GE
Grid Solutions

MiCOM P40 Agile

P44T

Technical Manual
Catenary Distance Protection Relay

Hardware version: M
Software version: 03
Publication reference: P44T-EN-TM-D

INTRODUCTION

CHAPTER 1

1 FOREWORD

This technical manual provides a functional and technical description of General Electric's MiCOM P44T range of IEDs, as well as a comprehensive set of instructions for using the device.

1.1 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 and that system and protection engineers have a thorough knowledge of protection systems and associated equipment.

1.2 Conventions

1.2.1 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.
- Menu hierarchies in documentation describing software applications use the > sign to indicate the next level
  For example: Select **File > Save**
- Filenames and paths use the courier font
  For example: `Example\File.text`
- Special terminology is written with leading capitals
  For example: Sensitive Earth Fault
- When reference is made to General Electric's Courier database, the column text is written in upper case
  For example: The SYSTEM DATA column
- When reference is made to General Electric's Courier database, the cell text is written in bold type
  For example: The **Language** cell in the SYSTEM DATA column
- When reference is made to General Electric's Courier database, the value of a cell's content is enclosed in single quotation marks
  For example: The **Language** cell in the SYSTEM DATA column contains the value 'English'

1.2.2 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 General Electric. 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'.

1.3 Manual Structure

The manual consists of the following chapters:

- Chapter 1: Introduction
- Chapter 2: Safety Information
- Chapter 3: Hardware Design
- Chapter 4: Software Design
- Chapter 5: Configuration
- Chapter 6: Settings and Records
- Chapter 7: Operation
- Chapter 8: Application Examples
- Chapter 9: SCADA Communications
- Chapter 10: Cyber Security
- Chapter 11: PSL Editor
- Chapter 12: PSL Schemes
- Chapter 13: Installation
- Chapter 14: Commissioning Instructions
- Chapter 15: Maintenance & Troubleshooting
- Chapter 16: Technical Specifications
- Chapter 17: Symbols and Glossary
- Chapter 18: Wiring Diagrams
- Chapter 19: Firmware Version History
- Appendix A: Commissioning Record Forms
- Appendix B: P59x Commissioning Instructions
- Appendix C: DDB Signals

1.4 Product Scope

The MiCOM P44T has been designed for protection of classic or auto-transformer fed rail catenaries applications in systems with nominal frequencies 50 or 60 Hz (settable). The MiCOM P44T is used for single breaker applications.

The MiCOM P44T is available in four variants; models A, B, C and D. The difference between the variants is the amount of I/O and the type of output contacts used. These differences are summarized in the following table:

Feature	Model A	Model B	Model C	Model D
Number of CT Inputs	3	3	3	3
Number of VT inputs	3	3	3	3
Opto-coupled digital inputs	16	16	24	24
Standard relay output contacts	16	8	32	16
High speed high break output contacts		4	0	8

Table 1: Difference in model variants

1.5 Features and Functions

The product supports the following functions:

Distance/DEF/Delta features

Feature	IEC61850	ANSI
Distance zones, full-scheme protection (5)	DisPDIS	21/21N
Phase characteristic (Quadrilateral)		
Ground characteristic (Quadrilateral)		
CVT transient overreach elimination		
Load blinder		
Easy setting mode		
Communication-aided schemes, PUTT, POTT, Blocking	DisPSCH	85
Accelerated tripping – Z1 extension		
Switch on to fault and trip on reclose – elements for fast fault clearance on breaker closure	SofPSOF/ TorPSOF	50SOTF/27SOTF
Delta directional comparison - fast channel schemes operating on fault generated superimposed quantities		78DCB/78DCUB

Table 2: Distance/DEF/Delta features

Protection Features

Feature	IEC61850	ANSI
Tripping Mode (1 & All pole)	PTRC	
Phase overcurrent stages, with optional directionality (4)	OcpPTOC/RDIR	50/51/67
Broken conductor (open jumper), used to detect open circuit faults		46
Thermal overload protection	ThmPTTR	49
Undervoltage protection stages (2)	VtpPhsPTUV	27
Overvoltage protection stages (2)	VtpPhsPTOV	59
Wrong Phase Coupling		
Panto Flash Over		
Train Startup		
Remote overvoltage protection stages (2)	VtpCmpPTOV	59R
High speed breaker fail - two-stage, suitable for re-tripping and backtripping	RBRF	50BF
Voltage transformer supervision		47/27
Auto-reclose - shots supported (4)	RREC	79

Feature	IEC61850	ANSI
Check synchronization, 2 stages	RSYN	25
InterMiCOM^{64} teleprotection for direct relay-relay communication (optional)		

Table 3: Protection features

Communication Features

Feature	IEC61850	ANSI	P44T
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	•
IEC61850 (optional)		16E	(•)
IEC60870-5-103 (optional)		16S	•
DNP3.0 over serial link (optional)		16S	•
DNP3.0 over Ethernet (optional)		16E	(•)
IRIG-B time synchronization (optional)		CLK	(•)

Table 4: Communication features

General Features

Feature	IEC61850	ANSI	P44T
NERC compliant cyber security			•
Multiple password access control levels			•
Function keys	FnkGGIO		10
Programmable LEDs	LedGGIO		18
Programmable hotkeys			2
Programmable allocation of digital inputs and outputs			•
Fully customizable menu texts			•
Measurement of all instantaneous & integrated values		MET	•
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)			4
Fault locator	RFLO		•
Event records		SER	1024
Disturbance recorder for waveform capture – specified in samples per cycle (48)	RDRE	DFR	48
Graphical programmable scheme logic (PSL)			•

Table 5: General features

2 COMPLIANCE

The unit has undergone a range of extensive testing and certification processes to ensure and prove compatibility with all target markets. Table 6 summarizes a list of standards with which the device is compliant. A detailed description of these criteria can be found in the *Technical Specifications* chapter.

Condition	Compliance
EMC compliance (compulsory)	2004/108/EC (demonstrated by EN50263:2000)
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, IEC 61000-4-5/6/8/9/10, EN61000-4-3/18, IEEE/ANSI C37.90.1/2, ENV50204, EN55022
Product Safety for North America	UL/CL File No. UL/CUL E202519
Environmental conditions	IEC 60068-2-1/30/60/78
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 60529:1999 – IP10, IP30, IP52
Mechanical robustness	IEC 60255-21-1/2/3

Table 6: Compliance standards

3 APPLICATION OVERVIEW

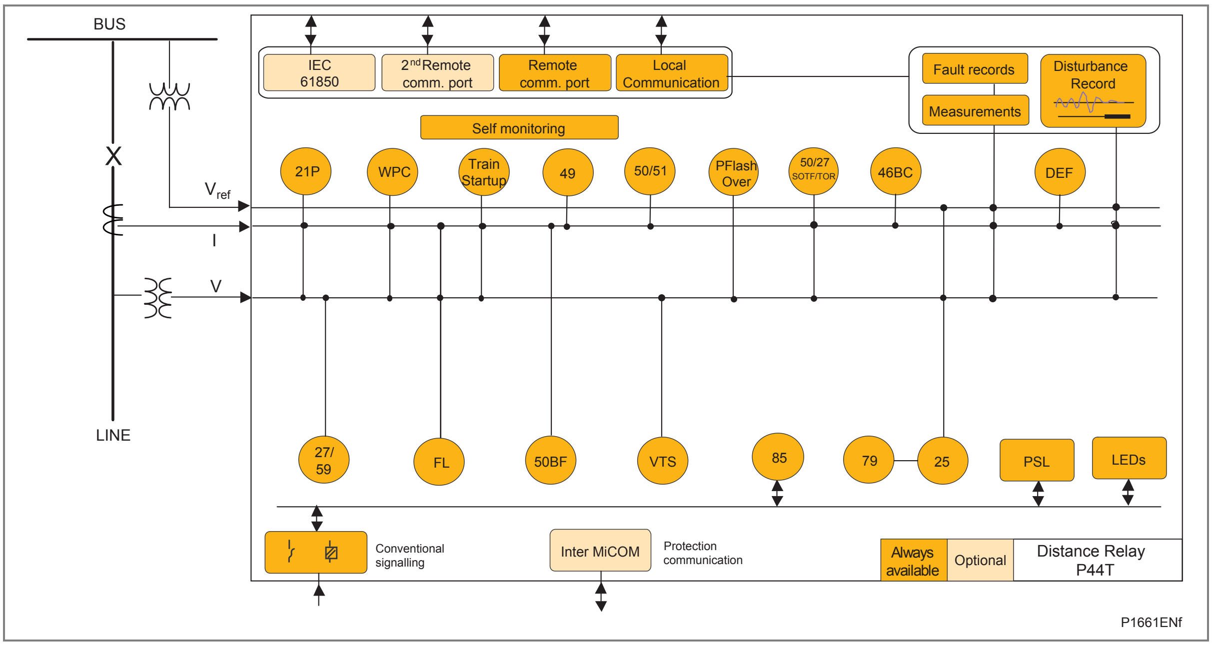


Figure 1: Application Overview

4 ORDERING OPTIONS

Variants		Order No.										
MiCOM P44T (QUAD Railway Distance Protection)		P44T								**		
Nominal auxiliary voltage												
24-54 Vdc			7									
48-125 Vdc (40-100 Vac)			8									
110-250 Vdc (100-240 Vac)			9									
In/Vn rating												
Dual rated CT (1 & 5A : 100 - 120V)				1								
Hardware options	**Protocol Compatibilty**											
Standard - None	1, 3 & 4				1							
IRIG-B Only (Modulated)	1, 3 & 4				2							
Fibre Optic Converter Only	1, 3 & 4				3							
IRIG-B (Modulated) & Fibre Optic Converter	1, 3 & 4				4							
Ethernet (100Mbit/s)	6, 7 & 8				6							
Ethernet (100Mbit/s) plus IRIG-B (Modulated)	6, 7 & 8				A							
Ethernet (100Mbit/s) plus IRIG-B (Un-modulated)	6, 7 & 8				B							
IRIG-B (Un-modulated)	1, 3 & 4				C							
InterMiCOM + Courier Rear Port	1, 3 & 4				E							
InterMiCOM + Courier Rear Port + IRIG-B modulated	1, 3 & 4				F							
Redundant Ethernet Self-Healing Ring, 2 multi-mode fibre ports + Modulated IRIG-B	6, 7 & 8				G							
Redundant Ethernet Self-Healing Ring, 2 multi-mode fibre ports + Un-modulated IRIG-B	6, 7 & 8				H							
Redundant Ethernet RSTP, 2 multi-mode fibre ports + Modulated IRIG-B	6, 7 & 8				J							
Redundant Ethernet RSTP, 2 multi-mode fibre ports + Un-modulated IRIG-B	6, 7 & 8				K							
Redundant Ethernet Dual-Homing Star, 2 multi-mode fibre ports + Modulated IRIG-B	6, 7 & 8				L							
Redundant Ethernet Dual-Homing Star, 2 multi-mode fibre ports + Un-modulated IRIG-B	6, 7 & 8				M							
Redundant Ethernet PRP/HSR, 2 fibre ports + Modulated IRIG-B	6, 7 & 8				N							
Redundant Ethernet PRP/HSR, 2 fibre ports + Unmodulated IRIG-B	6, 7 & 8				P							
* HSR – contact Alstom for details												
Product Options												
Size 12 case, 16 inputs and 16-standard outputs						A						
Size 12 case, 16 inputs and 8-standard plus 4-high break outputs						B						
Size 16 case, 24 inputs and 32-standard outputs						C						
Size 16 case, 24 inputs and 16-standard plus 8-high break outputs						D						
Size 12 case, 16 inputs and 16-standard outputs with 850nm dual mode, dual channel fibre interface						E						
Size 12 case, 16 inputs and 8-standard plus 4-high break outputs with 850nm dual mode, dual channel fibre interface						F						
Size 16 case, 24 inputs and 32-standard outputs with 850nm dual mode, dual channel fibre interface						G						
Size 16 case, 24 inputs and 16-standard plus 8-high break outputs with 850nm dual mode, dual channel fibre interface						H						
Size 12 case, 16 inputs and 16-standard outputs with 1300nm single mode, single channel fibre interface						I						
Size 12 case, 16 inputs and 8-standard plus 4-high break outputs with 1300nm single mode, single channel fibre interface						J						
Size 16 case, 24 inputs and 32-standard outputs with 1300nm single mode, single channel fibre interface						K						
Size 16 case, 24 inputs and 16-standard plus 8-high break outputs with 1300nm single mode, single channel fibre interface						L						
Size 12 case, 16 inputs and 16-standard outputs with 1300nm single mode, dual channel fibre interface						M						
Size 12 case, 16 inputs and 8-standard plus 4-high break outputs with 1300nm single mode, dual channel fibre interface						N						
Size 16 case, 24 inputs and 32-standard outputs with 1300nm single mode, dual channel fibre interface						O						
Size 16 case, 24 inputs and 16-standard plus 8-high break outputs with 1300nm single mode, dual channel fibre interface						P						
Size 12 case, 16 inputs and 16-standard outputs with 1300nm multi mode, single channel fibre interface						Q						
Size 12 case, 16 inputs and 8-standard plus 4-high break outputs with 1300nm multi mode, single channel fibre interface						R						
Size 16 case, 24 inputs and 32-standard outputs with 1300nm multi mode, single channel fibre interface						S						
Size 16 case, 24 inputs and 16-standard plus 8-high break outputs with 1300nm multi mode, single channel fibre interface						T						
Size 12 case, 16 inputs and 16-standard outputs with 1300nm multi mode, dual channel fibre interface						U						
Size 12 case, 16 inputs and 8-standard plus 4-high break outputs with 1300nm multi mode, dual channel fibre interface						V						
Size 16 case, 24 inputs and 32-standard outputs with 1300nm multi mode, dual channel fibre interface						W						
Size 16 case, 24 inputs and 16-standard plus 8-high break outputs with 1300nm multi mode, dual channel fibre interface						X						
Protocol options	**Hardware Compatibilty**											
K-Bus	1, 2, 3, 4, C, E & F						1					
IEC870	1, 2, 3, 4, C, E & F						3					
DNP3.0	1, 2, 3, 4, C, E & F						4					
IEC61850 + Courier via rear RS485 port	6, A, B, G, H, J, K, L, M, N, P						6					
IEC61850+IEC60870-5-103 via rear RS485 port	6, A, B, G, H, J, K, L, M, N, P						7					
DNP3.0 Over Ethernet	6, A, B, G, H, J, K, L, M, N, P						8					
Mounting												
Flush/panel mounting with Harsh Environment Coating								M				
19" Rack mounting with Harsh Environmental Coating								N				
Language												
English, French, German, Spanish									0			
Software version												
Date and application dependant										**		
Customer specific options												
Standard version											0	
Customer version											A	
Hardware version												
As K plus increased main processor memory (XCPU3)												M

