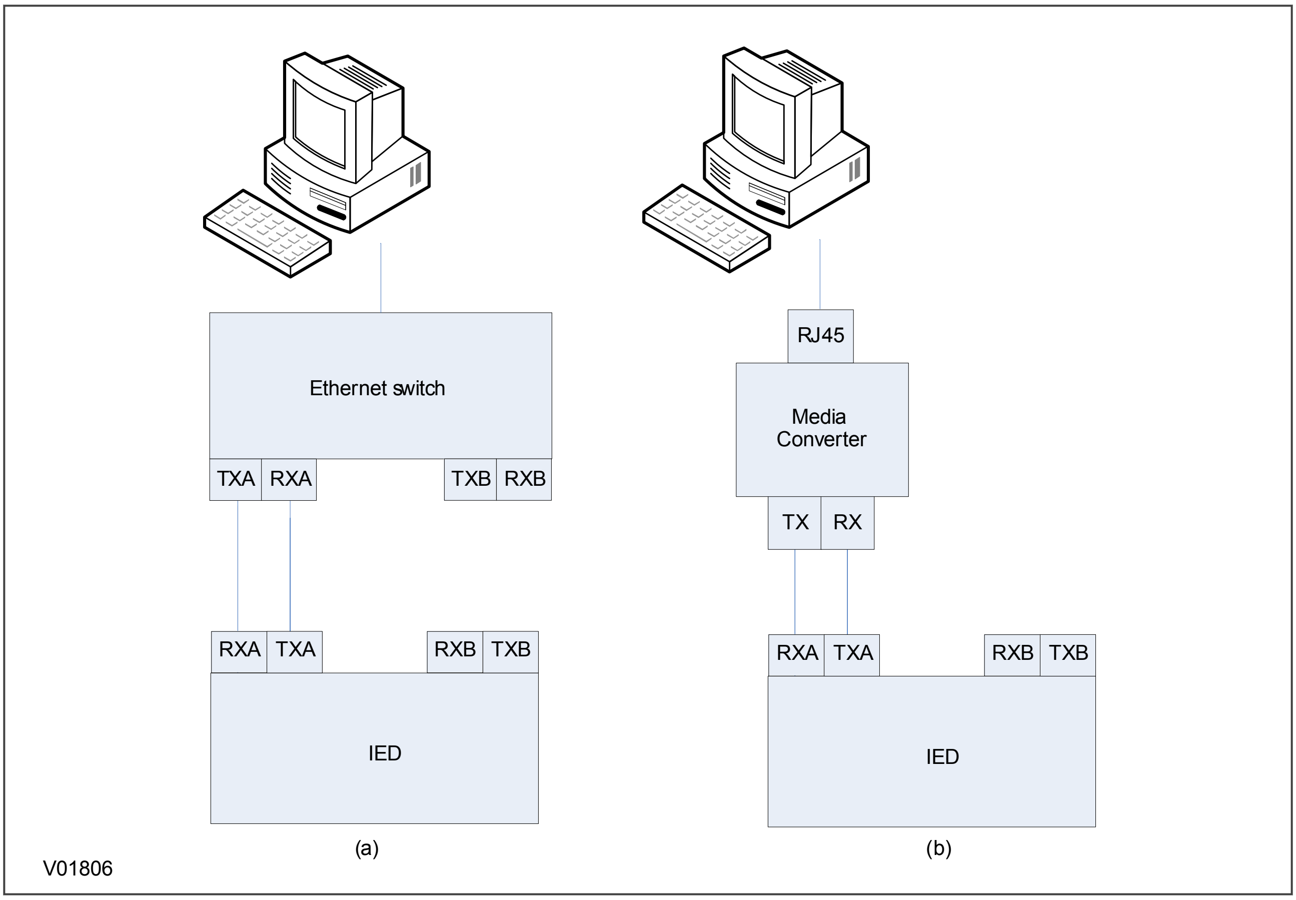


Figure 69: Connection using (a) an Ethernet switch and (b) a media converter

7.2 INSTALLING THE CONFIGURATOR

If you install S1 Agile, the Configurator is installed automatically. Otherwise you will need to install it manually.

1. Double click the WinPcap installer.
2. Double click the Configurator installer.
3. Click **Next** and follow the on-screen instructions.

7.3 STARTING THE CONFIGURATOR

If you install S1 Agile, the Configurator is launched from the S1 Agile menu. Otherwise:

1. Select the Configurator from the Windows **Programs** menu.
2. The Login screen appears. For user mode login, enter the **Login name** as **User** and click **OK** with no password.
3. If the login screen does not appear, check all network connections.
4. The main window appears. In the bottom right-hand corner of the main window, click the **Language** button to select the language.
5. The **Network Board** drop-down list shows the Network Board, IP Address and MAC Address of the PC in which the Configurator is running.

7.4 PRP DEVICE IDENTIFICATION

To configure the redundant Ethernet board, go to the main window and click **Identify Device**.

The redundant Ethernet board connected to the PC is identified and its details are listed.

- Device address
- MAC address
- Version number of the firmware
- SNTP IP address
- Date & time of the real-time clock, from the board.

7.5 PRP IP ADDRESS CONFIGURATION

To change the network address component of the IP address,

1. From the main window click the **IP Config** button. The **Device setup** screen appears.
2. Enter the required board IP address and click **OK**. This is the redundancy network address, not the IEC 61850 IP address.
3. The board network address is updated and displayed in the main window.

7.6 SNTP IP ADDRESS CONFIGURATION

To Configure the SNTP server IP address,

1. From the main window click the **SNTP Config** button. The **Device setup** screen appears.
2. Enter the required **MAC SNTP address** and server **IP SNTP Address**. Click **OK**.
3. The updated MAC and IP SNTP addresses appear in the main screen.

7.7 CHECK FOR CONNECTED EQUIPMENT

To check what devices are connected to the device being monitored:

1. From the main window, select the device.
2. Click the **Equipment** button.
3. At the bottom of the main window, a box shows the ports where devices are connected and their MAC addresses.

7.8 PRP CONFIGURATION

To view or configure the PRP Parameters, from the main window, click the device address to select the device. The selected device MAC address appears highlighted.

1. Click the **PRP Config** button. The **PRP Config** screen appears.
2. To view the available parameters in the board that is connected, click the **Get PRP Parameters** button.
3. To set **Node Forget Time**, **Life Check Interval** and **Max Valid Size**, click the **Set Parameters** button and modify their values.

If you need to restore the default values of the PRP parameters, click the **Restore Defaults** button.

7.9 FILTERING DATABASE

1. To access the forwarding database functions, if required, click the Filtering Database button in the main window.
2. To view the Forwarding Database Size, Number of Static Entries and Number of Dynamic Entries, click **Read Database Info**.
3. To set the Aging Time, enter the number of seconds in the text box and click the **Set** button.
4. To add a static entry in the forwarding database, click the **Filtering Entries** tab. Select the Port Number, MAC Address, Unicast/Multicast, MGMT and Rate Limit, then click the **Set** button. The new entry appears in the forwarding database.
5. To add a dynamic entry in the forwarding database, click the **Filtering Entries** tab and select the Port Number and MAC Address and click the **Set** button. The new entry appears in the forwarding database.
6. To delete an entry from the forwarding database, select the entry and click the **Delete Entry** button.

7.10 END OF SESSION

To finish the session:

1. In the main window, click the **Quit** button, a new screen appears.
2. If a database backup is required, click **Yes**, a new screen appears.
3. Click the **...** button to browse the path. Enter the name in the text box.

8 RSTP CONFIGURATOR

The RSTP Configurator tool is intended for MiCOM Px4x IEDs with redundant Ethernet using RSTP (Rapid Spanning Tree Protocol). This tool is used to identify IEDs, configure the redundancy IP address, configure the SNTP IP address and configure the RSTP parameters.

8.1 CONNECTING THE IED TO A PC

Connect the IED to the PC on which the Configurator tool is used. This connection is done through an Ethernet switch or through a media converter.

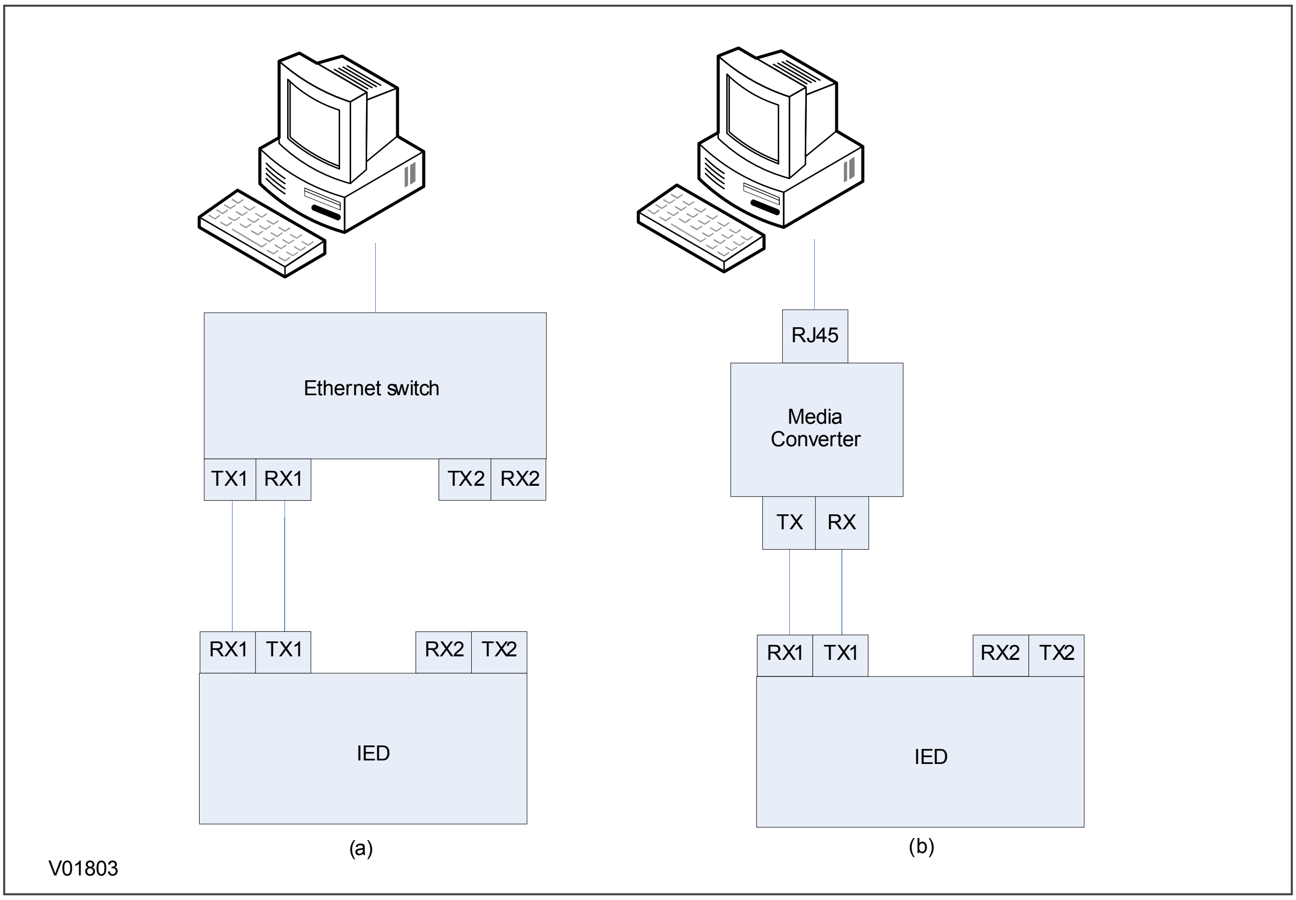


Figure 70: Connection using (a) an Ethernet switch and (b) a media converter

8.2 INSTALLING THE CONFIGURATOR

If you install S1 Agile, the Configurator is installed automatically. Otherwise you will need to install it manually.

1. Double click the WinPcap installer.
2. Double click the Configurator installer.
3. Click **Next** and follow the on-screen instructions.

8.3 STARTING THE CONFIGURATOR

If you install S1 Agile, the Configurator is launched from the S1 Agile menu. Otherwise:

1. Select the Configurator from the Windows **Programs** menu.
2. The Login screen appears. For user mode login, enter the **Login name** as **User** and click **OK** with no password.
3. If the login screen does not appear, check all network connections.
4. The main window appears. In the bottom right-hand corner of the main window, click the **Language** button to select the language.
5. The **Network Board** drop-down list shows the Network Board, IP Address and MAC Address of the PC in which the Configurator is running.

8.4 RSTP DEVICE IDENTIFICATION

To configure the redundant Ethernet board, go to the main window and click **Identify Device**.

> *Note:*
> *Due to the time needed to establish the RSTP protocol, wait 25 seconds between connecting the PC to the IED and clicking the Identify Device button.*

The redundant Ethernet board connected to the PC is identified and its details are listed.

- Device address
- MAC address
- Version number of the firmware
- SNTP IP address
- Date & time of the real-time clock, from the board.

8.5 RSTP IP ADDRESS CONFIGURATION

To change the network address component of the IP address,

1. From the main window click the **IP Config** button.
2. The **Device Setup** screen appears showing the **IP Base Address**. This is the board redundancy network address, not the IEC 61850 IP address.
3. Enter the required board IP address. The first two octets can be configured. The third octet is always 254. The last octet is set using the DIP switches (SW2) on the redundant Ethernet board, next to the ribbon connector.
4. Click **OK**. The board network address is updated and displayed in the main window.

8.6 SNTP IP ADDRESS CONFIGURATION

To Configure the SNTP server IP address,

1. From the main window click the **SNTP Config** button. The **Device setup** screen appears.
2. Enter the required **MAC SNTP address** and server **IP SNTP Address**. Click **OK**.
3. The updated MAC and IP SNTP addresses appear in the main screen.

8.7 CHECK FOR CONNECTED EQUIPMENT

To check what devices are connected to the device being monitored:

1. From the main window, select the device.
2. Click the **Equipment** button.
3. At the bottom of the main window, a box shows the ports where devices are connected and their MAC addresses.

8.8 RSTP CONFIGURATION

1. To view or configure the RSTP Bridge Parameters, from the main window, click the device address to select the device. The selected device MAC address appears highlighted.
2. Click the **RSTP Config** button. The **RSTP Config** screen appears.
3. To view the available parameters in the board that is connected, click the **Get RSTP Parameters** button.
4. To set the configurable parameters such as Bridge Max Age, Bridge Hello Time, Bridge Forward Delay, and Bridge Priority, modify the parameter values according to the following table and click **Set RSTP Parameters**.

S.No	Parameter	Default value (second)	Minimum value (second)	Maximum value (second)
1	Bridge Max Age	20	6	40
2	Bridge Hello Time	2	1	10
3	Bridge Forward Delay	15	4	30
4	Bridge Priority	32768	0	61440

8.8.1 BRIDGE PARAMETERS

To read the RSTP bridge parameters from the board,

1. From the main window click the device address to select the device. The **RSTP Config** window appears and the default tab is **Bridge Parameters**.
2. Click the Get **RSTP Parameters** button. This displays all the RSTP bridge parameters from the Ethernet board.
3. To modify the RSTP parameters, enter the values and click **Set RSTP Parameters**.
4. To restore the default values, click **Restore Default** and click **Set RSTP Parameters**.

The grayed parameters are read-only and cannot be modified.

8.8.2 PORT PARAMETERS

This function is useful if you need to view the parameters of each port.

1. From the main window, click the device address to select the device. The **RSTP Config** window appears.
2. Select the **Port Parameters** tab, then click **Get Parameters** to read the port parameters. Alternatively, select the port numbers to read the parameters.

8.8.3 PORT STATES

This is used to see which ports of the board are enabled or disabled.

1. From the main window, click the device address to select the device. The **RSTP Config** window appears.
2. Select the **Port States** tab then click the **Get Port States** button. This lists the ports of the Ethernet board. A tick shows they are enabled.

8.9 END OF SESSION

To finish the session:

1. In the main window, click the **Quit** button, a new screen appears.
2. If a database backup is required, click **Yes**, a new screen appears.
3. Click the **...** button to browse the path. Enter the name in the text box.

9 SWITCH MANAGER

Switch Manager is used to manage Ethernet ring networks and MiCOM H35x-V2 and H36x-V2 SNMP facilities. It is a set of tools used to manage, optimize, diagnose and supervise your network. It also handles the version software of the switch.

The Switch Manager tool is also intended for MiCOM Px4x IEDs with redundant Ethernet using Self Healing Protocol (SHP) and Dual Homing Protocol (DHP). This tool is used to identify IEDs and Alstom Switches, and to configure the redundancy IP address for the Alstom proprietary Self Healing Protocol and Dual Homing Protocol.

Switch hardware

Alstom switches are stand-alone devices (H3xx, H6x families) or embedded in a computer device rack, for example MiCOM C264 (SWDxxx, SWRxxx, SWUxxx Ethernet boards) or PC board (MiCOM H14x, MiCOM H15x, MiCOM H16x).

Switch range

There are 3 types of Alstom switches:

- Standard switches: SWU (in C264), H14x (PCI), H34x, H6x
- Redundant Ring switches: SWR (in C264), H15x (PCI), H35x,
- Redundant Dual Homing switches: SWD (in C264), H16x (PCI), H36x

Switch Manager allows you to allocate an IP addresses for Alstom switches. Switches can then be synchronized using the Simple Network Time Protocol (SNTP) or they can be administrated using the Simple Network Management Protocol (SNMP).

All switches have a single 6-byte MAC address.

Redundancy Management

Standard Ethernet does not support a loop at the OSI link layer (layer 2 of the 7 layer model). A mesh topology cannot be created using a standard Hub and switch. Redundancy needs separate networks using hardware in routers or software in dedicated switches using STP (Spanning Tree Protocol). However, this redundancy mechanism is too slow for one link failure in electrical automation networks.

Alstom has developed its own Redundancy ring and star mechanisms using two specific Ethernet ports of the redundant switches. This redundancy works between Alstom switches of the same type. The two redundant Ethernet connections between Alstom switches create one private redundant Ethernet LAN.

The Ethernet ports dedicated to the redundancy are optical Ethernet ports. The Alstom redundancy mechanism uses a single specific address for each Ethernet switch of the private LAN. This address is set using DIP switches or jumpers.

Switch Manager monitors the redundant address of the switches and the link topology between switches.

9.1 INSTALLATION

Switch Manager requirements

- PC with Windows XP or later
- Ethernet port
- 200 MB hard disk space
- PC IP address configured in Windows in same IP range as switch

Network IP address

IP addressing is needed for time synchronization of Alstom switches and for SNMP management.

Switch Manager is used to define IP addresses of Alstom switches. These addresses must be in the range of the system IP, depending on the IP mask of the engineering PC for substation maintenance.

Alstom switches have a default multicast so the 3rd word of the IP address is always 254.

Installation procedure

Run **Setup.exe** and follow the on-screen instructions.

9.2 SETUP

1. Make sure the PC has one Ethernet port connected to the Alstom switch.
2. Configure the PC's Ethernet port on the same subnet as the Alstom switch.
3. Select **User** or **Admin** mode. In User mode enter the user name as **User**, leave the password blank and click **OK**. In Admin mode you can not upload the firmware on the Ethernet repeaters.
4. In Admin mode enter the user name as **Admin**, enter the password and click **OK**. All functions are available including Expert Maintenance facilities.
5. Click the **Language** button in the bottom right of the screen and select your language.
6. If several Ethernet interfaces are used, in the **Network** board drop-down box, select the PC Network board connected to the Alstom switch. The IP and MAC addresses are displayed below the drop-down box.
7. Periodically click the **Ring Topology** button (top left) to display or refresh the list of Alstom switches that are connected.

9.3 NETWORK SETUP

To configure the network options:

1. From the main window click the **Settings** button. The Network Setup screen appears.
2. Enter the required board IP address. The first two octets can be configured. The third octet is always 254. The last octet is set using the DIP switches (SW2) on the redundant Ethernet board, next to the ribbon connector.
3. Click **OK**. The board network address is updated and displayed in the main window.
4. From the main window click the **SNTP Config** button. The Device setup screen appears.
5. Enter the required **MAC SNTP Address** and server **IP SNTP Address**. Click **OK**.
6. The updated MAC and IP SNTP addresses appear in the main screen.
7. Click the **Saturation** button. A new screen appears.
8. Set the saturation level and click **OK**. The default value is 300.

9.4 BANDWIDTH USED

To show how much bandwidth is used in the ring,

Click the **Ring**% button, at the bottom of the main window. The percentage of bandwidth used in the ring is displayed.

9.5 RESET COUNTERS

To reset the switch counters,

1. Click **Switch Counter Reset**.
2. Click **OK**.

9.6 CHECK FOR CONNECTED EQUIPMENT

To check what devices are connected to the device being monitored:

1. From the main window, select the device.
2. Click the **Equipment** button.
3. At the bottom of the main window, a box shows the ports where devices are connected and their MAC addresses.

9.7 MIRRORING FUNCTION

Port mirroring is a method of monitoring network traffic that forwards a copy of each incoming and outgoing packet from one port of the repeater to another port where the data can be studied. Port mirroring is managed locally and a network administrator uses it as a diagnostic tool.

To set up port mirroring:

1. Select the address of the device in the main window.
2. Click the Mirroring button, a new screen appears.
3. Click the checkbox to assign a a mirror port. A mirror port copies the incoming and outgoing traffic of the port.

9.8 PORTS ON/OFF

To enable or disable ports:

1. Select the address of the device in the main window.
2. Click **Ports On/Off**, a new screen appears.
3. Click the checkbox to enable or disable a port. A disabled port has an empty checkbox.

9.9 VLAN

The Virtual Local Area Network (VLAN) is a technique used to split an interconnected physical network into several networks. This technique can be used at all ISO/OSI levels. The VLAN switch is mainly at OSI level 1 (physical VLAN) which allows communication only between some Ethernet physical ports.

Ports on the switch can be grouped into Physical VLANs to limit traffic flooding. This is because it is limited to ports belonging to that VLAN and not to other ports.

Port-based VLANs are VLANs where the packet forwarding decision is based on the destination MAC address and its associated port. You must define outgoing ports allowed for each port when using port-based VLANs. The VLAN only governs the outgoing traffic so is unidirectional. Therefore, if you wish to allow two subscriber ports to talk to each other, you must define the egress port for both ports. An egress port is an outgoing port, through which a data packet leaves.

To assign a physical VLAN to a set of ports:

1. Select the address of the device in the main window.
2. Click the **VLAN** button, a new screen appears.
3. Use the checkboxes to select which ports will be in the same VLAN. By default all the ports share the same VLAN.

9.10 END OF SESSION

To finish the session:

1. In the main window, click the **Quit** button, a new screen appears.
2. If a database backup is required, click **Yes**, a new screen appears.
3. Click the **...** button to browse the path. Enter the name in the text box.

CYBER-SECURITY

CHAPTER 9

1 OVERVIEW

In the past, substation networks were traditionally isolated and the protocols and data formats used to transfer information between devices were often proprietary.

For these reasons, the substation environment was very secure against cyber-attacks. The terms used for this inherent type of security are:

- Security by isolation (if the substation network is not connected to the outside world, it cannot be accessed from the outside world).
- Security by obscurity (if the formats and protocols are proprietary, it is very difficult to interpret them).

The increasing sophistication of protection schemes, coupled with the advancement of technology and the desire for vendor interoperability, has resulted in standardisation of networks and data interchange within substations. Today, devices within substations use standardised protocols for communication. Furthermore, substations can be interconnected with open networks, such as the internet or corporate-wide networks, which use standardised protocols for communication. This introduces a major security risk making the grid vulnerable to cyber-attacks, which could in turn lead to major electrical outages.

Clearly, there is now a need to secure communication and equipment within substation environments. This chapter describes the security measures that have been put in place for our range of Intelligent Electronic Devices (IEDs).

Note:
Cyber-security compatible devices do not enforce NERC compliance, they merely facilitate it. It is the responsibility of the user to ensure that compliance is adhered to as and when necessary.

This chapter contains the following sections:

2 THE NEED FOR CYBER-SECURITY

Cyber-security provides protection against unauthorised disclosure, transfer, modification, or destruction of information or information systems, whether accidental or intentional. To achieve this, there are several security requirements:

- Confidentiality (preventing unauthorised access to information)
- Integrity (preventing unauthorised modification)
- Availability / Authentication (preventing the denial of service and assuring authorised access to information)
- Non-repudiation (preventing the denial of an action that took place)
- Traceability / Detection (monitoring and logging of activity to detect intrusion and analyse incidents)

The threats to cyber-security may be unintentional (e.g. natural disasters, human error), or intentional (e.g. cyber-attacks by hackers).

Good cyber-security can be achieved with a range of measures, such as closing down vulnerability loopholes, implementing adequate security processes and procedures and providing technology to help achieve this.

Examples of vulnerabilities are:

- Indiscretions by personnel (users keep passwords on their computer)
- Bad practice (users do not change default passwords, or everyone uses the same password to access all substation equipment)
- Bypassing of controls (users turn off security measures)
- Inadequate technology (substation is not firewalled)

Examples of availability issues are:

- Equipment overload, resulting in reduced or no performance
- Expiry of a certificate preventing access to equipment

To help tackle these issues, standards organisations have produced various standards. Compliance with these standards significantly reduces the threats associated with lack of cyber-security.

3 STANDARDS

There are several standards, which apply to substation cyber-security. The standards currently applicable to Alstom Grid IEDs are NERC and IEEE1686.

Standard	Country	Description
NERC CIP (North American Electric Reliability Corporation)	USA	Framework for the protection of the grid critical Cyber Assets
BDEW (German Association of Energy and Water Industries)	Germany	Requirements for Secure Control and Telecommunication Systems
ANSI ISA 99	USA	ICS oriented then Relevant for EPU completing existing standard and identifying new topics such as patch management
IEEE 1686	International	International Standard for substation IED cyber-security capabilities
IEC 62351	International	Power system data and Comm. protocol
ISO/IEC 27002	International	Framework for the protection of the grid critical Cyber Assets
NIST SP800-53 (National Institute of Standards and Technology)	USA	Complete framework for SCADA SP800-82and ICS cyber-security
CPNI Guidelines (Centre for the Protection of National Infrastructure)	UK	Clear and valuable good practices for Process Control and SCADA security

3.1 NERC COMPLIANCE

The North American Electric Reliability Corporation (NERC) created a set of standards for the protection of critical infrastructure. These are known as the CIP standards (Critical Infrastructure Protection). These were introduced to ensure the protection of 'Critical Cyber Assets', which control or have an influence on the reliability of North America’s electricity generation and distribution systems.

These standards have been compulsory in the USA for several years now. Compliance auditing started in June 2007, and utilities face extremely heavy fines for non-compliance.

NERC CIP standards

CIP standard	Description
CIP-002-1 Critical Cyber Assets	Define and document the Critical Assets and the Critical Cyber Assets
CIP-003-1 Security Management Controls	Define and document the Security Management Controls required to protect the Critical Cyber Assets
CIP-004-1 Personnel and Training	Define and Document Personnel handling and training required protecting Critical Cyber Assets
CIP-005-1 Electronic Security	Define and document logical security perimeters where Critical Cyber Assets reside. Define and document measures to control access points and monitor electronic access
CIP-006-1 Physical Security	Define and document Physical Security Perimeters within which Critical Cyber Assets reside
CIP-007-1 Systems Security Management	Define and document system test procedures, account and password management, security patch management, system vulnerability, system logging, change control and configuration required for all Critical Cyber Assets
CIP-008-1 Incident Reporting and Response Planning	Define and document procedures necessary when Cyber-security Incidents relating to Critical Cyber Assets are identified
CIP-009-1 Recovery Plans	Define and document Recovery plans for Critical Cyber Assets

3.1.1 CIP 002

CIP 002 concerns itself with the identification of:

- Critical assets, such as overhead lines and transformers
- Critical cyber assets, such as IEDs that use routable protocols to communicate outside or inside the Electronic Security Perimeter; or are accessible by dial-up

Power utility responsibilities:	Alstom Grid's contribution:
Create the list of the assets	We can help the power utilities to create this asset register automatically. We can provide audits to list the Cyber assets

3.1.2 CIP 003

CIP 003 requires the implementation of a cyber-security policy, with associated documentation, which demonstrates the management's commitment and ability to secure its Critical Cyber Assets.

The standard also requires change control practices whereby all entity or vendor-related changes to hardware and software components are documented and maintained.

Power utility responsibilities:	Alstom Grid's contribution:
To create a Cyber-security Policy	We can help the power utilities to have access control to its critical assets by providing centralized Access control. We can help the customer with its change control by providing a section in the documentation where it describes changes affecting the hardware and software.

3.1.3 CIP 004

CIP 004 requires that personnel with authorized cyber access or authorized physical access to Critical Cyber Assets, (including contractors and service vendors), have an appropriate level of training.

Power utility responsibilities:	Alstom Grid's contribution:
To provide appropriate training of its personnel	We can provide cyber-security training

3.1.4 CIP 005

CIP 005 requires the establishment of an Electronic Security Perimeter (ESP), which provides:

- The disabling of ports and services that are not required
- Permanent monitoring and access to logs (24x7x365)
- Vulnerability Assessments (yearly at a minimum)
- Documentation of Network Changes

Power utility responsibilities:	Alstom Grid's contribution:
To monitor access to the ESP To perform the vulnerability assessments To document network changes	To disable all ports not used in the IED To monitor and record all access to the IED

3.1.5 CIP 006

CIP 006 states that Physical Security controls, providing perimeter monitoring and logging along with robust access controls, must be implemented and documented. All cyber assets used for Physical Security are considered critical and should be treated as such:

Power utility responsibilities:	Alstom Grid's contribution:
Provide physical security controls and perimeter monitoring. Ensure that people who have access to critical cyber assets don't have criminal records.	Alstom Grid cannot provide additional help with this aspect.

3.1.6 CIP 007

CIP 007 covers the following points:

- Test procedures
- Ports and services
- Security patch management
- Antivirus
- Account management
- Monitoring
- An annual vulnerability assessment should be performed

Power utility responsibilities:	Alstom Grid's contribution:
To provide an incident response team and have appropriate processes in place	Test procedures, we can provide advice and help on testing. Ports and services, our devices can disable unused ports and services Security patch management, we can provide assistance Antivirus, we can provide advise and assistance Account management, we can provide advice and assistance Monitoring, our equipment monitors and logs access

3.1.7 CIP 008

CIP 008 requires that an incident response plan be developed, including the definition of an incident response team, their responsibilities and associated procedures.

Power utility responsibilities:	Alstom Grid's contribution:
To provide an incident response team and have appropriate processes in place.	Alstom Grid cannot provide additional help with this aspect.

3.1.8 CIP 009

CIP 009 states that a disaster recovery plan should be created and tested with annual drills.

Power utility responsibilities:	Alstom Grid's contribution:
To implement a recovery plan	To provide guidelines on recovery plans and backup/restore documentation

3.2 IEEE 1686-2007

IEEE 1686-2007 is an IEEE Standard for substation IEDs' cyber-security capabilities. It proposes practical and achievable mechanisms to achieve secure operations.

The following features described in this standard apply:

- Passwords are 8 characters long and can contain upper-case, lower-case, numeric and special characters.
- Passwords are never displayed or transmitted to a user.

- IED functions and features are assigned to different password levels. The assignment is fixed.
- The audit trail is recorded, listing events in the order in which they occur, held in a circular buffer.
- Records contain all defined fields from the standard and record all defined function event types where the function is supported.
- No password defeat mechanism exists. Instead a secure recovery password scheme is implemented.
- Unused ports (physical and logical) may be disabled.

4 CYBER-SECURITY IMPLEMENTATION

The Alstom Grid 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.

This section describes the current implementation of cyber-security. This is valid for the release of platform software to which this manual pertains. This current cyber-security implementation is known as Cyber-security Phase 1.

At the IED level, these cyber-security measures have been implemented:

- NERC-compliant default display
- Four-level access
- Enhanced password security
- Password recovery procedure
- Disabling of unused physical and logical ports
- Inactivity timer
- Security events management

External to the IEDs, the following cyber-security measures have been implemented:

- Antivirus
- Security patch management

4.1 NERC-COMPLIANT DISPLAY

For the device to be NERC-compliant, it must provide the option for a NERC-compliant default display. The default display that is implemented in our cyber-security concept contains a warning that the IED can be accessed by authorised users. You can change this if required with the ***User Banner*** setting in the *SECURITY CONFIG* column.

```
ACCESS ONLY FOR
AUTHORISED USERS
HOTKEY
```

If you try to change the default display from the NERC-compliant one, a further warning is displayed:

```
DISPLAY NOT NERC
COMPLIANT OK?
```

The default display navigation map shows how NERC-compliance is achieved with the product's default display concept.

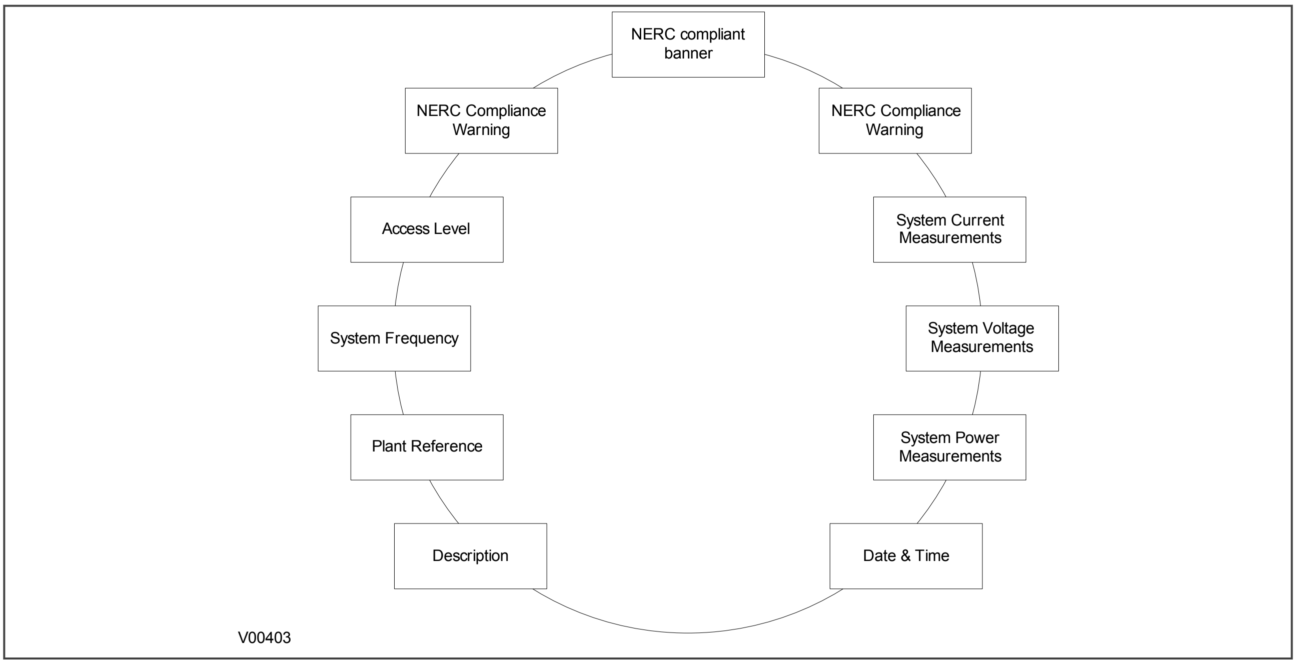


Figure 71: Default display navigation

4.2 FOUR-LEVEL ACCESS

The menu structure contains four levels of access, three of which are password protected.