SAFETY INFORMATION

CHAPTER 2

1 CHAPTER OVERVIEW

The Safety Information chapter provides information for the safe handling of the equipment. You must be familiar with information contained in this chapter before unpacking, installing, commissioning, or servicing the equipment.

The chapter contains the following sections

2 HEALTH AND SAFETY

The information in this chapter is intended to ensure that equipment is properly installed and handled in order to maintain it in a safe condition and to keep personnel safe at all times.

When electrical equipment is in operation, dangerous voltages will be 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.
- familiar with accepted safety engineering practices and are authorized to energize and de-energize equipment in the correct manner.
- trained in the care and use of safety apparatus in accordance with safety engineering practices
- trained in emergency procedures (first aid).

The documentation provides instructions for installing, commissioning and operating the equipment. It cannot, however cover all conceivable circumstances. In the event of questions or problems, do not take any action without proper authorization. Please contact your local sales office and request the necessary information.

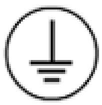
3 SYMBOLS

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

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

Risk of electric shock

Earth terminal. Note: This symbol may also be used for a protective conductor (earth) terminal if that terminal is part of a terminal block or sub-assembly.



Protective conductor (earth) terminal

Instructions on disposal requirements

The term 'Earth' used in this manual is the direct equivalent of the North American term 'Ground'.

4 INSTALLATION, COMMISSIONING AND SERVICING

4.1 Lifting Hazards

Many injuries are caused by:

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

Plan carefully, identify any possible hazards and determine how best to move the product. Look at other ways of moving the load to avoid manual handling. Use the correct lifting techniques and Personal Protective Equipment (PPE) to reduce the risk of injury.

4.2 Electrical Hazards

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

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

Always use the equipment as specified. Failure to do so will jeopardise the protection provided by the equipment.

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

Isolate the equipment before working on the terminal strips.

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

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.

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

Testing may leave capacitors charged to dangerous voltage levels. Discharge capacitors by reducing test voltages to zero before disconnecting test leads.

Operate the equipment within the specified electrical and environmental limits.

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

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.

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).

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

Where UL/CSA listing of the equipment is required for external fuse protection, a UL or CSA Listed fuse must be used for the auxiliary supply. 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).

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 the auxiliary supply (for example Red Spot type NIT or TIA).
For P50 models, use a 1A maximum T-type fuse.
For P60 models, use a 4A maximum T-type fuse.

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.

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

4.5 Equipment Connections

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

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.

Always use insulated crimp terminations for voltage and current connections.

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

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

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

Do not remove the PCT.

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

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

The recommended minimum PCT wire size is 2.5 mm² for countries whose mains supply is 230 V (e.g. Europe) and 3.3 mm² 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 mm². See product documentation for details.

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

All connections to the equipment must have a defined potential. Connections that are pre-wired, but not used, should be earthed, or connected to a common grouped potential.

4.7 Pre-energization Checklist

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

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

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

Check integrity of the PCT connection.

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

4.8 Peripheral Circuitry

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.

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

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.

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

4.9 Upgrading/Servicing

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.

Internal modules and assemblies can be heavy and may have sharp edges. Take care when inserting or removing modules into or out of the IED.

5 DECOMMISSIONING AND DISPOSAL

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 decommissioning.

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

6 REGULATORY COMPLIANCE

Compliance with the European Commission Directive on EMC and LVD is demonstrated using a technical file.

CE

6.1 EMC Compliance: 2014/30/EU

The product specific Declaration of Conformity (DoC) lists the relevant harmonised standard(s) or conformity assessment used to demonstrate compliance with the EMC directive.

6.2 LVD Compliance: 2014/35/EU

The product specific Declaration of Conformity (DoC) lists the relevant harmonized standard(s) or conformity assessment used to demonstrate compliance with the LVD directive.

Safety related information, such as the installation I overvoltage category, pollution degree and operating temperature ranges are specified in the Technical Data section of the relevant product documentation and/or on the product labelling.

Unless otherwise stated in the Technical Data section of the relevant product documentation, the equipment is intended for indoor use only. Where the equipment is required for use in an outdoor location, it must be mounted in a specific cabinet or housing to provide the equipment with the appropriate level of protection from the expected outdoor environment.

6.3 R&TTE Compliance: 2014/53/EU

Radio and Telecommunications Terminal Equipment (R&TTE) directive 2014/53/EU.

Conformity is demonstrated by compliance to both the EMC directive and the Low Voltage directive, to zero volts.

6.4 UL/CUL Compliance

If marked with this logo, the product is compliant with the requirements of the Canadian and USA Underwriters Laboratories.

The relevant UL file number and ID is shown on the equipment.

6.5 ATEX Compliance: 2014/34/EU

Products marked with the 'explosion protection' Ex symbol (shown in the example, below) are compliant with the ATEX directive. The product specific Declaration of Conformity (DoC) lists the Notified Body, Type Examination Certificate, and relevant harmonized standard or conformity assessment used to demonstrate compliance with the ATEX directive.

The ATEX Equipment Protection level, Equipment group, and Zone definition will be marked on the product.

For example:

Where:

'II' Equipment Group: Industrial.

'(2)G' High protection equipment category, for control of equipment in gas atmospheres in Zone 1 and 2. This equipment (with parentheses marking around the zone number) is not itself suitable for operation within a potentially explosive atmosphere.

HARDWARE DESIGN

CHAPTER 3

1 CHAPTER OVERVIEW

The Hardware Design chapter describes the design of the product's hardware platform. It consists of the following sections:

2 HARDWARE DESIGN

All products based on the Px40 platform have common hardware architecture. The unit's hardware is based on a modular design philosophy and is made up of several modules drawn from a standard range.

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 – 40TE or smaller	Main Processor board – without support for function keys
Main Processor board – 60TE or larger	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
High-break output relay board	Output relay board with high breaking capacity relays
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

Board	Use
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
Output relay output board (7 outputs)	Standard output relay board with 7 outputs
Combined opto-input/output relay board	Combined digital input/output board with opto-inputs + output relays
Power line carrier board	Power line carrier board for phase comparison
Coprocessor board	Coprocessor board for processing special algorithms
Coprocessor board with on-board GPS	Coprocessor board with GPS input for time synchronisation

Table 1 Board options

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 data buses are shown as a single interconnection module in the following figure, which shows typical modules and the flow of data between them.

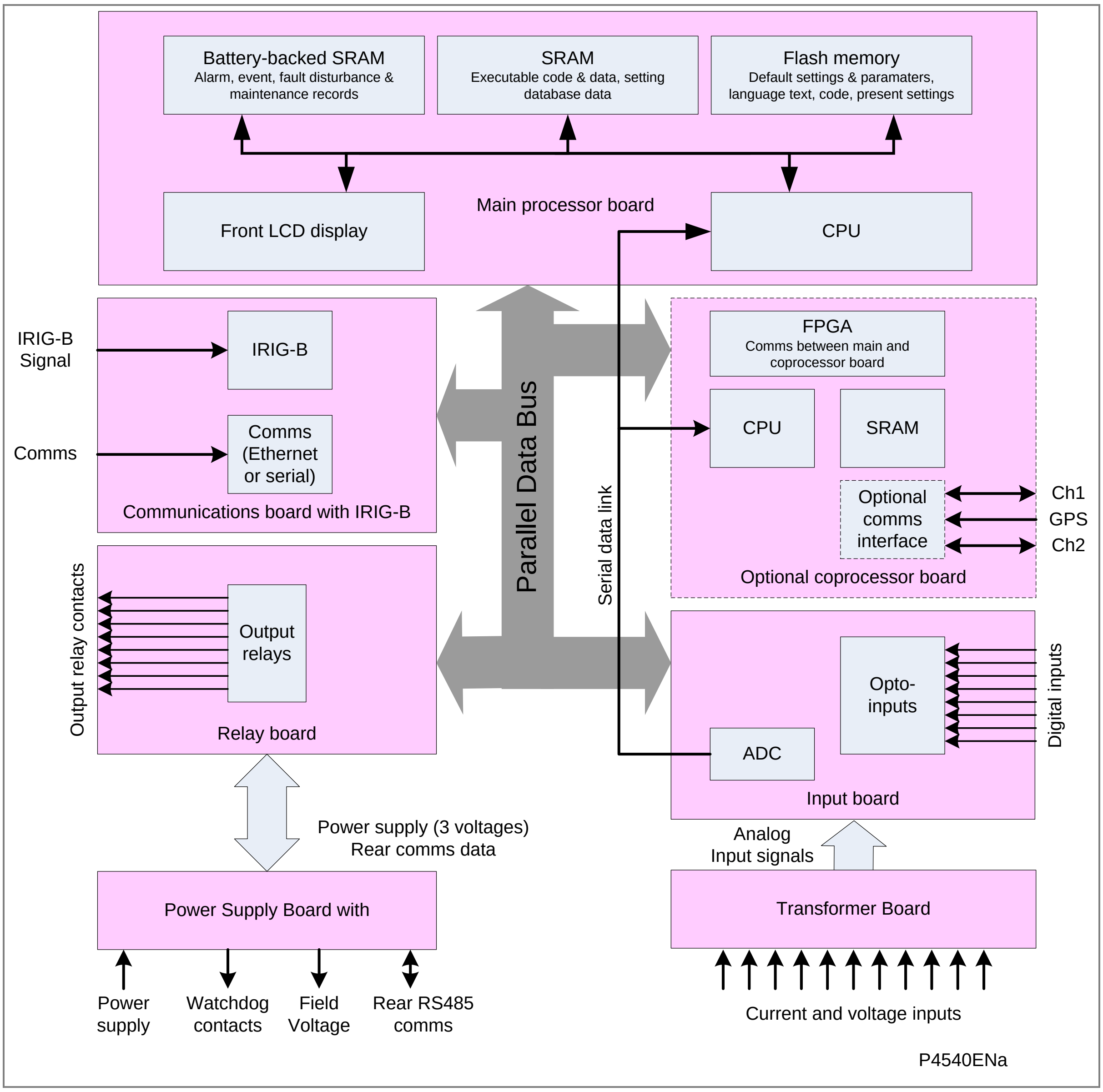


Figure 1: Hardware functional diagram

Some products are equipped with a coprocessor board for extra computing power. There are several variants of coprocessor board, depending on the required communication requirements. Some models do not need any external communication inputs, some models need inputs for current differential functionality and some models need an input for GPS time synchronisation.

3 HOUSING VARIANTS

The Px4x ranges 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

Table 2 Case widths

4 FRONT PANEL

The following diagram shows the front panel of a typical 60TE unit. The front panels of the products based on 40TE and 80TE cases have a lot of commonality and differ only in the number of hotkeys and user-programmable LEDs. 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.

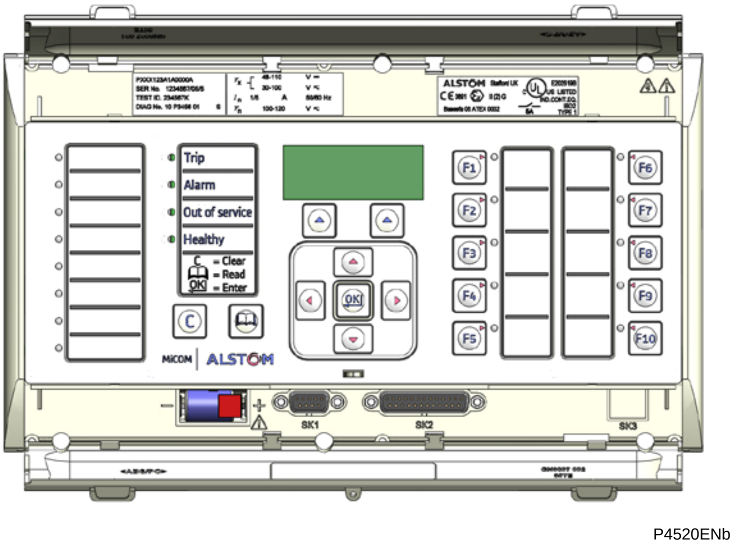


Figure 2: Front panel (60TE)

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

A top compartment with a 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.

Liquid Crystal Display (LCD)

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

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	

Function keys  to 

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.

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.

Programmable Alarm LEDs

Depending on the model, the unit has up to eight programmable LEDs (numbers 1 to 8), which are used for alarm indications. All of the programmable LEDs on the unit are tri-colour and can be set to RED, YELLOW or GREEN.

Programmable Function LEDs

Depending on the model, the unit has up to ten further programmable LEDs (F1 to F10) to show the status of the function keys. All of the programmable LEDs on the unit are tri-color and can be set to RED, YELLOW or GREEN.

4.1 Front panel ports

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.

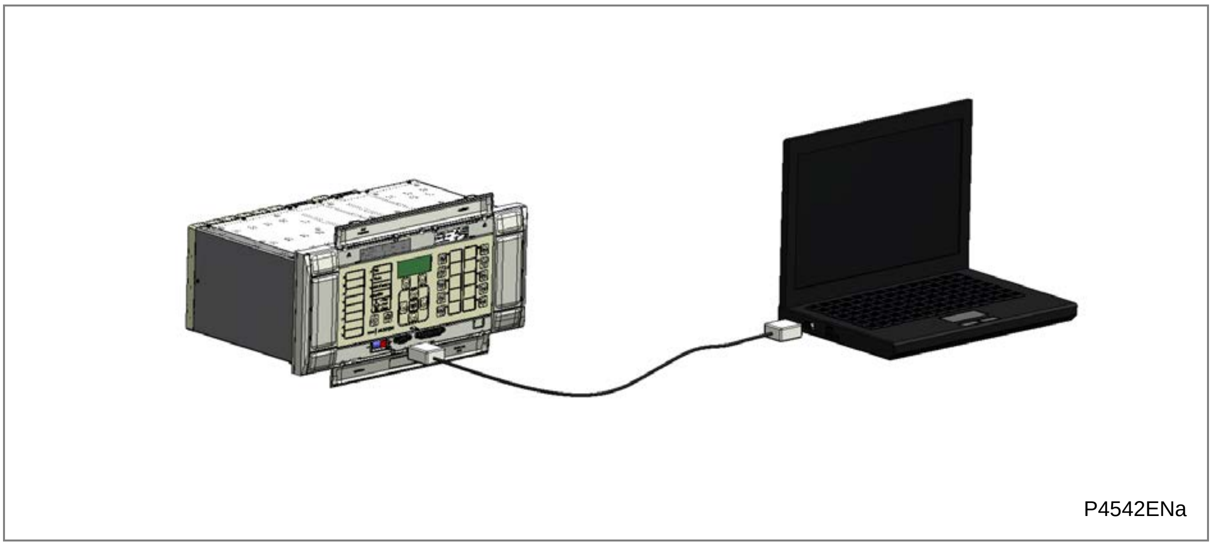


Figure 3: Front serial port connection

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

Table 3 DCE 9-pin serial port connections

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

Table 4 RS232 communication settings

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

Front Parallel Port (SK2)

This is a 25 pin D-type port. This port is used for commissioning, downloading firmware updates and menu text editing.

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. This depends 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 60TE case populated with various boards.

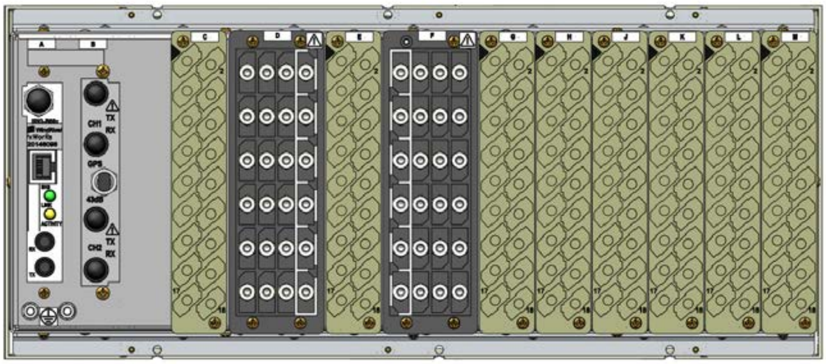


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Figure 4: Rear view of populated 80TE case

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

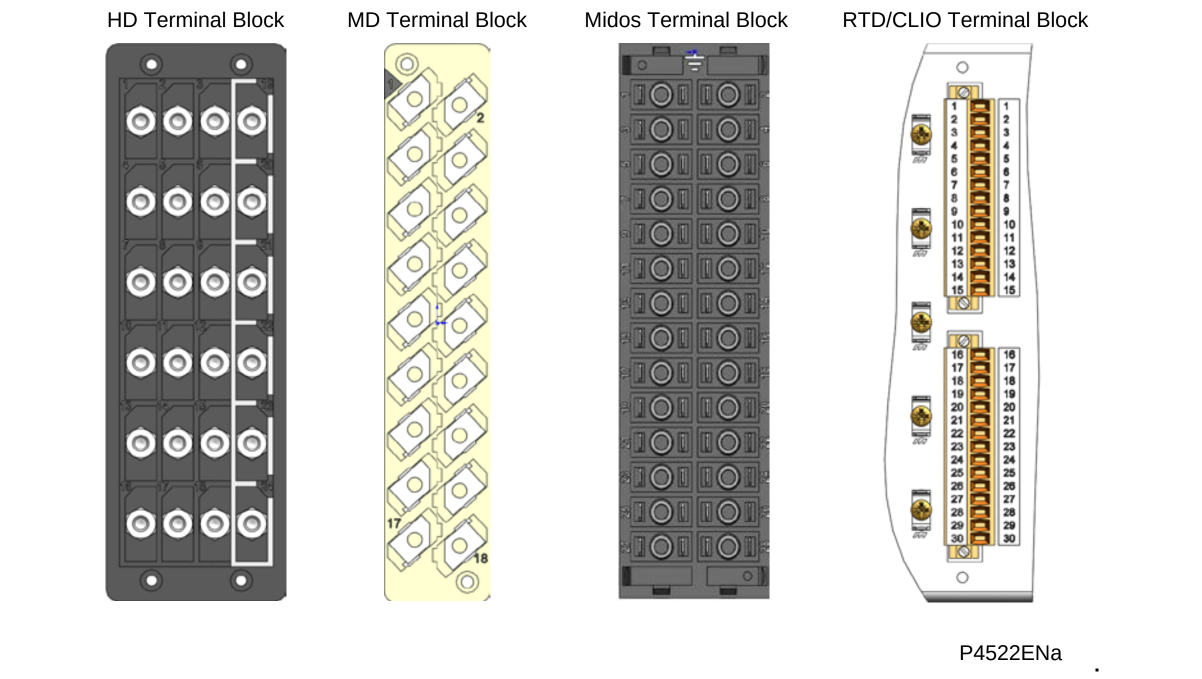

Figure 5: Terminal block types

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

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.

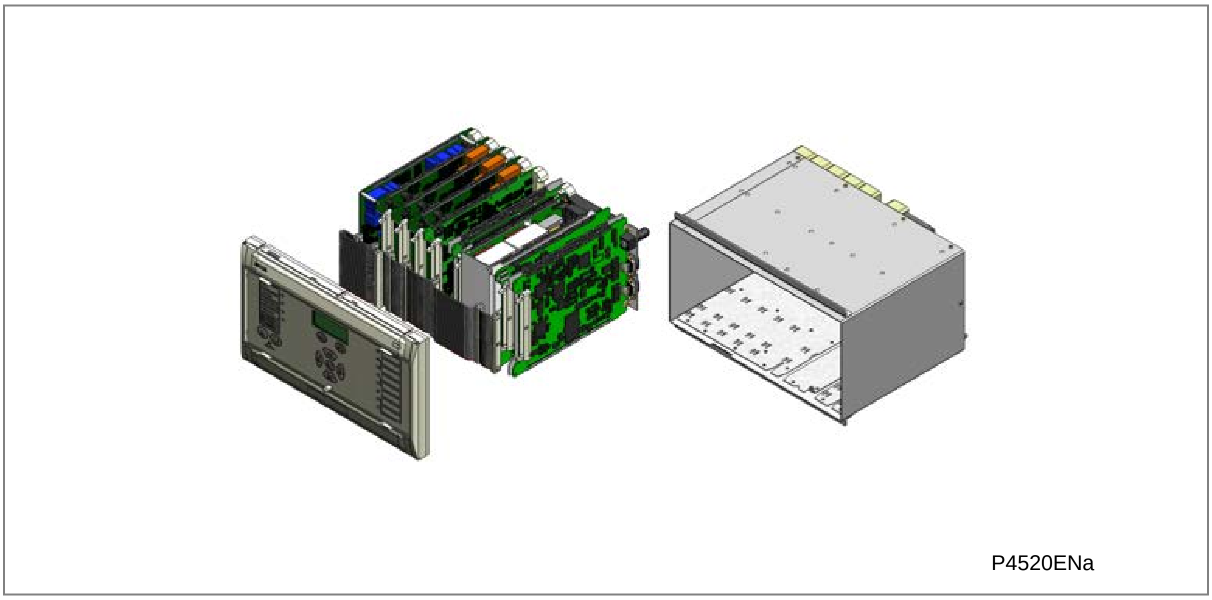

Figure 6: Exploded view of IED

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

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)

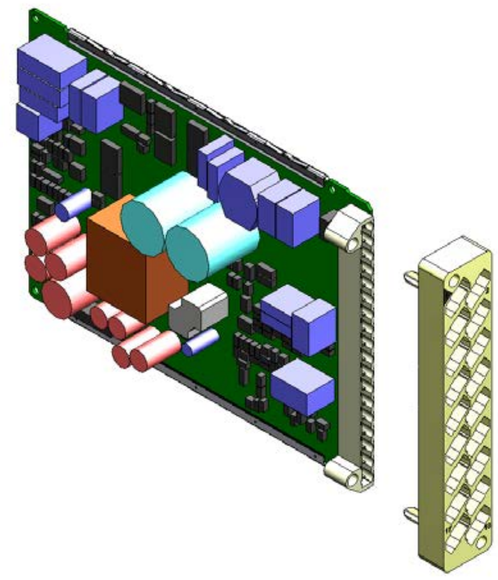

Figure 7: Rear connection to terminal block

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.

6.1 Main Processor Board

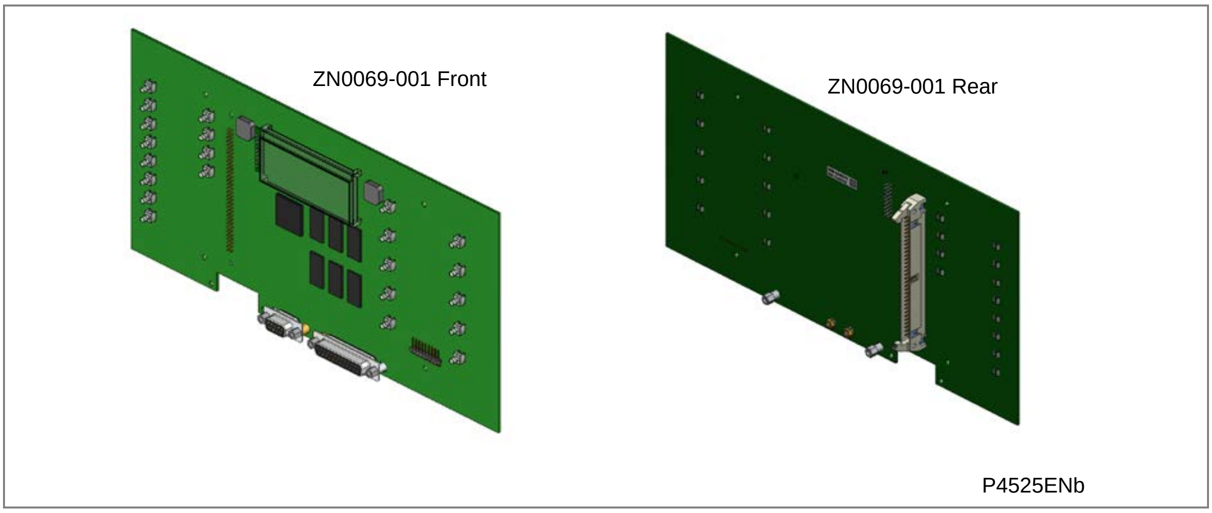

Figure 8: Main processor ZN0069

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

6.2 Power Supply Board

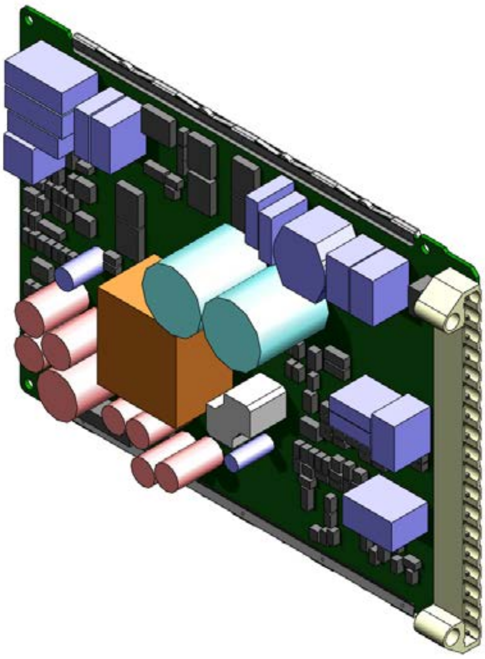

Figure 9: Power supply board

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.