Password levels

Level	Meaning	Read Operation	Write Operation
0	Read Some Write Minimal	SYSTEM DATA column: Description Plant Reference Model Number Serial Number S/W Ref. Access Level Security Feature SECURITY CONFIG column: User Banner Attempts Remain Blk Time Remain Fallback PW level Security Code (UI only)	Password Entry LCD Contrast (UI only)
1	Read All Write Few	All data and settings are readable. Poll Measurements	All items writeable at level 0. Level 1 Password setting Extract Disturbance Record Select Event, Main and Fault (upload) Extract Events (e.g. via MiCOM S1 Studio)

Level	Meaning	Read Operation	Write Operation
2	Read All Write Some	All data and settings are readable. Poll Measurements	All items writeable at level 1. Setting Cells that change visibility (Visible/Invisible). Setting Values (Primary/Secondary) selector Commands: Reset Indication Reset Demand Reset Statistics Reset CB Data / counters Level 2 Password setting
3	Read All Write All	All data and settings are readable. Poll Measurements	All items writeable at level 2. Change all Setting cells Operations: Extract and download Setting file. Extract and download PSL Extract and download MCL61850 (IEC61850 CONFIG) Auto-extraction of Disturbance Recorder Courier/Modbus Accept Event (auto event extraction, e.g. via A2R) Commands: Change Active Group setting Close / Open CB Change Comms device address. Set Date & Time Switch MCL banks / Switch Conf. Bank in UI (IEC61850 CONFIG) Enable / Disable Device ports (in SECURITY CONFIG column) Level 3 password setting

4.2.1 BLANK PASSWORDS

A blank password is effectively a zero-length password. Through the front panel it is entered by confirming the password entry without actually entering any password characters. Through a communications port the Courier and Modbus protocols each have a means of writing a blank password to the IED. A blank password disables the need for a password at the level that this password is applied.

Blank passwords have a slightly different validation procedure. If a blank password is entered through the front panel, the following text is displayed, after which the procedure is the same as already described:

```
BLANK PASSWORD
ENTERED CONFIRM
```

Blank passwords cannot be configured if the lower level password is not blank.

Blank passwords affect the fall back level after inactivity timeout or logout.

The ‘fallback level’ is the password level adopted by the IED after an inactivity timeout, or after the user logs out. This will be either the level of the highest-level password that is blank, or level 0 if no passwords are blank.

4.2.2 PASSWORD RULES

- Default passwords are blank for Level 1 and are AAAA for Levels 2 and 3
- Passwords may be any length between 0 and 8 characters long

- Passwords may or may not be NERC compliant
- Passwords may contain any ASCII character in the range ASCII code 33 (21 Hex) to ASCII code 122 (7A Hex) inclusive
- Only one password is required for all the IED interfaces

4.2.3 ACCESS LEVEL DDBS

The 'Access level' cell is in the 'System data' column (address 00D0). Also the current level of access for each interface is available for use in the Programming Scheme Logic (PSL) by mapping to these Digital Data Bus (DDB) signals:

- ***HMI Access Lvl 1***
- ***HMI Access Lvl 2***
- ***FPort AccessLvl1***
- ***FPort AccessLvl2***
- ***RPrt1 AccessLvl1***
- ***RPrt1 AccessLvl2***
- ***RPrt2 AccessLvl1***
- ***RPrt2 AccessLvl2***

Each pair of DDB signals indicates the access level as follows:

- Level 1 off, Level 2 off = 0
- Level 1 on, Level 2 off = 1
- Level 1 off, Level 2 on = 2
- Level 1 on, Level 2 on = 3

Key:

HMI = Human Machine Interface

FPort = Front Port

RPrt = Rear Port

Lvl = Level

4.3 ENHANCED PASSWORD SECURITY

Cyber-security requires strong passwords and validation for NERC compliance.

4.3.1 PASSWORD STRENGTHENING

NERC compliant passwords have the following requirements:

- At least one upper-case alpha character
- At least one lower-case alpha character
- At least one numeric character
- At least one special character (%,$...)
- At least six characters long

4.3.2 PASSWORD VALIDATION

The IED checks for NERC compliance. If the password is entered through the front panel, this is briefly displayed on the LCD.

If the entered password is NERC compliant, the following text is displayed.

```
NERC COMPLIANT
P/WORD WAS SAVED
```

If the password entered is not NERC-compliant, the user is required to actively confirm this, in which case the non-compliance is logged.

If the entered password is not NERC compliant, the following text is displayed:

```
NERC COMPLIANCE
NOT MET CONFIRM?
```

On confirmation, the non-compliant password is stored and the following acknowledgement message is displayed for 2 seconds.

```
NON-NERC P/WORD
SAVED OK
```

If the action is cancelled, the password is rejected and the following message is displayed for 2 seconds.

```
NON-NERC P/WORD
NOT SAVE
```

If the password is entered through a communications port using Courier or Modbus protocols, the device will store the password, irrespective of whether it is NERC-compliant or not. It then uses appropriate response codes to inform the client of the NERC-compliancy status. You can then choose to enter a new NERC-compliant password or accept the non-NERC compliant password just entered.

4.3.3 PASSWORD BLOCKING

You are locked out temporarily, after a defined number of failed password entry attempts. Each invalid password entry attempt decrements the 'Attempts Remain' data cell by 1. 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.

An attempt is only counted if the attempted password uses only characters in the valid range, but the attempted password is not correct (does not match the corresponding password in the IED). Any attempt where one or more characters of the attempted password are not in the valid range will not be counted.

Once the password entry is blocked, a 'blocking timer' is started. Attempts to access the interface while the 'blocking timer' is running results in an error message, irrespective of whether the correct password is entered or not. Once the 'blocking timer' has expired, access to the interface is unblocked and the attempts counter is reset to zero.

If you try to enter the password while the interface is blocked, the following message is displayed for 2 seconds.

```
NOT ACCEPTED
ENTRY IS BLOCKED
```

A similar response occurs if you try to enter the password through a communications port.

The parameters can then be configured using the ***Attempts Count***, ***Attempts Timer*** and ***Blocking Timer*** settings in the *SYSTEM CONFIG* column.

Password blocking configuration

Setting	Cell col row	Units	Default Setting	Available Setting
Attempts Limit	25 02		3	0 to 3 step 1
Attempts Timer	25 03	Minutes	2	1 to 3 step 1
Blocking Timer	25 04	Minutes	5	1 to 30 step 1

4.4 PASSWORD RECOVERY

If you mislay a device's password, they can be recovered. To obtain the recovery password you must contact the Contact Centre and supply the Serial Number and its Security Code. The Contact Centre will use these items to generate a Recovery Password.

The security code is a 16-character string of upper case characters. It is a read-only parameter. The device generates its own security code randomly. A new code is generated under the following conditions:

- On power up
- Whenever settings are set back to default
- On expiry of validity timer (see below)
- When the recovery password is entered

As soon as the security code is displayed on the LCD, a validity timer is started. This validity timer is set to 72 hours and is not configurable. This provides enough time for the contact centre to manually generate and send a recovery password. The Service Level Agreement (SLA) for recovery password generation is one working day, so 72 hours is sufficient time, even allowing for closure of the contact centre over weekends and bank holidays.

To prevent accidental reading of the IED security code, the cell will initially display a warning message:

```
PRESS ENTER TO
READ SEC. CODE
```

The security code is displayed on confirmation. The validity timer is then started. The security code can only be read from the front panel.

4.4.1 PASSWORD RECOVERY

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 causes the IED to reset all passwords back to default. This is all it is designed to do. After the passwords have been set back to default, it is up to the user to enter new passwords. Each password should be appropriate for its intended function, ensuring NERC compliance, if required.

On this action, the following message is displayed:

```
PASSWORDS HAVE
BEEN SET TO
DEFAULT
```

The recovery password can be applied through any interface, local or remote. It will achieve the same result irrespective of which interface it is applied through.

4.4.2 PASSWORD ENCRYPTION

The IED supports encryption for passwords entered remotely. The encryption key can be read from the IED through a specific cell available only through communication interfaces, not the front panel. Each time the key is read the IED generates a new key that is valid only for the next password encryption write. Once used, the key is invalidated and a new key must be read for the next encrypted password write. The encryption mechanism is otherwise transparent to the user.

4.5 DISABLING PHYSICAL PORTS

It is possible to disable unused physical ports. A level 3 password 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
```

The following ports can be disabled, depending on the model.

- Front port (***Front Port*** setting)
- Rear port 1 (***Rear Port 1*** setting)
- Rear port 2 (***Rear Port 2*** setting)
- Ethernet port (***Ethernet*** setting)

> *Note:*
> *It is not possible to disable a port from which the disabling port command originates.*

> *Note:*
> *We do not generally advise disabling the physical Ethernet port.*

4.6 DISABLING LOGICAL PORTS

It is possible to disable unused logical ports. A level 3 password is needed to perform this action.

> *Note:*
> *The port disabling setting cells are not provided in the settings file. It is only possible to do this using the HMI front panel.*

The following protocols can be disabled:

- IEC 61850 (***IEC61850*** setting)
- DNP3 Over Ethernet (***DNP3 OE*** setting)
- Courier Tunnelling (***Courier Tunnel*** setting)

> *Note:*
> *If any of these protocols are enabled or disabled, the Ethernet card will reboot.*

4.7 SECURITY EVENTS MANAGEMENT

To implement NERC-compliant cyber-security, a range of Event records need to be generated. These log security issues such as the entry of a non-NERC-compliant password, or the selection of a non-NERC-compliant default display.

Security event values

Event Value	Display
PASSWORD LEVEL UNLOCKED	USER LOGGED IN ON {int} LEVEL {n}
PASSWORD LEVEL RESET	USER LOGGED OUT ON {int} LEVEL {n}
PASSWORD SET BLANK	P/WORD SET BLANK BY {int} LEVEL {p}
PASSWORD SET NON-COMPLIANT	P/WORD NOT-NERC BY {int} LEVEL {p}
PASSWORD MODIFIED	PASSWORD CHANGED BY {int} LEVEL {p}
PASSWORD ENTRY BLOCKED	PASSWORD BLOCKED ON {int}
PASSWORD ENTRY UNBLOCKED	P/WORD UNBLOCKED ON {int}
INVALID PASSWORD ENTERED	INV P/W ENTERED ON <int}
PASSWORD EXPIRED	P/WORD EXPIRED ON {int}
PASSWORD ENTERED WHILE BLOCKED	P/W ENT WHEN BLK ON {int}
RECOVERY PASSWORD ENTERED	RCVY P/W ENTERED ON {int}
IED SECURITY CODE READ	IED SEC CODE RD ON {int}
IED SECURITY CODE TIMER EXPIRED	IED SEC CODE EXP -
PORT DISABLED	PORT DISABLED BY {int} PORT {prt}
PORT ENABLED	PORT ENABLED BY {int} PORT {prt}
DEF. DISPLAY NOT NERC COMPLIANT	DEF DSP NOT-NERC
PSL SETTINGS DOWNLOADED	PSL STNG D/LOAD BY {int} GROUP {grp}

Event Value	Display
DNP SETTINGS DOWNLOADED	DNP STNG D/LOAD BY {int}
TRACE DATA DOWNLOADED	TRACE DAT D/LOAD BY {int}
IEC61850 CONFIG DOWNLOADED	IED CONFG D/LOAD BY {int}
USER CURVES DOWNLOADED	USER CRV D/LOAD BY {int} GROUP {crv}
PSL CONFIG DOWNLOADED	PSL CONFG D/LOAD BY {int} GROUP {grp}
SETTINGS DOWNLOADED	SETTINGS D/LOAD BY {int} GROUP {grp}
PSL SETTINGS UPLOADED	PSL STNG UPLOAD BY {int} GROUP {grp}
DNP SETTINGS UPLOADED	DNP STNG UPLOAD BY {int}
TRACE DATA UPLOADED	TRACE DAT UPLOAD BY {int}
IEC61850 CONFIG UPLOADED	IED CONFG UPLOAD BY {int}
USER CURVES UPLOADED	USER CRV UPLOAD BY {int} GROUP {crv}
PSL CONFIG UPLOADED	PSL CONFG UPLOAD BY {int} GROUP {grp}
SETTINGS UPLOADED	SETTINGS UPLOAD BY {int} GROUP {grp}
EVENTS HAVE BEEN EXTRACTED	EVENTS EXTRACTED BY {int} {nov} EVNTS
ACTIVE GROUP CHANGED	ACTIVE GRP CHNGE BY {int} GROUP {grp}
CS SETTINGS CHANGED	C & S CHANGED BY {int}
DR SETTINGS CHANGED	DR CHANGED BY {int}
SETTING GROUP CHANGED	SETTINGS CHANGED BY {int} GROUP {grp}
POWER ON	POWER ON -
SOFTWARE_DOWNLOADED	S/W DOWNLOADED -

where:

- int is the interface definition (UI, FP, RP1, RP2, TNL, TCP)
- prt is the port ID (FP, RP1, RP2, TNL, DNP3, IEC, ETHR)
- grp is the group number (1, 2, 3, 4)
- crv is the Curve group number (1, 2, 3, 4)

- n is the new access level (0, 1, 2, 3)
- p is the password level (1, 2, 3)
- nov is the number of events (1 – nnn)

Each new event has an incremented unique number, therefore missing events appear as ‘gap’ in the sequence. The unique identifier forms part of the event record that is read or uploaded from the IED.

> *Note:*
> *It is no longer possible to clear Event, Fault, Maintenance, and Disturbance Records.*

4.8 LOGGING OUT

If you have been configuring the IED, you should 'log out'. 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:

```
DO YOU WANT TO
LOG OUT?
```

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 #
```

Where x is the current fallback level.

If you decide not to log out, the following message is displayed for 2 seconds.

```
LOGOUT CANCELLED
Access Level #
```

where # is the current access level.

5 CYBER-SECURITY SETTINGS

General security settings, which are necessary for cyber-security implementation can be found in the SYSTEM DATA column as follows:

Menu Text	Col	Row	Default Setting	Available Options
Description				
SYSTEM DATA	00	00		
This column contains general system settings and records.				
Password	00	02		ASCII text (characters 33 to 122 inclusive)
This setting sets the device default password				
Access Level	00	D0	2 = Read + Execute + Edit	0 = Read only or 1 = Read + Execute, or 2 = Read + Execute + Edit
This cell displays the current access level.				
Password Level 1	00	D2	blank	ASCII text (characters 33 to 122 inclusive)
This setting allows you to change password level 1.				
Password Level 2	00	D3	BBBB	ASCII text (characters 33 to 122 inclusive)
This setting allows you to change password level 2.				
Password Level 3	00	D4	AAAA	ASCII text (characters 33 to 122 inclusive)
This setting allows you to change password level 3.				
Security Features	00	DF	1	{cyber-security level}
This setting displays the level of cyber-security implemented, 1 = phase 1.				
Password	00	E1		ASCII text (characters 33 to 122 inclusive)
This cell allows you to enter the encrypted password. It is not visible via the user interfaced.				
Password Level 1	00	E2		ASCII text (characters 33 to 122 inclusive)
This setting allows you to change the encrypted password level 1. This is not visible via the user interface.				
Password Level 2	00	E3		ASCII text (characters 33 to 122 inclusive)
This setting allows you to change the encrypted password level 2. This is not visible via the user interface.				
Password Level 3	00	E4		ASCII text (characters 33 to 122 inclusive)
This setting allows you to change the encrypted password level 3. This is not visible via the user interface.				

Cyber-security specific settings can be found in the SECURITY CONFIGURATION column as follows:

Menu Text	Col	Row	Default Setting	Available Options
Description				
SECURITY CONFIG	25	00		
This column contains settings for the Cyber-Security configuration				
User Banner	25	01	ACCESS ONLY FOR AUTHORISED USERS	ASCII 32 to 234
With this setting, you can enter text for the NERC compliant banner.				
Attempts Limit	25	02	2	0 to 3 step 1
This setting defines the maximum number of failed password attempts before action is taken.				
Attempts Timer	25	03	2	1 to 3 step 1
This setting defines the time window used in which the number of failed password attempts is counted.				
Blocking Timer	25	04	5	1 to 30 step 1
This setting defines the time duration for which the user is blocked, after exceeding the maximum attempts limit.				

Menu Text	Col	Row	Default Setting	Available Options
Description				
Front Port	25	05	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the physical Front Port.				
Rear Port 1	25	06	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the primary physical rear port (RP1).				
Rear Port 2	25	07	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the secondary physical rear port (RP2).				
Ethernet	25	08	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the physical Ethernet Port				
Courier Tunnel	25	09	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the logical tunnelled Courier port				
IEC61850	25	0A	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the logical IEC61850 port.				
DNP3 OE	25	0B	Enabled	0 = Disabled or 1 = Enabled
This setting enables or disables the logical DNP3 over Ethernet port.				
Attempts Remain	25	11	2	Not Settable
This cell displays the number of password attempts remaining				
Blk Time Remain	25	12	0	Not Settable
This cell displays the remaining blocking time.				
Fallbck PW Level	25	20	1	0 = Password Level 0, 1 = Password Level 1, 2 = Password Level 2, 3 = Password Level 3
This cell displays the password level adopted by the IED after an inactivity timeout, or after the user logs out. This will be either the level of the highest level password that is blank, or level 0 if no passwords are blank.				
Security Code	25	FF		Not Settable
This cell displays the 16-character security code required when requesting a recovery password. UI only cell.				

SETTINGS APPLICATION SOFTWARE

CHAPTER 10

1 INTRODUCTION TO THE SETTINGS APPLICATION SOFTWARE

The settings application software used in this range of IEDs is called MiCOM S1 Agile. It is a collection of software tools, which is used for managing all aspects of the IEDs. This chapter provides a brief summary of each software tool. Further information is available in the Help system and in the Settings Application Software Guide P40-M&CR-UG-EN-n, where n is the latest version of the settings application software.

The software allows you to edit device settings and commands for Alstom Grid's range of IEDs. It is compatible with Windows XP, Windows Vista and Windows 7 operating systems.

It also enables you to manage the MiCOM devices in your system. You can build a list of devices and organise them in the same way as they physically exist in a system. Parameters can be created and uploaded for each device, and devices can be supervised directly.

It also includes a Product Selector tool. This is an interactive product catalogue, which makes it easier to choose the right device for each application.

1.1 GETTING STARTED

S1 Agile allows you to create a model of a protection system which simulates a real-world protection system. You can add substations, bays, voltage levels and devices to the system. First you need to download the data models for the devices in the system. Then you can either create a new system or open an existing system. You can connect to an IED either directly through the front port or to an IED in the system model. You can then send or extract settings. You can also extract PSL, DNP3, Events or Disturbance Record files.

If there is no default system, use **Quick Connect** to automatically create one. If a system is no longer needed, right-click it and select **Delete** to permanently delete it. Systems are not opened automatically. To change this, select **Options** then **Preferences** then check the checkbox **Reopen last System at start-up**.

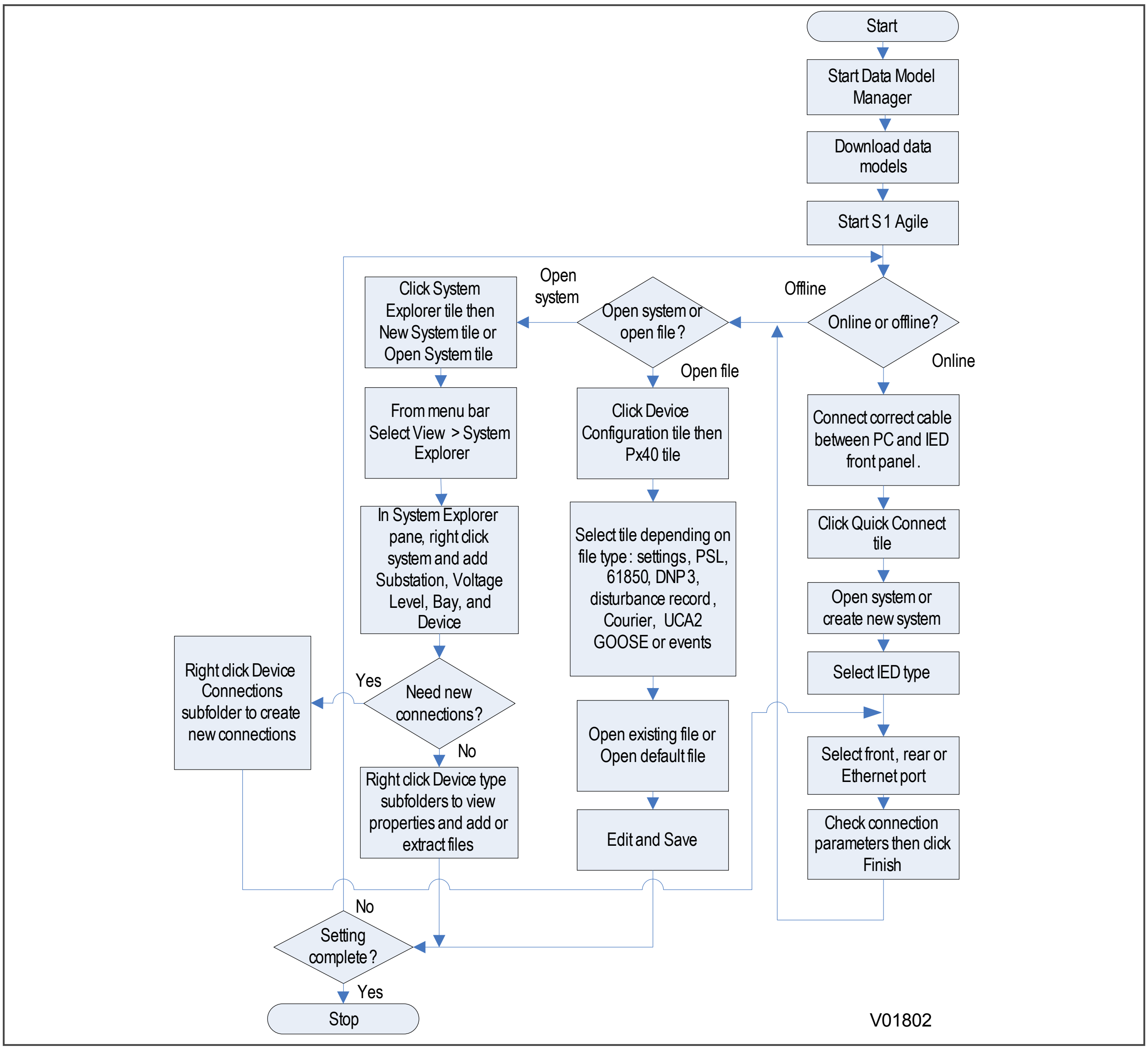


Figure 72: Flowchart showing how S1 Agile can be used to set up and save a protection system offline or online.

1.1.1 QUICK SYSTEM GUIDE

S1 Agile allows you to create a model of a protection system which simulates a real-world protection system. You can add substations, bays, voltage levels and devices to the system. First you need to download the data models for the devices in the system. Then you can either create a new system or open an existing system.

You can connect to an IED either directly through the front port or to an IED in the system model. You can then send or extract settings. You can also extract a PSL, DNP3, Events or Disturbance Record file.

If there is no default system, use **Quick Connect** to automatically create one. If a system is no longer needed, right-click it and select **Delete** to permanently delete it.

Systems are not opened automatically. To change this, select **Options** then **Preferences** then check the checkbox **Reopen last System at start-up**.

1.1.2 DOWNLOAD DATA MODELS

1. Close S1 Agile and run the Data Model Manager.
2. Follow the on-screen instructions.

1.1.3 SET UP A SYSTEM

1. Click the System **Explorer** tile then the **New System** tile or **Open System** tile.
2. From the menu bar select **View** then **System Explorer**.
3. In the System Explorer pane, right click **System** and select **New Substation**, **New Voltage Level**, **New Bay**, and **New Device**.
4. Right-click the **Device** subfolders to view properties and add or extract files.

1.1.4 CONNECT TO AN IED FRONT PORT

1. Connect the cable between the PC and IED.
2. From the main screen, click **Quick Connect**.
3. Select the product range.
4. Select connection to the **Front Port**.
5. Set the connection parameters and click **Finish**.

1.1.5 CONNECT TO AN IED IN A SYSTEM

1. Make sure that the correct serial rear port or Ethernet cables are in place.
2. From the main screen, click **Quick Connect**.
3. Select the product range.
4. Select connection to the **Rear Port** or **Ethernet Port**.
5. Set the connection parameters and click **Finish**.

1.1.6 SEND SETTINGS TO A DEVICE

To send settings to a device there must be at least one setting file in a settings folder for a device.

1. Right-click the device name in System Explorer and select **Send**.
2. In the **Send To** dialog select the setting files and click **Send**.
3. Click **Close** to close the **Send To** dialog.

1.1.7 EXTRACT SETTINGS FROM A DEVICE

1. Using System Explorer, find the device.
2. Right-click the device's Settings folder and select **Extract Settings** or **Extract Full Settings**.
3. Once the settings file is retrieved, click **Close**.

1.1.8 EXTRACT A PSL FILE FROM A DEVICE

1. Using System Explorer, find the Px4x device.
2. Right-click the device's **PSL** folder and select **Extract**.
3. Once the file is retrieved, click **Close**.

> *Note:*
> *If you extract a PSL file from a device that does not store the position information of the PSL scheme elements, the layout of the scheme may not be the same as originally drawn. Also the Original and Logic Only CRC values may not match the original scheme. However, the scheme will be logically correct.*

1.1.9 EXTRACT A DNP3 FILE FROM A DEVICE

1. Using System Explorer, find the device.
2. Right-click the device's **DNP3** folder and select **Extract**.
3. Once the file is retrieved, click **Close**.

1.1.10 EXTRACT AN EVENTS FILE FROM A DEVICE

1. Using System Explorer, find the device.
2. Right-click the device's **Events** folder and select **Extract Events**.
3. Once the file is retrieved, click **Close**.

1.1.11 EXTRACT A DISTURBANCE RECORD FROM A DEVICE

1. Using System Explorer, find the device.
2. Right-click the device's **Disturbance Records** folder and select **Extract Disturbances**.
3. Select a disturbance record to extract.
4. Choose a COMTRADE format, 1991 or 2001.
5. Click **Extract** or **Save**. Save leaves the record in the device, Extract deletes it.
6. Once the disturbance records file is retrieved, click **Close**.

1.2 PSL EDITOR

The Programmable Scheme Logic (PSL) is a module of programmable logic gates and timers in the IED, which can be used to create customised internal logic. This is done by combining the IED's digital inputs with internally generated digital signals using logic gates and timers, then mapping the resultant signals to the IED's digital outputs and LEDs.

The Programmable Scheme Logic (PSL) Editor allows you to create and edit scheme logic diagrams to suit your own particular application.

1.3 IEC 61850 CONFIGURATOR

IEC 61850 is a substation communications standard. It standardizes the way data is transferred to and from IEC 61850 compliant IEDs, making the communication independent of the manufacturer. This makes it easier to connect different manufacturers' products together and simplifies wiring and network changes.

The IEC 61850 Configurator tool is used to configure the IEC 61850 settings of MiCOM IEDs, not the protection settings. It also allows you to extract a configuration file so you can view, check and modify the IEC 61850 settings during precommissioning.

1.4 DNP3 CONFIGURATOR

DNP3 (Distributed Network Protocol) is a master/slave protocol developed for reliable communications between various types of data acquisition and control equipment. It allows interoperability between various SCADA components in substations. It was designed to function with adverse electrical conditions such as electromagnetic distortion, aging components and poor transmission media.

The DNP3 Configurator allows you to retrieve and edit its settings and send the modified file back to a MiCOM IED.

1.5 CURVE TOOL

The User Programmable Curve Tool (UPCT) allows you to create user-defined curves and to download and upload these curves to and from the IED. You can use this tool to create programmable operate and reset curves. You can also create and visualize curves either by entering formulae or data points.

1.6 S&R COURIER

Settings and Records - Courier enables you to connect to any Courier device, retrieve and edit its settings and send the modified settings back to a Courier device, including DNP 3.0 configuration if supported by the device.

Although each device has different settings, each cell is presented in a uniform style, showing the permissible range and step size allowed.

Settings and Records - Courier also enables you to:

- extract events from a device
- extract disturbance records from a device
- control breakers and isolators
- set the date and time on a device
- set the active group on a device
- change the address of a device
- save settings, DNP 3.0 configuration, events and disturbance files to disk

1.7 AEDR2

AutoExtract Disturbance Records 2 (AEDR2) automatically reads COMTRADE disturbance records from the rear communication ports of both K-Series and MiCOM Px40 devices with the Courier protocol, and from Px40 or Px30 devices with the IEC 60870-5-103 protocol.

AEDR2 is configured with an initialisation file. This file contains all settings, file names and file directories needed for configuration. This file can be created and edited using a standard text editor. Log files are also defined in the initialisation file which are used by AEDR2 to record a history of events and errors.

Once configured, disturbance records are automatically extracted according to a schedule from devices connected in a defined range of addresses. This is done using the Windows® Scheduled Task facility which can be used to execute one or several schedules. All new disturbance records are saved to a user-defined drive and filename.

AEDR2 also has a test function to ensure the initialisation file has been properly configured. The command line is used to execute the test function and validate the initialisation file. The command line can also be used to manually execute the AEDR2 application on demand.

WinAEDR2 is a management facility for AEDR2. It shows the history of all previous extractions and has shortcut buttons to launch WaveWin, Windows Explorer and the Scheduled Task facility. It can also be used to view log files, and edit and test the initialisation file.

1.8 WINAEDR2

WinAEDR2 is a management facility for AEDR2. It shows the history of all previous extractions and has shortcut buttons to launch WaveWin, Windows Explorer and the Scheduled Task facility. It can also be used to view log files, and edit and test the initialisation file.

1.9 WAVEWIN

Wavewin is used for viewing and analysing waveforms from disturbance records. It can be used to determine the sequence of events that led to a fault.

Wavewin provides the following functions.

- File management
- Query management
- Log management
- Report generation
- Sequence of Events(SOE)
- Conversion of COMTRADE files
- Waveform summary

1.10 DEVICE (MENU) TEXT EDITOR

The Menu Text Editor enables you to modify and replace the menu texts held in MiCOM Px4x IEDs. For example, you may want to customise an IED so that menus appear in a language other than one of the standard languages.

By loading a copy of the current menu text file in one of the standard languages into the reference column, you can type the appropriate translation of each menu entry into the target column.

This can then be sent from the PC to the IED, replacing one of the current standard languages. New menu text files created this way can also be saved to disk for later use or further editing.

1.11 EVENT VIEWER

IEDs record all events in an event log. This allows you to establish the sequence of events that led up to a particular situation. For example, a change in a digital input signal or protection element output signal would cause an event record to be created and stored in the event log. This could be used to analyse how a particular power system condition was caused.

When available space is exhausted, the oldest event is overwritten by the new one. The IED's internal clock provides a time tag for each event.

The event records can be displayed on an IED's front panel but it is easier to view them through the settings application software. This can extract the events log from the device and store it as a single .evt file for analysis on a PC.

1.12 GOOSE EDITOR

Using the GOOSE Editor you can edit the UCA2 GOOSE settings for a MiCOM Px4x series IED. You can also map GOOOSE inputs and outputs to the DDB signals of an IED.

The GOOSE Editor can extract settings from and send settings to an IED using a Courier port on the IED. It can also save IED settings to a file on your PC or print them.

1.13 PRP CONFIGURATOR

The PRP Configurator tool is intended for MiCOM Px4x IEDs with redundant Ethernet using PRP (Parallel Redundancy Protocol). This tool is used to identify IEDs, configure the redundancy IP address, configure the SNTP IP address and configure the PRP parameters.

1.14 RSTP CONFIGURATOR

The RSTP Configurator tool is intended for MiCOM Px4x IEDs with redundant Ethernet using RSTP (Rapid Spanning Tree Protocol). This tool is used to identify IEDs, configure the redundancy IP address, configure the SNTP IP address and configure the RSTP parameters.

1.15 SWITCH MANAGER

Switch Manager is used to manage Ethernet ring networks and MiCOM H35x-V2 and H36x-V2 SNMP facilities. It is a set of tools used to manage, optimize, diagnose and supervise your network. It also handles the version software of the switch.

The Switch Manager tool is also intended for MiCOM Px4x IEDs with redundant Ethernet using Self Healing Protocol (SHP) and Dual Homing Protocol (DHP). This tool is used to identify IEDs and Alstom Switches, and to configure the redundancy IP address for the Alstom proprietary Self Healing Protocol and Dual Homing Protocol.

Switch hardware

Alstom switches are stand-alone devices (H3xx, H6x families) or embedded in a computer device rack, for example MiCOM C264 (SWDxxx, SWRxxx, SWUxxx Ethernet boards) or PC board (MiCOM H14x, MiCOM H15x, MiCOM H16x).

Switch range

There are 3 types of Alstom switches:

- Standard switches: SWU (in C264), H14x (PCI), H34x, H6x
- Redundant Ring switches: SWR (in C264), H15x (PCI), H35x,
- Redundant Dual Homing switches: SWD (in C264), H16x (PCI), H36x

Switch Manager allows you to allocate an IP addresses for Alstom switches. Switches can then be synchronized using the Simple Network Time Protocol (SNTP) or they can be administrated using the Simple Network Management Protocol (SNMP).

All switches have a single 6-byte MAC address.

Redundancy Management

Standard Ethernet does not support a loop at the OSI link layer (layer 2 of the 7 layer model). A mesh topology cannot be created using a standard Hub and switch. Redundancy needs separate networks using hardware in routers or software in dedicated switches using STP (Spanning Tree Protocol). However, this redundancy mechanism is too slow for one link failure in electrical automation networks.

Alstom has developed its own Redundancy ring and star mechanisms using two specific Ethernet ports of the redundant switches. This redundancy works between Alstom switches of the same type. The two redundant Ethernet connections between Alstom switches create one private redundant Ethernet LAN.

The Ethernet ports dedicated to the redundancy are optical Ethernet ports. The Alstom redundancy mechanism uses a single specific address for each Ethernet switch of the private LAN. This address is set using DIP switches or jumpers.

Switch Manager monitors the redundant address of the switches and the link topology between switches.

BUSBAR COMMISSIONING TOOL

CHAPTER 11

1 P747 BUSBAR COMMISSIONING TOOL (REMOTE HMI)

This tool is intended for busbar commissioning. It allows you to create a scheme and display the measured data. It consists of a scheme editor and a monitor that shows protection data in real time. The scheme editor allows you to quickly draw schemes from a library of elements, then validate the scheme. The monitor continually updates information about the scheme and shows the status of DDBs and values of measured data.

2 SCHEME EDITOR

The Scheme Editor allows you to quickly draw schemes from a library of elements, then validate the scheme.

To select your language, select **File** then **Options** then **Language**.

To create, open, save or print a scheme, select the **File** tab.

2.1 CONNECTIONS

To enable connection bridges:

1. Select **File** then **Options** then **Diagram Settings**.
2. Check **Enable Connection Bridges**.

The following table shows which elements can be connected together.

Element	Busbar	Feeder Isolator (Q)	Circuit Breaker	Current Transformer	Voltage Transformer	Busbar Isolator (Qbus)
Busbar	No	Always	No	No	Busbar can be connected to max 1 VT element. VT has only one end connected	Always
Feeder Isolator (Q)	Always	No	CB can be connected to 1 to 4 isolators	CT can be connected to 1 to 2 isolators	VT has only one end connected	No
Circuit Breaker	No	CB can be connected to 1 to 4 isolators	No	Always. Max 1 CB to 1 CT	No	No
Current Transformer	No	CT can be connected to 1 to 2 isolators	Always. Max 1 CB to 1 CT	No	No	No
Voltage Transformer	Busbar can be connected to max 1 VT element. VT has only one end connected	VT has only one end connected	No	No	No	No
Busbar Isolator (Qbus)	Always	No	No	No	No	No

2.1.1 MANUAL CONNECTIONS

To connect two elements:

1. Select **File** then **Options** then **Diagram Settings**.
2. Uncheck **Enable Auto Connections**.
3. Drag and drop two objects onto a scheme.
4. Drag a connection to each element. A green border shows the connection is complete.

2.1.2 AUTOMATIC CONNECTIONS

To connect two elements:

1. Select **File** then **Options** then **Diagram Settings**.
2. Check **Enable Auto Connections**.
3. Drag and drop two objects next to each other onto a scheme. The connection is made automatically.

2.1.3 REMOVE CONNECTION

To remove a connection:

1. Select a connection.
2. Pess the **Delete** key or click the **Remove** icon.

2.2 SCHEME ELEMENTS

The following table shows the number of elements allowed in a scheme.

Element	Minimum number	Maximum number
Busbar	1	4
Isolator	2	74
Circuit Breaker	2	18
Current Transformer	2	18
Voltage Transformer	0	4

2.2.1 ADD ELEMENTS TO A SCHEME

To add elements to a scheme, drag and drop them from the toolbox.

2.2.2 REMOVE AN ELEMENT

To remove an element from a scheme:

1. Select an element.
2. Pess the **Delete** key or click the **Remove** icon.

2.2.3 GROUP ELEMENTS IN A SCHEME

To group elements in a scheme:

1. Drag and drop the elements into the scheme.
2. Add any connections between them.
3. Select the elements you want to group.
4. Click the **Group** icon.

2.2.4 ROTATE ELEMENTS IN A GROUP

To rotate an element or group, select the item and click the **Rotate Left** or **Rotate Right** icon.

2.3 WORKING WITH TEXT ON THE SCHEME

You can add labels or free text onto the scheme:

- Circuit Breakers can be labelled CB1 to CB18.
- Current Transformers can be labelled CT1 to CT18.
- Voltage Transformers can be labelled VT1 to VT4.
- Feeder Isolators can be labelled QxZy where x=1 to 18 and y=1 to 4.
- Busbar Isolators can be labelled QBus1 to Qbus2.

2.3.1 ADD A LABEL TO AN ELEMENT

To add a label to an element:

1. Double-click the element and select a label from the drop-down list.
   If many labels are available it can sometimes be difficult to find a specific one from the drop-down list. A search function helps you to find the one you need.
2. Double-click the element.
3. Enter the seach text in the box at the top of the drop-down list.

2.3.2 REMOVE A LABEL FROM AN ELEMENT

To remove a label from an element, right-click the element and select **Remove Label**.

2.3.3 CHANGE AN ELEMENT'S LABEL

To change the label of an element, right-click the element and select **Edit Label**.

2.3.4 ADD OR REMOVE FREE TEXT

To add or remove free text, drag and drop the **Free Text** object onto the scheme and enter the text.

To edit the text, double click it.

To remove the text block, right-click it and select **Remove**.

2.3.5 VALIDATE A SCHEME

This checks for potential errors in the scheme and makes suggestions of how to correct them.

To validate scheme elements and the connections between them, click the **Validate** icon. To display the latest validation results, click the **Validation Report** icon.

3 PROTECTION DATA MONITOR

The Protection Data Monitor shows the status of DDBs and measured data in the scheme.

To start the Protection Data Monitor:

1. Select **File** then **Save** or **Save As** to save the scheme.
2. Click the icon **Switch to Dynamic Synoptic Mode**.

3.1 CONNECT TO THE IED

To read the IED data, first set up the connection:

1. Click the **Connect to P747** icon.
2. Select **Single Device** or **Many Devices**.
3. From the drop-down list select **Front Serial Port**, **Rear Serial Port** or **Ethernet**.
   The table is populated with default values. Check they are suitable for your application. You can set the Device Address from 1 to 255.
4. Click the **Connect** button. The connection status appears in the bottom left-hand corner of the screen. Green shows the IED is connected.

3.1.1 POLLING TIMER

The Protection Data Monitor polls the IED and updates the states of the elements in the scheme. The Polling Timer sets the time in seconds between each update.

To set the polling timer:

1. Click the **Polling Timer** icon.
2. Select the polling time in seconds from the drop-down list and click **OK**.

To stop or restart polling, click the **Stop Polling** icon or **Resume Polling** icon.

3.1.2 READ IED DATA

To read the IED data, click the Get Device Data icon.

This shows the Device Address, Model Number, Serial Number and device Description for each device that is connected.

3.1.3 MEASUREMENTS DATA

The Measurements Panel is on the left-hand side of the screen. The top left-hand corner shows the measurements for each zone and for each phase. The bottom left-hand corner shows the protection data and any alarms. The phase angle and magnitude are shown at each CT on the scheme.

SCHEME LOGIC

CHAPTER 12

1 CHAPTER OVERVIEW

Alstom Grid products are supplied with pre-loaded Fixed Scheme Logic (FSL) and Programmable Scheme Logic (PSL). The FSL schemes cannot be modified. They have been individually designed to suit the model in question. Each model also provides default PSL schemes, which have also been designed to suit each model. If these schemes suit your requirements, you do not need to take any action. However, if you want to change the input-output mappings, or to implement custom scheme logic, you can change these, or create new PSL schemes using the PSL editor.

This chapter provides details of the in-built FSL schemes and the default PSL schemes.

This chapter contains the following sections:

2 INTRODUCTION TO THE SCHEME LOGIC

The Scheme Logic is a functional module within the IED, through which all mapping of inputs to outputs is handled. The scheme logic can be split into two parts; the Fixed Scheme Logic (FSL) and the Programmable Scheme Logic (PSL).

The FSL Scheme Logic is logic that has been designed and implemented at the factory. It is logic that is necessary for the fundamental workings of the IED. It is fixed and cannot be changed.

The PSL is logic that is user-programmable. The PSL consists of logic gates and timers, which combine and condition the DDB signals. 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. There are also counters available. The PSL logic is event driven. 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 used by the PSL, when compared to some competition devices. The device is shipped with a selection of default schemes, which should cover basic applications, but you can modify these default schemes to create custom schemes, if desired. You can also create new schemes from scratch, should you wish to do so.

The Scheme Logic module is built around a concept called the digital data bus (DDB). The DDB is a parallel data bus containing all of the digital signals (inputs, outputs, and internal signals), which are available for use in the FSL and PSL

The following diagram shows how the scheme logic interacts with the rest of the IED.

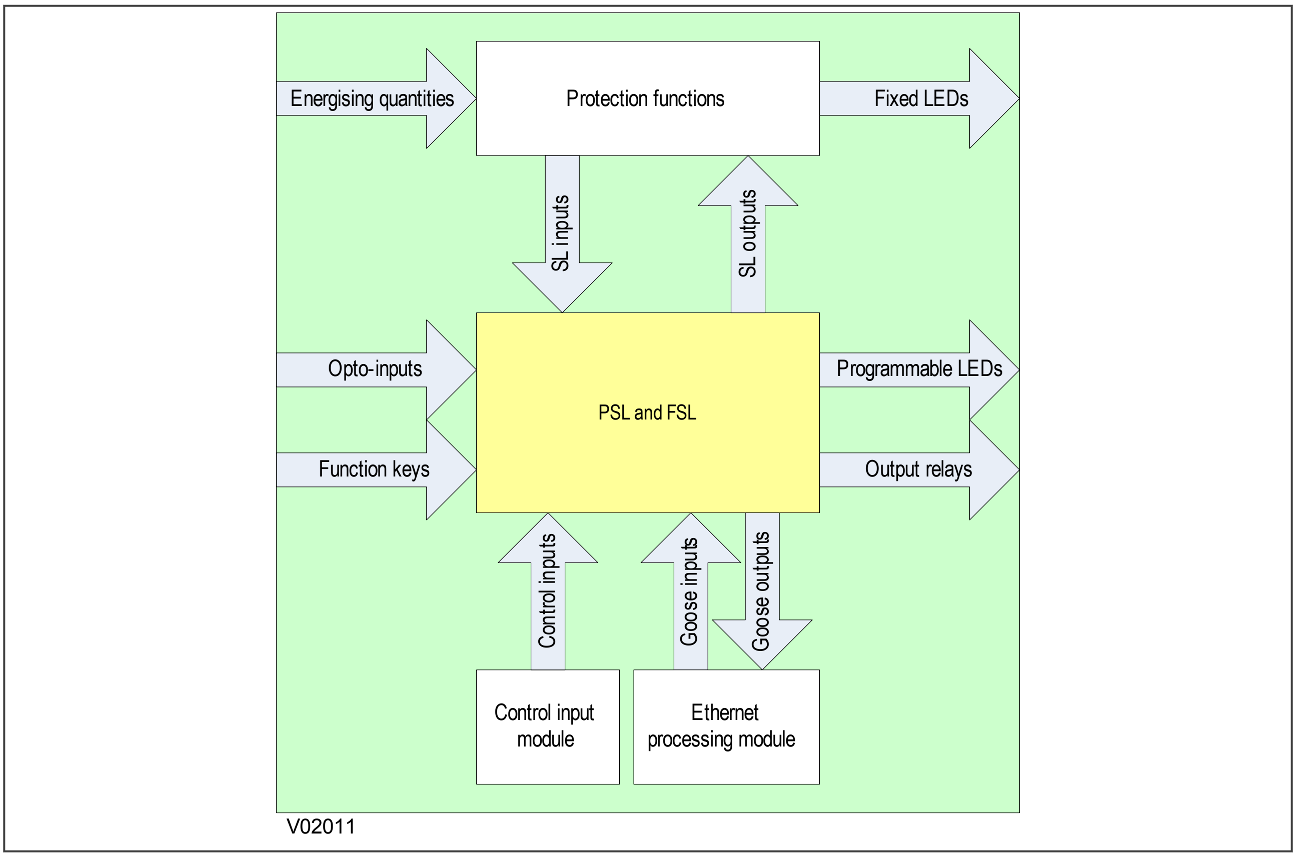


Figure 73: Scheme Logic Interfaces

The inputs to the scheme logic are:

- Opto-inputs: Optically-coupled logic inputs
- Function keys: Keys on the device (not on all models)

- Control inputs: Software inputs for controlling functionality
- Goose inputs: Messages from other devices via the IEC 61850 interface (not on all models)
- Scheme Logic inputs: Inputs from the protection functions (SL inputs are protection function outputs)

The outputs from the scheme logic are:

- Programmable LEDs
- Output relays
- Goose outputs: Messages to other devices via the IEC 61850 interface (not on all models)
- Scheme Logic outputs: Outputs to the protection functions (SL outputs are protection function inputs)

Examples of internal inputs and outputs include:

- ***IN>1 Trip***: This is an output from the Stage 1 Earth Fault protection function, which can be input into the PSL to create further functionality. This is therefore an ***SL input***.
- ***User Alarm 1***: This is an output, which can be input into the PSL to create further functionality. This is therefore an ***SL input***.
- ***Reset Relays/LED***: This is an ***SL output***, which can be asserted to reset the output relays and LEDs.

The FSL is fixed, but the PSL allows you to create your own scheme logic design. For this, you need a suitable PC support package to facilitate the design of the PSL scheme. This PC support package is provided in the form of the PSL Editor, which is included as part of the MiCOM S1 Agile engineering tool. The PSL Editor is one of a suite of applications available in the settings application software, but is also available as a standalone package. This tool is described in the Settings Application Software chapter.

3 FIXED SCHEME LOGIC

This section contains logic diagrams of the fixed scheme logic, which covers all of the device models. You must be aware that some models do not contain all the functionality described in this section.

3.1 ANY START LOGIC

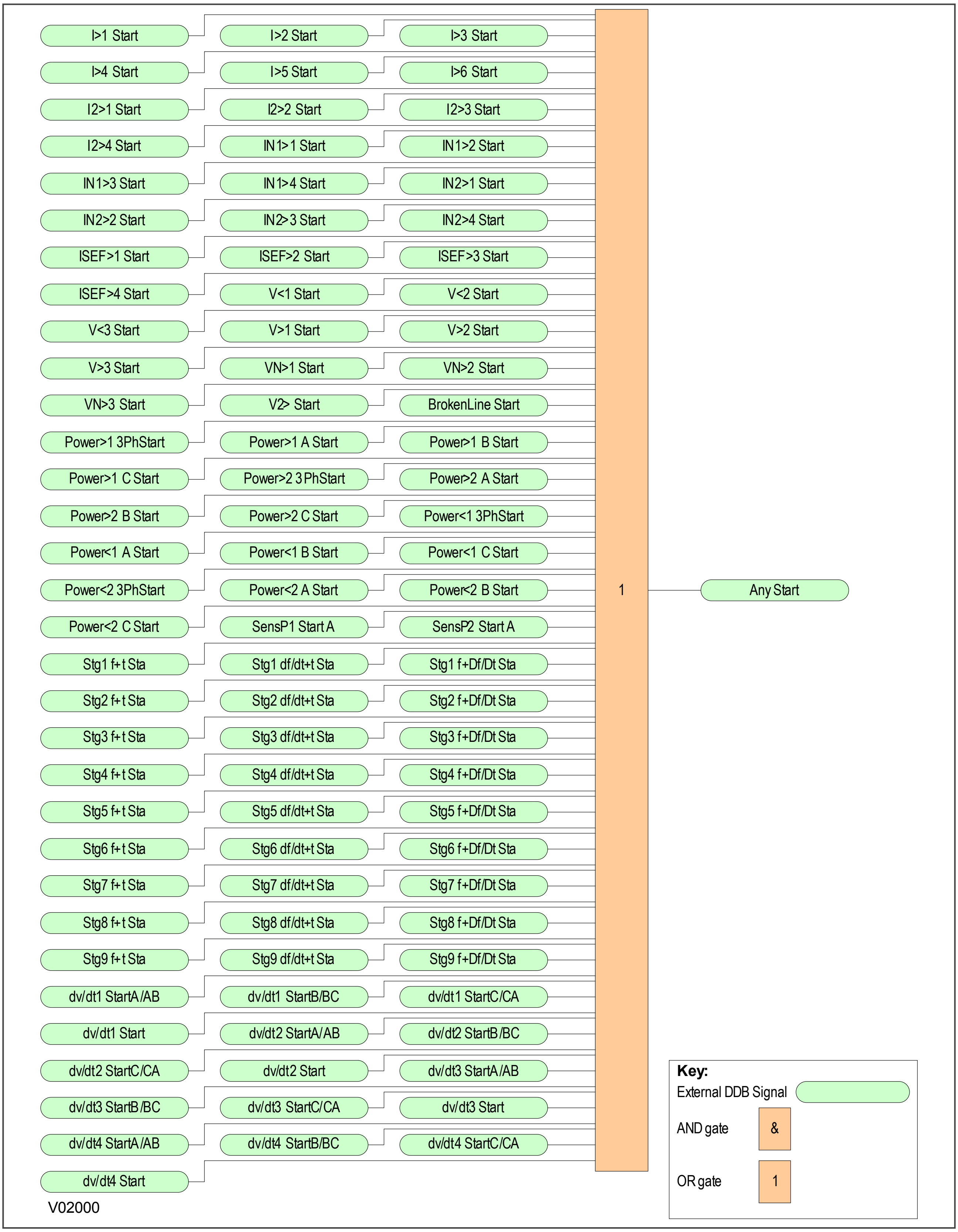


Figure 74: Any Start Logic

3.2 VTS ACCELERATION INDICATION LOGIC

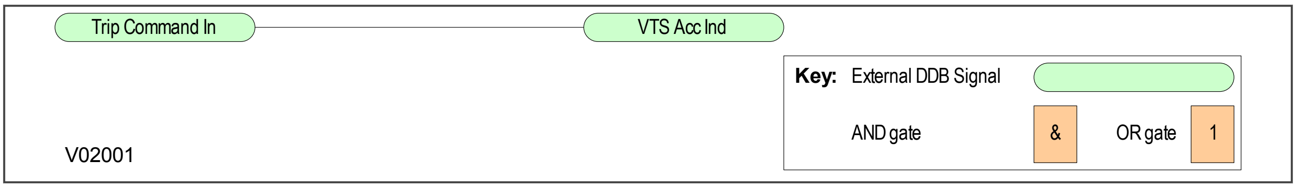


Figure 75: VTS Acceleration Indication Logic

3.3 CB FAIL SEF PROTECTION LOGIC

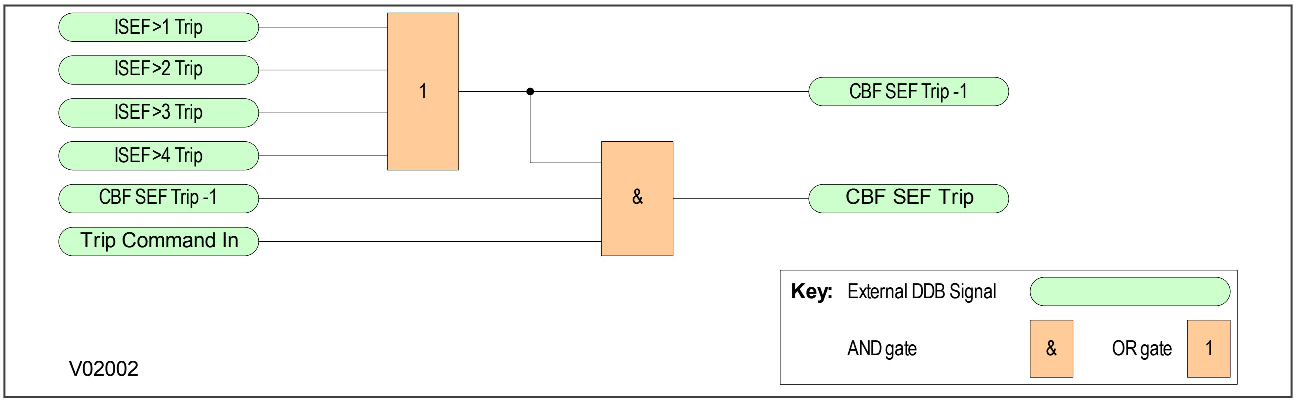


Figure 76: CB Fail SEF Protection Logic

3.4 CB FAIL NON CURRENT PROTECTION LOGIC

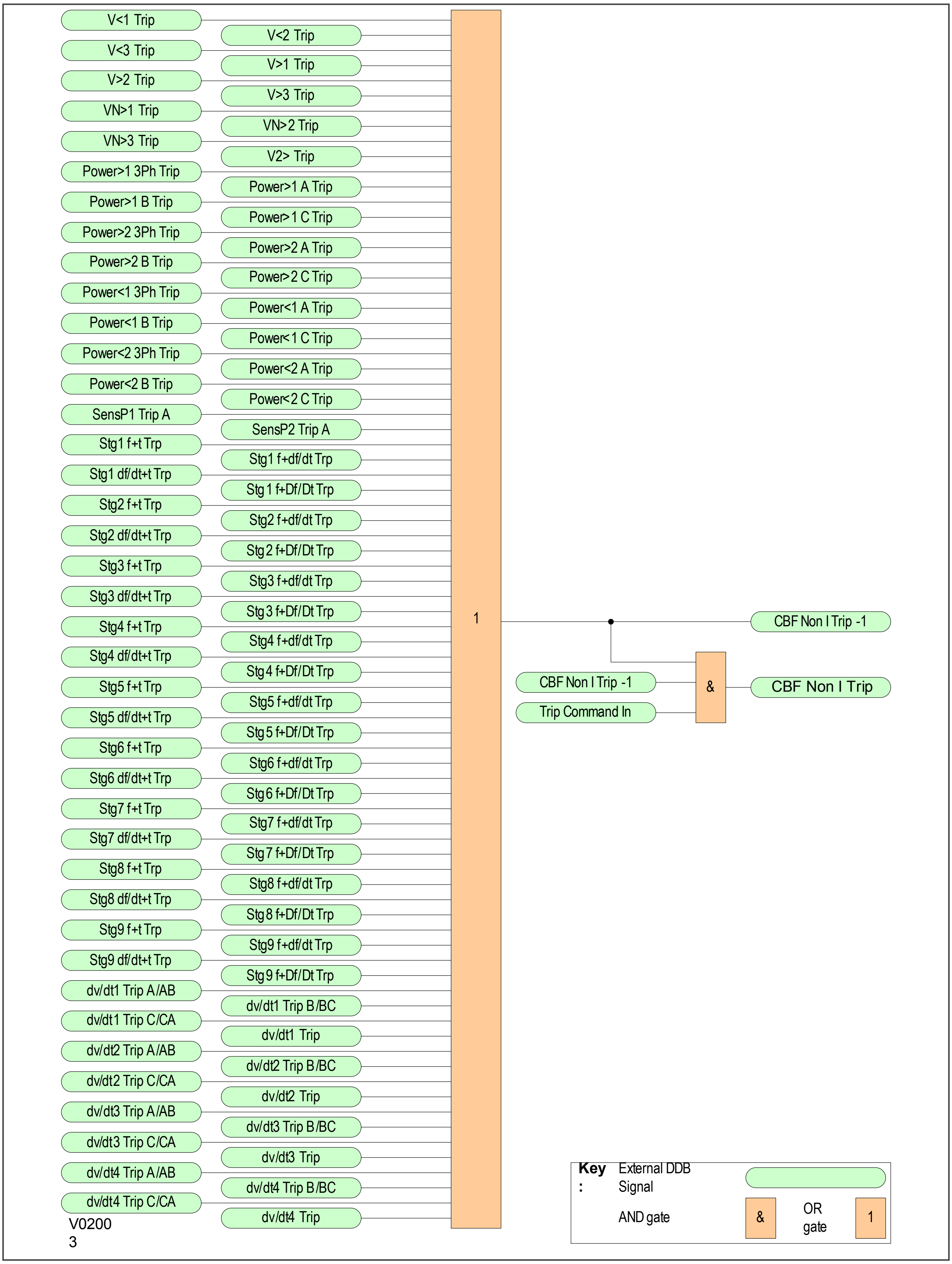


Figure 77: CB Fail Non Current Protection Logic

3.5 COMPOSITE EARTH FAULT START LOGIC

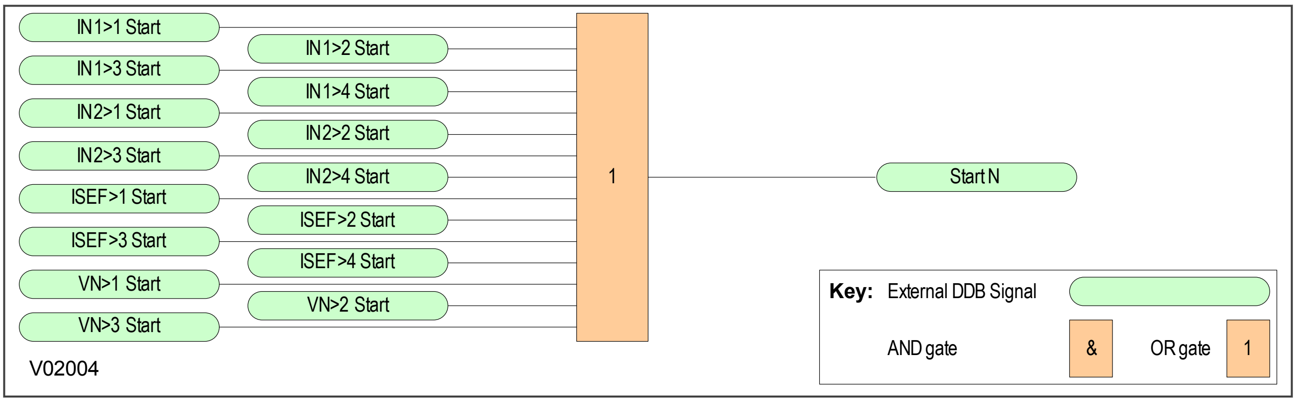


Figure 78: Composite Earth Fault Start Logic

3.6 ANY TRIP LOGIC

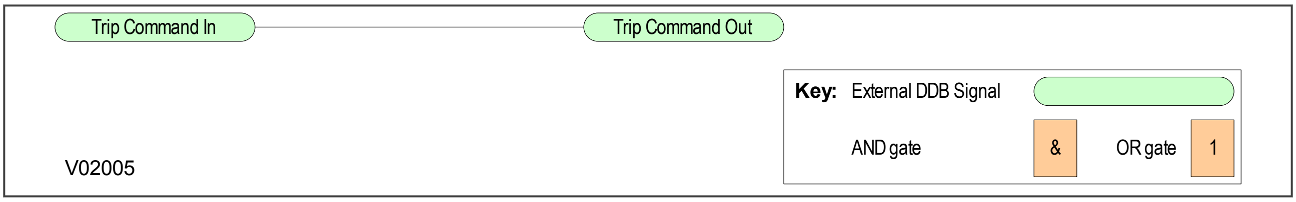


Figure 79: Any Trip Logic

3.7 SEF ANY START LOGIC

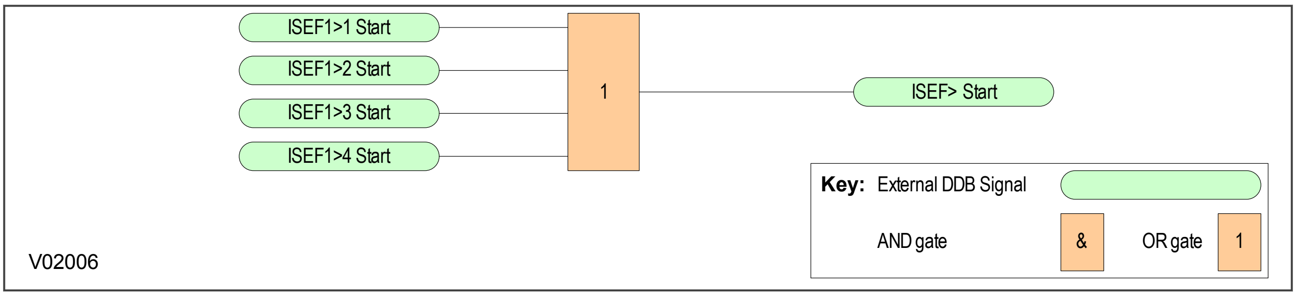


Figure 80: SEF Any Start Logic

4 PROGRAMMABLE SCHEME LOGIC

This section contains tables and logic diagrams of the default programmable scheme logic, which covers all of the device models. You must be aware that some models do not contain all the functionality described in this section.

All these diagrams can be viewed, edited and printed from the PSL Editor.

4.1 VIEWING AND PRINTING PSL DIAGRAMS

You can view and print the PSL diagrams for the device. Typically these diagrams allow you to see the following mappings:

- Opto Input Mappings
- Output Relay Mappings
- LED Mappings
- Start Indications
- Phase Trip Mappings
- System Check Mapping

To download the default PSL diagrams for the device and print them:

1. Close S1 Agile.
2. Select **Programs** then **Alstom Grid** then **S1 Agile** then **Data Model Manager**.
3. Click **Add** then **Next**.
4. Click **Internet** then **Next.**
5. Select your language then click **Next**.
6. From the tree view, select the model and software version.
7. Click **Install**. When complete click **OK**.
8. Close the Data Model Manager and start S1 Agile.
9. Select **Tools** then **PSL Editor (Px40)**.
10. In the PSL Editor select **File** then **New** then **Default Scheme**.
11. Select the IED type
12. Use the advance button to select the software, then select the model number.
13. Highlight the required PSL diagram and select **File** then **Print**.

Caution:
Read the notes in the default PSL diagrams, as these provide critical information.