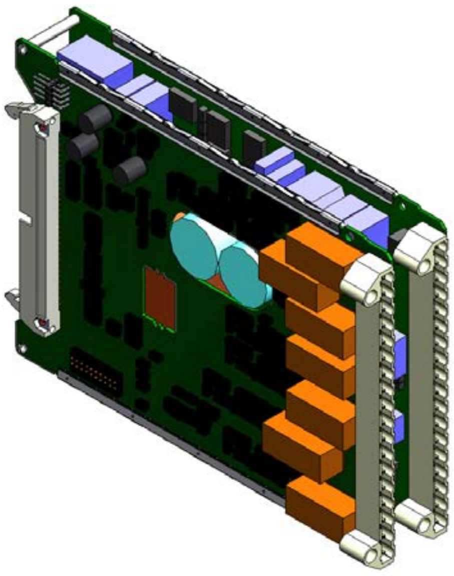

Figure 10: Power Supply Assembly

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.

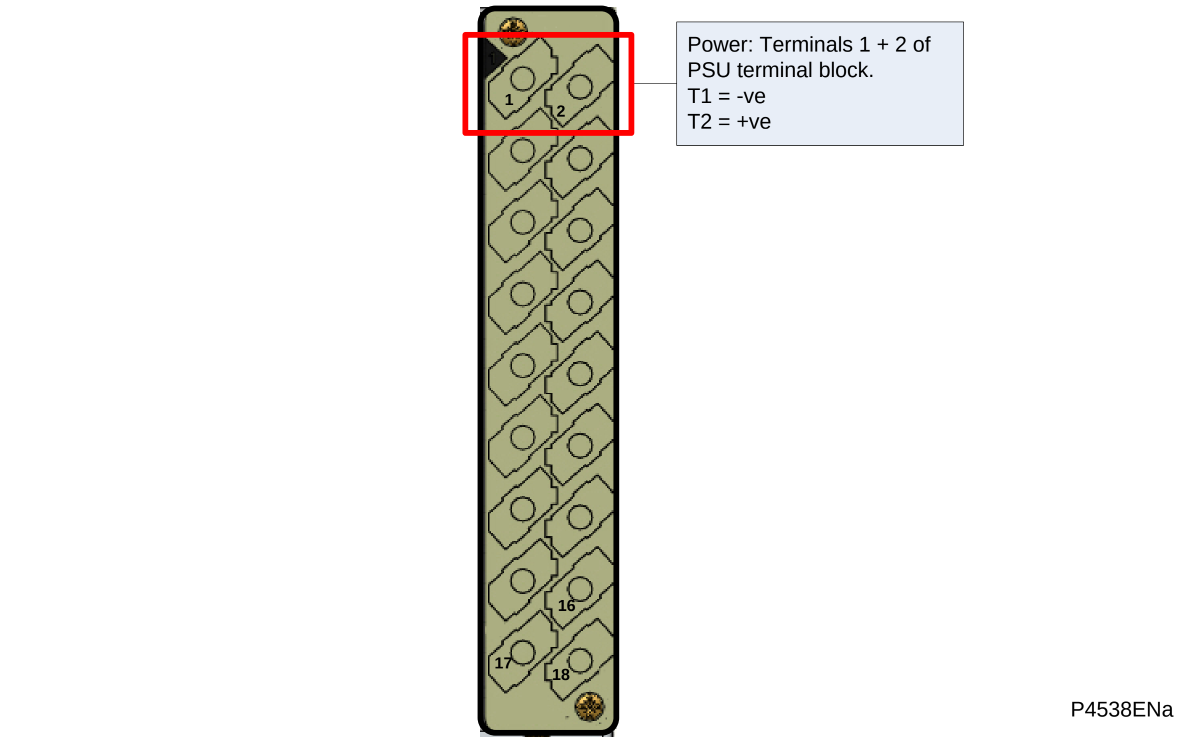

Figure 11: Power supply terminals

Watchdog Facility

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.

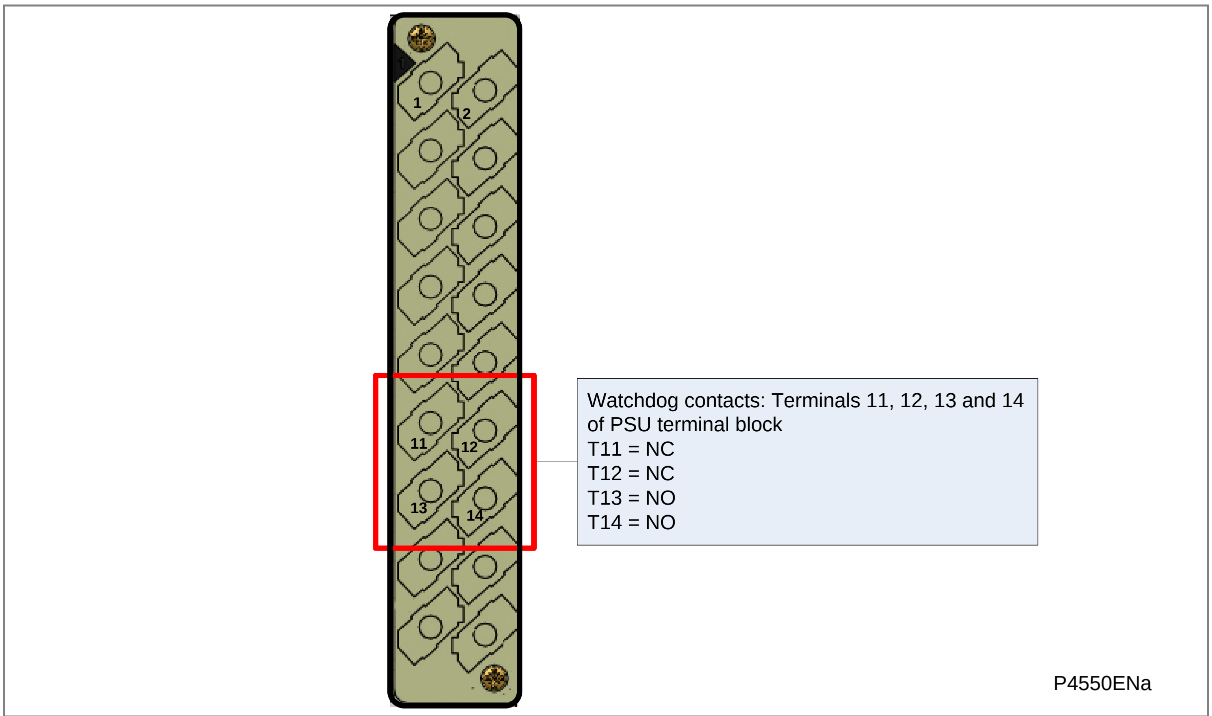

Figure 12: Watchdog contact terminals

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

Note:	*The polarity independent K-bus can only be used for the Courier data protocol. The polarity conscious MODBUS, IEC60870-5-103 and DNP3.0 protocols need RS485.*

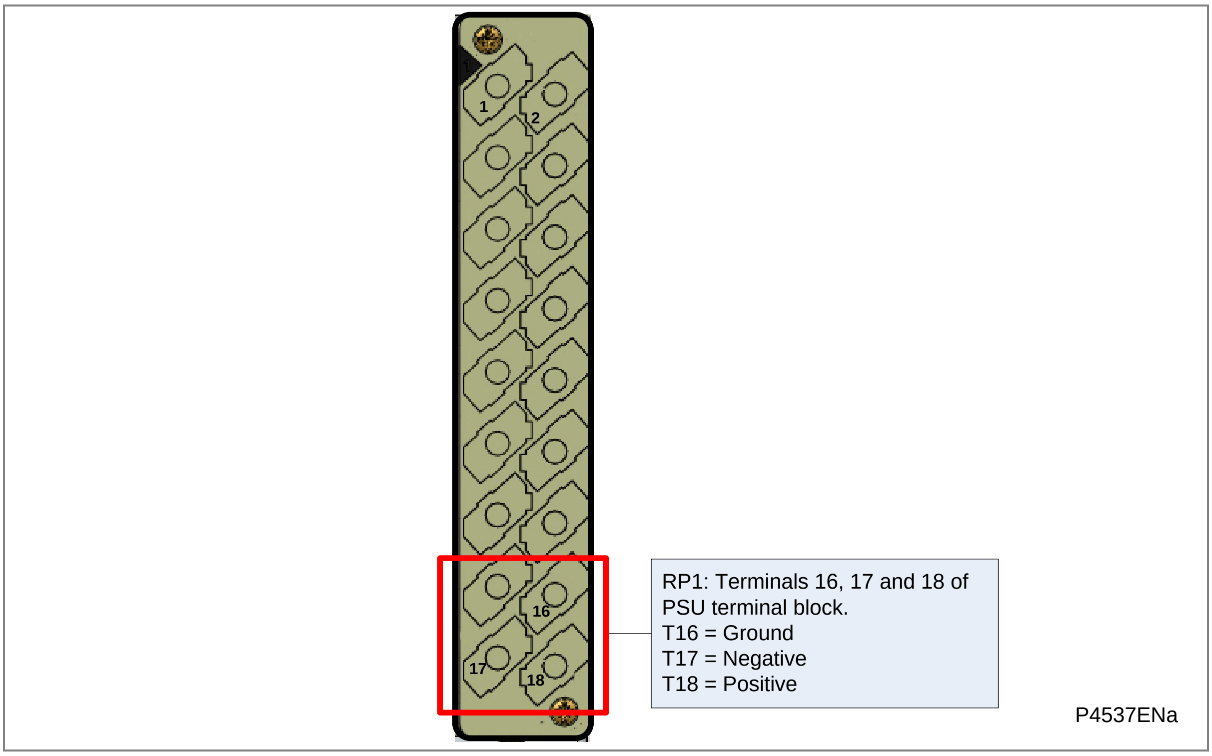

Figure 13: Rear serial port terminals

Note:	*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.

6.3 Standard Output Relay Board

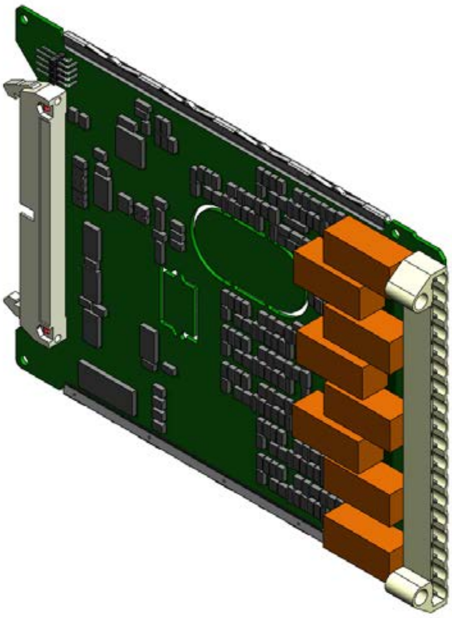

Figure 14: Standard output relay board

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 Number	Output Relay
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

Table 5 Pin-out of 8-relay board

6.4 Input Module

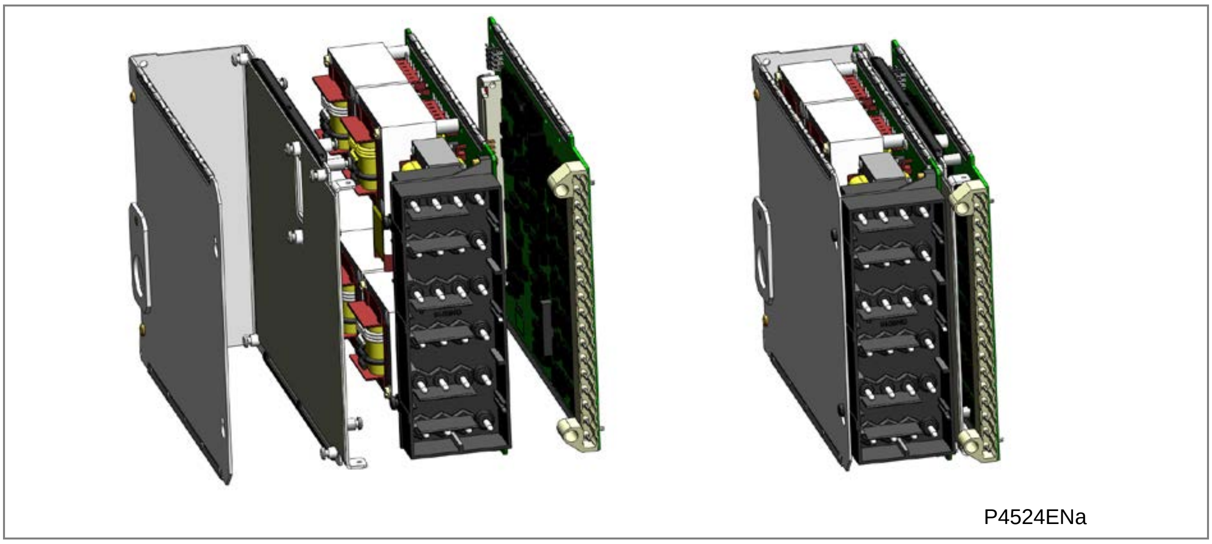

Figure 15: Input module with one transformer board

Figure 16: Input module with two transformer boards

The input module consists of the main input board coupled together with an instrument transformer board. The instrument transformer board contains 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 electromagnetic interference.