4.2 TRIP OUTPUT MAPPINGS

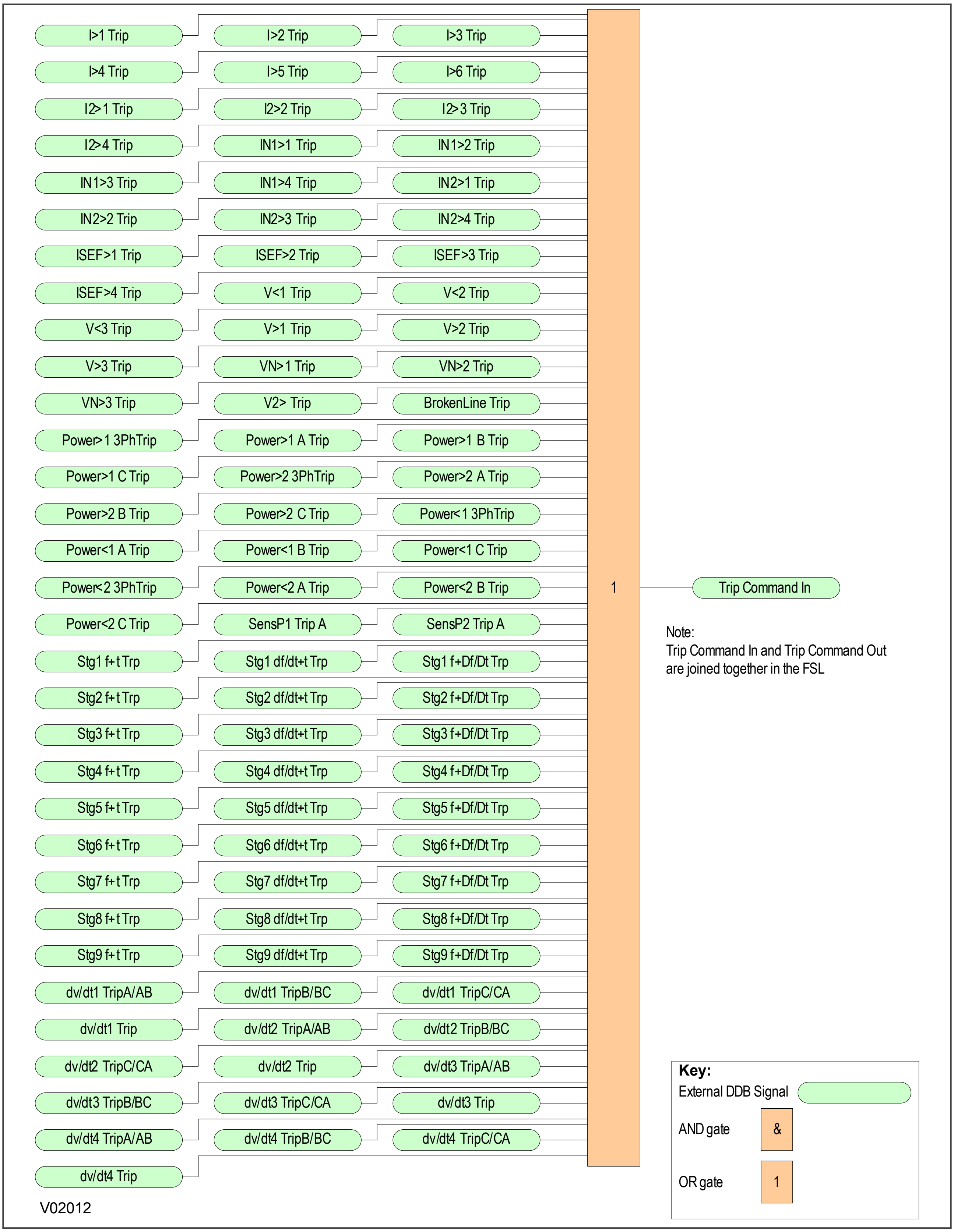


Figure 81: Trip Output Mappings

4.3 OPTO-INPUT MAPPINGS

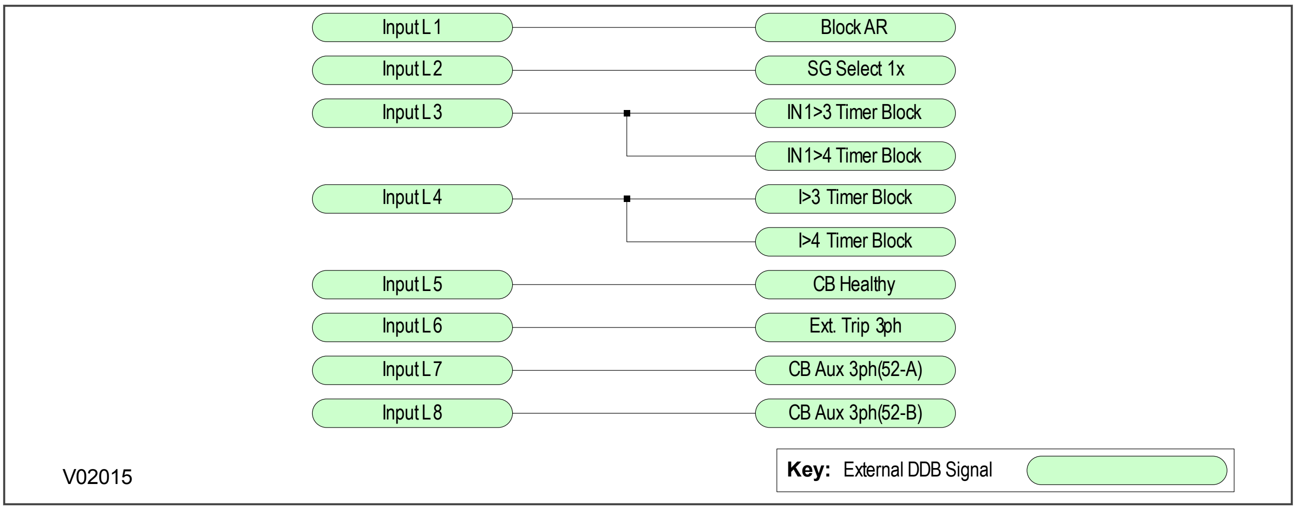


Figure 82: Opto-Input Mappings

4.4 OUTPUT RELAY MAPPINGS

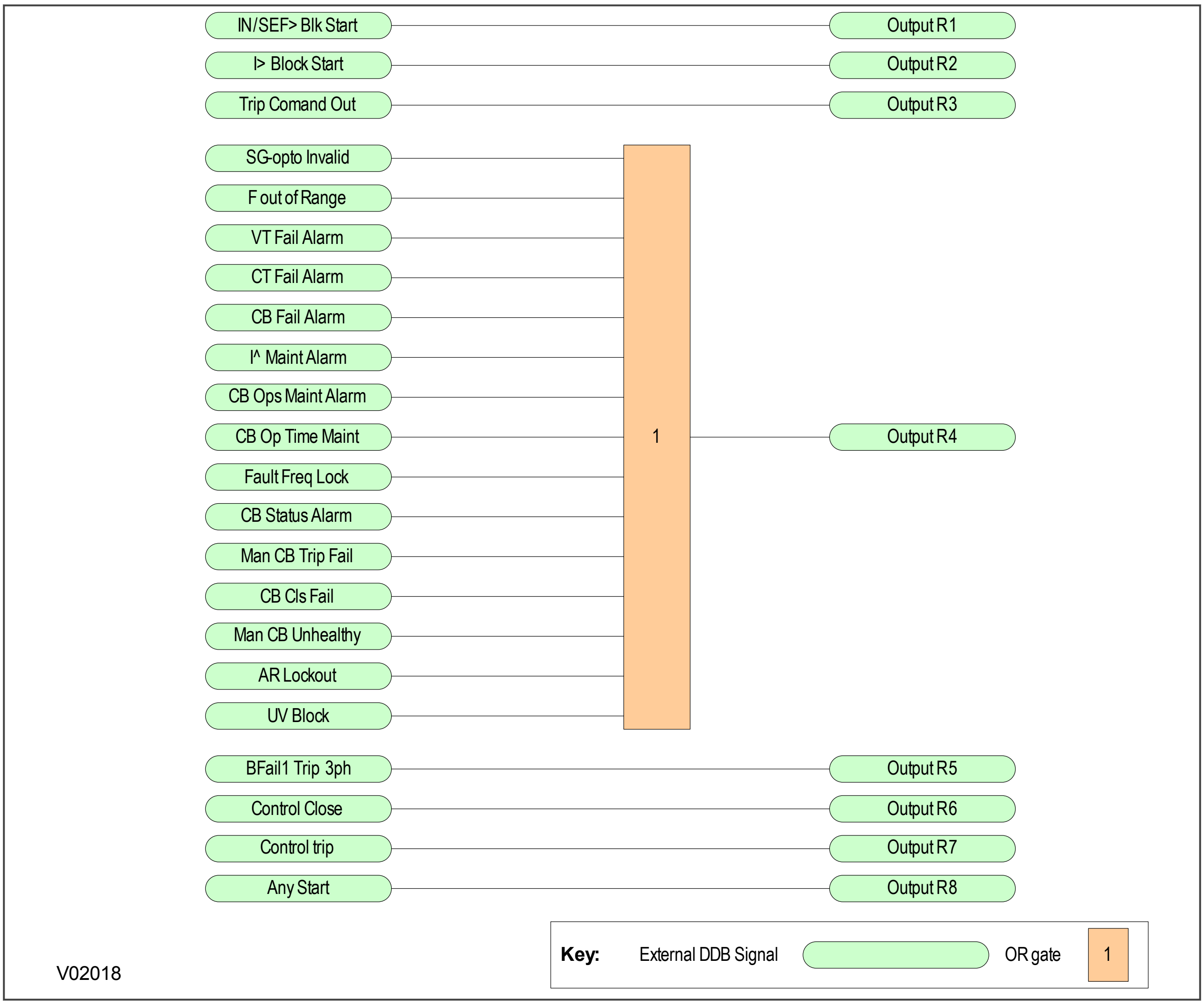


Figure 83: Output Relay Mappings

4.5 LED MAPPINGS

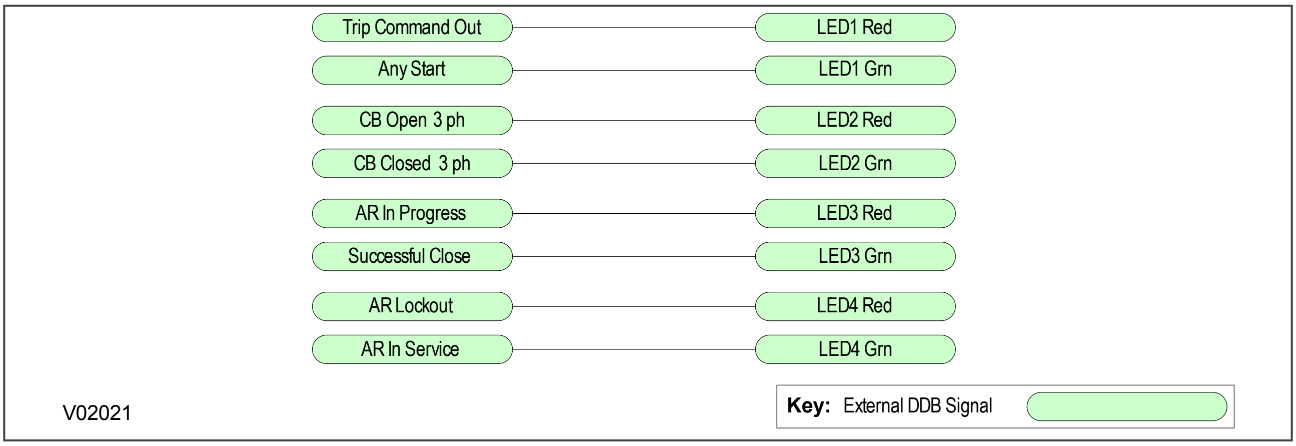


Figure 84: LED Mappings

4.6 CONTROL INPUT MAPPINGS

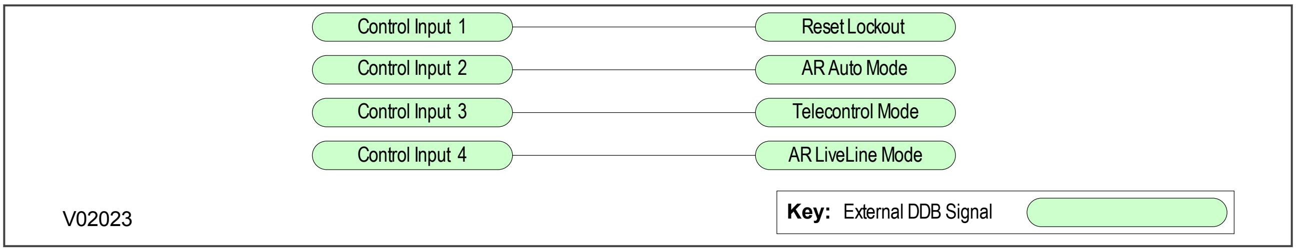


Figure 85: Control Input Mappings

4.7 FUNCTION KEY MAPPINGS

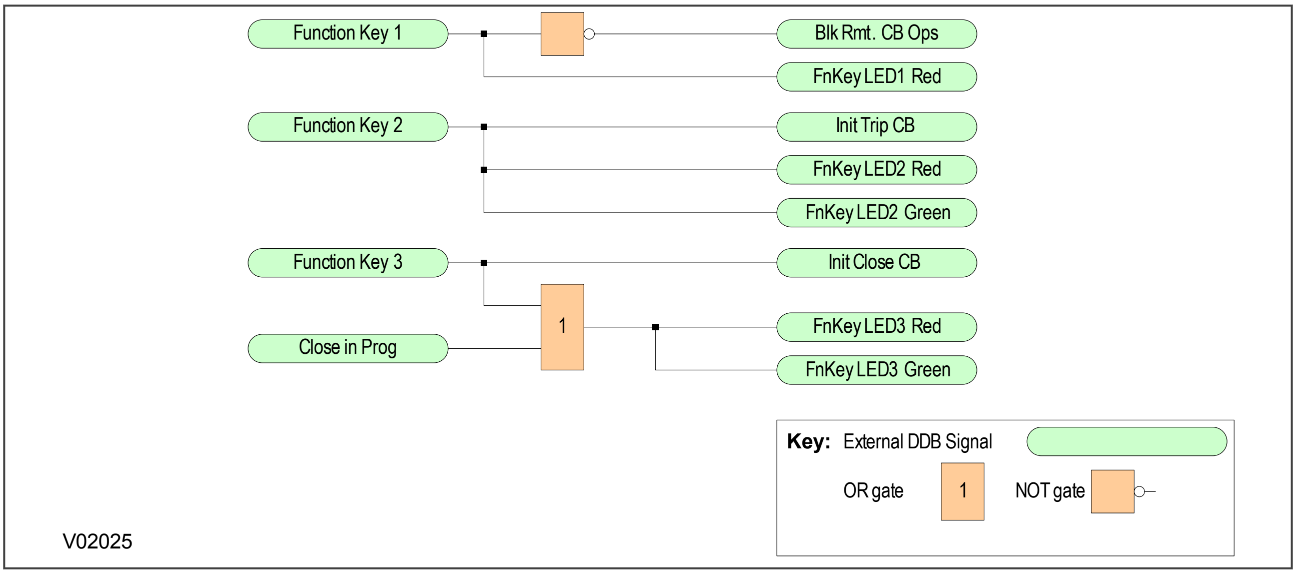


Figure 86: Function Key Mappings

4.8 CIRCUIT BREAKER MAPPING

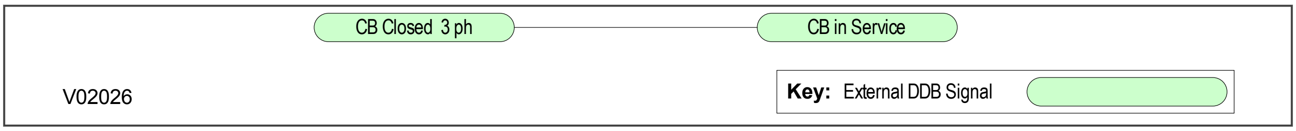


Figure 87: Circuit Breaker mapping

4.9 FAULT RECORD TRIGGER MAPPING

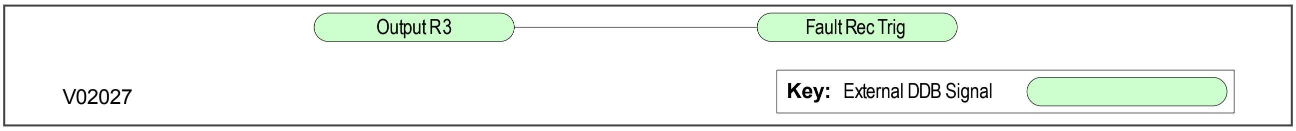


Figure 88: Fault Record Trigger mapping

4.10 CHECK SYNCHRONISATION AND VOLTAGE MONITOR MAPPINGS

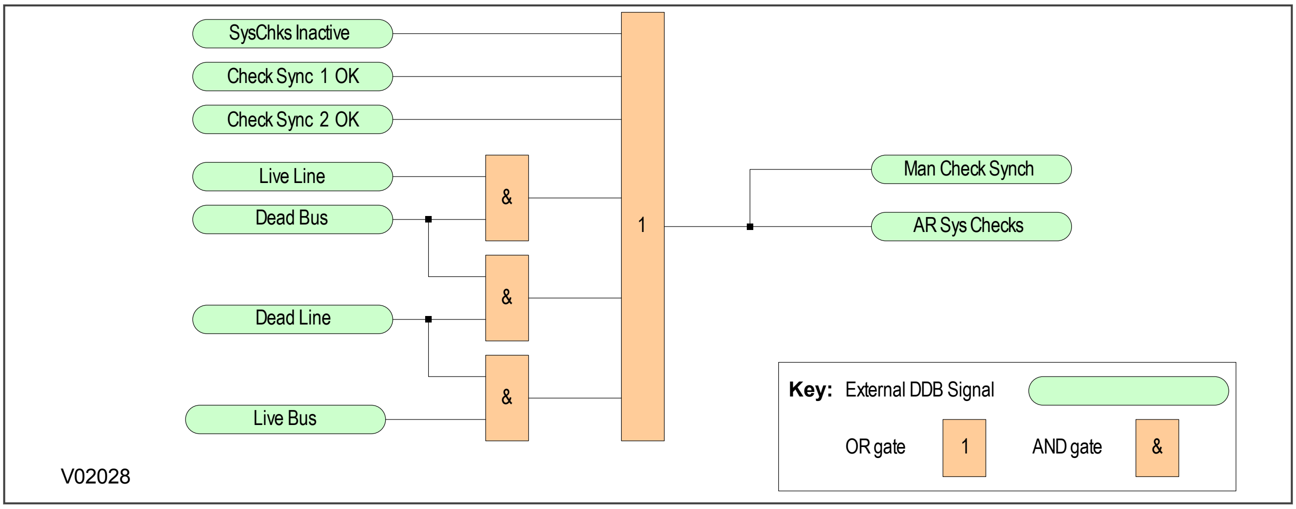


Figure 89: Check Synchronisation and Voltage Monitor mappings

4.11 SETTINGS

The device contains a *PSL DATA* column, which can be used to track PSL modifications. A total of 12 cells are contained in the *PSL DATA* column; 3 for each setting group.

Grp(n) PSL Ref: When downloading a PSL scheme to an IED, you will be prompted to enter the relevant group number and a reference identifier. The first 32 characters of the reference identifier are displayed in this cell. The horizontal cursor keys can scroll through the 32 characters as the LCD display only displays 16 characters.

Example:

```
Grp. PSL Ref.
```

Date/time: This cell displays the date and time when the PSL scheme was downloaded to the IED.

Example:

```
18 Nov 2002
08:59:32.047
```

Grp(n) PSL ID: This cell displays a unique ID number for the downloaded PSL scheme.

Example:

```
Grp. 1 PSL
ID - 2062813232
```

The complete Settings table is shown below:

Menu Text	Col	Row	Default Setting	Available Options
Description				
PSL DATA	B7	00		
This column contains information about the Programmable Scheme Logic				
Grp1 PSL Ref	B7	01		Not settable
This setting displays the Group 1 PSL reference				
Date/Time	B7	02		Not settable
This setting displays the date and time the PSL was created				
Grp1 PSL ID	B7	03		Not settable
This setting displays the Group 1 PSL ID				
Grp2 PSL Ref	B7	11		Not settable
This setting displays the Group 2 PSL reference				
Date/Time	B7	12		Not settable
This setting displays the date and time the PSL was created				
Grp2 PSL ID	B7	13		Not settable
This setting displays the Group 2 PSL ID				
Grp3 PSL Ref	B7	21		Not settable
This setting displays the Group 3 PSL reference				
Date/Time	B7	22		Not settable
This setting displays the date and time the PSL was created				
Grp3 PSL ID	B7	23		Not settable
This setting displays the Group 3 PSL ID				
Grp4 PSL Ref	B7	31		Not settable
This setting displays the Group 4 PSL reference				
Date/Time	B7	32		Not settable
This setting displays the date and time the PSL was created				
Grp4 PSL ID	B7	33		Not settable
This setting displays the Group 4 PSL ID				

INSTALLATION

CHAPTER 13

1 CHAPTER OVERVIEW

This chapter provides information about installing the product.

This chapter contains the following sections:

2 HANDLING THE GOODS

Our products are of robust construction but require careful treatment before installation on site. This section discusses the requirements for receiving and unpacking the goods, as well as associated considerations regarding product care and personal safety.

Caution:
Before lifting or moving the equipment you should be familiar with the Safety Information chapter of this manual.

2.1 RECEIPT OF THE GOODS

On receipt, ensure the correct product has been delivered. Unpack the product immediately to ensure there has been no external damage in transit. If the product has been damaged, make a claim to the transport contractor and notify us promptly.

For products not intended for immediate installation, repack them in their original delivery packaging.

2.2 UNPACKING THE GOODS

When unpacking and installing the product, take care not to damage any of the parts and make sure that additional components are not accidentally left in the packing or lost. Do not discard any CDROMs or technical documentation. These should accompany the unit to its destination substation and put in a dedicated place.

The site should be well lit to aid inspection, clean, dry and reasonably free from dust and excessive vibration. This particularly applies where installation is being carried out at the same time as construction work.

2.3 STORING THE GOODS

If the unit is not installed immediately, store it in a place free from dust and moisture in its original packaging. Keep any de-humidifier bags included in the packing. The de-humidifier crystals lose their efficiency if the bag is exposed to ambient conditions. Restore the crystals before replacing it in the carton. Ideally regeneration should be carried out in a ventilating, circulating oven at about 115°C. Bags should be placed on flat racks and spaced to allow circulation around them. The time taken for regeneration will depend on the size of the bag. If a ventilating, circulating oven is not available, when using an ordinary oven, open the door on a regular basis to let out the steam given off by the regenerating silica gel.

On subsequent unpacking, make sure that any dust on the carton does not fall inside. Avoid storing in locations of high humidity. In locations of high humidity the packaging may become impregnated with moisture and the de-humidifier crystals will lose their efficiency.

The device can be stored between –25º to +70ºC for unlimited periods or between -40°C to + 85°C for up to 96 hours (see technical specifications).

2.4 DISMANTLING THE GOODS

If you need to dismantle the device, always observe standard ESD (Electrostatic Discharge) precautions. The minimum precautions to be followed are as follows:

- Use an antistatic wrist band earthed to a suitable earthing point.
- Avoid touching the electronic components and PCBs.

3 MOUNTING THE DEVICE

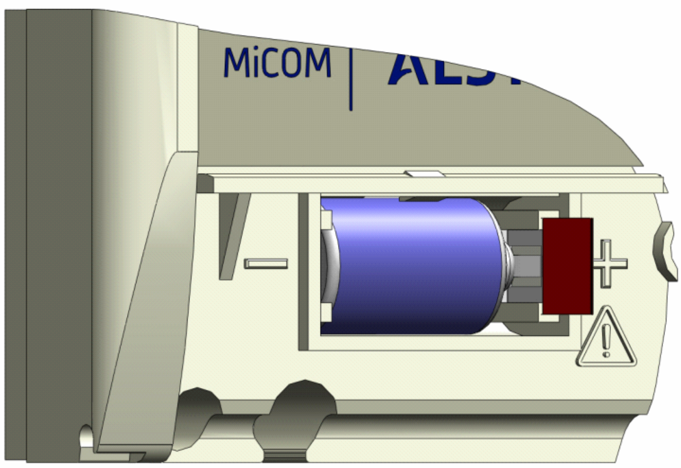
The products are dispatched either individually or as part of a panel or rack assembly.

Individual products are normally supplied with an outline diagram showing the dimensions for panel cut-outs and hole centres.

The products are designed so the fixing holes in the mounting flanges are only accessible when the access covers are open.

If you use a P991 or MMLG test block with the product, when viewed from the front, position the test block on the right-hand side of the associated product. This minimises the wiring between the product and test block, and allows the correct test block to be easily identified during commissioning and maintenance tests.

If you need to test the product for correct operation during installation, open the lower access cover, hold the battery in place and pull the red tab to remove the battery isolation strip.



V01412

Figure 90: Location of battery isolation strip

3.1 FLUSH PANEL MOUNTING

Panel-mounted devices are 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 five (our part number ZA0005 104).

Caution:
Do not use conventional self-tapping screws, because they have larger heads and could damage the faceplate.

Alternatively, you can use tapped holes if the panel has a minimum thickness of 2.5 mm.

For applications where the product needs to be semi-projection or projection mounted, a range of collars are available.

If several products are mounted in a single cut-out in the panel, mechanically group them horizontally or vertically into rigid assemblies before mounting in the panel.

Caution:
Do not fasten products with pop rivets because this makes them difficult to remove if repair becomes necessary.

If the product is mounted on a BS EN60529 IP52 compliant panel, fit a metallic sealing strip between adjoining products (part no GN2044 001) and fit a sealing ring around the complete assembly, according to the following table.

Width	Sealing ring for single tier	Sealing ring for double tier
10TE	GJ9018 002	GJ9018 018
15TE	GJ9018 003	GJ9018 019
20TE	GJ9018 004	GJ9018 020
25TE	GJ9018 005	GJ9018 021
30TE	GJ9018 006	GJ9018 022
35TE	GJ9018 007	GJ9018 023
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

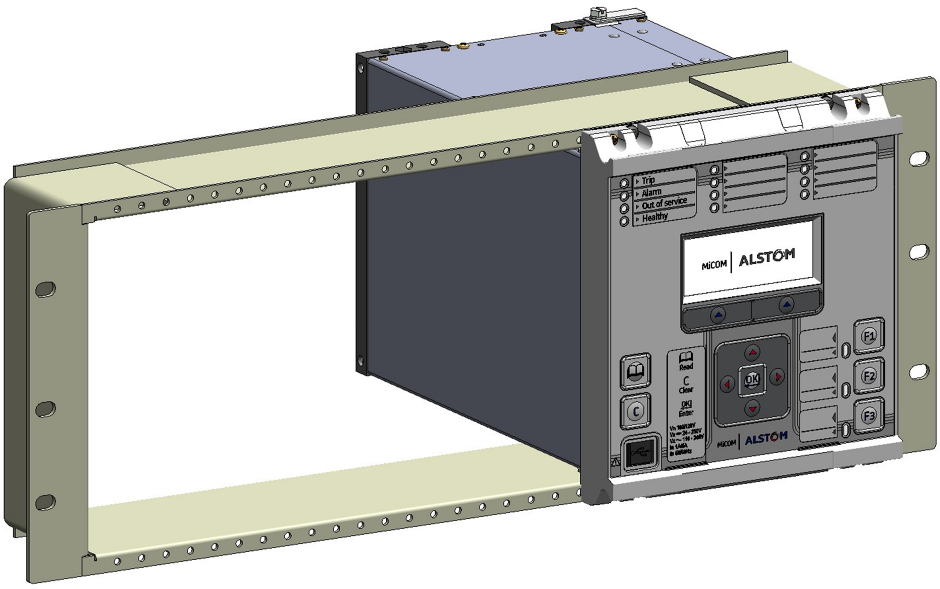
3.2 RACK MOUNTING

Panel-mounted variants can also be rack mounted using single-tier rack frames (our part number FX0021 101), as shown in the figure below. These frames are designed with dimensions in accordance with IEC 60297 and are supplied pre-assembled ready to use. On a standard 483 mm (19 inch) 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. Attach the products by 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 five (our part number ZA0005 104).

Caution:
Risk of damage to the front cover molding. Do not use conventional self-tapping screws, including those supplied for mounting MiDOS products 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.



R01400

Figure 91: Rack mounting of products

Products can be mechanically grouped into single tier (4U) or multi-tier arrangements using the rack frame. This enables schemes using products from different product ranges to be pre-wired together before mounting.

Use blanking plates to fill any empty spaces. The spaces may be used for installing future products or because the total size is less than 80TE on any tier. Blanking plates can also be used to mount ancillary components. The part numbers are as follows:

Case size summation	Blanking plate part number
5TE	GJ2028 101
10TE	GJ2028 102
15TE	GJ2028 103
20TE	GJ2028 104
25TE	GJ2028 105
30TE	GJ2028 106
35TE	GJ2028 107
40TE	GJ2028 108

4 CABLES AND CONNECTORS

This section describes the type of wiring and connections that should be used when installing the device. For pin-out details please refer to the Hardware Design chapter or the wiring diagrams.

Caution:
Before carrying out any work on the equipment you should be familiar with the Safety Section and the ratings on the equipment's rating label.

4.1 TERMINAL BLOCKS

The device may use one or more of the terminal block types shown in the following diagram. The terminal blocks are fastened to the rear panel with screws.

- Heavy duty (HD) terminal blocks for CT and VT circuits
- Medium duty (MD) terminal blocks for the power supply, relay outputs and rear communications port
- MiDOS terminal blocks for CT and VT circuits
- RTD/CLIO terminal block for connection to analogue transducers

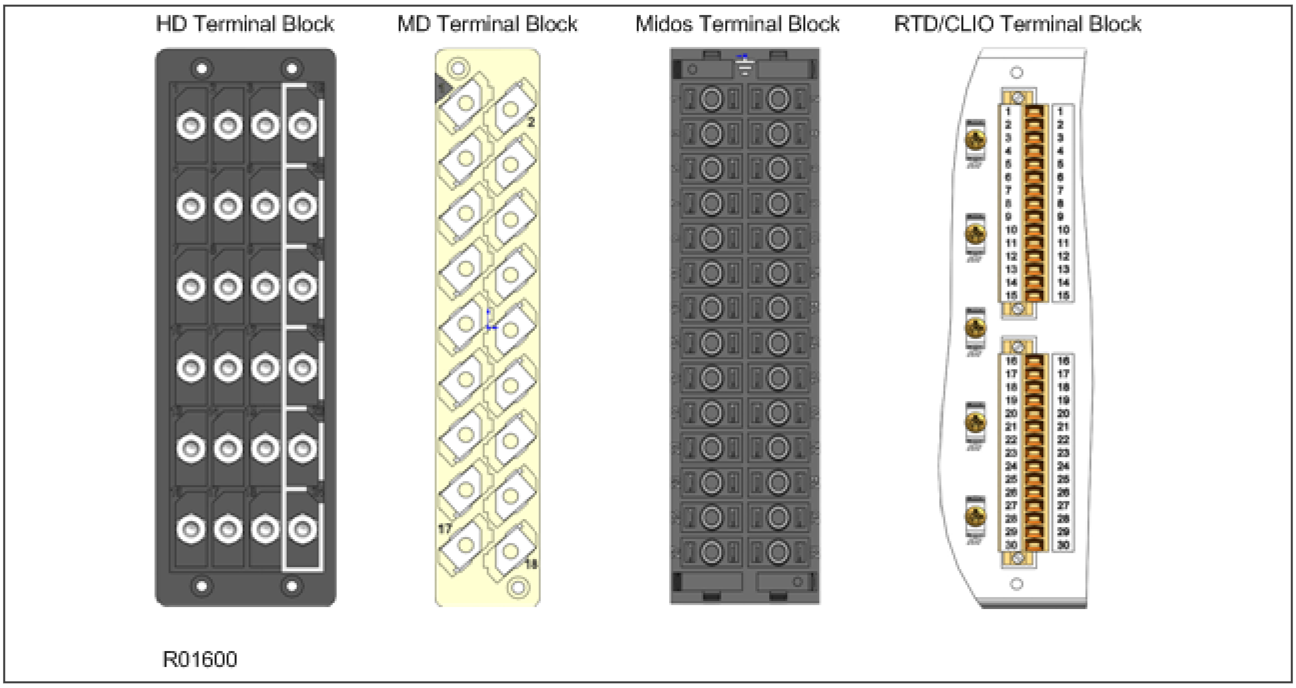


Figure 92: Terminal block types

MiCOM products 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 terminal.

If required, M4 90° crimp ring terminals can be supplied in three different sizes depending on wire size. Each type is available in bags of 100.

Part number	Wire size	Insulation color
ZB9124 901	0.25 - 1.65 mm^2 (22 – 16 AWG)	Red
ZB9124 900	1.04 - 2.63 mm^2 (16 – 14 AWG)	Blue
ZB9124 904	2.53 - 6.64 mm^2 (12 – 10 AWG)	Un-insulated

Warning:
For safety reasons always fit an insulating sleeve over the ring terminal.

4.2 POWER SUPPLY CONNECTIONS

These should be wired with 1.5 mm PVC insulated multi-stranded copper wire terminated with M4 ring terminals.

The wire should have a minimum voltage rating of 300 V RMS.

Caution:
Protect the auxiliary power supply wiring with a maximum 16 A high rupture capacity (HRC) type NIT or TIA fuse.

4.3 EARTH CONNNECTION

Every device must be connected to the cubicle earthing bar using the M4 earth terminal.

Use a wire size of at least 2.5 mm^2 terminated with a ring terminal.

Due to the physical limitations of the ring terminal, the maximum wire size you can use is 6.0 mm^2 using ring terminals that are not pre-insulated. If using pre insulated ring terminals, the maximum wire size is reduced to 2.63 mm^2 per ring terminal. If you need a greater cross-sectional area, use two wires in parallel, each terminated in a separate ring terminal.

The wire should have a minimum voltage rating of 300 V RMS.

Note:
To prevent any possibility of electrolytic action between brass or copper ground conductors and the rear panel of the product, precautions should be taken to isolate them from one another. This could be achieved in several ways, including placing a nickel-plated or insulating washer between the conductor and the product case, or using tinned ring terminals.

4.4 CURRENT TRANSFORMERS

Current transformers would generally be wired with 2.5 mm^2 PVC insulated multi-stranded copper wire terminated with M4 ring terminals.

Due to the physical limitations of the ring terminal, the maximum wire size you can use is 6.0 mm^2 using ring terminals that are not pre-insulated. If using pre insulated ring terminals, the maximum wire size is reduced to 2.63 mm^2 per ring terminal. If you need a greater cross-sectional area, use two wires in parallel, each terminated in a separate ring terminal.

The wire should have a minimum voltage rating of 300 V RMS.

Caution:
Current transformer circuits must never be fused.

Note:
If there are CTs present, spring-loaded shorting contacts ensure that the terminals into which the CTs connect are shorted before the CT contacts are broken.

Note:
For 5A CT secondaries, we recommend using 2 x 2.5 mm^2 PVC insulated multi-stranded copper wire.

4.5 VOLTAGE TRANSFORMER CONNECTIONS

Voltage transformers should be wired with 2.5 mm^2 PVC insulated multi-stranded copper wire terminated with M4 ring terminals.

The wire should have a minimum voltage rating of 300 V RMS.

4.6 WATCHDOG CONNECTIONS

These should be wired with 1 mm PVC insulated multi-stranded copper wire terminated with M4 ring terminals.

The wire should have a minimum voltage rating of 300 V RMS.

4.7 EIA(RS)485 AND K-BUS CONNECTIONS

For connecting the EIA(RS485) / K-Bus ports, use 2-core screened cable with a maximum total length of 1000 m or 200 nF total cable capacitance.

A typical cable specification would be:

- Each core: 16/0.2 mm^2 copper conductors, PVC insulated
- Nominal conductor area: 0.5 mm^2 per core
- Screen: Overall braid, PVC sheathed

To guarantee the performance specifications, you must ensure continuity of the screen, when daisy chaining the connections.

4.8 IRIG-B CONNECTION

The IRIG-B input and BNC connector have a characteristic impedance of 50 ohms. We recommend that connections between the IRIG-B equipment and the product are made using coaxial cable of type RG59LSF with a halogen free, fire retardant sheath.

4.9 OPTO-INPUT CONNECTIONS

These should be wired with 1 mm^2 PVC insulated multi-stranded copper wire terminated with M4 ring terminals.

Each opto-input has a selectable preset ½ cycle filter. This makes the input immune to noise induced on the wiring. This can, however slow down the response. If you need to switch off the ½ cycle filter, either use double pole switching on the input, or screened twisted cable on the input circuit.

Caution:
Protect the opto-inputs and their wiring with a maximum 16 A high rupture capacity (HRC) type NIT or TIA fuse.

4.10 OUTPUT RELAY CONNECTIONS

These should be wired with 1 mm PVC insulated multi-stranded copper wire terminated with M4 ring terminals.

4.11 ETHERNET METALLIC CONNECTIONS

If the device has a metallic Ethernet connection, it can be connected to either a 10Base-T or a 100Base-TX Ethernet hub. Due to noise sensitivity, we recommend this type of connection only for short distance connections, ideally where the products and hubs are in the same cubicle. For increased noise immunity, CAT 6 (category 6) STP (shielded twisted pair) cable and connectors can be used.

The connector for the Ethernet port is a shielded RJ-45. The pin-out is as follows:

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

4.12 ETHERNET FIBRE CONNECTIONS

We recommend the use of fibre-optic connections for permanent connections in a substation environment. The 100 Mbps fibre optic port uses type ST connectors (one for Tx and one for Rx), compatible with 50/125 µm or 62.5/125 µm multimode fibres at 1300 nm wavelength.

Note:
Note: For models equipped with redundant Ethernet connections the product must be partially dismantled to set the fourth octet of the second IP address. This ideally, should be done before installation.

4.13 RS232 CONNECTION

Short term connections to the EIA(RS)232 port, located behind the bottom access cover, 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 product end with a standard 9-pin D-type male connector.

4.14 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 4 m long. The cable should be terminated at the product end with a 25-pin D-type male connector.

4.15 GPS FIBRE CONNECTION

Some products use a GPS 1 PPS timing signal. If applicable, this is connected to a fibre-optic port on the coprocessor board in slot B. The fibre-optic port uses an ST type connector, compatible with fibre multimode 50/125 µm or 62.5/125 µm – 850 nm.

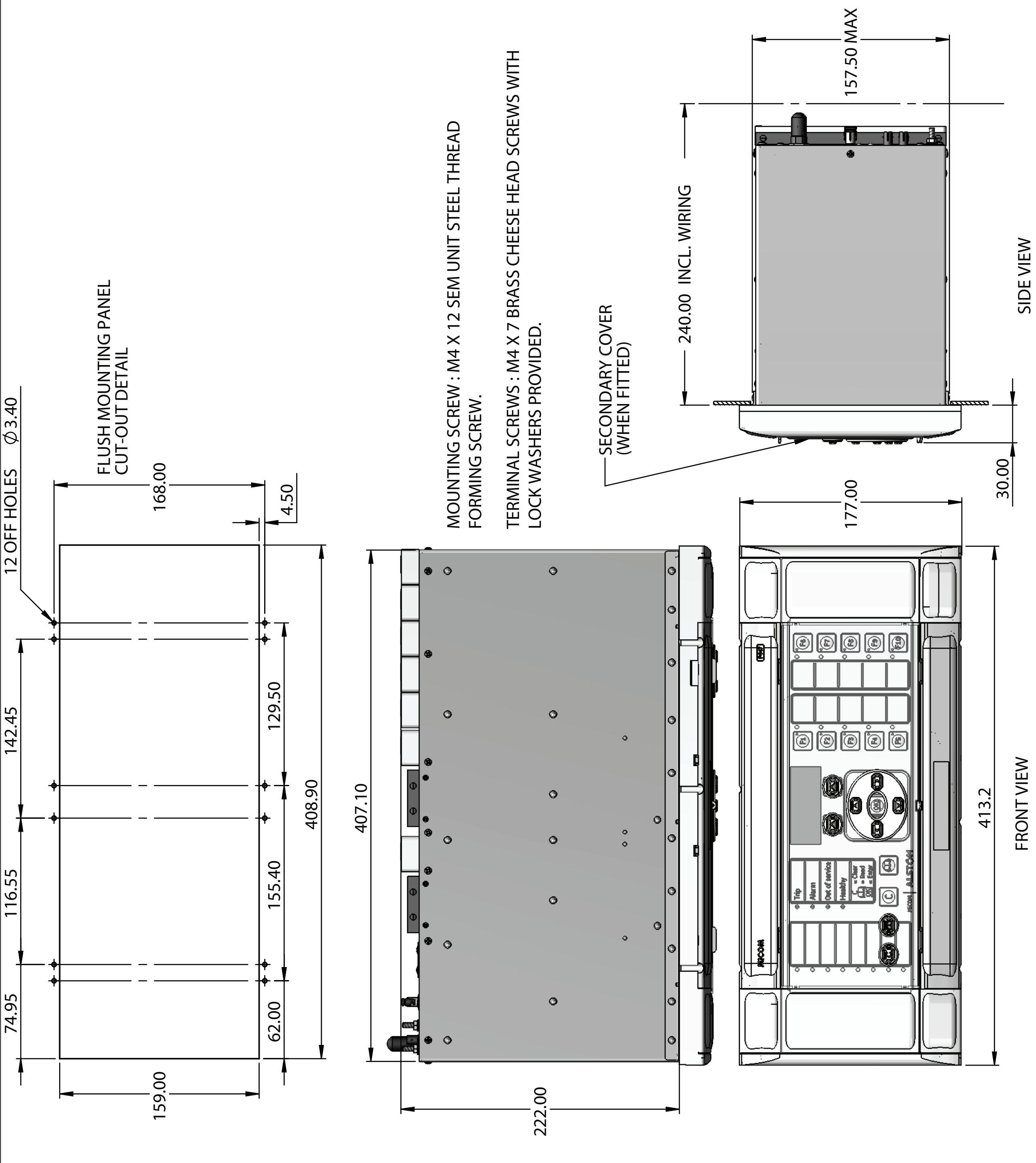
4.16 FIBRE COMMUNICATION CONNECTIONS

The fibre optic port consists of one or two channels using ST type connectors (one for Tx and one for Rx). The type of fibre used depends on the option selected.