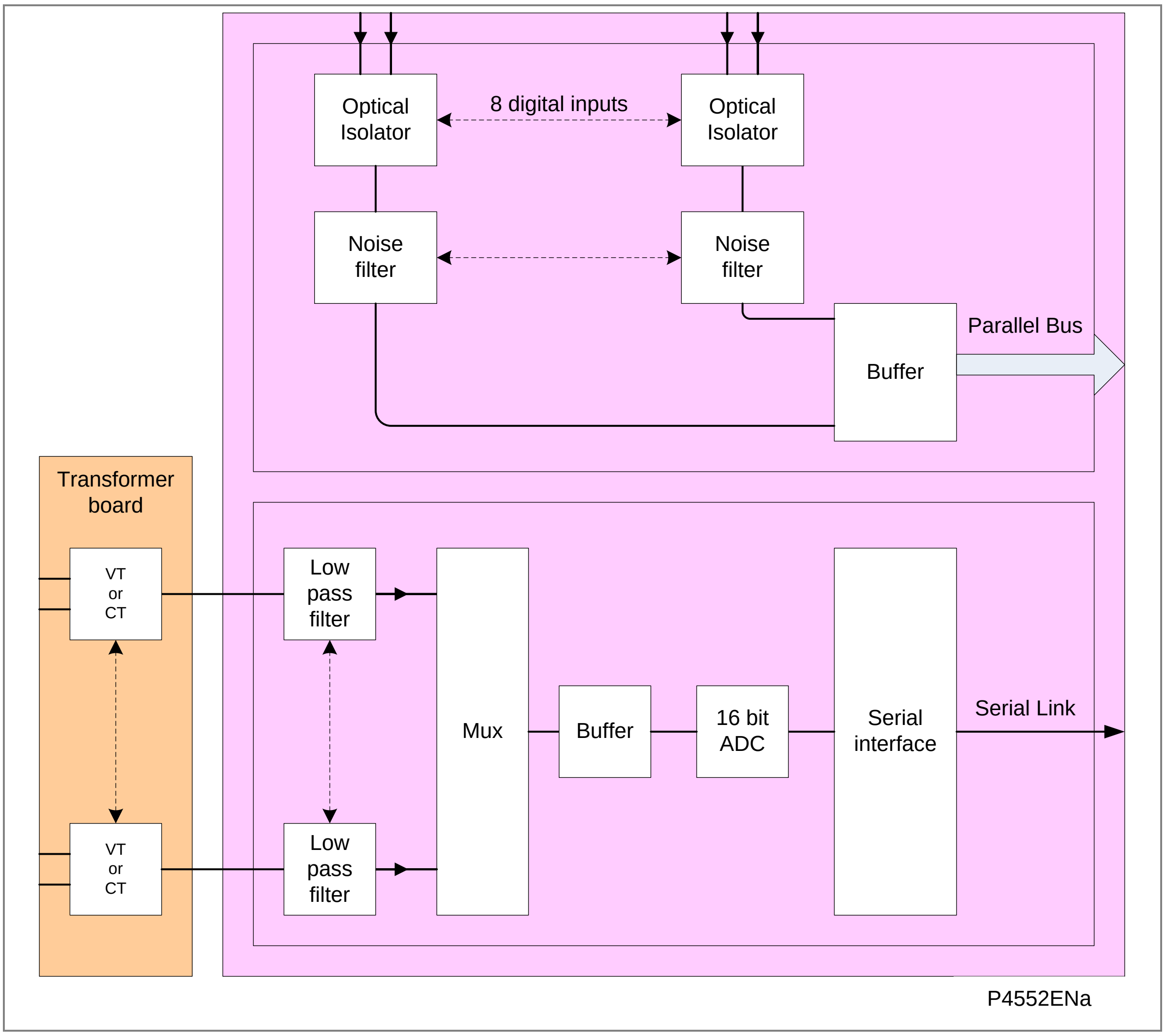

Figure 17: Input module schematic

6.4.1 Input board

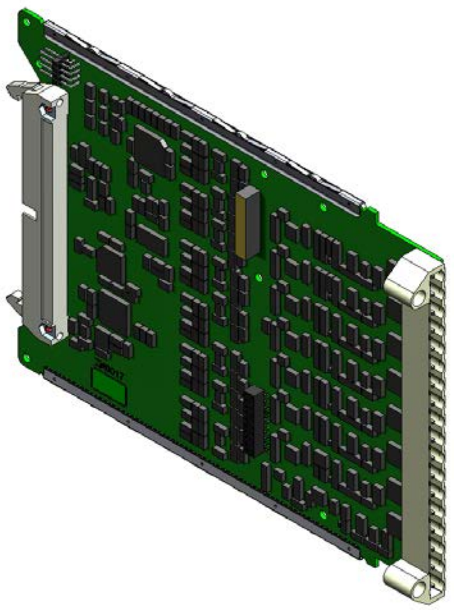

Figure 18: Input board

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 Number	Opto-Input
Terminal 15	Opto 8 –ve
Terminal 16	Opto 8 +ve
Terminal 17	Common
Terminal 18	Common

Table 6 Pin-out of opto board

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 analogue inputs are sampled and converted to digital, then filtered to remove unwanted properties. The samples are then 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 state of 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 drop-off 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

Table 7 Opto-input thresholds

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.

Opto-Inputs

The pin-out of the opto-inputs are shown in the table below.

Terminal Number	
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

Table 8 Opto-input pin-out

6.4.2 Transformer Board

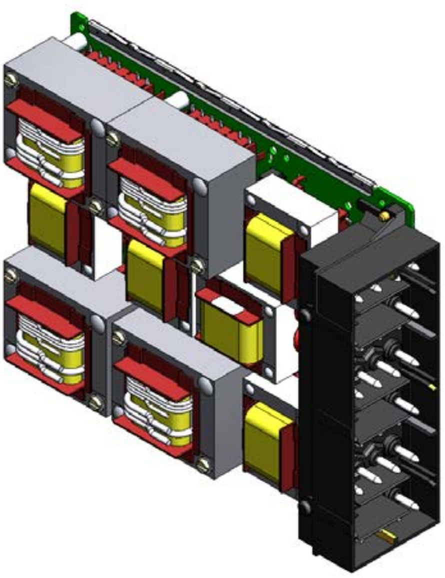

Figure 19: Typical Transformer board

The transformer board hosts the current and voltage transformers. These are used to step down the currents and voltages originating from the power systems' current and voltage transformers to levels that can be used by the devices' 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	I_A 5A tapping
Terminal 2	I_A common
Terminal 3	I_A 1A tapping
Terminal 4	I_B 5A tapping
Terminal 5	I_B common
Terminal 6	I_B 1A tapping
Terminal 7	I_C 5A tapping
Terminal 8	I_C common
Terminal 9	I_C 1A tapping
Terminal 10	I_N 5A tapping
Terminal 11	I_N common
Terminal 12	I_N 1A tapping
Terminal 13	I_N sen 5A tapping
Terminal 14	I_N sen common
Terminal 15	I_N sen 1A tapping
Terminal 16	
Terminal 17	
Terminal 18	
Terminal 19	V_A
Terminal 20	V_B
Terminal 21	V_C
Terminal 22	V_N
Terminal 23	V_{CS1}
Terminal 24	V_{CS2}

Table 9 Transformer input pin-out

6.5 Coprocessor board

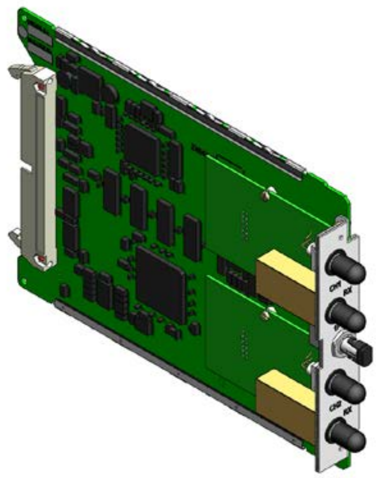

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Figure 20: Co-processor board with communication interfaces

> *Note:* *The above figure shows a coprocessor complete with GPS input and 2 fibre-optic serial data interfaces, and is not necessarily representative of the product and model described in this manual. These interfaces will not be present on boards that do not require them.*

Where applicable, a second processor board is used to process the special algorithms associated with the device. This second processor board provides fast access (zero wait state) SRAM for use with both program and data memory storage. This memory can be accessed by the main processor board via the parallel bus. This is how the software is transferred from the flash memory on the main processor board to the coprocessor board on power up. Further communication between the two processor boards is achieved via interrupts and the shared SRAM. The serial bus carrying the sample data is also connected to the co-processor board, using the processor's built-in serial port, as on the main processor board.

There are several different variants of this board, which can be chosen depending on the exact device and model. The variants are:

- Coprocessor board with current differential inputs and GPS input
- Coprocessor board only (with no external inputs)
- Coprocessor board with current differential inputs only
- Coprocessor board with GPS input only

6.6 IRIG-B board

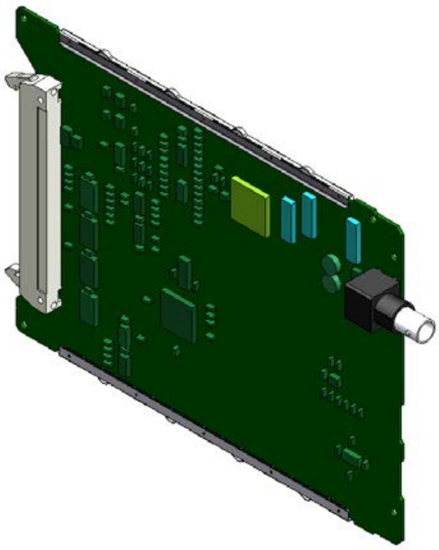


Figure 21: IRIG-B board

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.

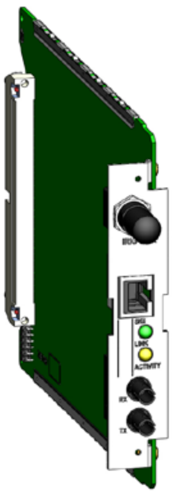
GPS Inputs

In some applications, where the communication links between two remote devices are provided by a third party telecommunications partner, the transmit and receive paths associated with one channel may differ considerably in length, resulting in very different transmission and receive times.

If, for example, Device A is transmitting to Device B information about the value of its measured current, the information Device A is receiving from Device B about the current measured at the same time, may reach device B at a different time. This has to be compensated for. A 1pps GPS timing signal applied to both devices will help the IEDs achieve this, because it is possible to measure the exact time taken for both transmission and receive paths.

> *Notes:* *1 pps signal is always supplied by a P594 device.*
>
> *The signal is used to control the sampling process, and timing calculations and is not used for time stamping or real time synchronisation.*

6.7 Ethernet board



P4532ENa

Figure 22: Ethernet board with IRIG-B

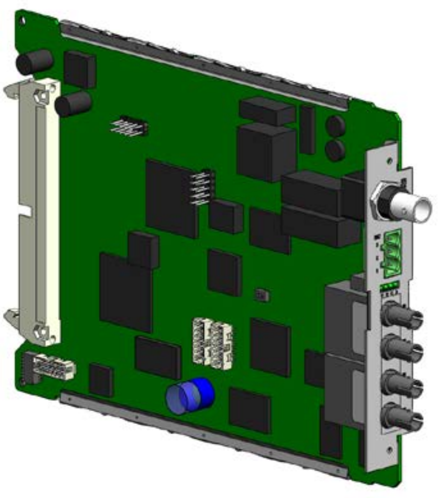
This is a communications board that provides a standard 100-Base Ethernet interface. This board supports one electrical copper connection and one fibre-pair connection.

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.

6.8 Redundant Ethernet with IRIG-B input



P4533ENa

Figure 23: Redundant Ethernet board with IRIG-B

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

6.9 Rear Communications Board

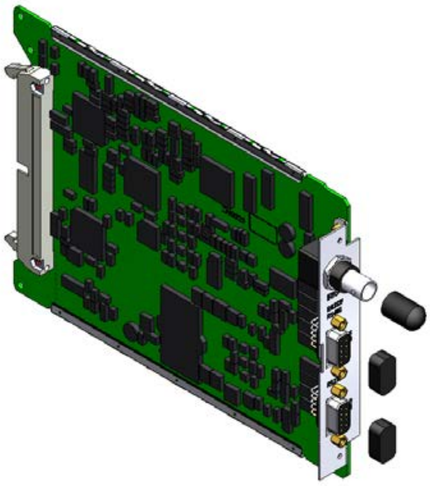


Figure 24: Rear communications board

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.

6.10 Fibre Board

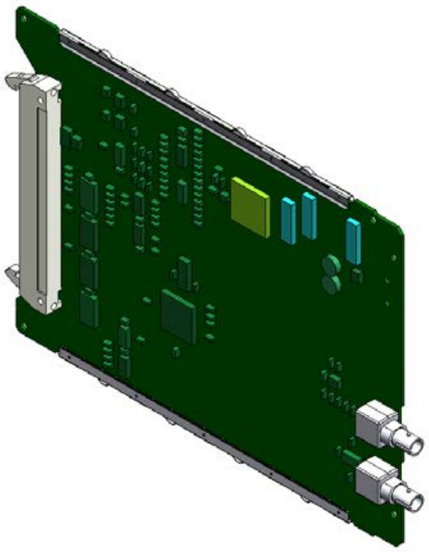


Figure 25: Fibre board

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:

- Fibre board without IRIG-B
- Fibre board with IRIG-B input

6.11 High Break Relay Output Board

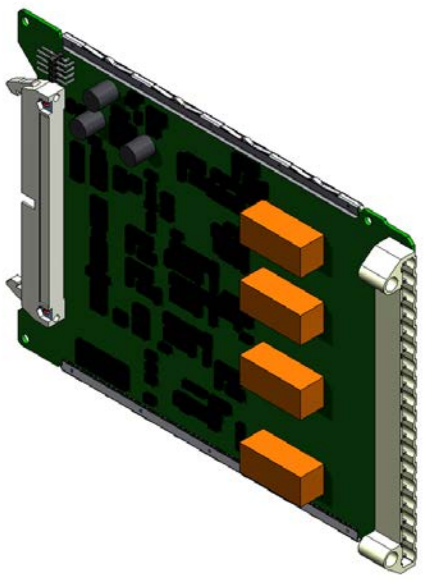


Figure 26: High break relay output board

A High Break output relay board is available as an option. It comprises four normally open output contacts, which are suitable for high breaking loads.

A High Break contact consists of a high capacity relay with a MOSFET in parallel with it. The MOSFET has a varistor placed across it to provide protection, which is required when switching off inductive loads. This is because the stored energy in the inductor causes a high reverse voltage that could damage the MOSFET, if not protected.

When there is a control input command to operate an output contact the miniature relay is operated at the same time as the MOSFET. The miniature relay contact closes in nominally 3.5 ms and is used to carry the continuous load current. The MOSFET operates in less than 0.2 ms, but is switched off after 7.5 ms.

When the control input is reset, the MOSFET is again turned on for 7.5 mS. The miniature relay resets in nominally 3.5 ms before the MOSFET. This means the MOSFET is used to break the load. The MOSFET absorbs the energy when breaking inductive loads and so limits the resulting voltage surge. This contact arrangement is for switching DC circuits only.

The following figure shows the timing diagram for High Break contact operation:

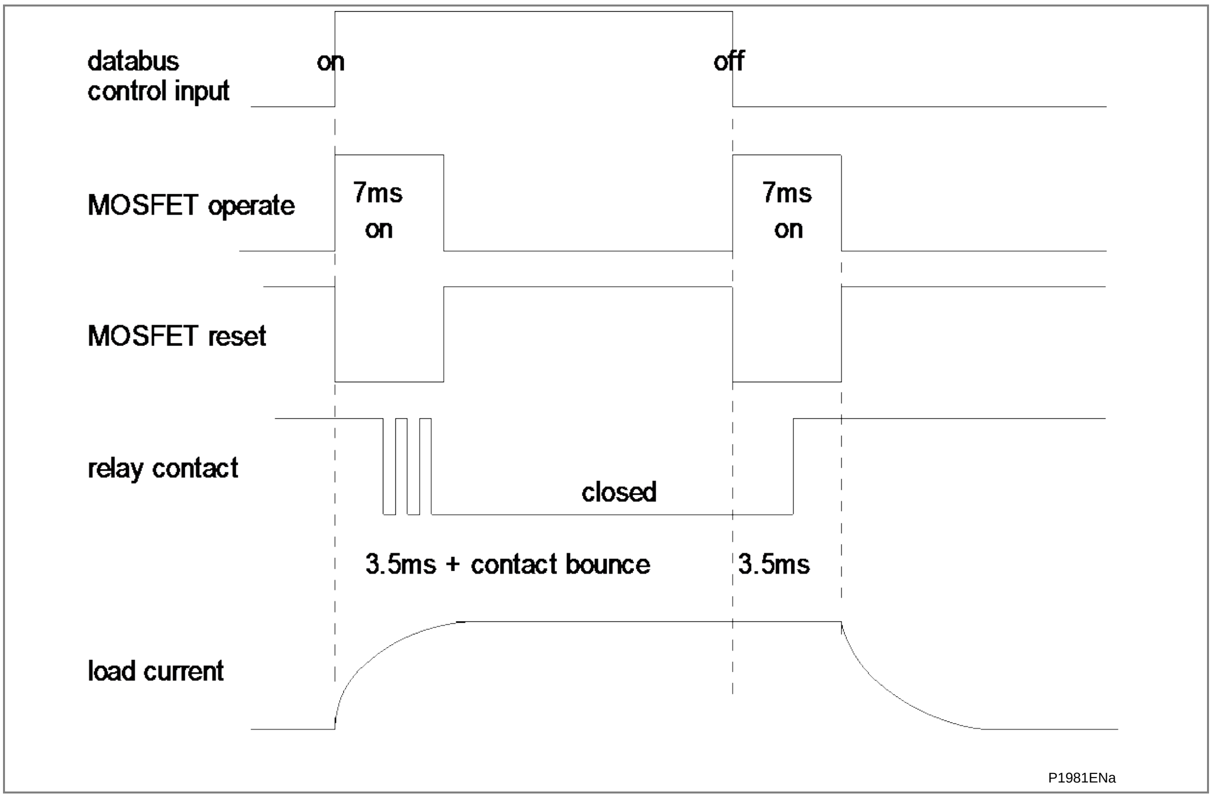


Figure 27: High break contact operation

High Break Contact Applications

- Efficient scheme engineering

  In traditional hardwired scheme designs, High Break capability could only be achieved using external electromechanical trip relays. Instead, these internal High Break contacts can be used thus reducing space requirements.

- Accessibility of CB auxiliary contacts

  It is common practice to use circuit breaker 52a (CB Closed) auxiliary contacts to break the trip coil current on breaker opening, thereby easing the duty on the protection contacts. In some cases (such as operation of disconnectors, or retrofitting), it may be that 52a contacts are either unavailable or unreliable. In such cases, High Break contacts can be used to break the trip coil current in these applications.

- Breaker fail

  In the event of failure of the local circuit breaker (stuck breaker), or defective auxiliary contacts (stuck contacts), it is incorrect to use 52a contact action. The interrupting duty at the local breaker then falls on the relay output contacts, which may not be rated to perform this duty. High Break contacts should be used in this case to avoid the risk of burning out relay contacts.

- Initiation of teleprotection

  The High Break contacts also offer fast making, which results in faster tripping. In addition, fast keying of teleprotection is a benefit. Fast keying bypasses the usual contact operation time, such that permissive, blocking and intertrip commands can be routed faster.

Warning: These relay contacts are POLARITY SENSITIVE. External wiring must comply with the polarity requirements described in the external connection diagram to ensure correct operation.

SOFTWARE DESIGN

CHAPTER 4

1 CHAPTER OVERVIEW

The Software Design chapter describes the design of the product's software platform. It consists of the following sections:

2 SOFTWARE DESIGN OVERVIEW

The product's software can be conceptually categorized into several elements as follows:

- The system level software
- The platform software
- The protection and control software
- Optional coprocessor software (not applicable to all products)

These elements are not distinguishable to the user, and the distinction is made purely for the purposes of explanation. Figure 1 shows the software structure.

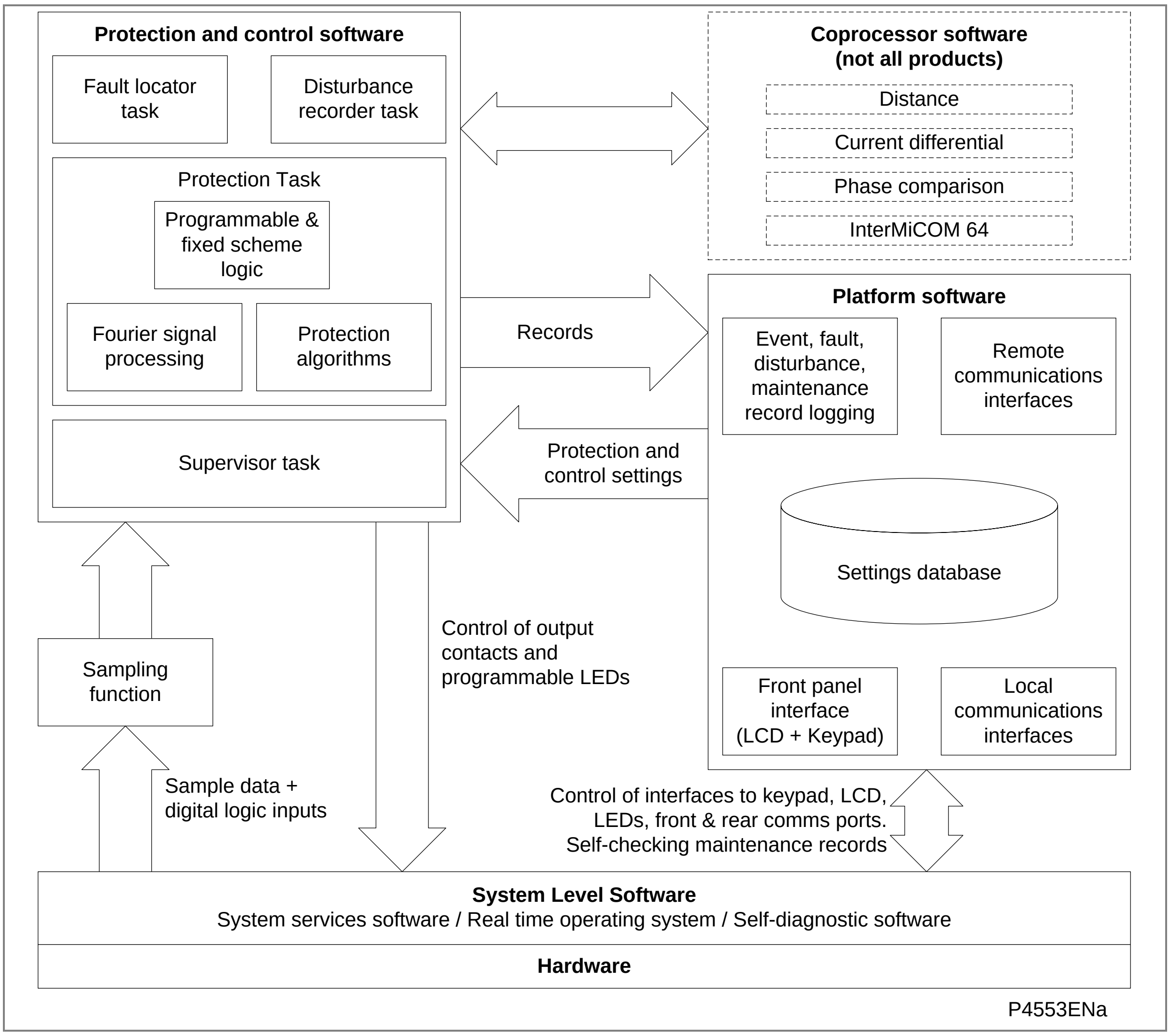


Figure 1: Software structure

The software, which executes on the main processor, can be divided into a number of functions as illustrated above. Each function is further broken down into a number of separate tasks. These tasks are then run according to a scheduler. They are run at either a fixed rate or they are event driven. The tasks communicate with each other as required.

3 SYSTEM LEVEL SOFTWARE

3.1 Real Time Operating system

The real-time operating system is used to schedule the processing of the various tasks. This ensures that they are processed in the time available and in the desired order of priority. The operating system also plays a part in controlling the communication between the software tasks.