850 nm and 1300 nm multimode systems use 50/125 µm or 62.5/125 µm multimode fibres. 1300 nm and 1550 nm single mode systems use 9/125 µm single mode fibres.

5 CASE DIMENSIONS

5.1 CASE DIMENSIONS 80TE



E01410

Figure 93: 80TE case dimensions

COMMISSIONING INSTRUCTIONS

CHAPTER 14

1 CHAPTER OVERVIEW

This chapter contains the following sections:

2 GENERAL GUIDELINES

Alstom Grid IEDs are self-checking devices and will raise an alarm in the unlikely event of a failure. This is why the commissioning tests are less extensive than those for non-numeric electronic devices or electro-mechanical relays.

To commission the devices, you (the commissioning engineer) do not need to test every function. You need only verify that the hardware is functioning correctly and that the application-specific software settings have been applied. You can check the settings by extracting them using the settings application software, or by means of the front panel interface (HMI panel).

The menu language is user-selectable, so you can change it for commissioning purposes if required.

Note:
Remember to restore the language setting to the customer's preferred language on completion.

Caution:
Before carrying out any work on the equipment you should be familiar with the contents of the Safety Section or Safety Guide SFTY/4LM as well as the ratings on the equipment's rating label.

Warning:
With the exception of the CT shorting contacts check, do not disassemble the device during commissioning.

3 COMMISSIONING TEST MENU

The IED provides several test facilities under the *COMMISSION TESTS* menu heading. There are menu cells that allow you to monitor the status of the opto-inputs, output relay contacts, internal Digital Data Bus (DDB) signals and user-programmable LEDs. This section describes these commissioning test facilities.

3.1 OPTO I/P STATUS CELL (OPTO-INPUT STATUS)

This cell can be used to monitor the status of the opto-inputs while they are sequentially energised with a suitable DC voltage. The cell is a binary string that displays the status of the opto-inputs where '1' means energised and '0' means de-energised. If you move the cursor along the binary numbers, the corresponding label text is displayed for each logic input.

3.2 RELAY O/P STATUS CELL (RELAY OUTPUT STATUS)

This cell can be used to monitor the status of the relay outputs. The cell is a binary string that displays the status of the relay outputs where '1' means energised and '0' means de-energised. If you move the cursor along the binary numbers, the corresponding label text is displayed for each relay output.

The cell indicates the status of the output relays when the IED is in service. You can check for relay damage by comparing the status of the output contacts with their associated bits.

> *Note:*
> *When the Test Mode cell is set to Contacts Blocked, the relay output status indicates which contacts would operate if the IED was in-service. It does not show the actual status of the output relays, as they are blocked.*

3.3 TEST MODE CELL

This cell allows you to perform secondary injection testing. It also lets you test the output contacts directly by applying menu-controlled test signals.

To go into test mode, select the `Test Mode` option in the ***Test Mode*** cell. This takes the IED out of service causing an alarm condition to be recorded and the ***Out of Service*** LED to illuminate. This also freezes any information stored in the *CB CONDITION* column. In IEC 60870-5-103 versions, it changes the Cause of Transmission (COT) to Test Mode.

In Test Mode, the output contacts are still active. To disable the output contacts you must select the `Contacts Blocked` option

Once testing is complete, return the device back into service by setting the ***Test Mode*** Cell back to `Disabled`.

> **Caution:**
> **When the cell is in Test Mode, the Scheme Logic still drives the output relays, which could result in tripping of circuit breakers. To avoid this, set the *Test Mode* cell to `Contacts Blocked`.**

> *Note:*
> `Test mode` *and* `Contacts Blocked` *mode can also be selected by energising an opto-input mapped to the Test Mode signal, and the Contact Block signal respectively.*

3.4 TEST PATTERN CELL

The ***Test Pattern*** cell is used to select the output relay contacts to 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 and '0' to not operate it.

3.5 CONTACT TEST CELL

When the `Apply Test` command in this cell is issued, the contacts set for operation change state. Once 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 by issuing the `Remove Test` command. The command text on the LCD will show ***No Operation*** after the `Remove Test` command has been issued.

> *Note:*
> *When the **Test Mode** cell is set to `Contacts Blocked` the **Relay O/P Status** cell does not show the current status of the output relays and therefore cannot be used to confirm operation of the output relays. Therefore it will be necessary to monitor the state of each contact in turn.*

3.6 TEST LEDS CELL

When the `Apply Test` command in this cell is issued, the user-programmable LEDs illuminate for approximately 2 seconds before switching off, and the command text on the LCD reverts to ***No Operation***.

3.7 RED AND GREEN LED STATUS CELLS

These cells contain binary strings that indicate which of the user-programmable red and green LEDs are illuminated when accessing from a remote location. A '1' indicates that a particular LED is illuminated.

> *Note:*
> *When the status in both Red LED Status and Green LED Status cells is ‘1’, this indicates the LEDs illumination is yellow.*

3.8 PSL VERIFICIATION

3.8.1 TEST PORT STATUS CELL

This cell displays the status of the DDB signals that have been allocated in the ***Monitor Bit*** cells. If you move the cursor along the binary numbers, the corresponding DDB signal text string is 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 IED. This allows you to test the Programmable Scheme Logic (PSL).

3.8.2 MONITOR BIT 1 TO 8 CELLS

The eight Monitor Bit cells allows you to select eight DDB signals that can be observed in the Test Port Status cell or downloaded via the front port.

Each Monitor Bit cell can be assigned to a particular DDB signal. You set it by entering the required DDB signal number from the list of available DDB signals.

The pins of the monitor/download port used for monitor bits are as follows:

Monitor Bit	1	2	3	4	5	6	7	8

Monitor/Download Port Pin	11	12	15	13	20	21	23	24

The signal ground is available on pins 18, 19, 22 and 25.

Caution:
The monitor/download port is not electrically isolated against induced voltages on the communications channel. It should therefore only be used for local communications.

3.8.3 USING A MONITOR PORT TEST BOX

A test box containing eight LEDs and a switchable audible indicator is available. It is housed in a small plastic box with a 25-pin male D-connector that plugs directly into the monitor/download port. There is also a 25-pin female D-connector which allows other connections to be made to the monitor/download port while the monitor/download port test box is in place.

Each LED corresponds to one of the monitor bit pins on the monitor/download port. ***Monitor Bit 1*** is on the left-hand side when viewed from the front of the IED. The audible indicator can be selected to sound if a voltage appears on any of the eight monitor pins. Alternatively it can be set to remain silent, using only the LEDs.

4 COMMISSIONING EQUIPMENT

4.1 MINIMUM EQUIPMENT REQUIRED

As a minimum, the following equipment is required:

- Multifunctional current and voltage injection test set (where applicable)
- Multimeter with suitable AC current range, and DC voltage ranges of 0 - 440 V and 0 - 250 V respectively
- Continuity tester
- A portable PC, installed with appropriate software

4.2 OPTIONAL EQUIPMENT REQUIRED

- Multi-finger test plug:
  - P992 for test block type P991
  - MMLB for test block type MMLG blocks
- Electronic or brushless insulation tester with a DC output not exceeding 500 V
- KITZ K-Bus - EIA(RS)232 protocol converter for testing EIA(RS)485 K-Bus port, if applicable
- EIA(RS)485 to EIA(RS)232 converter for testing EIA(RS)485 Courier/MODBUS/IEC60870-5-103/ DNP3 port, if applicable
- A portable printer (for printing a setting record from the portable PC).
- Phase angle meter (where applicable)
- Phase rotation meter
- Fibre optic power meter (where applicable)
- Fibre optic test leads (where applicable)

5 PRODUCT CHECKS

These product checks are designed to ensure that the device has not been physically damaged prior to commissioning, is functioning correctly and that all input quantity measurements are within the stated tolerances.

If the application-specific settings have been applied to the IED prior to commissioning, you should make a copy of the settings. This will allow you to restore them at a later date if necessary. This can be done by:

- Obtaining a setting file from the customer.
- Extracting the settings from the IED itself, using a portable PC with appropriate setting software.

If the customer has changed the password that prevents unauthorised changes to some of the settings, either the revised password should be provided, or the original password restored before testing.

Note:
If the password has been lost, a recovery password can be obtained from Alstom Grid.

5.1 PRODUCT CHECKS WITH THE IED DE-ENERGISED

Warning:
The following group of tests should be carried out without the auxiliary supply being applied to the IED and, if applicable, with the trip circuit isolated.

The current and voltage transformer connections must be isolated from the IED for these checks. If a P991 test block is provided, the required isolation can be achieved by inserting test plug type P992. This open circuits all wiring routed through the test block.

Before inserting the test plug, you should check the scheme diagram to ensure that this will not cause damage or a safety hazard (the test block may, for example, be associated with protection current transformer circuits). The sockets in the test plug, which correspond to the current transformer secondary windings, must be linked before the test plug is inserted into the test block.

Warning:
Never open-circuit the secondary circuit of a current transformer since the high voltage produced may be lethal and could damage insulation.

If a test block is not provided, the voltage transformer supply to the IED should be isolated by means of the panel links or connecting blocks. The line current transformers should be short-circuited and disconnected from the IED terminals. Where means of isolating the auxiliary supply and trip circuit (for example isolation links, fuses and MCB) are provided, these should be used. If this is not possible, the wiring to these circuits must be disconnected and the exposed ends suitably terminated to prevent them from being a safety hazard.

5.1.1 VISUAL INSPECTION

Warning:
Check the rating information under the top access cover on the front of the IED.

Warning:
Check that the IED being tested is correct for the line or circuit.

Warning:
Record the circuit reference and system details.

Warning:
Check the CT secondary current rating and record the CT tap which is in use.

Carefully examine the IED to see that no physical damage has occurred since installation.

Ensure that the case earthing connections (bottom left-hand corner at the rear of the IED case) are used to connect the IED to a local earth bar using an adequate conductor.

5.1.2 CURRENT TRANSFORMER SHORTING CONTACTS

Check the current transformer shorting contacts to ensure that they close when the heavy-duty terminal block is disconnected from the current input board.

The heavy-duty terminal blocks are fastened to the rear panel using four crosshead screws. These are located two at the top and two at the bottom.

Note:
Use a magnetic bladed screwdriver to minimise the risk of the screws being left in the terminal block or lost.

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.

5.1.3 INSULATION

Insulation resistance tests are only necessary during commissioning if explicitly requested.

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 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 IED.

5.1.4 EXTERNAL WIRING

Caution:
Check that the external wiring is correct according to the relevant IED and scheme diagrams. Ensure that phasing/phase rotation appears to be as expected.

5.1.5 WATCHDOG CONTACTS

Using a continuity tester, check that the Watchdog contacts are in the following states:

Terminals	De-energised contact
11 - 12 on power supply board	Closed
13 - 14 on power supply board	Open

5.1.6 POWER SUPPLY

Depending on its nominal supply rating, the IED can be operated from either a DC only or an AC/DC auxiliary supply. The incoming voltage must be within the operating range specified below.

Without energising the IED measure the auxiliary supply to ensure it is within the operating range.

Nominal supply rating DC (AC RMS)		DC operating range	AC operating range
24 - 54 V	N/A	19 to 65 V	N/A
48 - 125 V	30 - 100 V	37 to 150 V	24 - 110 V
110 - 250 V	100 - 240 V	87 to 300 V	80 to 265 V

Note:
The IED can withstand an ac ripple of up to 12% of the upper rated voltage on the dc auxiliary supply.

Warning:
Do not energise the IED or interface unit using the battery charger with the battery disconnected as this can irreparably damage the power supply circuitry.

Caution:
Energise the IED only if the auxiliary supply is within the specified operating ranges. 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 IED.

5.2 PRODUCT CHECKS WITH THE IED ENERGISED

Warning:
The current and voltage transformer connections must remain isolated from the IED for these checks. The trip circuit should also remain isolated to prevent accidental operation of the associated circuit breaker.

The following group of tests verifies that the IED hardware and software is functioning correctly and should be carried out with the supply applied to the IED.

5.2.1 WATCHDOG CONTACTS

Using a continuity tester, check that the Watchdog contacts are in the following states:

Terminals	De-energised contact
11 - 12 on power supply board	Open
13 - 14 on power supply board	Closed

5.2.2 TEST LCD

The Liquid Crystal Display (LCD) is designed to operate in a wide range of substation ambient temperatures. For this purpose, the IEDs have an ***LCD Contrast*** setting. The contrast is factory pre-set, but it may be necessary to adjust the contrast to give the best in-service display.

To change the contrast, you can increment or decrement the ***LCD Contrast*** cell in the *CONFIGURATION* column.

Caution:
Before applying a contrast setting, make sure that it will not make the display so light or dark such that menu text becomes unreadable. It is possible to restore the visibility of a display by downloading a setting file, with the LCD Contrast set within the typical range of 7 - 11.

5.2.3 DATE AND TIME

The date and time is stored in memory, which is backed up by an auxiliary battery situated at the front of the device behind the lower access cover. When delivered, this battery is isolated to prevent battery drain during transportation and storage.

Before setting the date and time, ensure that the isolation strip has been removed. With the lower access cover open, the battery isolation strip can be identified by a red tab protruding from the positive side of the battery compartment. Press on the battery lightly, to prevent it from falling out of the battery compartment, then pull the red tab to remove the isolation strip.

The date and time should now be set to the correct values. The method of setting will depend on whether accuracy is being maintained by the IRIG-B port at the rear, or by the IED's internal clock.

Note:
If the auxiliary supply fails, the time and date will be maintained by the auxiliary battery. Therefore, when the auxiliary supply is restored, you should not have to set the time and date again. To test this, remove the IRIG-B signal, and then remove the auxiliary supply. Leave the device de-energised for approximately 30 seconds. On re energization, the time should be correct.

When using IRIG-B to maintain the clock, the IED must first be connected to the satellite clock equipment (usually a P594), which should be energised and functioning.

1. Set the IRIG-B Sync cell in the *DATE AND TIME* column to `Enabled`.
2. Ensure the IED is receiving the IRIG-B signal by checking that cell IRIG-B Status reads `Active`.

3. Once the IRIG-B signal is active, adjust the time offset of the universal co coordinated time (satellite clock time) on the satellite clock equipment so that local time is displayed.
4. Check that the time, date and month are correct in the Date/Time cell. The IRIG-B signal does not contain the current year so it will need to be set manually in this cell.
5. Reconnect the IRIG-B signal.

If the time and date is not being maintained by an IRIG-B signal, ensure that the IRIG-B Sync cell in the *DATE AND TIME* column is set to `Disabled`.

1. Set the date and time to the correct local time and date using Date/Time cell or using the serial protocol.

5.2.4 TEST LEDS

On power-up, all LEDs should first flash yellow. Following this, the green "Healthy" LED should illuminate indicating that the device is healthy.

The IED's non-volatile memory stores the states of the alarm, the trip, and the user-programmable LED indicators (if configured to latch). These indicators may also illuminate when the auxiliary supply is applied.

If any of these LEDs are ON then they should be reset before proceeding with further testing. If the LEDs successfully reset (the LED goes off), no testing is needed for that LED because it is obviously operational.

5.2.5 TEST ALARM AND OUT-OF-SERVICE LEDS

The alarm and out of service LEDs can be tested using the *COMMISSION TESTS* menu column.

1. Set the ***Test Mode*** cell to `Contacts Blocked`.
2. Check that the out of service LED illuminates continuously and the alarm LED flashes.

It is not necessary to return the ***Test Mode*** cell to `Disabled` at this stage because the test mode will be required for later tests.

5.2.6 TEST TRIP LED

The trip LED can be tested by initiating a manual circuit breaker trip. However, the trip LED will operate during the setting checks performed later. Therefore no further testing of the trip LED is required at this stage.

5.2.7 TEST USER-PROGRAMMABLE LEDS

To test these LEDs, set the Test LEDs cell to `Apply Tes`t. Check that all user-programmable LEDs illuminate.

5.2.8 TEST OPTO-INPUTS

This test checks that all the opto-inputs on the IED are functioning correctly.

The opto-inputs should be energised one at a time. For terminal numbers, please see the external connection diagrams in the "Wiring Diagrams" chapter. Ensuring correct polarity, connect the supply voltage to the appropriate terminals for the input being tested.

The status of each opto-input can be viewed using either the ***Opto I/P Status*** cell in the *SYSTEM DATA* column, or the ***Opto I/P Status*** cell in the *COMMISSION TESTS* column.

A '1' indicates an energised input and a '0' indicates a de-energised input. When each opto-input is energised, one of the characters on the bottom line of the display changes to indicate the new state of the input.

If you are using the Settings Application Software tool you can check the physical changes of the equipment status directly in your topology scheme.

5.2.9 TEST OUTPUT RELAYS

This test checks that all the output relays are functioning correctly.

1. Ensure that the IED is still in test mode by viewing the Test Mode cell in the *COMMISSION TESTS* column. Ensure that it is set to `Blocked`.
2. The output relays should be energised one at a time. To select output relay 1 for testing, set the Test Pattern cell as appropriate.
3. Connect a continuity tester across the terminals corresponding to output relay 1 as shown in the external connection diagram.
4. To operate the output relay set the Contact Test cell to `Apply Test`.
5. Check the operation with the continuity tester.
6. Measure the resistance of the contacts in the closed state.
7. Reset the output relay by setting the Contact Test cell to `Remove Test`.
8. Repeat the test for the remaining output relays.
9. Return the IED to service by setting the Test Mode cell in the *COMMISSION TESTS* menu to `Disabled`.

5.2.10 TEST SERIAL COMMUNICATION PORT RP1

You need only perform this test if the IED is to be accessed from a remote location. The test will vary depending on the communications protocol used.

It is not the intention of this test to verify the operation of the complete communication link between the IED and the remote location, just the IED's rear communication port and, if applicable, the protocol converter.

5.2.10.1 CHECK PHYSICAL CONNECTIVITY

The rear communication port RP1 is presented on terminals 16, 17 and 18 of the power supply terminal block. Screened twisted pair cable is used to make a connection to the port. The cable screen should be connected to pin 16 and pins 17 and 18 are for the communication signal:

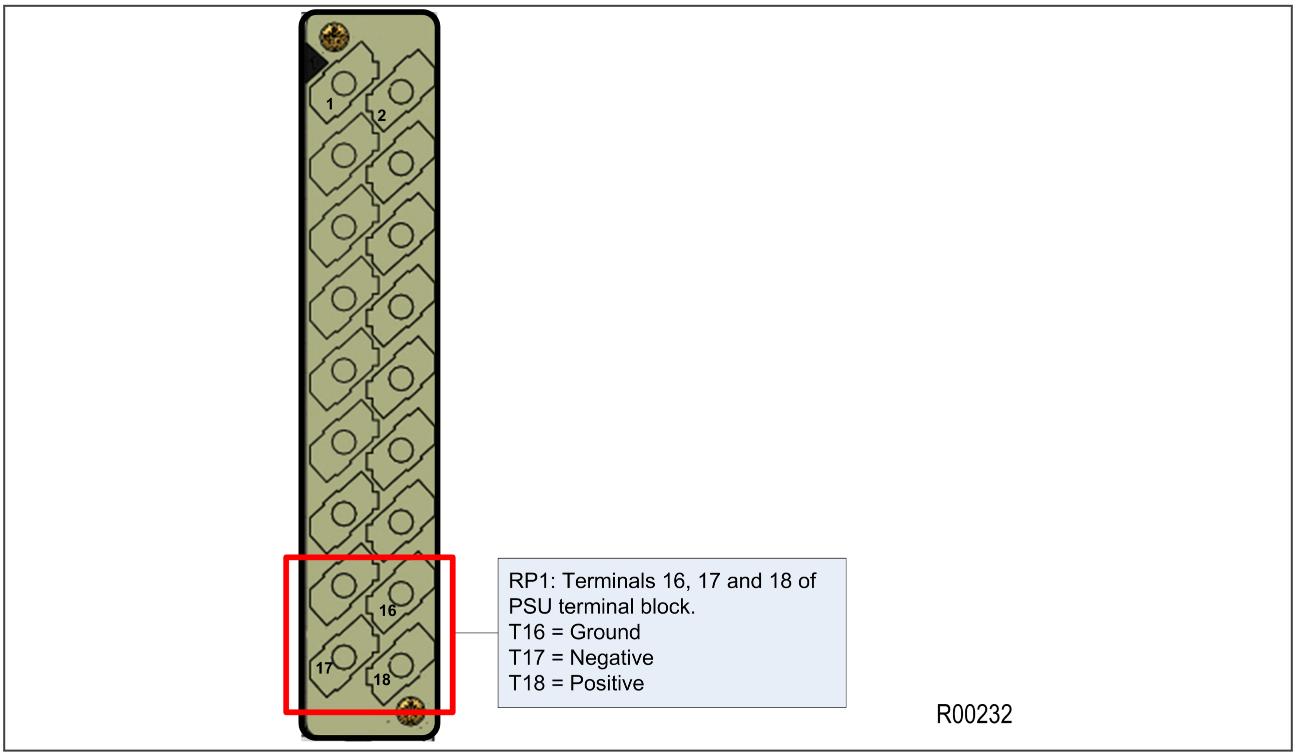


Figure 94: RP1 physical connection

For K-Bus applications, pins 17 and 18 are not polarity sensitive and it does not matter which way round the wires are connected. EIA(RS)485 is polarity sensitive, so you must ensure the wires are connected the correct way round (pin 18 is positive, pin 17 is negative).

If K-Bus is being used, a Kitz protocol converter (KITZ101, KITZ102 OR KITZ201) will have been installed to convert the K-Bus signals into RS232. Likewise, if RS485 is being used, an RS485-RS232 converter will have been installed. In the case where a protocol converter is being used, a laptop PC running appropriate software (such as MiCOM S1 Agile) can be connected to the incoming side of the protocol converter. An example for K-bus to RS232 conversion is shown below. RS485 to RS232 would follow the same principle, only using a RS485-RS232 converter. Most modern laptops have USB ports, so it is likely you will also require a RS232 to USB converter too.

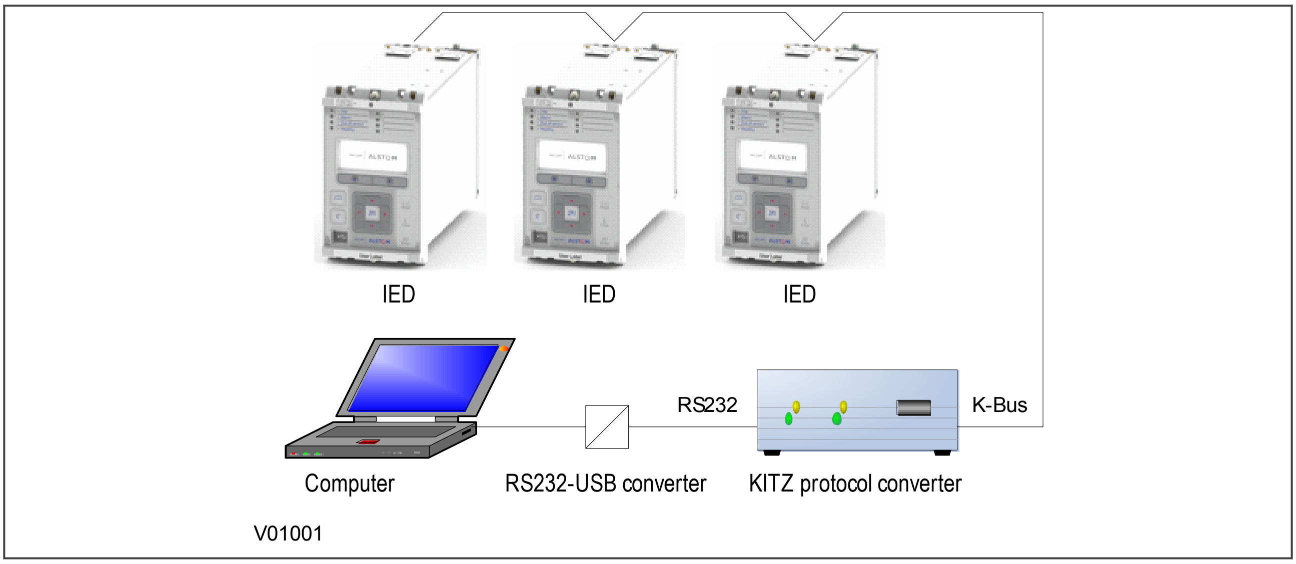


Figure 95: Remote communication using K-bus

Fibre Connection

Some models have an optional fibre optic communications port fitted (on a separate communications board). The communications port to be used is selected by setting the Physical Link cell in the *COMMUNICATIONS* column, the values being `Copper` or `K-Bus` for the RS485/K-bus port and `Fibre Optic` for the fibre optic port.

5.2.10.2 CHECK LOGICAL CONNECTIVITY

The logical connectivity depends on the chosen data protocol, but the principles of testing remain the same for all protocol variants:

1. Ensure that the communications baud rate and parity settings in the application software are set the same as those on the protocol converter.
2. For Courier models, ensure that you have set the correct RP1 address
3. Check that communications can be established with this IED using the portable PC/Master Station.

5.2.11 TEST SERIAL COMMUNICATION PORT RP2

RP2 is an optional second serial port board providing additional serial connectivity. It provides two 9-pin D-type serial port connectors SK4 and SK5. SK4 can be configured as an EIA(RS232), EIA(RS485), or K-Bus connection for Courier protocol only, whilst SK5 is fixed to EIA(RS)232 for InterMiCOM signalling only.

It is not the intention of this test to verify the operation of the complete communication link between the IED and the remote location, just the IED's rear communication port and, if applicable, the protocol converter.

The only checks that need to be made are as follows:

1. Set the ***RP2 Port Config*** cell in the *COMMUNICATIONS* column to the required physical protocol; (K-Bus, EIA(RS)485, or EIA(RS)232.
2. Set the IED's Courier address to the correct value (it must be between 1 and 254).

5.2.12 TEST ETHERNET COMMUNICATION

For products that employ Ethernet communications, we recommend that testing be limited to a visual check that the correct ports are fitted and that there is no sign of physical damage.

5.2.13 TEST CURRENT INPUTS

This test verifies that the current measurement inputs are configured correctly.

All devices leave the factory set for operation at a system frequency of 50 Hz. If operation at 60 Hz is required then this must be set in the Frequency cell in the *SYSTEM DATA* column.

1. Apply and measure nominal rated current to each CT in turn.
2. Check its magnitude using a multi-meter or test set readout. The corresponding reading can then be checked in the *MEASUREMENTS 1* column.
3. Record the displayed value. The measured current values will either be in primary or secondary Amperes. If the Local Values cell in the *MEASURE'T SETUP* column 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* column). If the Local Values cell is set to Secondary, the value displayed should be equal to the applied current.

> *Note:*
> *If a PC connected to the IED using the rear communications port is being used to display the measured current, the process will be similar. However, the setting of the Remote Values cell in the MEASURE'T SETUP column will determine whether the displayed values are in primary or secondary Amperes.*

The measurement accuracy of the IED is +/- 1%. However, an additional allowance must be made for the accuracy of the test equipment being used.

5.2.14 TEST VOLTAGE INPUTS

This test verifies that the voltage measurement inputs are configured correctly.

1. Apply rated voltage to each voltage transformer input in turn
2. Check its magnitude using a multimeter or test set readout. The corresponding reading can then be checked in the *MEASUREMENTS 1* column.
3. Record the value displayed. The measured voltage values will either be in primary or secondary Volts. If the Local Values cell in the *MEASURE'T SETUP* column is set to 'Primary', the values displayed should be equal to the applied voltage multiplied by the corresponding voltage transformer ratio (set in the *CT AND VT RATIOS* column). If the Local Values cell is set to Secondary, the value displayed should be equal to the applied voltage.

> *Note:*
> *If a PC connected to the IED using the rear communications port is being used to display the measured current, the process will be similar. However, the setting of the Remote Values cell in the MEASURE'T SETUP column will determine whether the displayed values are in primary or secondary Amperes.*

The measurement accuracy of the IED is +/- 1%. However, an additional allowance must be made for the accuracy of the test equipment being used.

6 SETTING CHECKS

The setting checks ensure that all of the application-specific settings (both the IED's function and programmable scheme logic settings) have been correctly applied.

> *Note:*
> *If applicable, the trip circuit should remain isolated during these checks to prevent accidental operation of the associated circuit breaker.*

6.1 APPLY APPLICATION-SPECIFIC SETTINGS

There are two different methods of applying the settings to the IED

- Transferring settings to the IED from a pre-prepared setting file using MiCOM S1 Agile
- Enter the settings manually using the IED's front panel HMI

6.1.1 TRANSFERRING SETTINGS FROM A SETTINGS FILE

This is the preferred method for transferring function settings. It is much faster and there is a lower margin for error.

1. Connect a PC running the Settings Application Software to the IED's front port. This could be serial RS232 or USB depending on the product. Alternatively connect to a rear Courier communications port, using a KITZ protocol converter if necessary.
2. Power on the IED
3. Right-click the appropriate device name in the System Explorer pane and select **Send**
4. In the **Send to** dialog select the setting files and click **Send**

> *Note:*
> *The device name may not already exist in the system shown in **System Explorer**. In this case, perform a **Quick Connect** to the IED, then manually add the settings file to the device name in the system. Refer to the Settings Application Software help for details of how to do this.*

6.1.2 ENTERING SETTINGS USING THE HMI

It is not possible to change the PSL using the IED's front panel HMI.

1. Starting at the default display, press the Down cursor key to show the first column heading.
2. Use the horizontal cursor keys to select the required column heading.
3. Use the vertical cursor keys to view the setting data in the column.
4. To return to the column header, either press the Up cursor key for a second or so, or press the **Cancel** key once. It is only possible to move across columns at the column heading level.
5. To return to the default display, press the Up cursor key or the Cancel key from any of the column headings. If you use the auto-repeat function of the Up cursor 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. 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 that the value can be changed. You may be prompted for a password first.
7. To change the setting value, press the vertical cursor 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 left and right cursor keys.

8. Press the **Enter** key to confirm the new setting value or the **Clear** key to discard it. The new setting is automatically discarded if it is not confirmed within 15 seconds.
9. For protection group settings and disturbance recorder settings, the changes must be confirmed before they are used. When all required changes have been entered, return to the column heading level and press the down cursor key. Before returning to the default display, the following prompt appears.

```
Update settings?
ENTER or CLEAR
```

10. Press the **Enter** key to accept the new settings or press the **Clear** key 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.*
> *It is not possible to change the PSL using the IED's front panel HMI.*

Caution:
Where the installation needs application-specific PSL, the relevant .psl files, must be transferred to the IED, for each and every setting group that will be used. If you do not do this, the factory default PSL will still be resident. This may have severe operational and safety consequences.

7 BUSBAR PROTECTION CHECKS

There is no need to check every protection function. However, it is necessary to test both a simple protection function on one feeder and the complete system.

It is important to use the correct configuration topology and test specification. The test specification must also be complete. Otherwise an inadvertent or false trip and damage to numerous circuits can result.

7.1 BUSBAR DIFFERENTIAL PROTECTION CHECKS

The number of different tests you need to perform can increase with the complexity of the topology.

1. Check for any possible dependency conditions and simulate as appropriate.
2. In the *CONFIGURATION* column, disable all protection elements other than the one being tested.
3. Make a note of which elements need to be re-enabled after testing.
4. Connect the test circuit according to the diagram.
5. Perform the test according to the specifications.
6. Check the operating time.

> *Note:*
> *If you use the busbar differential protection function, we advise that you also use test switches. These are used in each output circuit and in the coil of the lockout relay to control multiple breakers. The test switches ensure there is no inadvertent trip when removing the relay from service or returning it to service.*

7.2 CONNECTING THE TEST CIRCUIT

Use the PSL to determine which output relay operates when a busbar differential trip occurs.

1. Use the output relay assigned to ***IDIFF_TRIP***.
2. Use the PSL to map the protection stage under test directly to an output relay.

> *Note:*
> *If using the default PSL, use output relay 11 as this is already mapped to the DDB signal **IDIFF_TRIP**.*

1. Connect the output relay so that it trips the test set and stops the timer.
2. Connect the current output of the test set to the CT inputs of the phases and terminals according to the test specifications.
3. Ensure that the timer starts when the current is applied.

> *Note:*
> *If the timer does not stop when the current applied is greater than stage ID>1, the connections may be incorrect or the function could be blocked.*

7.3 PERFORMING THE TEST

1. Ensure the timer is reset.
2. Apply a current of twice the setting shown in the ***I>1 Current*** cell in the *DIFF PROTECTION* column.
3. Note the time displayed when the timer stops.
4. Check the red trip LED is on.

7.4 CHECK THE OPERATING TIME

Check that the operating time recorded by the timer is within the setting in the ***tDiff*** cell. Allowance must be made for the accuracy of the test equipment being used.

Note:
For Definite Time characteristics there is an additional delay of up to 0.02 seconds. You may need to add this the IED's acceptable range of operating times.

Caution:
On completion of the tests, you must restore all settings to customer specifications.