3.2 System Services Software

The system services software provides the layer between the unit's hardware and the higher-level functionality of the platform software and the protection & control software. For example, the system services software provides drivers for items such as the LCD display, the keypad and the remote communication ports. It also controls things like the booting of the processor and the downloading of the processor code into SRAM from Flash memory at startup.

3.3 Self-diagnostic Software

The IED includes several self-monitoring functions to check the operation of its hardware and software while in service. If there is a problem with the unit's 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 unit would be out of service for a short time, during which the 'Healthy' LED on the front of the unit 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 unit attempts to store a maintenance record in battery-backed SRAM 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 when the unit is booted-up, and secondly a continuous self-checking operation which checks the operation of the critical functions whilst it is in service.

3.3.1 Start-up Self-Testing

The self-testing takes a few seconds to complete, during which time the unit's measurement, recording, control, and protection functions are unavailable. On a successful start-up and self-test, the 'health-state' LED on the front of the unit is switched on. If a problem is detected during the start-up testing, the unit remains out of service until it is manually restored to working order.

The operations that are performed at start-up are as follows:

3.3.1.1 System Boot

The integrity of the Flash memory is verified using a checksum before the program code and stored data is loaded into SRAM for execution by the processor. When the loading has been completed, the data held in SRAM is compared to that held in the Flash memory to ensure that no errors have occurred in the data transfer and that the two are the same. The entry point of the software code in SRAM is then called. This is the unit's initialization code.

3.3.1.2 Initialization Software

The initialization process initializes the processor registers and interrupts, starts the watchdog timers (used by the hardware to determine whether the software is still running), starts the real-time operating system and creates and starts the supervisor task. In the initialization process the unit checks the following:

- The status of the battery
- The integrity of the battery backed-up SRAM that is used to store event, fault and disturbance records
- The voltage level of the field voltage supply which can be used to drive the opto-isolated inputs
- The operation of the LCD controller
- The watchdog operation

At the conclusion of the initialization software the supervisor task begins the process of starting the platform software.

For products using a coprocessor, the startup checks are as follows:

- A check is made for the presence of the co-processor board, and if present a valid response
- The SRAM on the co-processor board is checked with a test bit pattern before the co-processor code is transferred from the flash EPROM

If any of these checks produce an error, the co-processor board remains out of service.

> *Note: A coprocessor board is used only in products with Distance, phase comparison, or current differential functionality.*

3.3.1.3 Platform Software Initialization & Monitoring

When starting the platform software, the unit checks the following:

- The integrity of the data held in non-volatile memory (using a checksum)
- The operation of the real-time clock
- The optional IRIG-B function
- The presence and condition of the input board
- The analogue data acquisition system (by sampling the reference voltage)

At the successful conclusion of all of these tests the unit is entered into service and the application software is started up.

3.3.2 Continuous Self-testing

When the unit is in service, it continually checks the operation of the critical parts of its hardware and software. The checking is carried out by the system services software and the results are reported to the platform software. The functions that are checked are as follows:

- The flash EPROM containing all program code and language text is verified by a checksum
- The code and constant data held in SRAM is checked against the corresponding data in flash EPROM to check for data corruption
- The SRAM containing all data other than the code and constant data is verified with a checksum
- The battery status
- The level of the 48 V field voltage (if available)
- The integrity of the digital signal I/O data from the opto-isolated inputs and the output relay coils is checked by the data acquisition function every time it is executed.

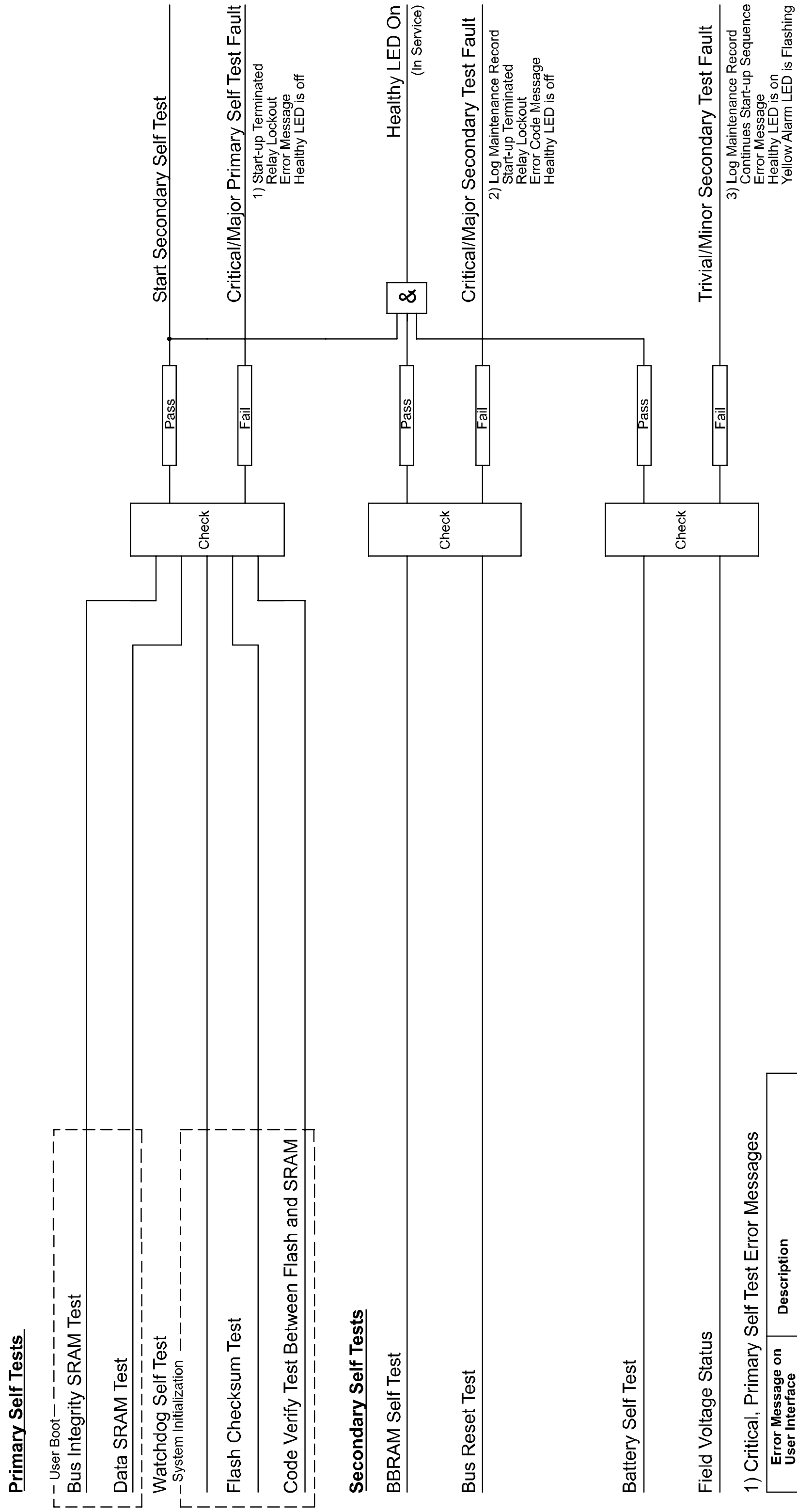
- The operation of the analogue data acquisition system is continuously checked by the acquisition function every time it is executed. This is done by sampling the reference voltages
- The operation of the optional Ethernet board is checked by the software on the main processor card. If the Ethernet board fails to respond an alarm is raised and the card is reset in an attempt to resolve the problem.
- The operation of the optional IRIG-B function is checked by the software that reads the time and date from the board

In the event that one of the checks detects an error in any of the unit's subsystems, the platform software is notified and it attempts to log a maintenance record in battery-backed SRAM.

If the problem is with the battery status or the IRIG-B board, the unit continues in operation. For problems detected in any other area, the unit initiates a shutdown and re-boot, resulting in a period of up to 10 seconds when the functionality is unavailable.

The complete restart of the unit including all initializations should clear most problems that may occur. If, however, the diagnostic self-check detects the same problem that caused the unit to restart, it is clear that the restart has not cleared the problem, and the unit takes itself permanently out of service. This is indicated by the ''health-state' LED on the front of the unit, which switches OFF, and the watchdog contact which switches ON.

The start-up and continuous self test logic diagrams are shown below.



1) Critical, Primary Self Test Error Messages

Error Message on User Interface	Description
Bus Fail	Integrity Bus Test Error
SRAM Fail	SRAM Test Error
Flash Fail (Checksum)	Flash test error detected in the flash structure
Code Verify Fail	Error in code comparison test flash
Watchdog Fail	Watchdog circuit fails to operate

2) Critical, Secondary Self Test Error Messages

Error Code	Description
0x0C170017	The secondary self tests detected an error in the Battery Backed SRAM (BBRAM)
0x0C170018	The secondary self tests detected an error in the Bus Circuit

3) Trivial, Secondary Power on Self Tests Alarm Indications

Alarm	Description
Battery Failure	The secondary self tests detected battery self test has failed
Field Volt Fail	The secondary self tests detected Field Voltage failure

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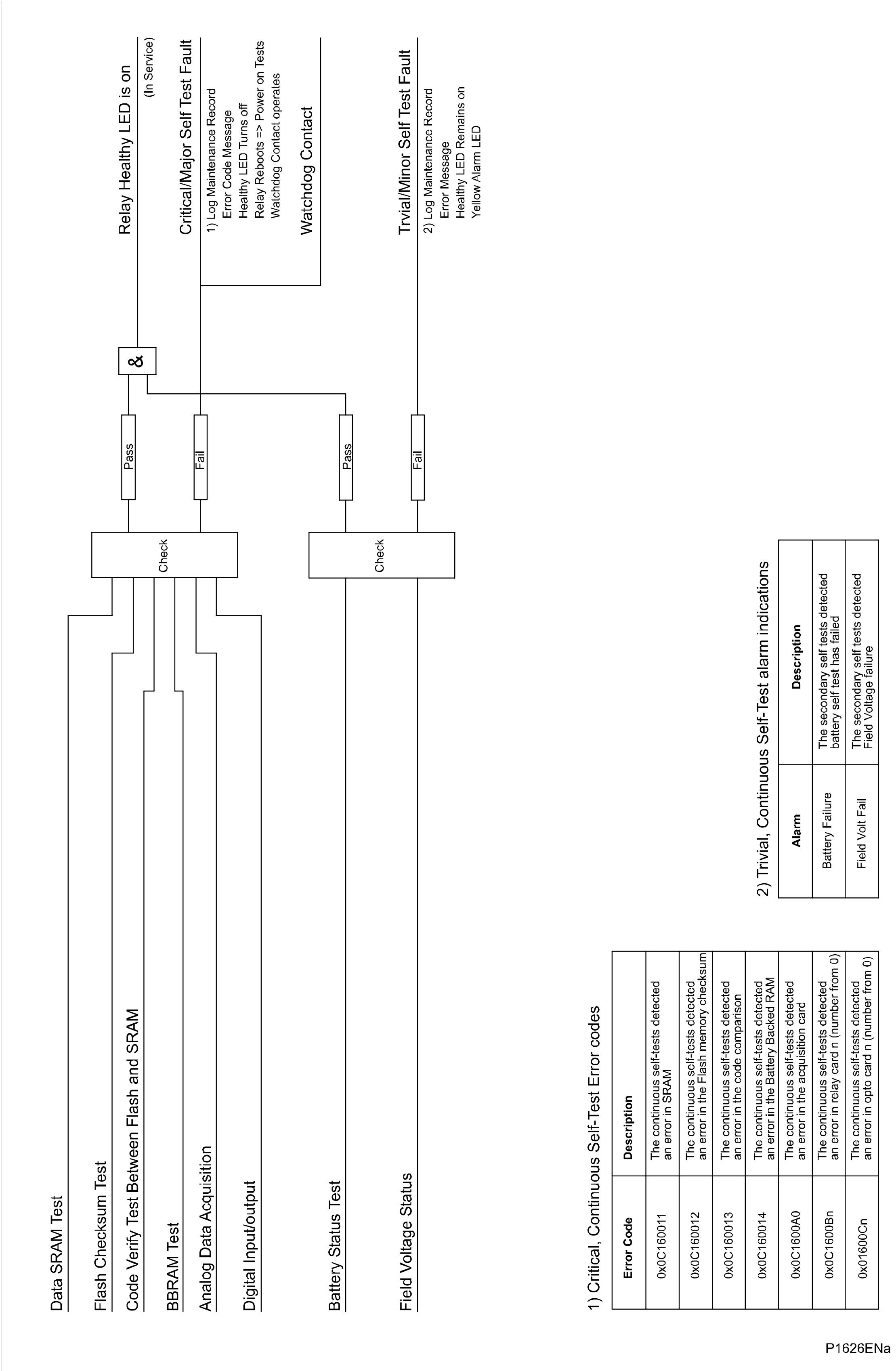
Figure 2: Start-up self-test logic



1) Critical, Continuous Self-Test Error codes

Error Code	Description
0x0C160011	The continuous self-tests detected an error in SRAM
0x0C160012	The continuous self-tests detected an error in the Flash memory checksum
0x0C160013	The continuous self-tests detected an error in the code comparison
0x0C160014	The continuous self-tests detected an error in the Battery Backed RAM
0x0C1600A0	The continuous self-tests detected an error in the acquisition card
0x0C1600Bn	The continuous self-tests detected an error in relay card n (number from 0)
0x01600Cn	The continuous self-tests detected an error in opto card n (number from 0)

2) Trivial, Continuous Self-Test alarm indications

Alarm	Description
Battery Failure	The secondary self tests detected battery self test has failed
Field Volt Fail	The secondary self tests detected Field Voltage failure

Figure 3: Continuous self-test logic

4 PLATFORM SOFTWARE

The platform software has three main functions:

- To control the logging of records generated by the protection software, including alarms, events, faults, and maintenance records
- To store and maintain a database of all of the settings in non-volatile memory
- To provide the internal interface between the Settings database and the unit's user interfaces, using the front panel interface and the front and rear communication ports.