8 ONLOAD CHECKS

Onload checks can only be carried out if there are no restrictions preventing the energisation of the plant, and the other devices in the group have already been commissioned.

Remove all test leads and temporary shorting links, then replace any external wiring that has been removed to allow testing.

Warning:
If any external wiring has been disconnected for the commissioning process, replace it in accordance with the relevant external connection or scheme diagram.

8.1 CONFIRM CURRENT CONNECTIONS

1. Measure the current transformer secondary values for each input using a multimeter connected in series with the corresponding current input.
2. 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 centre.
3. Ensure the current flowing in the neutral circuit of the current transformers is negligible.
4. Compare the values of the secondary phase currents and phase angle with the measured values, which can be found in the *MEASUREMENTS 1* column.

If the ***Local Values*** cell is set to `Secondary`, the values displayed should be equal to the applied secondary voltage. The values should be within 1% of the applied secondary voltages. However, an additional allowance must be made for the accuracy of the test equipment being used.

If the ***Local Values*** cell 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* column. The values should be within 1% of the expected values, plus an additional allowance for the accuracy of the test equipment being used.

8.2 CONFIRM VOLTAGE CONNECTIONS

1. Using a multimeter, measure the voltage transformer secondary voltages to ensure they are correctly rated.
2. Compare the values of the secondary phase voltages with the measured values, which can be found in the *MEASUREMENTS 1* menu column.

Cell in MEASUREMENTS 1 Column	Corresponding VT ratio in CT/VT RATIOS column
VXN MAGNITUDE Z1 *VXN MAGNITUDE Z2* *VXN MAGNITUDE Z3* *VXN MAGNITUDE Z4*	Main VT Primary / Main VT Sec'y

If the ***Local Values*** cell is set to `Secondary`, the values displayed should be equal to the applied secondary voltage. The values should be within 1% of the applied secondary voltages. However, an additional allowance must be made for the accuracy of the test equipment being used.

If the ***Local Values*** cell 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* column. The values should be within 1% of the expected values, plus an additional allowance for the accuracy of the test equipment being used.

8.3 ON-LOAD BUSBAR DIFFERENTIAL TEST

This test ensures the busbar differential protection function has the correct load conditions. For this test you must first know the actual direction of current flow in the complete system. If you do not already know this, you must determine it using adjacent instrumentation or protection already in-service.

For a differential load current flowing in zone x, the ***Ix Zx Diff*** cell in the *MEASUREMENTS 2* column should show a value near 0 (where x=zone 1 to 4).

If there is any uncertainty, check the phase angles of the phase currents and the status of all equipment in the topology. Also confirm the correct terminal connections in their respective zones.

9 FINAL CHECKS

1. Remove all test leads and temporary shorting leads.
2. If you have had to disconnect any of the external wiring in order to perform the wiring verification tests, replace all wiring, fuses and links in accordance with the relevant external connection or scheme diagram.
3. The settings applied should be carefully checked against the required application-specific settings to ensure that they are correct, and have not been mistakenly altered during testing.
4. Ensure that all protection elements required have been set to ***Enabled*** in the *CONFIGURATION* column.
5. Ensure that the IED has been restored to service by checking that the ***Test Mode*** cell in the *COMMISSION TESTS* column is set to 'Disabled'.
6. If the IED 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 the ***Reset All Values*** cell. If the required access level is not active, the device will prompt for a password to be entered so that the setting change can be made.
7. If the menu language has been changed to allow accurate testing it should be restored to the customer's preferred language.
8. If a P991/MMLG test block is installed, remove the P992/MMLB test plug and replace the cover so that the protection is put into service.
9. Ensure that all event records, fault records, disturbance records, alarms and LEDs and communications statistics have been reset.

> *Note:*
> *Remember to restore the language setting to the customer's preferred language on completion.*

10 COMMISSIONING TEST SETTINGS

Courier Text	Col	Row	Default Setting	Available Options
Description				
COMMISSION TESTS	0F	00		
This column contains settings for the commissioning tests setup				
Opto I/P Status	0F	01		Not Settable
This cell displays the status of the fist set of available opto-inputs.				
Opto I/P Status2	0F	02		Not Settable
This cell displays the status of the second set of available opto-inputs.				
Relay O/P Status	0F	03		Not Settable
This cell displays the status of the available output relays.				
Test Port Status	0F	05		Not Settable
This cell displays the logic state of the DDB signals that have been allocated in the ***Monitor Bit*** cells.				
Monitor Bit 1 to 8	0F	07 to 0E	64 to 71	From 0 to 2047 step 1
The 'Monitor Bit' cells allow you to select which DDB signals can be observed in the ***Test Port Status*** cell.				
Test Mode	0F	0F	Disabled	0 = Disabled, 1 = Test Mode, 2 = Contacts Blocked
This setting allows the test pattern to be sent in the GOOSE message. Using *Pass Through*, the data in the GOOSE message is sent as normal. Using *Forced*, the data sent in the GOOSE message follows the ***VOP Test Pattern*** setting.				
Test Pattern	0F	10	0	Binary flag (data type G9) 0=Not Operated 1=Operated
This cell is used to select the output relay contacts to be tested when the ***Contact Test*** cell is set to *Apply Test*.				
Contact Test	0F	11	No Operation	0 = No Operation, 1 = Apply Test, 2 = Remove Test
This cell is used to test the output relays.				
Test LEDs	0F	12	No Operation	0 = No Operation or 1 = Apply Test
This cell is used to test the user-programmable LEDs. The *Apply Test* setting forces the LEDs on for 2 secs. The setting then reverts to *No Operation*.				
Red LED Status	0F	15		Binary string: 0 = not illuminated, 1 = illuminated
This cell indicates which of the user-programmable red LEDs are on.				
Green LED Status	0F	16		Binary string: 0 = not illuminated, 1 = illuminated
This cell indicates which of the user-programmable green LEDs are on.				
Commissioning mode	0F	18	Disabled	0 = Disabled or 1 = Enabled
This cell allows you to enter commissioning mode by zone or by terminal.				
Zone Block Diff. Prot. Mode	0F	19	0000	0x0001 Zone 1 0x0002 Zone 2 0x0004 Zone 3 0x0008 Zone 4
This cell allows you to define the zones in which you want to block the current differential protection function. This may be during normal operation or to perform secondary injection testing. All other protection functions are operational.				
Zone Block Diff. & CBF Prot. Mode	0F	1A	0000	0x0001 Zone 1 0x0002 Zone 2 0x0004 Zone 3 0x0008 Zone 4

Courier Text	Col	Row	Default Setting	Available Options
Description				
This cell allows you to define the zones in which you want to block the current differential protection and circuit breaker fail function. This may be during normal operation or to perform secondary injection testing. All other protection functions are operational.				
Terminal Maintenance Mode	0F	1B	000000000000000000	0x00000001 Terminal 1 0x00000002 Terminal 2 0x00000004 Terminal 3 0x00000008 Terminal 4 0x00000010 Terminal 5 0x00000020 Terminal 6 0x00000040 Terminal 7 0x00000080 Terminal 8 0x00000100 Terminal 9 0x00000200 Terminal 10 0x00000400 Terminal 11 0x00000800 Terminal 12 0x00001000 Terminal 13 0x00002000 Terminal 14 0x00004000 Terminal 15 0x00008000 Terminal 16 0x00010000 Terminal 17 0x00020000 Terminal 18
From the existing topology, this cell allows you to define which terminal you set in maintenance mode. This may be during normal operation or to perform secondary injection testing. Only the other terminals contribute to differential calculation.				
Z1 – Z4 Terminals	0F	1C – 1F		Not Settable
This cell allows you to see the status of all terminals connected in Zone 1 - 4 in the existing topology.				
DDB 0 - 2047	0F	20 - 5F		32 bit binary flag
These cells display the logic state of the DDB signals				

MAINTENANCE AND TROUBLESHOOTING

CHAPTER 15

1 CHAPTER OVERVIEW

The Maintenance and Troubleshooting chapter provides details of how to maintain and troubleshoot products based on the Px4x and P40Agile platforms. Always follow the warning signs in this chapter. Failure to do so may result injury or defective equipment.

Caution:
Before carrying out any work on the equipment you should be familiar with the contents of the Safety Section or the Safety Guide SFTY/4LM and the ratings on the equipment's rating label.

The troubleshooting part of the chapter allows an error condition on the IED to be identified so that appropriate corrective action can be taken.

If the device develops a fault, it is usually possible to identify which module needs replacing. It is not possible to perform an on-site repair to a faulty module.

If you return a faulty unit or module to the manufacturer or one of their approved service centres, you should include a completed copy of the Repair or Modification Return Authorization (RMA) form.

This chapter contains the following sections:

2 MAINTENANCE

2.1 MAINTENANCE CHECKS

In view of the critical nature of the application, Alstom Grid products should be checked at regular intervals to confirm they are operating correctly. Alstom Grid products are designed for a life in excess of 20 years.

The devices are self-supervising and so require less maintenance than earlier designs of protection devices. Most problems will result in an alarm, indicating that remedial action should be taken. However, some periodic tests should be carried out to ensure that they are functioning correctly and that the external wiring is intact. It is the responsibility of the customer to define the interval between maintenance periods. If your organisation 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

Although some functionality checks can be performed from a remote location, these are predominantly restricted to checking that the unit is measuring the applied currents and voltages accurately, and checking the circuit breaker maintenance counters. For this reason, maintenance checks should also be performed locally at the substation.

Caution:
Before carrying out any work on the equipment you should be familiar with the contents of the Safety Section or the Safety Guide SFTY/4LM and the ratings on the equipment's rating label.

2.1.1 ALARMS

First check the alarm status LED to see if any alarm conditions exist. If so, press the Read key repeatedly to step through the alarms.

After dealing with any problems, clear the alarms. This will clear the relevant LEDs.

2.1.2 OPTO-ISOLATORS

Check the opto-inputs by repeating the commissioning test detailed in the Commissioning chapter.

2.1.3 OUTPUT RELAYS

Check the output relays by repeating the commissioning test detailed in the Commissioning chapter.

2.1.4 MEASUREMENT ACCURACY

If the power system is energised, the measured values can be compared with known system values to check that they are in the expected range. If they are within a set range, this indicates that the A/D conversion and the calculations are being performed correctly. Suitable test methods can be found in Commissioning chapter.

Alternatively, the measured values can be checked against known values injected into the device using the test block, (if fitted) or injected directly into the device's terminals. Suitable test methods can be found in the Commissioning chapter. These tests will prove the calibration accuracy is being maintained.

2.2 REPLACING THE DEVICE

If your product should develop a fault while in service, depending on the nature of the fault, the watchdog contacts will change state and an alarm condition will be flagged. In the case of a fault, you can replace either the complete device or just the faulty PCB, identified by the in-built diagnostic software.

If possible you should replace the complete device, as this reduces the chance of damage due to electrostatic discharge and also eliminates the risk of fitting an incompatible replacement PCB. However, we understand it may be difficult to remove an installed product and you may be forced to replace the faulty PCB on-site. The case and rear terminal blocks are designed to allow removal of the complete device, without disconnecting the scheme wiring

Caution:
Replacing PCBs requires the correct on-site environment (clean and dry) as well as suitably trained personnel.

Caution:
If the repair is not performed by an approved service centre, the warranty will be invalidated.

Caution:
Before carrying out any work on the equipment, you should be familiar with the contents of the Safety Information section of this guide or the Safety Guide SFTY/4LM, as well as the ratings on the equipment's rating label. This should ensure that no damage is caused by incorrect handling of the electronic components.

Warning:
Before working at the rear of the device, isolate all voltage and current supplying it.

Note:
The current transformer inputs are equipped with integral shorting switches which will close for safety reasons, when the terminal block is removed

To replace the complete device:

1. Carefully disconnect the cables not connected to the terminal blocks (e.g. IRIG-B, fibre optic cables, earth), as appropriate, from the rear of the device.
2. Remove the terminal block screws using a magnetic screwdriver to minimise the risk of losing the screws or leaving them in the terminal block.
3. Without exerting excessive force or damaging the scheme wiring, pull the terminal blocks away from their internal connectors.

4. Remove the terminal block screws that fasten the device to the panel and rack. These are the screws with the larger diameter heads that are accessible when the access covers are fitted and open.

⚠ If the top and bottom access covers have been removed, some more screws with smaller diameter heads are made accessible. Do NOT remove these screws, as they secure the front panel to the device.

5. Withdraw the device from the panel and rack. Take care, as the device will be heavy due to the internal transformers.
6. To reinstall the device, follow the above instructions in reverse, ensuring that each terminal block is relocated in the correct position and the chassis ground, IRIG-B and fibre optic connections are replaced. The terminal blocks are labelled alphabetically with 'A' on the left hand side when viewed from the rear.

Once the device has been reinstalled, it should be re-commissioned as set out in the Commissioning chapter.

Note:
There are four possible types of terminal block: RTD/CLIO input, heavy duty, medium duty, and MiDOS. The terminal blocks are fastened to the rear panel with slotted or cross-head screws depending on the type of terminal block. Not all terminal block types are present on all products.

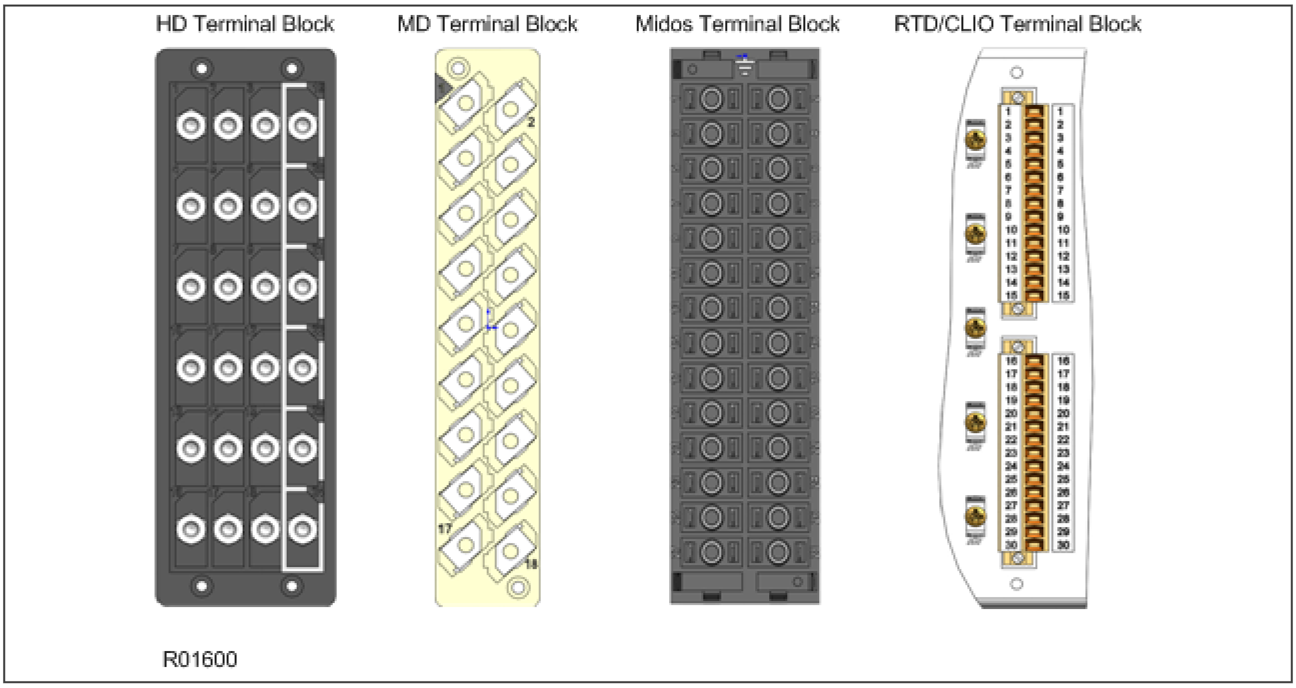


Figure 96: Possible terminal block types

2.3 REPAIRING THE DEVICE

If your product should develop a fault while in service, depending on the nature of the fault, the watchdog contacts will change state and an alarm condition will be flagged. In the case of a fault, either the complete unit or just the faulty PCB, identified by the in-built diagnostic software, should be replaced.

Replacement of printed circuit boards and other internal components must be undertaken by approved Service Centres. Failure to obtain the authorization of after-sales engineers prior to commencing work may invalidate the product warranty.

We recommend that you entrust any repairs to Automation Support teams, which are available world-wide.

2.4 REMOVING THE FRONT PANEL

Warning:
Before removing the front panel to replace a PCB, you must first remove the auxiliary power supply and wait 5 seconds for the internal capacitors to discharge. You should also isolate voltage and current transformer connections and trip circuit.

Caution:
Before removing the front panel, you should be familiar with the contents of the Safety Information section of this guide or the Safety Guide SFTY/4LM, as well as the ratings on the equipment's rating label.

To remove the front panel:

1. Open the top and bottom access covers. You must open the hinged access covers by more than 90° before they can be removed.
2. If fitted, remove the transparent secondary front cover.
3. Apply outward pressure to the middle of the access covers to bow them and disengage the hinge lug, so the access cover can be removed. The screws that fasten the front panel to the case are now accessible.
4. Undo and remove the screws. The 40TE case has four cross-head screws fastening the front panel to the case, one in each corner, in recessed holes. The 60TE/80TE cases have an additional two screws, one midway along each of the top and bottom edges of the front plate.

   Do not remove the screws with the larger diameter heads which are accessible when the access covers are fitted and open. These screws hold the relay in its mounting (panel or cubicle).

5. When the screws have been removed, pull the complete front panel forward to separate it from the metal case. The front panel is connected to the rest of the circuitry by a 64-way ribbon cable.

   The internal circuitry is now exposed and is not protected against electrostatic discharge and dust ingress. Therefore ESD precautions and clean working conditions must be maintained at all times.

6. The ribbon cable is fastened to the front panel using an IDC connector; a socket on the cable and a plug with locking latches on the front panel. Gently push the two locking latches outwards which eject the connector socket slightly. Remove the socket from the plug to disconnect the front panel.

2.5 REPLACING PCBS

1. To replace any of the PCBs, first remove the front panel.
2. Once the front panel has been removed, the PCBs are accessible. The numbers above the case outline identify the guide slot reference for each printed circuit board. Each printed circuit board has a label stating the corresponding guide slot number to ensure correct relocation after removal. To serve as a reminder of the slot numbering there is a label on the rear of the front panel metallic screen.
3. Remove the 64-way ribbon cable from the PCB that needs replacing
4. Remove the PCB in accordance with the board-specific instructions detailed later in this section.

Note:
To ensure compatibility, always replace a faulty PCB with one of an identical part number.

2.5.1 REPLACING THE MAIN PROCESSOR BOARD

The main processor board is situated in the front panel. This board contains application-specific settings in its non-volatile memory. You may wish to take a backup copy of these settings. This could save time in the re-commissioning process.

To replace the main processor board:

1. Remove front panel.
2. Place the front panel with the user interface face down and remove the six screws from the metallic screen, as shown in the figure below. Remove the metal plate.
3. Remove the two screws either side of the rear of the battery compartment recess. These are the screws that hold the main processor board in position.
4. Carefully disconnect the ribbon cable. Take care as this could easily be damaged by excessive twisting.
5. Replace the main processor board
6. Reassemble the front panel using the reverse procedure. Make sure the ribbon cable is reconnected to the main processor board and that all eight screws are refitted.
7. Refit the front panel.
8. Refit and close the access covers then press the hinge assistance T-pieces so they click back into the front panel moulding.
9. Once the unit has been reassembled, carry out the standard commissioning procedure as defined in the Commissioning chapter.

Note:
After replacing the main processor board, all the settings required for the application need to be re-entered. This may be done either manually or by downloading a settings file.

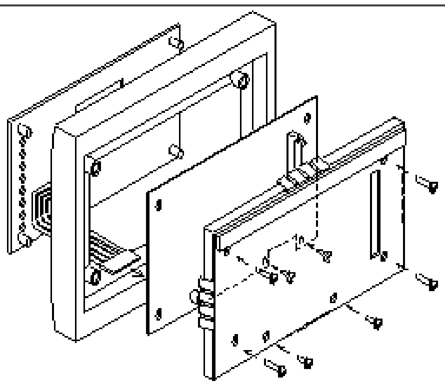


Figure 97: Front panel assembly

2.5.2 REPLACEMENT OF COMMUNICATIONS BOARDS

Most products will have at least one communications board of some sort fitted. There are several different boards available offering various functionality, depending on the application. Some products may even be fitted two boards of different types.

To replace a faulty communications board:

1. Remove front panel.
2. Disconnect all connections at the rear.
3. The board is secured in the relay case by two screws, one at the top and another at the bottom. Remove these screws carefully as they are not captive in the rear panel.
4. Gently pull the communications board forward and out of the case.
5. Before fitting the replacement PCB check that the number on the round label next to the front edge of the PCB matches the slot number into which it will be fitted. If the slot number is missing or incorrect, write the correct slot number on the label.
6. Fit the replacement PCB carefully into the correct slot. Make sure it is pushed fully back and that the securing screws are refitted.
7. Reconnect all connections at the rear.
8. Refit the front panel.
9. Refit and close the access covers then press the hinge assistance T-pieces so they click back into the front panel moulding.
10. Once the unit has been reassembled, commission it according to the Commissioning chapter.

2.5.3 REPLACEMENT OF THE INPUT MODULE

Depending on the product, the input module consists of two or three boards fastened together and is contained within a metal housing. One board contains the transformers and one contains the analogue to digital conversion and processing electronics. Some devices have an additional auxiliary transformer contained on a third board.

To replace an input module:

1. Remove front panel.
2. The module is secured in the case by two screws on its right-hand side, accessible from the front, as shown below. Move these screws carefully as they are not captive in the front plate of the module.
3. On the right-hand side of the module there is a small metal tab which brings out a handle (on some modules there is also a tab on the left). Grasp the handle(s) and pull the module firmly forward, away from the rear terminal blocks. A reasonable amount of force is needed due to the friction between the contacts of the terminal blocks.

   ⚠ With non-mounted IEDs, the case needs to be held firmly while the module is withdrawn. Withdraw the input module with care as it suddenly comes loose once the friction of the terminal blocks is overcome.

4. Remove the module from the case. The module may be heavy, because it contains the input voltage and current transformers.
5. Slot in the replacement module and push it fully back onto the rear terminal blocks. To check that the module is fully inserted, make sure the v-shaped cut-out in the bottom plate of the case is fully visible.
6. Refit the securing screws.
7. Refit the front panel.
8. Refit and close the access covers then press the hinge assistance T-pieces so they click back into the front panel moulding.
9. Once the unit has been reassembled, commission it according to the Commissioning chapter.

> *Note:*
> *If individual boards within the input module are replaced, recalibration will be necessary. We therefore recommend replacement of the complete module to avoid on-site recalibration.*

2.5.4 REPLACEMENT OF THE POWER SUPPLY BOARD

Caution:
Before removing the front panel, you should be familiar with the contents of the Safety Information section of this guide or the Safety Guide SFTY/4LM, as well as the ratings on the equipment's rating label.

The power supply board is fastened to an output relay board with push fit nylon pillars. This doubled-up board is secured on the extreme left hand side, looking from the front of the unit.

1. Remove front panel.
2. Pull the power supply module forward, away from the rear terminal blocks and out of the case. A reasonable amount of force is needed due to the friction between the contacts of the terminal blocks.
3. Separate the boards by pulling them apart carefully. The power supply board is the one with two large electrolytic capacitors.
4. Before reassembling the module, check that the number on the round label next to the front edge of the PCB matches the slot number into which it will be fitted. If the slot number is missing or incorrect, write the correct slot number on the label
5. Reassemble the module with a replacement PCB. Push the inter-board connectors firmly together. Fit the four push fit nylon pillars securely in their respective holes in each PCB.
6. Slot the power supply module back into the housing. Push it fully back onto the rear terminal blocks.
7. Refit the front panel.
8. Refit and close the access covers then press the hinge assistance T-pieces so they click back into the front panel moulding.
9. Once the unit has been reassembled, commission it according to the Commissioning chapter.

2.5.5 REPLACEMENT OF THE I/O BOARDS

There are several different types of I/O boards, which can be used, depending on the product and application. Some boards have opto-inputs, some have relay outputs and others have a mixture of both.

1. Remove front panel.
2. Gently pull the board forward and out of the case
3. If replacing the I/O board, make sure the setting of the link above IDC connector on the replacement board is the same as the one being replaced.
4. Before fitting the replacement board check the number on the round label next to the front edge of the board matches the slot number into which it will be fitted. If the slot number is missing or incorrect, write the correct slot number on the label.
5. Carefully slide the replacement board into the appropriate slot, ensuring that it is pushed fully back onto the rear terminal blocks.
6. Refit the front panel.
7. Refit and close the access covers then press at the hinge assistance T-pieces so they click back into the front panel moulding.
8. Once the unit has been reassembled, commission it according to the Commissioning chapter.

2.6 RECALIBRATION

Recalibration is not needed when a PCB is replaced, unless it is one of the boards in the input module. If any of the boards in the input module is replaced, the unit must be recalibrated.

Although recalibration is needed when a board inside the input module is replaced, it is not needed if the input module is replaced in its entirety.

Although it is possible to carry out recalibration on site, this requires special test equipment and software. We therefore recommend that the work be carried out by the manufacturer, or entrusted to an approved service centre.

2.7 CHANGING THE BATTERY

Each 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.

As part of the product's continuous self-monitoring, an alarm is given if the battery condition becomes poor. Nevertheless, you should change the battery periodically to ensure reliability.

To replace the battery:

1. Open the bottom access cover on the front of the relay.
2. Gently remove the battery. If necessary, use a small insulated screwdriver.
3. Make sure the metal terminals in the battery socket are free from corrosion, grease and dust.
4. Remove the replacement battery from its packaging and insert it in the battery holder, ensuring correct polarity.

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 held securely in its socket and that the battery terminals make good contact with the socket terminals.
6. Close the bottom access cover.

> *Note:*
> *Events, disturbance and maintenance records will be lost if the battery is replaced whilst the IED is de-energised.*

2.7.1 POST MODIFICATION TESTS

To ensure that the replacement battery maintains the time and status data if the auxiliary supply fails, scroll across to the *DATE AND TIME* cell, then scroll down to Battery Status which should read Healthy.

2.7.2 BATTERY DISPOSAL

Dispose of the removed battery according to the disposal procedure for Lithium batteries in the country in which the relay is installed.

2.8 CLEANING

Warning:
Before cleaning the device, ensure that all AC and DC supplies and transformer connections are isolated, to prevent any chance of an electric shock while cleaning.

Only clean the equipment with a lint-free cloth dampened with clean water. Do not use detergents, solvents or abrasive cleaners as they may damage the product's surfaces and leave a conductive residue.

3 TROUBLESHOOTING

3.1 SELF-DIAGNOSTIC SOFTWARE

The device includes several self-monitoring functions to check the operation of its hardware and software while in service. If there is a problem with the hardware or software, it should be able to detect and report the problem, and attempt to resolve the problem by performing a reboot. In this case, the device would be out of service for a short time, during which the 'Healthy' LED on the front of the device is switched OFF and the watchdog contact at the rear is ON. If the restart fails to resolve the problem, the unit 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 device attempts to store a maintenance record to allow the nature of the problem to be communicated to the user.

The self-monitoring is implemented in two stages: firstly a thorough diagnostic check which is performed on boot-up, and secondly a continuous self-checking operation, which checks the operation of the critical functions whilst it is in service.

3.2 POWER-UP ERRORS

If the IED does not appear to power up, use the following to determine whether the fault is in the external wiring, auxiliary fuse, IED power supply module or IED front panel.

Test	Check	Action
1	Measure the auxiliary voltage on terminals 1 and 2. Verify the voltage level and polarity against the rating label on the front. Terminal 1 is –dc, 2 is +dc	If the auxiliary voltage is correct, go to test 2. Otherwise check the wiring and fuses in the auxiliary supply.
2	Check the LEDs and LCD backlight switch on at power-up. Also check the N/O (normally open) watchdog contact for closing.	If the LEDs and LCD backlight switch on, or the contact closes and no error code is displayed, the error is probably on the main processor board in the front panel. If the LEDs and LCD backlight do not switch on and the contact does not close, go to test 3.
3	Check the field voltage output (nominally 48 V DC)	If there is no field voltage, the fault is probably in the IED power supply module.

3.3 ERROR MESSAGE OR CODE ON POWER-UP

The IED performs a self-test during power-up. If it detects an error, a message appears on the LCD and the power-up sequence stops. If the error occurs when the IED application software is running, a maintenance record is created and the device reboots.

Test	Check	Action
1	Is an error message or code permanently displayed during power up?	If the IED locks up and displays an error code permanently, go to test 2. If the IED prompts for user input, go to test 4. If the IED reboots automatically, go to test 5.
2	Record displayed error, and then remove and re-apply IED auxiliary supply.	Record whether the same error code is displayed when the IED is rebooted. If no error code is displayed, contact the local service centre stating the error code and IED information. If the same code is displayed, go to test 3.

Test	Check	Action
3	Error Code Identification The following text messages (in English) are 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 The following hex error codes relate to errors detected in specific IED modules:	These messages indicate that a problem has been detected on the IED's main processor board in the front panel.
3.1	0c140005/0c0d0000	Input Module (including opto-isolated inputs)
3.2	0c140006/0c0e0000	Output IED Cards
3.3	The last four digits provide details on the actual error.	Other error codes relate to hardware or software problems on the main processor board. Contact with details of the problem for a full analysis.
4	The IED displays a message for corrupt settings and prompts for the default values to be restored for the affected settings.	The power-up tests have detected corrupted IED settings. Restore the default settings to allow the power-up to complete, and then reapply the application-specific settings.
5	The IED resets when the power-up is complete. A record error code is displayed	Error 0x0E080000, programmable scheme logic error due to excessive execution time. Restore the default settings by powering up with both horizontal cursor keys pressed, then confirm restoration of defaults at the prompt using the Enter key. If the IED powers up successfully, check the programmable logic for feedback paths. Other error codes relate to software errors on the main processor board, contact .

3.4 OUT OF SERVICE LED ON AT POWER-UP

Test	Check	Action	
1	Using the IED menu, confirm the Commission Test or Test Mode setting is Enabled. If it is not Enabled, go to test 2.	If the setting is Enabled, disable the test mode and make sure the Out of Service LED is OFF.	
2	Select the *VIEW RECORDS* column then view the last maintenance record from the menu.	Check for the H/W Verify Fail maintenance record. This indicates a discrepancy between the IED model number and the hardware. Examine the ***Maint Data***; cell. 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 (110 V VTs fitted)
		7	The VT type field in the model number is incorrect (440 V VTs fitted)

Test	Check	Action	
		8	The VT type field in the model number is incorrect (no VTs fitted)

3.5 ERROR CODE DURING OPERATION

The IED performs continuous self-checking. If the IED detects an error it displays an error message, logs a maintenance record and after a short delay resets itself. A permanent problem (for example due to a hardware fault) is usually detected in the power-up sequence. In this case the IED displays an error code and halts. If the problem was transient, the IED reboots correctly and continues operation. By examining the maintenance record logged, the nature of the detected fault can be determined.

3.5.1 BACKUP BATTERY

If the IED's self-check detects a failure of the lithium battery, the IED displays an alarm message and logs a maintenance record but the IED does not reset.

To prevent the IED from issuing an alarm when there is a battery failure, select *DATE AND TIME* then ***Battery Alarm*** then `Disabled`. The IED can then be used without a battery and no battery alarm message appears.

3.6 MAL-OPERATION DURING TESTING

3.6.1 FAILURE OF OUTPUT CONTACTS

An apparent failure of the relay output contacts can be caused by the configuration. Perform the following tests to identify the real cause of the failure. The self-tests verify that the coils of the output relay contacts have been energized. An error is displayed if there is a fault in the output relay board.

Test	Check	Action
1	Is the Out of Service LED ON?	If this LED is ON, the relay may be in test mode or the protection has been disabled due to a hardware verify error.
2	Examine the Contact status in the Commissioning section of the menu.	If the relevant bits of the contact status are operated, go to test 4; if not, go to test 3.
3	Examine the fault record or use the test port to check the protection element is operating correctly.	If the protection element does not operate, check the test is correctly applied. If the protection element operates, check the programmable logic to make sure the protection element is correctly mapped to the contacts.
4	Using the Commissioning or Test mode function, apply a test pattern to the relevant relay output contacts. Consult the correct external connection diagram and use a continuity tester at the rear of the relay to check the relay output contacts operate.	If the output relay operates, the problem must be in the external wiring to the relay. If the output relay does not operate the output relay contacts may have failed (the self-tests verify that the relay coil is being energized). Ensure the closed resistance is not too high for the continuity tester to detect.

3.6.2 FAILURE OF OPTO-INPUTS

The opto-isolated inputs are mapped onto the IED's internal DDB signals using the programmable scheme logic. If an input is not recognised by the scheme logic, use the ***Opto I/P Status*** cell in the *COMMISSION TESTS* column to check whether the problem is in the opto-input itself, or the mapping of its signal to the scheme logic functions.

If the device does not correctly read the opto-input state, test the applied signal. Verify the connections to the opto-input using the wiring diagram and the nominal voltage settings in the *OPTO CONFIG* column. To do this:

1. Select the nominal voltage for all opto-inputs by selecting one of the five standard ratings in the ***Global Nominal V*** cell.
2. Select `Custom` to set each opto-input individually to a nominal voltage.
3. Using a voltmeter, check that the voltage on its input terminals is greater than the minimum pick-up level (See the Technical Specifications chapter for opto pick-up levels).

If the signal is correctly applied, this indicates failure of an opto-input, which may be situated on standalone opto-input board, or on an opto-input board that is part of the input module. Separate opto-input boards can simply be replaced. If, however, the faulty opto-input board is part of the input module, the complete input module should be replaced. This is because the analogue input module cannot be individually replaced without dismantling the module and recalibration of the IED.

3.6.3 INCORRECT ANALOGUE SIGNALS

If the measured analogue quantities do not seem correct, use the measurement function to determine the type of problem. The measurements can be configured in primary or secondary terms.

1. Compare the displayed measured values with the actual magnitudes at the terminals.
2. Check the correct terminals are used.
3. Check the CT and VT ratios set are correct.
4. Check the phase displacement to confirm the inputs are correctly connected.

3.7 PSL EDITOR TROUBLESHOOTING

A failure to open a connection could be due to one or more of the following:

- The IED address is not valid (this address is always 1 for the front port)
- Password in not valid
- Communication set-up (COM port, Baud rate, or Framing) is not correct
- Transaction values are not suitable for the IED or the type of connection
- The connection cable is not wired correctly or broken
- The option switches on any protocol converter used may be incorrectly set

3.7.1 DIAGRAM RECONSTRUCTION

Although a scheme can be extracted from an IED, a facility is provided to recover a scheme if the original file is unobtainable.

A recovered scheme is logically correct but much of the original graphical information is lost. Many signals are 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 such as titles and notes are lost.

Sometimes a gate type does not appear as expected. For example, a single-input AND gate in the original scheme appears as an OR gate when uploaded. Programmable gates with an inputs-to-trigger value of 1 also appear as OR gates

3.7.2 PSL VERSION CHECK

The PSL is saved with a version reference, time stamp and CRC check (Cyclic Redundancy Check). This gives a visual check whether the default PSL is in place or whether a new application has been downloaded.

4 REPAIR AND MODIFICATION PROCEDURE

Please follow these steps to return an Automation product to us:

1. Get the Repair and Modification Return Authorization (RMA) form
An electronic version of the RMA form is available from the following web page:
http://www.alstom.com/grid/productrepair/
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. Send the RMA form to your local contact
For a list of local service contacts worldwide,visit the following web page:
http://www.alstom.com/grid/productrepair/
4. The local service contact provides the shipping information
Your local service contact provides you with all the information needed to ship the product:
    - Pricing details
    - RMA number
    - Repair centre address

    If required, an acceptance of the quote must be delivered before going to the next stage.
5. Send the product to the repair centre
    - Address the shipment to the repair centre specified by your local contact
    - Make sure all items are packaged in an anti-static bag and foam protection
    - Make sure a copy of the import invoice is attached with the returned unit
    - Make sure a copy of the RMA form is attached with the returned unit
    - E-mail or fax a copy of the import invoice and airway bill document to your local contact.

TECHNICAL SPECIFICATIONS

CHAPTER 16

1 CHAPTER OVERVIEW

This chapter describes the technical specifications of the product.

This chapter contains the following sections:

2 INTERFACES

2.1 FRONT SERIAL PORT

Front serial port (SK1)	
Use	For local connection to laptop for configuration purposes
Standard	EIA(RS)232
Designation	SK1
Connector	9 pin D-type female connector
Isolation	Isolation to ELV level
Protocol	Courier
Constraints	Maximum cable length 15 m

2.2 DOWNLOAD/MONITOR PORT

Front download port (SK2)	
Use	For firmware downloads or monitor connection
Standard	Compatible with IEEE1284-A
Designation	SK2
Connector	25 pin D-type female connector
Isolation	Isolation to ELV level
Protocol	Proprietary
Constraints	Maximum cable length 3 m

2.3 REAR SERIAL PORT 1

Rear serial port 1 (RP1)	
Use	For SCADA communications (multi-drop)
Standard	EIA(RS)485, K-bus
Connector	General purpose block, M4 screws (2 wire)
Cable	Screened twisted pair (STP)
Supported Protocols *	Courier, IEC-60870-5-103, DNP3.0, MODBUS
Isolation	Isolation to SELV level
Constraints	Maximum cable length 1000 m

* Not all models support all protocols - see ordering options

2.4 FIBRE REAR SERIAL PORT 1

Optional fibre rear serial port (RP1)	
Main Use	Serial SCADA communications over fibre
Connector	IEC 874-10 BFOC 2.5 –(ST®) (1 each for Tx and Rx)
Fibre type	Multimode 50/125 µm or 62.5/125 µm
Supported Protocols	Courier, IEC870-5-103, DNP 3.0, MODBUS
Wavelength	850 nm

2.5 REAR SERIAL PORT 2

Optional rear serial port (RP2 /SK4)	
Use	For SCADA communications (multi-drop)
Standard	EIA(RS)485, K-bus, EIA(RS)232
Designation	SK4
Connector	9 pin D-type female connector
Cable	Screened twisted pair (STP)
Supported Protocols	Courier
Isolation	Isolation to SELV level
Constraints	Maximum cable length 1000 m for RS485 and K-bus, 15 m for RS232

2.6 REDUNDANT ETHERNET PORTS

Redundant Ethernet Ports	
Use	Redundant serial communications over fibre
Connector	IEC 874-10 BFOC 2.5 –(ST®) (1 each for Tx and Rx)
Fibre Type	Multimode 50/125 µm or 62.5/125 µm
Supported Protocols	IEC 61850, DNP 3.0 over Ethernet
Supported Redundancy Protocols	SHR Self Healing Protocol RSTP Rapid Spanning Tree Protocol DHP Dual Homing Protocol PRP Parallel Redundancy Protocol
Wavelength	850 nm MM

2.7 IRIG-B (DEMODULATED)

IRIG-B Interface (Demodulated)	
Use	External clock synchronisation signal
Standard	IRIG 200-98 format B00X
Connector	BNC
Cable type	50 ohm coaxial
Isolation	Isolation to SELV level
Constraints	Maximum cable length 10 m
Input signal	TTL level
Input impedance	10 k ohm at dc
Accuracy	< +/- 1 s per day

2.8 IRIG-B (MODULATED)

IRIG-B Interface (Modulated)	
Use	External clock synchronisation signal
Standard	IRIG 200-98 format B12X
Connector	BNC
Cable type	50 ohm coaxial

IRIG-B Interface (Modulated)	
Isolation	Isolation to SELV level
Constraints	Maximum cable length 10 m
Input signal	peak to peak, 200 mV to 20 mV
Input impedance	6 k ohm at 1000 Hz
Accuracy	< +/- 1 s per day

2.9 REAR ETHERNET PORT COPPER

Rear Ethernet port using CAT 5/6/7 wiring	
Main Use	Substation Ethernet communications
Standard	IEEE 802.3 10BaseT/100BaseTX
Connector	RJ45
Cable type	Screened twisted pair (STP)
Isolation	1.5 kV
Supported Protocols	IEC 61850, DNP3.0 OE
Constraints	Maximum cable length 100 m

2.10 REAR ETHERNET PORT FIBRE

Rear Ethernet port using fibre-optic cabling	
Main Use	Substation Ethernet communications
Connector	IEC 874-10 BFOC 2.5 –(ST®) (1 each for Tx and Rx)
Standard	IEEE 802.3 100 BaseFX
Fibre type	Multimode 50/125 µm or 62.5/125 µm
Supported Protocols	IEC 61850, DNP3.0
Optional Redundancy Protocols Supported	Rapid spanning tree protocol (RSTP) Self-healing protocol (SHP) Dual homing protocol (DHP) Parallel Redundancy Protocol (PRP)
Wavelength	1300 nm

2.10.1 100 BASE FX RECEIVER CHARACTERISTICS

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

Conditions: TA = 0°C to 70°C, VCC = 4.75 V to 5.25 V

2.10.2 100 BASE FX TRANSMITTER CHARACTERISTICS

Parameter	Sym	Min.	Typ.	Max.	Unit
Output Optical Power BOL 62.5/125 µm NA = 0.275 Fibre EOL	PO	-19 -20	-16.8	-14	dBm avg.
Output Optical Power BOL 50/125 µm NA = 0.20 Fibre EOL	PO	-22.5 -23.5	-20.3	-14	dBm avg.
Optical Extinction Ratio				10 -10	% dB
Output Optical Power at Logic "0" State	PO			-45	dBm avg.

Conditions: TA = 0°C to 70°C, VCC = 4.75 V to 5.25 V

3 BUSBAR PROTECTION FUNCTIONS

3.1 BUSBAR CIRCUITRY FAULT PROTECTION

Accuracy	
Pick-up (IDMT)	Setting +/-5%, or 20 mA, whichever is greater
Pick-up (DT)	Setting +/-5%, or 20 mA, whichever is greater
Drop-off (IDMT and DT)	> 0.95 x setting +/-5% or 20 mA, whichever is greater
Busbar trip with high speed contact	For 50 Hz: 8 ms (min), 12 ms (typical) at 3.5 × tripping threshold For 60 Hz: 6 ms (min), 10 ms (typical) at 4.5 × tripping threshold
Busbar trip with standard contact	For 50 Hz: 13 ms (min), 17 ms (typical) at 3.5 × tripping threshold For 60 Hz: 11 ms (min) ,15 ms (typical) at 4.5 × tripping threshold

3.2 BUSBAR CIRCUITRY FAULT PROTECTION

Accuracy	
Pick-up (IDMT)	Setting +/-5%, or 20 mA, whichever is greater
Pick-up (DT)	Setting +/-5%, or 20 mA, whichever is greater
Drop-off (IDMT and DT)	> 0.95 x setting +/-5% or 20 mA, whichever is greater
DT operation	Setting +/-5% or 50 ms, whichever is greater

3.3 BUSBAR DEAD ZONE PROTECTION

Accuracy	
Pick-up (IDMT)	Setting +/-5%, or 20 mA, whichever is greater
Pick-up (DT)	Setting +/-5%, or 20 mA, whichever is greater
Drop-off (IDMT and DT)	> 0.95 x setting +/-5% or 20 mA, whichever is greater
Min. trip level	1.05 × Setting +/-5% or 20 mA, whichever is greater
DT operation	Setting +/-5% or 50 ms, whichever is greater

3.4 THREE-PHASE OVERCURRENT PROTECTION

IDMT pick-up	1.05 × Setting +/-5%
DT pick-up	Setting +/-5%
Drop-off (IDMT and DT)	0.95 x setting +/-5%
IDMT operate	+/-5% or 40 ms, whichever is greater
DT operate	+/-2% or 50 ms, whichever is greater
DT reset	Setting +/-5%
Overshoot of overcurrent elements	<30 ms

3.5 EARTH FAULT PROTECTION

Measured	
Pick-up (IDMT and DT)	Setting +/-5%, or 20 mA, whichever is greater
Drop-off (IDMT and DT)	> 0.95 x setting +/-5% or 20 mA, whichever is greater
Min. trip level (IDMT elements)	1.05 × Setting +/-5% or 10 mA, whichever is greater
IDMT characteristic shape	+/-5% or 40 ms, whichever is greater (under reference conditions)
IEEE reset	+/-5% or 40 ms, whichever is greater
DT operation	+/-2% or 50 ms, whichever is greater
DT reset	+/-2% or 50 ms, whichever is greater

Derived	
IDMT pick-up	1.05 × Setting +/-5%
DT pick-up	Setting +/-5%
Drop-off (IDMT and DT)	0.95 x setting +/-5%
IDMT operate	+/-5% or 40 ms, whichever is greater
DT operate	+/-2% or 50 ms, whichever is greater
DT reset	Setting +/-5%
Overshoot of overcurrent elements	<30 ms

3.6 TRANSIENT OVERREACH AND OVERSHOOT

Accuracy	
Additional tolerance due to increasing X/R ratios	+/-5% over the X/R ratio of 1 to 120
Overshoot of overcurrent elements	< 40 ms
Disengagement time	< 30 ms

4 PERFORMANCE OF MONITORING AND CONTROL FUNCTIONS

4.1 VOLTAGE TRANSFORMER SUPERVISION

Fast block operation	< 25 ms
Fast block reset	< 40 ms
Time delay	+/- 2% or 40 ms, whichever is greater

4.2 PSL TIMERS

Output conditioner timer	Setting +/- 2% or 50 ms, whichever is greater
Dwell conditioner timer	Setting +/- 2% or 50 ms, whichever is greater
Pulse conditioner timer	Setting +/- 2% or 50 ms, whichever is greater

5 MEASUREMENTS AND RECORDING

5.1 GENERAL

General Measurement Accuracy	
General measurement accuracy	Typically +/- 1%, but +/- 0.5% between 0.2 - 2 In/Vn
Phase	0° to 360° +/- 5.0%
Current (0.05 to 3 In)	+/- 1.0% of reading, or 4mA (1A input), or 20mA (5A input)
Voltage (0.05 to 2 Vn)	+/- 1.0% of reading
Frequency (40 to 70 Hz)	+/- 0.025 Hz
Power (W) (0.2 to 2 Vn and 0.05 to 3 In)	+/- 5.0% of reading at unity power factor
Reactive power (Vars) (0.2 to 2 Vn and 0.05 to 3 In)	+/- 5.0% of reading at zero power factor
Apparent power (VA) (0.2 to 2 Vn and 0.05 to 3 In)	+/- 5.0% of reading
Energy (Wh) (0.2 to 2 Vn and 0.2 to 3 In)	+/- 5.0% of reading at zero power factor
Energy (Varh) (0.2 to 2 Vn and 0.2 to 3)	In +/- 5.0% of reading at zero power factor

5.2 DISTURBANCE RECORDS

Disturbance Records Measurement Accuracy	
Minimum record duration	0.1 s
Maximum record duration	10.5 s
Minimum number of records at 10.5 seconds	8
Magnitude and relative phases accuracy	±5% of applied quantities
Duration accuracy	±2%
Trigger position accuracy	±2% (minimum Trigger 100 ms)

5.3 EVENT, FAULT AND MAINTENANCE RECORDS

Event, Fault & Maintenance Records	
Record location	Flash memory
Viewing method	Front panel display or MiCOM S1 Agile
Extraction method	Extracted via the USB port
Number of Event records	Up to 512 time tagged event records
Number of Fault Records	Up to 5
Number of Maintenance Records	Up to 10
Event time stamp resolution	1 ms

5.4 FAULT LOCATOR

Accuracy	
Fault Location	+/- 3.5% of line length up to SIR 30 Reference conditions: solid fault applied on line

6 STANDARDS COMPLIANCE

6.1 EMC COMPLIANCE: 2004/108/EC

Compliance with the European Commission Directive on EMC is demonstrated using a Technical File.

Compliance with EN60255-26:2009 was used to establish conformity.

6.2 PRODUCT SAFETY: 2006/95/EC

Compliance with the European Commission Low Voltage Directive (LVD) is demonstrated using a Technical File.

Compliance with EN 60255-27: 2005 was used to establish conformity:

6.3 R&TTE COMPLIANCE

Radio and Telecommunications Terminal Equipment (R&TTE) directive 99/5/EC.

Conformity is demonstrated by compliance to both the EMC directive and the Low Voltage directive, to zero volts.

6.4 UL/CUL COMPLIANCE

Canadian and USA Underwriters Laboratory

File Number E202519 (where marked)

7 MECHANICAL SPECIFICATIONS

7.1 PHYSICAL PARAMETERS

Case Types	40TE 60TE 80TE
Weight (40TE case)	7 kg – 8 kg (depending on chosen options)
Weight (60TE case)	9 kg – 12 kg (depending on chosen options)
Weight (80TE case)	13 kg - 14 kg (depending on chosen options)
Dimensions in mm (w x h x l) (40TE case)	W: 206.0 mm H: 177.0 mm D: 243.1 mm
Dimensions in mm (w x h x l) (60TE case)	W: 309.6 mm H: 177.0 mm D: 243.1 mm
Dimensions in mm (w x h x l) (80TE case)	W 413.2 mm H 177.0 mm D 243.1 mm
Mounting	Panel, rack, or retrofit

7.2 ENCLOSURE PROTECTION

Against dust and dripping water (front face)	IP52 as per IEC 60529:2002
Protection against dust (whole case)	IP50 as per IEC 60529:2002
Protection for sides of the case (safety)	IP30 as per IEC 60529:2002
Protection for rear of the case (safety)	IP10 as per IEC 60529:2002

7.3 MECHANICAL ROBUSTNESS

Mechanical Robustness	
Vibration test per EN 60255-21-1:1996	Response: class 2, Endurance: class 2
Shock and bump immunity per EN 60255-21-2:1995	Shock response: class 2, Shock withstand: class 1, Bump withstand: class 1
Seismic test per EN 60255-21-3: 1995	Class 2

7.4 TRANSIT PACKAGING PERFORMANCE

Primary packaging carton protection	ISTA 1C
Vibration tests	3 orientations, 7 Hz, amplitude 5.3 mm, acceleration 1.05g
Drop tests	10 drops from 610 mm height on multiple carton faces, edges and corners

8 RATINGS

8.1 AC MEASURING INPUTS

AC Measuring Inputs	
Nominal frequency	50 Hz or 60 Hz (settable)
Operating range	40 Hz to 70 Hz
Phase rotation	ABC or CBA

8.2 CURRENT TRANSFORMER INPUTS

AC Current Inputs	
Nominal current (In)	1A or 5A
Nominal burden per phase	< 0.05 VA at In
AC current thermal withstand (5A input)	20 A (continuous operation) 150 A (for 10 s) 500 A (for 1 s)
AC current thermal withstand (1A input)	4 A (continuous operation) 30 A (for 10 s) 100 A (for 1 s)
Linearity	Linear up to 64×In (non-offset)

8.3 VOLTAGE TRANSFORMER INPUTS

AC Voltage Inputs	
Nominal voltage	100 V to 120 V
Nominal burden per phase	< 0.1 VA at Vn
Thermal withstand	2 x Vn (continuous operation) 2.6 x Vn (for 10 seconds)
Linearity	Linear up to 200 V (100/120 V supply) Linear up to 800 V (380/400 V supply)

8.4 AUXILIARY SUPPLY VOLTAGE

Nominal operating range	Cortec option 1 (DC only) 24 to 48 V DC Cortec option 2 (rated for AC or DC operation) 48 to 110 V DC 40 to 100 V AC rms Cortec option 3 (rated for AC or DC operation) 110 to 250 V DC 100 to 240 V AC rms

Maximum operating range	Cortec option 1 (DC only) 19 to 65 V DC Cortec option 2 (rated for AC or DC operation) 48 to 110 V DC 40 to 100 V AC rms Cortec option 3 (rated for aAC or DC operation) 110 to 250 V DC 100 to 240 V AC rms
Frequency range for AC supply	45 to 65 Hz
Ripple	<15% for a DC supply (compliant with IEC 60255-11:2008)
Power up time	< 11 seconds

8.5 NOMINAL BURDEN

Quiescent burden	20TE	5 W max.
	30TE	6 W max.
	30TE with 2nd rear communications	6.2 W max.
	30TE with Ethernet or TCS	7 W max.
Additions for energised relay outputs		0.26 W per output relay
Opto-input burden	24 V	0.065 W max.
	48 V	0.125 W max.
	110 V	0.36 W max.
	220 V	0.9 W max.

8.6 POWER SUPPLY INTERRUPTION

Standard	IEC 60255-11:2008 (DC) IEC 61000-4-11:2004 (AC)
24-48V DC SUPPLY 100% interruption without de-energising	20 ms at 24 V (half and full load) 50 ms at 36 V (half and full load) 100 ms at 48 V (half and full load)
48-110V DC SUPPLY 100% interruption without de-energising	20 ms at 36V (half and full load) 50 ms at 60 V (half and full load) 100 ms at 72 V (half load) 100 ms at 85 V (full load) 200 ms at 110 V (half and full load)
110-250V DC SUPPLY 100% interruption without de-energising	20 ms at 85 V (half load) 50 ms at 110 V (half load) 50 ms at 98 V (full load) 100 ms at 160 V (half load) 100 ms at 135 V (full load) 200 ms at 210 V (half load) 200 ms at 174 V (full load)
40-100V AC SUPPLY 100% voltage dip without de-energising	50 ms at 27 V (half load) 10 ms at 27 V (full load)

100-240V AC SUPPLY 100% voltage dip without de-energising	50 ms at 80 V (full and half load)

> *Note:*
> *Maximum loading = all inputs/outputs energised.*

> *Note:*
> *Quiescent or 1/2 loading = 1/2 of all inputs/outputs energised.*

8.7 STANDARD OUTPUT CONTACTS

Compliance	In accordance with IEC 60255-1:2009
Use	General purpose relay outputs for signalling, tripping and alarming
Rated voltage	300 V
Maximum continuous current	10 A
Short duration withstand carry	30 A for 3 s 250 A for 30 ms
Make and break, dc resistive	50 W
Make and break, dc inductive	62.5 W (L/R = 50 ms)
Make and break, ac resistive	2500 VA resistive (cos f = unity)
Make and break, ac inductive	2500 VA inductive (cos f = 0.7)
Make and carry, dc resistive	30 A for 3 s, 10000 operations (subject to the above limits)
Make, carry and break, dc resistive	4 A for 1.5 s, 10000 operations (subject to the above limits)
Make, carry and break, dc inductive	0.5 A for 1 s, 10000 operations (subject to the above limits)
Make, carry and break ac resistive	30 A for 200 ms, 2000 operations (subject to the above limits)
Make, carry and break ac inductive	10 A for 1.5 s, 10000 operations (subject to the above limits)
Loaded contact	1000 operations min.
Unloaded contact	10000 operations min.
Operate time	< 5 ms
Reset time	< 10 ms

8.8 WATCHDOG CONTACTS

Use	Non-programmable contacts for relay healthy/relay fail indication
Breaking capacity, dc resistive	30 W
Breaking capacity, dc inductive	15 W (L/R = 40 ms)
Breaking capacity, ac inductive	375 VA inductive (cos f = 0.7)

8.9 ISOLATED DIGITAL INPUTS

Opto-isolated digital inputs (opto-inputs)	
Compliance	ESI 48-4
Rated nominal voltage	24 to 250 V dc
Operating range	19 to 265 V dc
Withstand	300 V dc
Recognition time with half-cycle ac immunity filter removed	< 2 ms
Recognition time with filter on	< 12 ms

8.9.1 NOMINAL PICKUP AND RESET THRESHOLDS

Nominal Battery voltage	Logic levels: 60-80% DO/PU	Logic Levels: 50-70% DO/PU
24/27 V	Logic 0 < 16.2 V : Logic 1 > 19.2 V	Logic 0 <12.0 V : Logic 1 > 16.8
30/34	Logic 0 < 20.4 V : Logic 1 > 24.0 V	Logic 0 < 15.0 V : Logic 1 > 21.0 V
48/54	Logic 0 < 32.4 V : Logic 1 > 38.4 V	Logic 0 < 24.0 V : Logic 1 > 33.6 V
110/125	Logic 0 < 75.0 V : Logic 1 > 88.0 V	Logic 0 < 55.0 V : Logic 1 > 77.0 V
220/250	Logic 0 < 150 V : Logic 1 > 176.0 V	Logic 0 < 110.V : Logic 1 > 154.0 V

Note:
Filter is required to make the opto-inputs immune to induced AC voltages.

9 ENVIRONMENTAL CONDITIONS

9.1 AMBIENT TEMPERATURE RANGE

Compliance	IEC 60255-27: 2005
Test Method	IEC 60068-2-1:2007 and IEC 60068-2-2 2007
Operating temperature range	-25°C to +55°C (continuous)
Storage and transit temperature range	-25°C to +70°C (continuous)

9.2 AMBIENT HUMIDITY RANGE

Compliance	IEC 60068-2-78: 2001 and IEC 60068-2-30: 2005
Durability	56 days at 93% relative humidity and +40°C
Damp heat cyclic	six (12 + 12) hour cycles, 93% RH, +25 to +55°C

9.3 CORROSIVE ENVIRONMENTS

Compliance	IEC 60068-2-42: 2003, IEC 60068-2-43: 2003
Industrial corrosive environment/poor environmental control, Sulphur Dioxide	21 days exposure to elevated concentrations (25ppm) of SO2 at 75% relative humidity and +25°C
Industrial corrosive environment/poor environmental control, Hydrogen Sulphide	21 days exposure to elevated concentrations (10ppm) of SO2 at 75% relative humidity and +25°C
Salt mist	IEC 60068-2-52: 1996 KB severity 3

10 TYPE TESTS

10.1 INSULATION

Compliance	IEC 60255-27: 2005
Insulation resistance	> 100 M ohm at 500 V DC (Using only electronic/brushless insulation tester)

10.2 CREEPAGE DISTANCES AND CLEARANCES

Compliance	IEC 60255-27: 2005
Pollution degree	3
Overvoltage category	III
Impulse test voltage (not RJ45)	5 kV
Impulse test voltage (RJ45)	1 kV

10.3 HIGH VOLTAGE (DIELECTRIC) WITHSTAND

IEC Compliance	IEC 60255-27: 2005
Between all independent circuits	2 kV ac rms for 1 minute
Between independent circuits and protective earth conductor terminal	2 kV ac rms for 1 minute
Between all case terminals and the case earth	2 kV ac rms for 1 minute
Across open watchdog contacts	1 kV ac rms for 1 minute
Across open contacts of changeover output relays	1 kV ac rms for 1 minute
Between all RJ45 contacts and protective earth	1 kV ac rms for 1 minute
Between all screw-type EIA(RS)485 contacts and protective earth	1 kV ac rms for 1 minute
ANSI/IEEE Compliance	ANSI/IEEE C37.90-1989
Across open contacts of normally open output relays	1.5 kV ac rms for 1 minute
Across open contacts of normally open changeover output relays	1 kV ac rms for 1 minute
Across open watchdog contacts	1 kV ac rms for 1 minute

10.4 IMPULSE VOLTAGE WITHSTAND TEST

Compliance	IEC 60255-27: 2005
Between all independent circuits	Front time: 1.2 µs, Time to half-value: 50 µs, Peak value: 5 kV, 0.5 J
Between terminals of all independent circuits	Front time: 1.2 µs, Time to half-value: 50 µs, Peak value: 5 kV, 0.5 J
Between all independent circuits and protective earth conductor terminal	Front time: 1.2 µs, Time to half-value: 50 µs, Peak value: 5 kV, 0.5 J

Note:
Exceptions are communications ports and normally-open output contacts, where applicable.

11 ELECTROMAGNETIC COMPATIBILITY

11.1 1 MHZ BURST HIGH FREQUENCY DISTURBANCE TEST

Compliance	IEC 60255-22-1: 2008, Class III
Common-mode test voltage (level 3)	2.5 kV
Differential test voltage (level 3)	1.0 kV

11.2 DAMPED OSCILLATORY TEST

Compliance	EN61000-4-18: 2011: Level 3, 100 kHz and 1 MHz. Level 4: 3 MHz, 10 MHz and 30 MHz
Common-mode test voltage (level 3)	2.5 kV
Common-mode test voltage (level 4)	4.0 kV
Differential mode test voltage	1.0 kV

11.3 IMMUNITY TO ELECTROSTATIC DISCHARGE

Compliance	IEC 60255-22-2: 2008 Class 3 and Class 4,
Class 4 Condition	15 kV discharge in air to user interface, display, and exposed metalwork
Class 3 Condition	8 kV discharge in air to all communication ports

11.4 ELECTRICAL FAST TRANSIENT OR BURST REQUIREMENTS

Compliance	IEC 60255-22-4: 2008 and EN61000-4-4:2004. Test severity level Ill and IV
Applied to communication inputs	Amplitude: 2 kV, burst frequency 5 kHz and 100 KHz (level 4)
Applied to power supply and all other inputs except for communication inputs	Amplitude: 4 kV, burst frequency 5 kHz and 100 KHz (level 4)

11.5 SURGE WITHSTAND CAPABILITY

Compliance	IEEE/ANSI C37.90.1: 2002
Condition 1	4 kV fast transient and 2.5 kV oscillatory applied common mode and differential mode to opto inputs, output relays, CTs, VTs, power supply
Condition 2	4 kV fast transient and 2.5 kV oscillatory applied common mode to communications, IRIG-B

11.6 SURGE IMMUNITY TEST

Compliance	IEC 61000-4-5: 2005 Level 4
Pulse duration	Time to half-value: 1.2/50 µs
Between all groups and protective earth conductor terminal	Amplitude 4 kV
Between terminals of each group (excluding communications ports, where applicable)	Amplitude 2 kV

11.7 IMMUNITY TO RADIATED ELECTROMAGNETIC ENERGY

Immunity to Radiated Electromagnetic Energy	
Compliance	IEC 60255-22-3: 2007, Class III
Frequency band	80 MHz to 1.0 GHz
Spot tests at	80, 160, 380, 450, 900, 1850, 2150 MHz
Test field strength	10 V/m
Test using AM	1 kHz @ 80%
Compliance	IEEE/ANSI C37.90.2: 2004
Frequency band	80 MHz to 1 GHz
Spot tests at	80, 160, 380, 450 MHz
Waveform	1 kHz @ 80% am and pulse modulated
Field strength	35 V/m

11.8 RADIATED IMMUNITY FROM DIGITAL COMMUNICATIONS

Compliance	IEC 61000-4-3: 2006, Level 4
Frequency bands	800 to 960 MHz, 1.4 to 2.0 GHz
Test field strength	30 V/m
Test using AM	1 kHz / 80%

11.9 RADIATED IMMUNITY FROM DIGITAL RADIO TELEPHONES

Compliance	IEC 61000-4-3: 2002
Frequency bands	900 MHz and 1.89 GHz
Test field strength	10 V/m

11.10 IMMUNITY TO CONDUCTED DISTURBANCES INDUCED BY RADIO FREQUENCY FIELDS

Compliance	IEC 61000-4-6: 2008, Level 3
Frequency bands	150 kHz to 80 MHz

Test disturbance voltage	10 V rms
Test using AM	1 kHz @ 80%
Spot tests	27 MHz and 68 MHz

11.11 MAGNETIC FIELD IMMUNITY

Compliance	IEC 61000-4-8: 2009 Level 5 IEC 61000-4-9/10: 2001 Level 5
IEC 61000-4-8 test	100 A/m applied continuously, 1000 A/m applied for 3 s
IEC 61000-4-9 test	1000 A/m applied in all planes
IEC 61000-4-10 test	100 A/m applied in all planes at 100 kHz/1 MHz with a burst duration of 2 seconds

11.12 CONDUCTED EMISSIONS

Compliance	EN 55022: 2010
Power supply test 1	0.15 - 0.5 MHz, 79 dBμV (quasi peak) 66 dBμV (average)
Power supply test 2	0.5 – 30 MHz, 73 dBμV (quasi peak) 60 dBμV (average)¤
RJ45 test 1 (where applicable)	0.15 - 0.5 MHz, 97 dBμV (quasi peak) 84 dBμV (average)
RJ45 test 2 (where applicable)	0.5 – 30 MHz, 87 dBμV (quasi peak) 74 dBμV (average)

11.13 RADIATED EMISSIONS

Radiated Emissions	
Compliance	EN 55022: 2010
Test 1	30 – 230 MHz, 40 dBμV/m at 10 m measurement distance
Test 2	230 – 1 GHz, 47 dBμV/m at 10 m measurement distance

11.14 POWER FREQUENCY

Compliance	IEC 60255-22-7:2003
Opto-inputs (Compliance is achieved using the opto-input filter)	300 V common-mode (Class A) 150 V differential mode (Class A)

Note:
Compliance is achieved using the opto-input filter.

SYMBOLS AND GLOSSARY

APPENDIX A

1 CHAPTER OVERVIEW

This appendix contains terms and symbols you will find throughout the manual.

This chapter contains the following sections:

2 ACRONYMS AND ABBREVIATIONS

Term	Description
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
ASDU	Application Service Data Unit
ASCII	American Standard Code for Information Interchange
AUX / Aux	Auxiliary
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
BOP	Blocking Overreach Protection - a blocking aided-channel scheme.
BRCB	Buffered Report Control Block
BRP	Beacon Redundancy Protocol
BU	Backup: Typically a back-up protection element
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 protection
CDC	Common Data Class
CF	Control Function
Ch	Channel: usually a communications or signaling channel
CIP	Critical Infrastructure Protection standards
CLIO	Current Limited Input Output
CLK / Clk	Clock
Cls	Close - generally used in the context of close functions in circuit breaker control.
CMV	Complex Measured Value
CNV	Current No Volts
COT	Cause of Transmission
CPNI	Centre for the Protection of National Infrastructure
CRC	Cyclic Redundancy Check

Term	Description
CRP	Cross-network Redundancy Protocol
CRV	Curve (file format for curve information)
CRx	Channel Receive: Typically used to indicate a teleprotection signal received.
CS	Check Synchronism.
CSV	Comma Separated Values (a file format for database information)
CT	Current Transformer
CTRL.	Control
CTS	Current Transformer Supervision: To detect CT input failure.
CTx	Channel Transmit: Typically used to indicate a teleprotection signal send.
CU	Communication Unit
CVT	Capacitor-coupled Voltage Transformer - equivalent to terminology CCVT.
DAU	Data Acquisition Unit
DC	Data Concentrator
DC / dc	Direct Current
DCC	An Omicron compatible format
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 scheme.
DG	Distributed Generation
DHCP	Dynamic Host Configuration Protocol
DHP	Dual Homing Protocol
Diff	Differential protection.
DIN	Deutsches Institut für Normung (German standards body)
Dist	Distance protection.
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-energized whilst the bus is energized.
DLR	Dynamic Line Rating
DLY / Dly	Time Delay
DMT	Definite Minimum Time
DNP	Distributed Network Protocol
DPWS	Device Profile for Web Services
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. Abbreviation of "Dead Time" in the context of auto-reclose:
DTD	Document Type Definition
DTOC	Definite Time Overcurrent
DTS	Date and Time Stamp
EF or E/F	Earth Fault (Directly equivalent to Ground Fault)
EIA	Electronic Industries Alliance
ELR	Environmental Lapse Rate

Term	Description
ER	Engineering Recommendation
FCB	Frame Count Bit
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
FWD, Fwd or Fwd.	Indicates an element responding to a flow in the "Forward" direction
GIF	Graphic Interchange Format – a file format for a computer graphic
GND / Gnd	Ground: used in distance settings to identify settings that relate to ground (earth) faults.
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
GUI	Graphical User Interface
HMI	Human Machine Interface
HIF	High Impedance Fault
HiZ	High Impedance (for Restricted Earth Fault)
HSR	High-availability Seamless Ring
HTML	Hypertext Markup Language
I	Current
I/O	Input/Output
I/P	Input
ICAO	International Civil Aviation Organization
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
IEEE	Institute of Electrical and Electronics Engineers
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
ISA	Instrumentation Systems and Automation Society
ISO	International Standards Organization
JPEF	Joint Photographic Experts Group – a file format for a computer graphic
L	Live

Term	Description
LAN	Local Area Network
LCD	Liquid Crystal Display: The front-panel text display on the relay.
LD	Level Detector: An element responding to a current or voltage below its set threshold.
LDOV	Level Detector for Overvoltage
LDUV	Level Detector for Undervoltage
LED	Light Emitting Diode: Red or green indicator on the front-panel.
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
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
MC	MultiCast
MCB	Miniature Circuit Breaker
MCL	MiCOM Configuration Language
MICS	Model Implementation Conformance Statement
MMF	Magneto-Motive Force
MMS	Manufacturing Message Specification
MRP	Media Redundancy Protocol
MU	Merging Unit
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
NIST	National Institute of Standards and Technology
NPS	Negative Phase Sequence
NVD	Neutral voltage displacement: Equivalent to residual overvoltage protection.
NXT	Abbreviation of "Next": In connection with hotkey menu navigation.
O/C	Overcurrent
O/P	Output
Opto	A generic term for a digital input.
OSI	Open Systems Interconnection
PCB	Printed Circuit Board
PCT	Protective Conductor Terminal (Ground)
PDC	Phasor Data Concentrator
Ph	Phase - used in distance settings to identify settings that relate to phase-phase faults.
PICS	Protocol Implementation Conformance Statement
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	Permissive Over Reach

Term	Description
POST	Power On Self Test
POTT	Permissive Over Reach Transfer Tripping
PRP	Parallel Redundancy Protocol
PSB	Power Swing Blocking, to detect power swing/out of step functions (ANSI 78).
PSL	Programmable Scheme Logic: The part of the relay's logic configuration that can be modified by the user, using the graphical editor within S1 Studio software.
PT	Power Transformer
PTP	Precision Time Protocol
PUR	A Permissive UnderReaching transfer trip scheme (alternative terminology: PUTT).
Q	Quantity defined as per unit value
R	Resistance
RBAC	Role Based Access Control
RCA	Relay Characteristic Angle - The center of the directional characteristic.
REB	Redundant Ethernet Board
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.
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
RTD	Resistive Temperature Device
RTU	Remote Terminal Unit
Rx	Receive: Typically used to indicate a communication transmit line/pin.
SBS	Straight Binary Second
SC	Synch-Check or system Synchronism Check.
SCADA	Supervisory Control and Data Acquisition
SCL	Substation Configuration Language
SCU	Substation Control Unit
SEF	Sensitive Earth Fault
SHP	Self Healing Protocol
SIR	Source Impedance Ratio
SMV	Sampled Measured Values
SNTP	Simple Network Time Protocol
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SOC	Second of Century
SOTF	Switch on to Fault protection. Modified protection on manual closure of the circuit breaker.
SP	Single pole.
SPAR	Single pole auto-reclose.
SPC	Single Point Controllable
SPDT	Single Pole Dead Time. The dead time used in single pole auto-reclose cycles.

Term	Description
SPS	Single Point Status
SQRT	Square Root
STP	Spanning Tree Protocol
SV	Sampled Values
SVM	Sampled Value Model
TAF	Turbine Abnormal Frequency
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 protocol
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
TUC	Timed UnderCurrent
TVE	Total Vector Error
Tx	Transmit
UDP	User Datagram Protocol
UPCT	User Programmable Curve Tool
USB	Universal Serial bus
UTC	Universal Time Coordinated
V	Voltage
VA	Phase A voltage: Sometimes L1, or red phase
VB	Phase B voltage: Sometimes L2, or yellow phase
VC	Phase C voltage: Sometimes L3, or blue phase
VDR	Voltage Dependant Resistor
VT	Voltage Transformer
VTS	Voltage Transformer Supervision: To detect VT input failure.
WAN	Wide Area Network
XML	Extensible Markup Language
XSD	XML Schema Definition
ZS / ZL	Source to Line Impedance Ratio

3 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)

4 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

5 LOGIC SYMBOLS AND TERMS

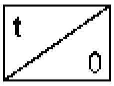
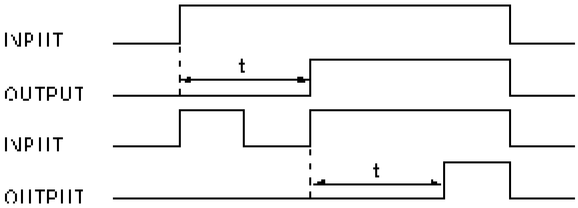
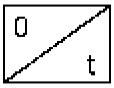
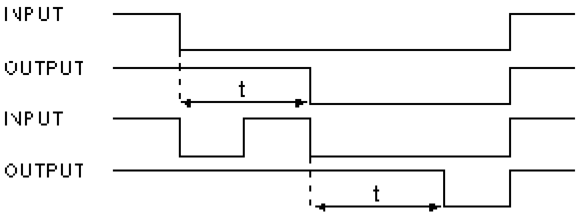
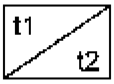
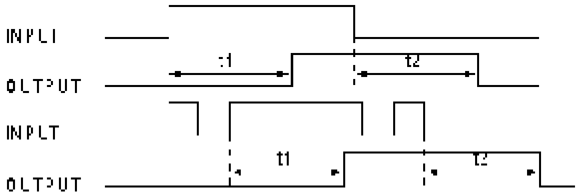
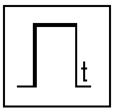
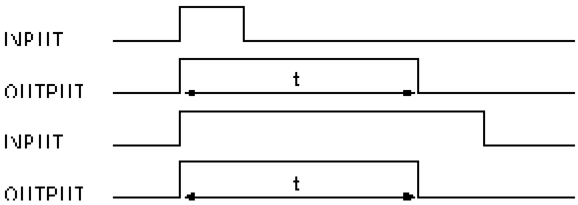
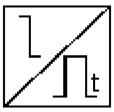
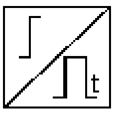
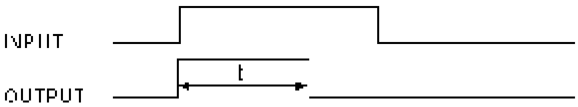
Symbol	Description	Units
&	Logical "AND": Used in logic diagrams to show an AND-gate function.	
Σ	"Sigma": Used to indicate a summation, such as cumulative current interrupted.	
τ	"Tau": Used to indicate a time constant, often associated with thermal characteristics.	
δ	Angular displacement	rad
θ	Angular displacement	rad
Φ	Flux	rad
ϕ	Phase shift	rad
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)	
1	Logical "OR": Used in logic diagrams to show an OR-gate function.	
ABC	Anti-clockwise phase rotation.	
ACB	Clock-wise 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<1	First stage of underfrequency protection: Could be labeled 81-U in ANSI terminology.	Hz
F>1	First stage of overfrequency protection: Could be labeled 81-O in ANSI terminology.	Hz
fmax	Minimum required operating frequency	Hz
fmin	Minimum required operating frequency	Hz
fn	Nominal operating frequency	Hz
I	Current	A
IÙ	Current raised to a power: Such as when breaker statistics monitor the square of ruptured current squared (Ù 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>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
I0	Earth fault current setting Zero sequence current: Equals one third of the measured neutral/residual current.	A
I1	Positive sequence current.	A
I2	Negative sequence current.	A
I2>	Negative sequence overcurrent protection (NPS element).	A
I2pol	Negative sequence polarizing current.	A
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
IC	Phase C current: Might be phase L3, blue phase.. or other, in customer terminology.	A
Idiff	Current setting of biased differential element	A

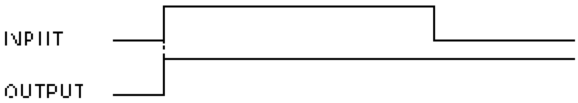
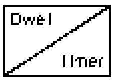
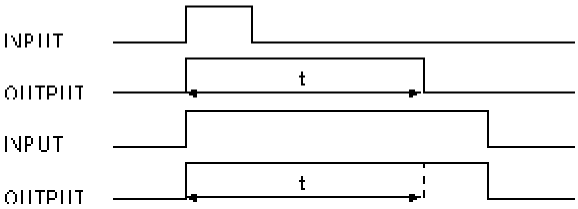
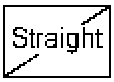
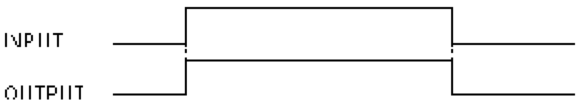
Symbol	Description	Units
If	Maximum secondary through-fault current	A
If max	Maximum secondary fault current (same for all feeders)	A
If max int	Maximum secondary contribution from a feeder to an internal fault	A
If Z1	Maximum secondary phase fault current at Zone 1 reach point	A
Ife	Maximum secondary 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
Im	Mutual current	A
IM64	InterMiCOM^{64}.	
IMx	InterMiCOM^{64} bit (x=1 to 16)	
In	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
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
ISEF>	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	
K1	Lower bias slope setting of biased differential element	%
K2	Higher bias slope setting of biased differential element	%
Ke	Dimensioning factor for earth fault	
km	Distance in kilometers	
Kmax	Maximum dimensioning factor	
Krpa	Dimensioning factor for reach point accuracy	
Ks	Dimensioning factor dependent upon through fault current	
Kssc	Short circuit current coefficient or ALF	
Kt	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
mi	Distance in miles.	
N	Indication of "Neutral" involvement in a fault: i.e. a ground (earth) fault.	
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.	
Pn	Rotating plant rated single phase power	W
PN>	Wattmetric earth fault protection: Calculated using residual voltage and current quantities.	

Symbol	Description	Units
R	Resistance	W
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	W
Rl	Resistance of single lead from relay to current transformer	W
Rr	Resistance of any other protective relays sharing the current transformer	W
Rrn	Resistance of relay neutral current input	W
Rrp	Resistance of relay phase current input	W
Rs	Value of stabilizing resistor	W
Rx	Receive: typically used to indicate a communication receive line/pin.	
S1	Used in IEC terminology to identify the secondary CT terminal polarity: Replace by a dot when using ANSI standards.	
S2	Used in IEC terminology to identify the secondary CT terminal polarity: The non-dot terminal.	
t	A time delay.	
t'	Duration of first current flow during auto-reclose cycle	s
T1	Primary system time constant	s
tfr	Auto-reclose dead time	s
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.	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.	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
V2pol	Negative sequence polarizing voltage.	V
VA	Phase A voltage: Might be phase L1, red phase.. or other, in customer terminology.	V
VB	Phase B voltage: Might be phase L2, yellow phase.. or other, in customer terminology.	V
VC	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
Vk	Required CT knee-point voltage. IEC knee point voltage of a current transformer.	V
VN	Neutral voltage displacement, or residual voltage.	V
Vn	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
Vres.	Neutral voltage displacement, or residual voltage.	V
Vs	Value of stabilizing voltage	V

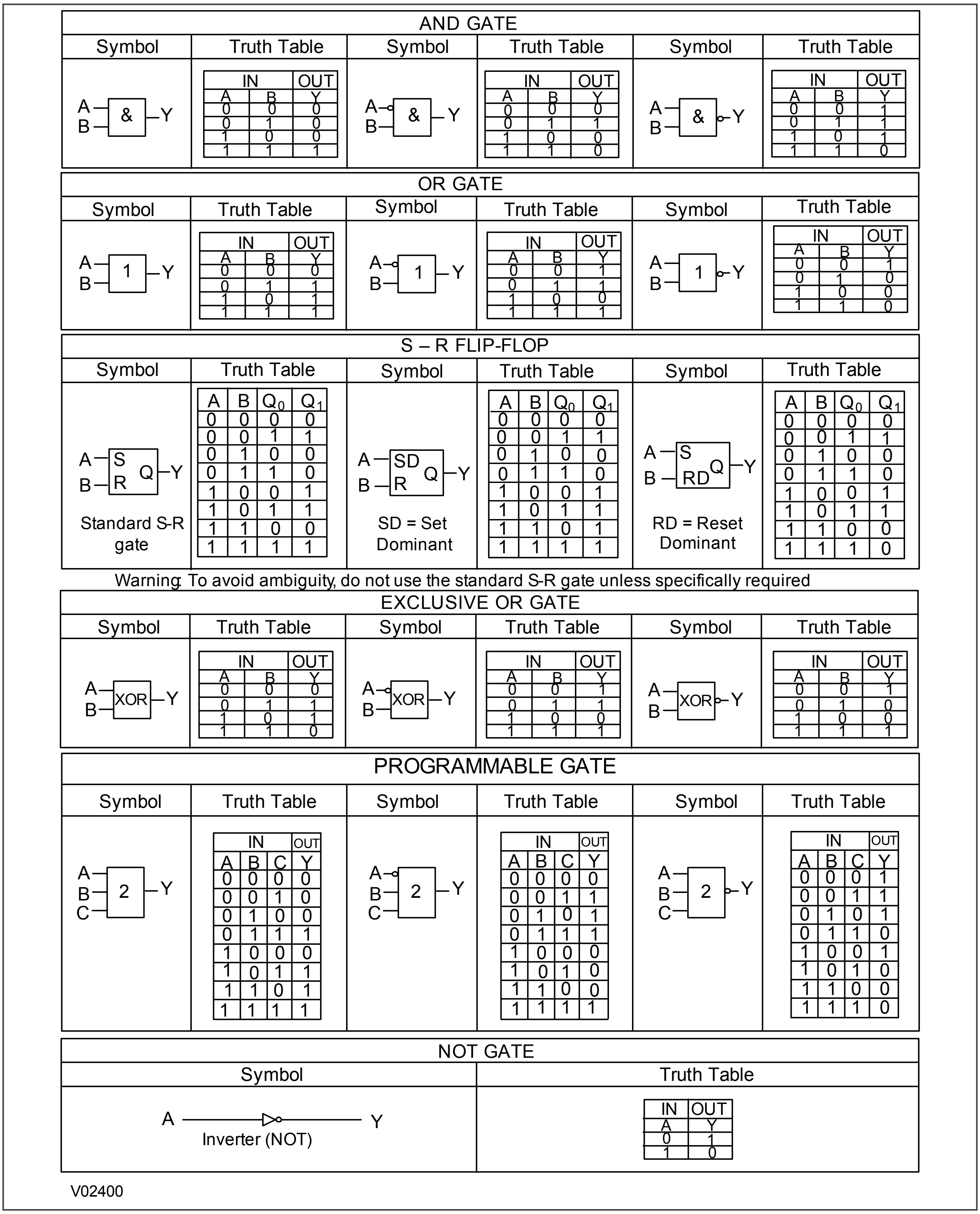
Symbol	Description	Units
Vx	An auxiliary supply voltage: Typically the substation battery voltage used to power the relay.	V
WI	Weak Infeed logic used in teleprotection schemes.	
X	Reactance	None
X/R	Primary system reactance/resistance ratio	None
Xe/Re	Primary system reactance/resistance ratio for earth loop	None
Xt	Transformer reactance (per unit)	p.u.
Y	Admittance	p.u.
Z	Impedance	p.u.
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

6 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
	Latch	
	Dwell timer	
	Straight (non latching): Hold value until input reset signal	

7 LOGIC GATES



AND GATE

Symbol: A, B → & → Y

A (IN)	B (IN)	Y (OUT)
0	0	0
0	1	0
1	0	0
1	1	1

Symbol: A (inverted), B → & → Y

A (IN)	B (IN)	Y (OUT)
0	0	0
0	1	1
1	0	0
1	1	0

Symbol: A, B → & → Y (inverted)

A (IN)	B (IN)	Y (OUT)
0	0	1
0	1	1
1	0	1
1	1	0

OR GATE

Symbol: A, B → 1 → Y

A (IN)	B (IN)	Y (OUT)
0	0	0
0	1	1
1	0	1
1	1	1

Symbol: A (inverted), B → 1 → Y

A (IN)	B (IN)	Y (OUT)
0	0	1
0	1	1
1	0	0
1	1	1

Symbol: A, B → 1 → Y (inverted)

A (IN)	B (IN)	Y (OUT)
0	0	1
0	1	0
1	0	0
1	1	0

S – R FLIP-FLOP

Standard S-R gate

A	B	Q_0	Q_1
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

SD = Set Dominant

A	B	Q_0	Q_1
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

RD = Reset Dominant

A	B	Q_0	Q_1
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

Warning: To avoid ambiguity, do not use the standard S-R gate unless specifically required

EXCLUSIVE OR GATE

Symbol: A, B → XOR → Y

A (IN)	B (IN)	Y (OUT)
0	0	0
0	1	1
1	0	1
1	1	0

Symbol: A (inverted), B → XOR → Y

A (IN)	B (IN)	Y (OUT)
0	0	1
0	1	1
1	0	0
1	1	1

Symbol: A, B → XOR → Y (inverted)

A (IN)	B (IN)	Y (OUT)
0	0	1
0	1	0
1	0	0
1	1	1

PROGRAMMABLE GATE

Symbol: A, B, C → 2 → Y

A (IN)	B (IN)	C (IN)	Y (OUT)
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: A (inverted), B, C → 2 → Y

A (IN)	B (IN)	C (IN)	Y (OUT)
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: A, B, C → 2 → Y (inverted)

A (IN)	B (IN)	C (IN)	Y (OUT)
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

NOT GATE

Symbol: A → Inverter (NOT) → Y

A (IN)	Y (OUT)
0	1
1	0

V02400

Figure 98: Logic Gates

COMMISSIONING RECORD

APPENDIX B

1 TEST RECORD

1.1 ENGINEER DETAILS

Item	Value
Engineer's name	
Commissioning date	
Station	
Circuit	
System Frequency	
VT Ratio	
CT Ratio	

1.2 FRONT PLATE INFORMATION

Item	Value
Device	
Model number	
Serial number	
Rated current In	
Rated voltage Vn	
Auxiliary voltage Vx	

1.3 TEST EQUIPMENT

Test Equipment	Model	Serial Number
Injection test set		
Phase angle meter		
Phase rotation meter		
Insulation tester		
Setting application software		
IEC 61850 configurator software		
DNP3 configurator software		

1.4 TESTS WITH PRODUCT DE-ENERGISED

Test	Result (mark where appropriate)
Was the IED damaged on visual inspection?	Yes / No
Is the rating information correct for installation?	Yes / No
Is the case earth installed?	Yes / No
Are the current transformer shorting contacts closed?	Yes / No / Not checked
Is the insulation resistance >100 MOhms at 500 V DC?	Yes / No / Not tested
Wiring checked against diagram?	Yes / No
Test block connections checked?	Yes / No / N/A

Test	Result (mark where appropriate)
N/C Watchdog contacts closed?	Yes / No
N/O Watchdog contacts open?	Yes / No
Measured auxiliary supply	……………………..V DC / AC

1.5 TESTS WITH PRODUCT ENERGISED

General Tests	Result (mark where appropriate)
N/C Watchdog contacts open?	Yes / No
N/O Watchdog contacts closed?	Yes / No
LCD contrast setting used	....
Clock set to local time?	Yes / No
Time maintained when auxiliary supply removed?	Yes / No
Alarm (yellow) LED working?	Yes / No
Out of service (yellow) LED working?	Yes / No
Programmable LEDs working?	Yes / No
All opto-inputs working?	Yes / No
All output relays working?	Yes / No

1.6 COMMUNICATION TESTS

Communications	Result (mark where appropriate)
SCADA Communication standard (Courier, DNP3.0, IEC 61850, IEC 60870, Modbus)	
Communications established?	Yes / No
Protocol converter tested?	Yes / No / N/A

1.7 CURRENT INPUT TESTS

Current Inputs (if applicable)		Result (mark where appropriate)
Displayed current		Primary / Secondary
Phase CT ratio (if applicable)		
Input CT	Applied Value	Displayed Value
IA		
IB		
IC		
IN		
ISEF (if applicable)		

> *Note:*
> *Reuse the table for each CT tested.*

1.8 VOLTAGE INPUT TESTS

Voltage Inputs (if applicable)		Result (mark where appropriate)
Displayed voltage		Primary / Secondary
Main VT ratio (if applicable)		
Input VT	Applied Value	Displayed value
VZ1		
VZ2		
VZ3		
VZ4		

1.9 OVERCURRENT CHECKS

Overcurrent Checks	Result
Overcurrent type	Directional / Non-directional
Applied voltage	V
Applied current	A
Expected operating time	s
Measured operating time	s

1.10 ON-LOAD CHECKS

On-load checks	Result
Test wiring removed?	Yes / No
Voltage inputs and phase rotation OK?	Yes / No
Current inputs and polarities OK?	Yes / No
On-load test performed?	Yes / No
(If No, give reason why) …	
IED is correctly directionalised?	Yes / No / N/A

1.11 FINAL CHECKS

Final Checks	Result
All test equipment, leads, shorts and test blocks removed safely?	Yes / No
Ethernet connected?	Yes / No / N/A
Disturbed customer wiring rechecked?	Yes / No / N/A
All commissioning tests 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

Final Checks	Result
LEDs reset?	Yes / No

WIRING DIAGRAMS

APPENDIX C

1 APPENDIX OVERVIEW

This chapter contains the wiring diagrams for all possible situations.

This chapter contains the following sections:

2 P747: BUSBAR PROTECTION

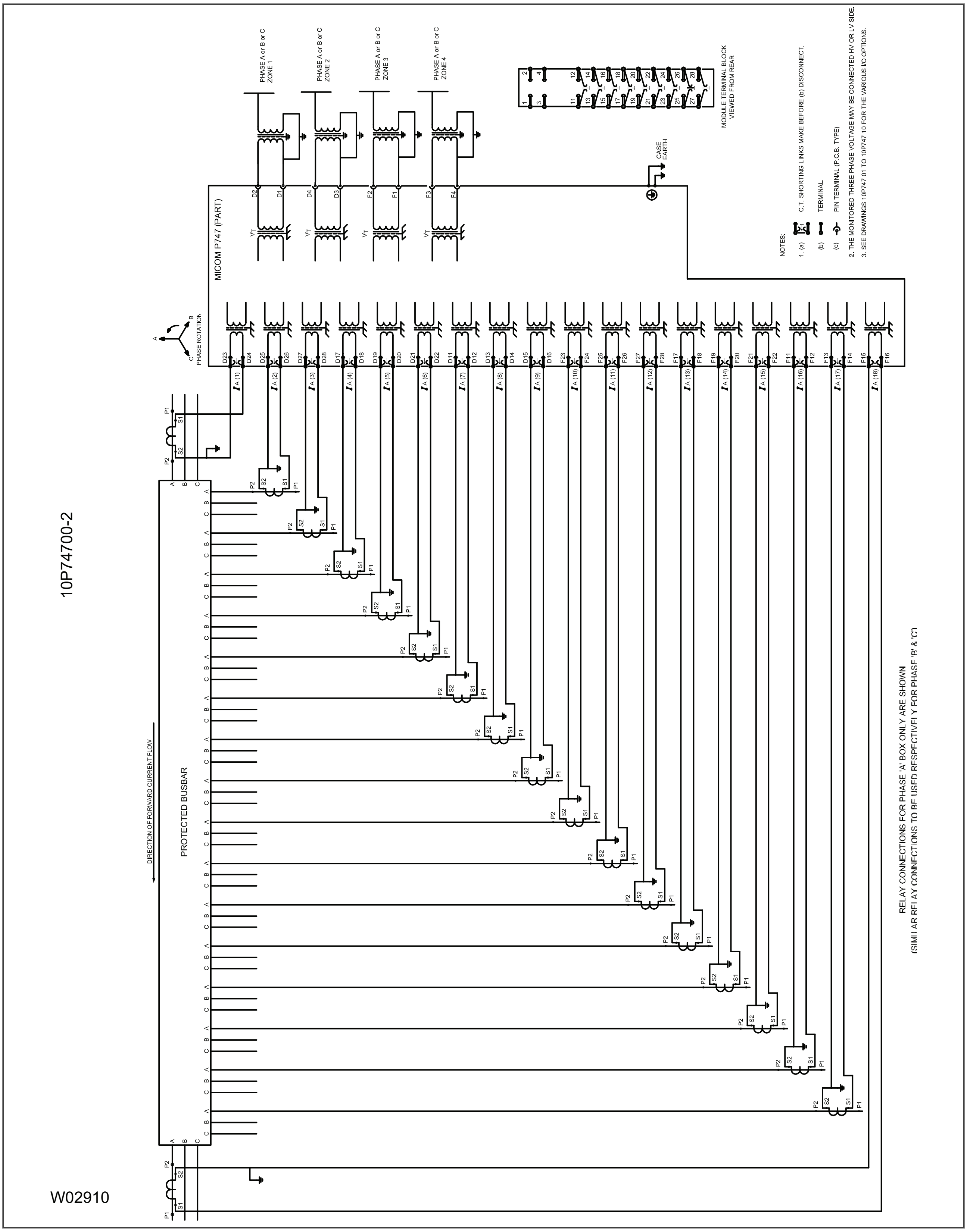


Figure 99: P747 busbar protection, 3 box solution

3 P747: I/O OPTION A

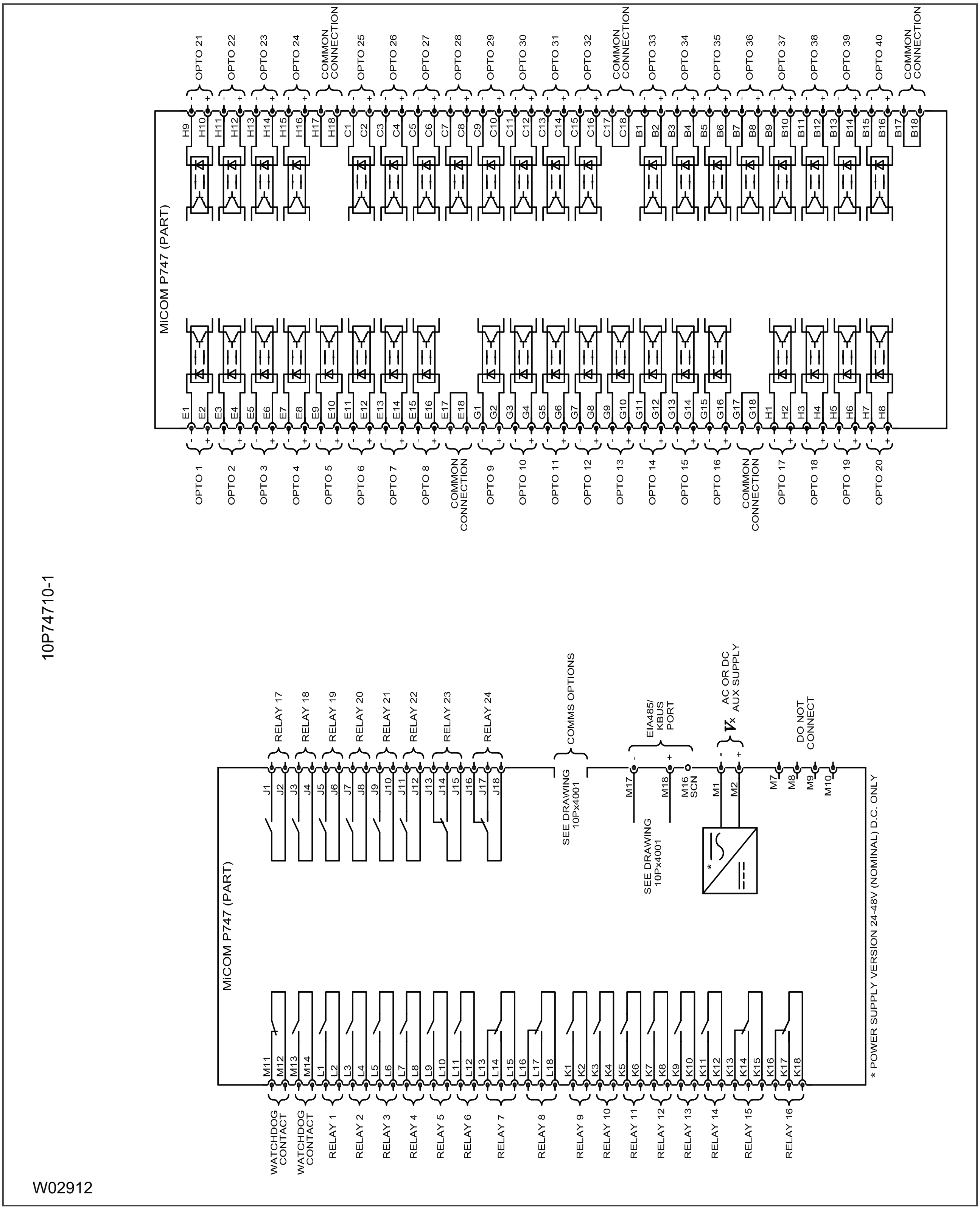


Figure 100: P747 busbar protection with 40 inputs, 24 outputs and coprocessor

4 P747: I/O OPTION B

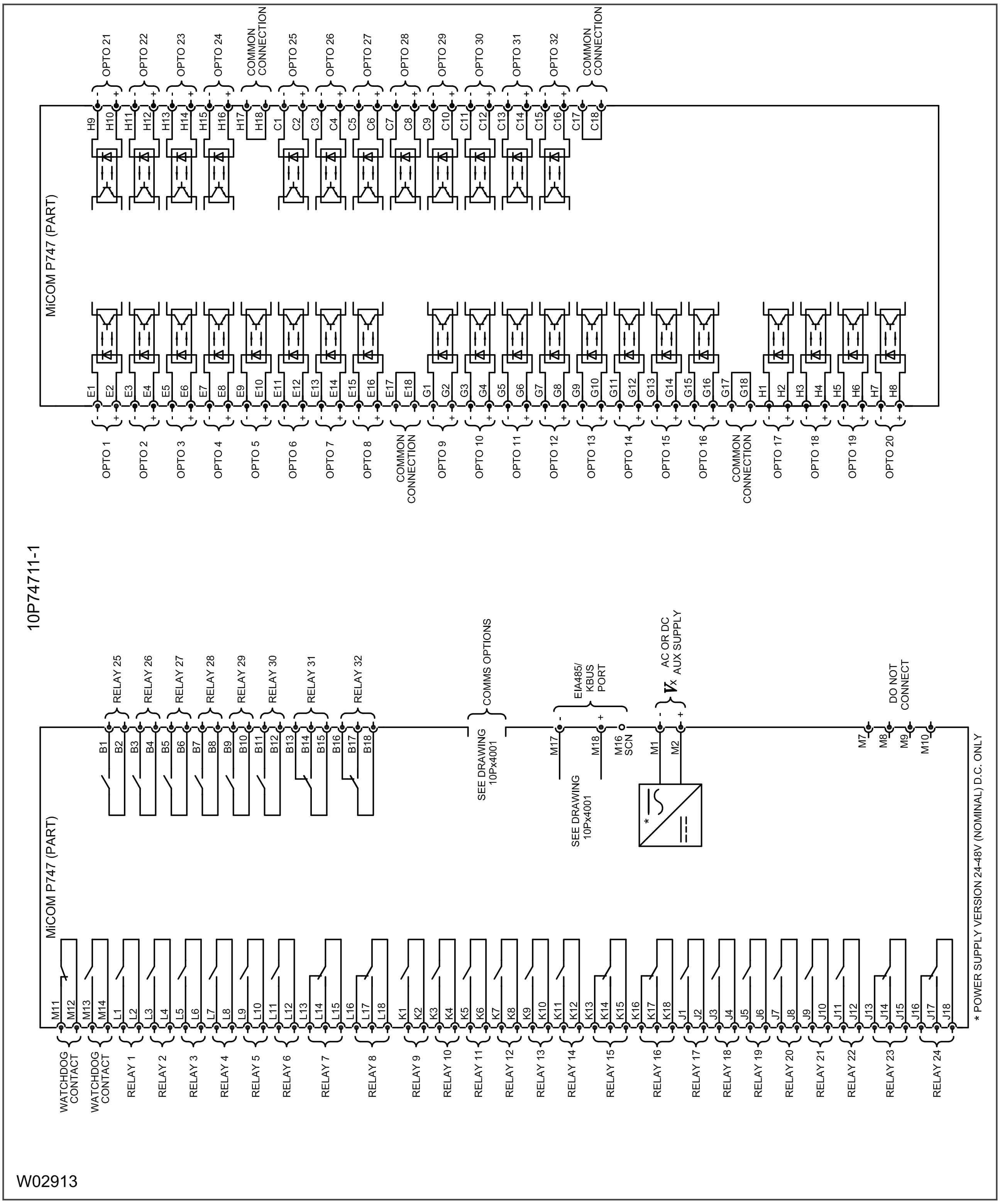


Figure 101: P747 busbar protection with 32 inputs, 32 outputs and coprocessor

5 P747: I/O OPTION C

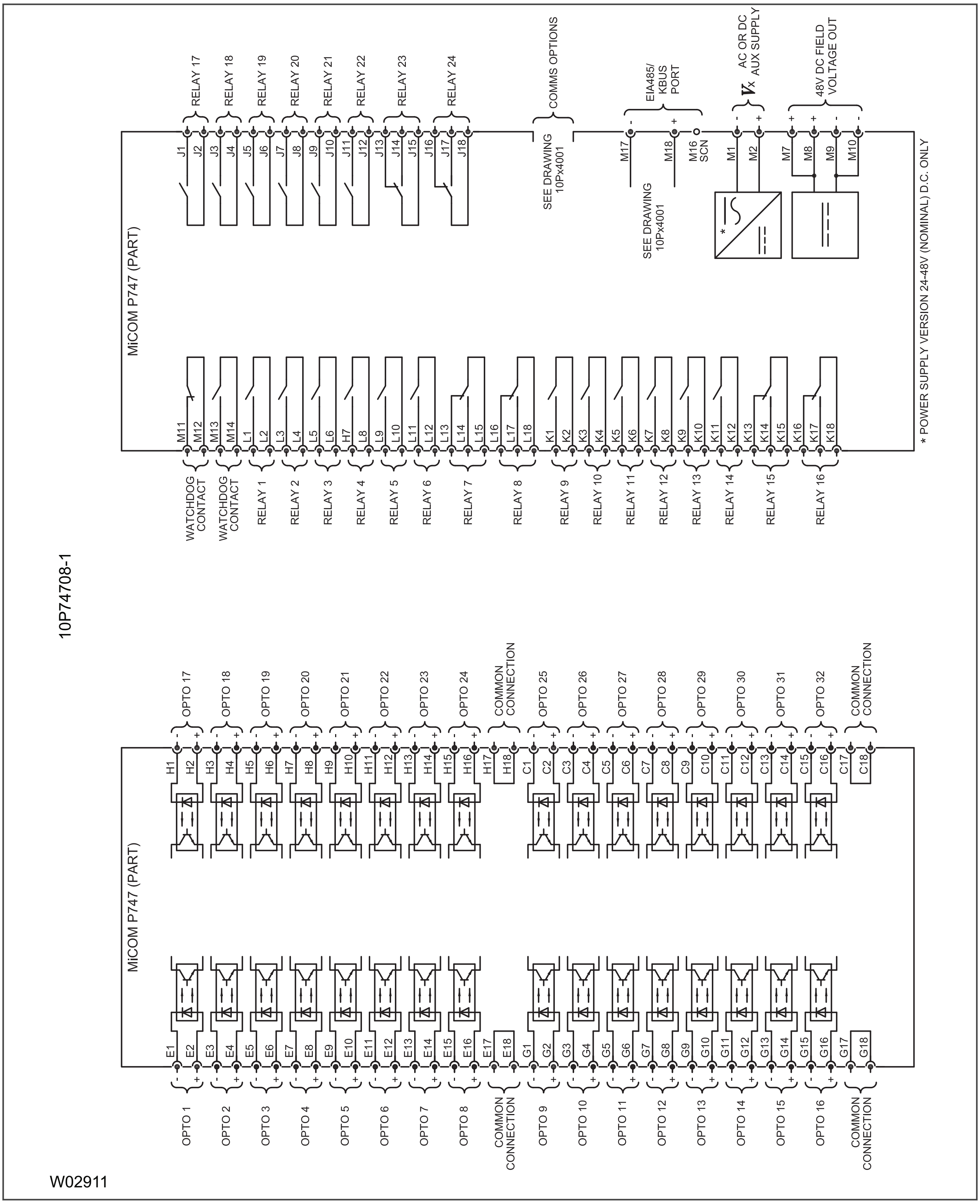


Figure 102: P747 busbar protection with 32 inputs, 24 outputs and standard coprocessor

Imagination at work

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P747-TM-EN-1.1