4.1 Record Logging

The logging function is used to store all alarms, events, faults and maintenance records. The records are stored in battery-backed SRAM to provide a non-volatile log of what has happened. The unit maintains four types of log on a first in first out basis (FIFO). These are:

- Alarms
- Event records
- Fault records
- Security records
- Maintenance records

The logs are maintained such that the oldest record is overwritten with the newest record. The logging function can be initiated from the protection software. The platform software is responsible for logging a maintenance record in the event of an IED failure. This includes errors that have been detected by the platform software itself or errors that are detected by either the system services or the protection software function. See the Settings and Records chapter for further details on record logging.

4.2 Settings Database

The settings database contains all the settings and data, which are stored in non-volatile memory. The platform software manages the settings database and ensures that only one user interface can modify the settings at any one time. This is a necessary restriction to avoid conflict between different parts of the software during a setting change.

Changes to protection settings and disturbance recorder settings, are first written to a temporary location SRAM memory. This is sometimes called 'Scratchpad' memory. These settings are not written into non-volatile memory immediately. This is because a batch of such changes should not be activated one by one, but as part of a complete scheme. Once the complete scheme has been stored in SRAM, the batch of settings can be committed to the non-volatile memory where they will become active.

4.3 Interfaces

The settings and measurements database must be accessible from all of the interfaces to allow read and modify operations. The platform software presents the data in the appropriate format for each of the interfaces (LCD display, keypad and all the communications interfaces).

5 PROTECTION AND CONTROL FUNCTIONS AND SOFTWARE

The protection and control software processes all of the protection elements and measurement functions. To achieve this it has to communicate with the system services software, the platform software and, if applicable, the coprocessor software, as well as organize its own operations.

The protection task software has the highest priority of any of the software tasks in the main processor board. This ensures the fastest possible protection response.

The protection and control software provides a supervisory task, which controls the start-up of the task and deals with the exchange of messages between the task and the platform software.

5.1 Protection and Control Scheduling

For products that use a coprocessor, the protection and control task on the main processor board is suspended until the co-processor board starts. The protection task is restarted at a rate that is dependent on the product (typically between two times and sixteen times per cycle).

5.2 Acquisition of Samples

The acquisition of samples on the main processor board is controlled by a ‘sampling function’ which is called by the system services software. This sampling function takes each set of new samples from the input module and stores them in a two-cycle buffer. For products that use a coprocessor, these samples are also stored concurrently by the co-processor.

5.3 Signal Processing

The sampling function provides filtering of the digital input signals from the opto-isolators and frequency tracking of the analogue signals.

The frequency tracking of the analogue input signals is achieved by a recursive Fourier algorithm which is applied to one of the input signals. It works by detecting a change in the signal’s measured phase angle. The calculated value of the frequency is used to modify the sample rate being used by the input module, in order to achieve a constant sample rate per cycle of the power waveform. The value of the tracked frequency is also stored for use by the protection and control task.

When the protection and control task is re-started by the sampling function, it calculates the Fourier components for the analogue signals. With the exception of the RMS measurements, all other measurements and protection functions are based on the Fourier derived fundamental component. The Fourier components are calculated using a single-cycle, Discrete Fourier Transform (DFT). The DFT is always calculated using the last cycle of samples from the 2-cycle buffer, i.e. the most recent data is used.

The DFT extracts the power frequency fundamental component from the signal to produce the magnitude and phase angle of the fundamental in rectangular component format. This gives good harmonic rejection for frequencies up to the 23rd harmonic. The 23rd is the first predominant harmonic that is not attenuated by the Fourier filter and this is known as ‘Alias’. However, the Alias is attenuated by approximately 85% by an additional, analogue anti-aliasing filter (low pass filter). The combined affect of the anti-aliasing and Fourier filters is shown in Figure 4:

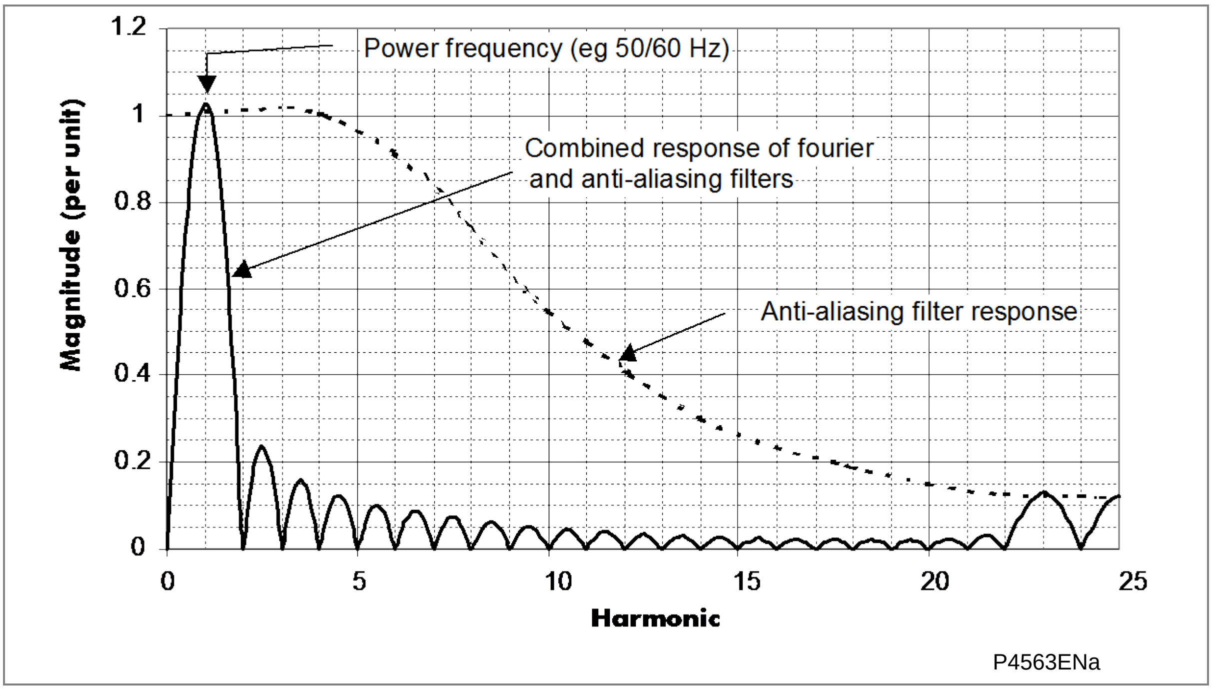


Figure 4: Frequency response

The Fourier components of the input current and voltage signals are stored in memory so that they can be accessed by all of the protection elements' algorithms. The disturbance recorder also uses the samples from the input module, in an unprocessed form. This is for waveform recording and the calculation of true RMS values of current, voltage and power for metering purposes.

5.4 Programmable Scheme Logic

The Programmable Scheme Logic (PSL) allows you to configure an individual protection scheme to suit your own application. It may be part of any of the four Protection Setting groups.

The input to the PSL can be any combination of the following:

- Digital input signals (from the opto-isolated inputs on the input board)
- Outputs of the protection elements (for example, protection starts and trips)
- Outputs of the fixed protection scheme logic (the fixed scheme logic is the standard set of protection schemes provided by default)
- InterMiCOM (IM), InterMiCOM^{64} (IM64) signals and Control Inputs
- IEC61850 GOOSE inputs (optional)
- Function keys (this option is not applicable to all products)

The PSL consists of programmable logic gates, latches and delay timers. The logic gates can be programmed to perform a range of different logic functions and can accept any number of inputs. The timers are used either to create a programmable delay, or to condition the logic outputs such as creating pulses of fixed duration. The outputs of the PSL are the LEDs on the front panel, the output contacts at the rear of the unit, IM and IM64 signals and GOOSE outputs.

The execution of the PSL logic is event driven, i.e. it only runs when an input changes state. This reduces the amount of processing time used by the PSL. The output of the latches, timers and relay contacts are updated at the end of the protection and control task.

The PSL allows you to design your own logic scheme. This means that it can be configured to form very complex systems. Because of this, the PSL can only be configured using the PSL Editor, which is a component of the PC support package MiCOM S1 Agile.

When you transfer a PSL file from the PSL editor to the IED, you can specify the Group to which it is downloaded, together with a 32-character reference description. This PSL reference is shown in the **Grp1/2/3/4 PSL Ref** cell in the PSL DATA column. The download date and time and file checksum for each of the group's PSL file is also shown in the cells **Date/Time** and **Grp 1/2/3/4 PSL ID** in the PSL DATA column. The PSL data can be used to indicate whether a PSL has been changed and thus be useful in providing information for version control of PSL files.

The default PSL Reference description is Default PSL followed by the model number, for example, "Default PSL PXXX??????0yy0?" where XXX refers to the product and yy refers to the software version. This is the same for all protection setting groups since the default PSL is the same for all groups. Since the LCD display (bottom line) only has space for 16 characters the display must be scrolled to see all 32 characters of the PSL Reference description.

> *Note:* *The PSL DATA column information is visible using the front panel interface or over the Courier communications protocol.*

5.5 Event Recording

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 battery-backed SRAM for non-volatile storage. It is possible for the fast buffer to overflow under avalanche conditions. If this occurs, a maintenance record is generated to indicate this loss of information.

5.6 Disturbance Recorder

The disturbance recorder operates as a separate task from the protection and control task. It can record the waveforms of the calibrated analogue channels, plus the values of the digital signals. The recording time is user selectable up to a maximum of 10 seconds. The disturbance recorder is supplied with data by the protection and control task once per cycle, and collates the received data into the required length disturbance record. The disturbance records can be extracted using MiCOM S1 Agile or the SCADA system, which can also store the data in COMTRADE format, allowing the use of other packages to view the recorded data.

5.7 Fault Locator

The fault locator uses 12 cycles of the analogue input signals to calculate the fault location. The result is returned to the protection and control task, which includes it in the fault record. The pre-fault and post-fault voltages are also presented in the fault record. When the fault record is complete, including the fault location, the protection and control task sends a message to the supervisor task to log the fault record.

5.8 Function Key Interface

The ten function keys interface directly into the PSL as digital input signals. A change of state is only recognized when a key press is executed on average for longer than 200 ms. The time to register a change of state depends on whether the function key press is executed at the start or the end of a protection task cycle, with the additional hardware and software scan time included. A function key press can provide a latched (toggled mode) or output on key press only (normal mode) depending on how it is programmed. It can be configured to individual protection scheme requirements. The latched state signal for each function key is written to non-volatile memory and read from non-volatile memory during relay power up thus allowing the function key state to be reinstated after power-up, should power be inadvertently lost.

6 COPROCESSOR SOFTWARE

For distance protection, phase comparison and differential protection functionality, a coprocessor software module, which runs on a coprocessor board, is required. There are three types, depending on the required functionality:

- Distance only (e.g. P443, P445, P446, P44T)
- Distance + Phase Comparison (e.g. P547)
- Distance + Current Differential (e.g. P543/5, P544/6)

All of the processing for the Differential, Phase Comparison, Distance and DEF protection algorithms is performed on the co-processor board.

The co-processor is also responsible for managing inter-tripping commands IM64 via the communication link.

Data exchange between the co-processor board and the main processor board is achieved through the use of shared memory on the co-processor board. When the main processor accesses this memory, the co-processor is temporarily halted. After the co-processor code has been copied onto the board at initialization, the main traffic between the two boards consists of setting change information, commands from the main processor, differential protection measurements and output data.

6.1 Distance Protection

The current and voltage inputs are filtered, using finite impulse response (FIR) digital filters to reduce the effects of non-power frequency components in the input signals, such as DC offsets in current waveforms, and capacitor voltage transformer (CVT) transients in the voltages. The device uses a combination of a 1/4 cycle filter using 12 coefficients, a 1/2 cycle filter using 24 coefficients, and a one cycle filter using 48 coefficients. The relay automatically performs intelligent switching in the application of the filters, to select the best balance of removal of transients with fast response.

> *Note: The protection elements perform additional filtering, for example implemented by the trip count strategy.*

Figure 5 shows the frequency response of the 12, 24 and 48 coefficient filters, noting that all have a gain of unity at the fundamental.

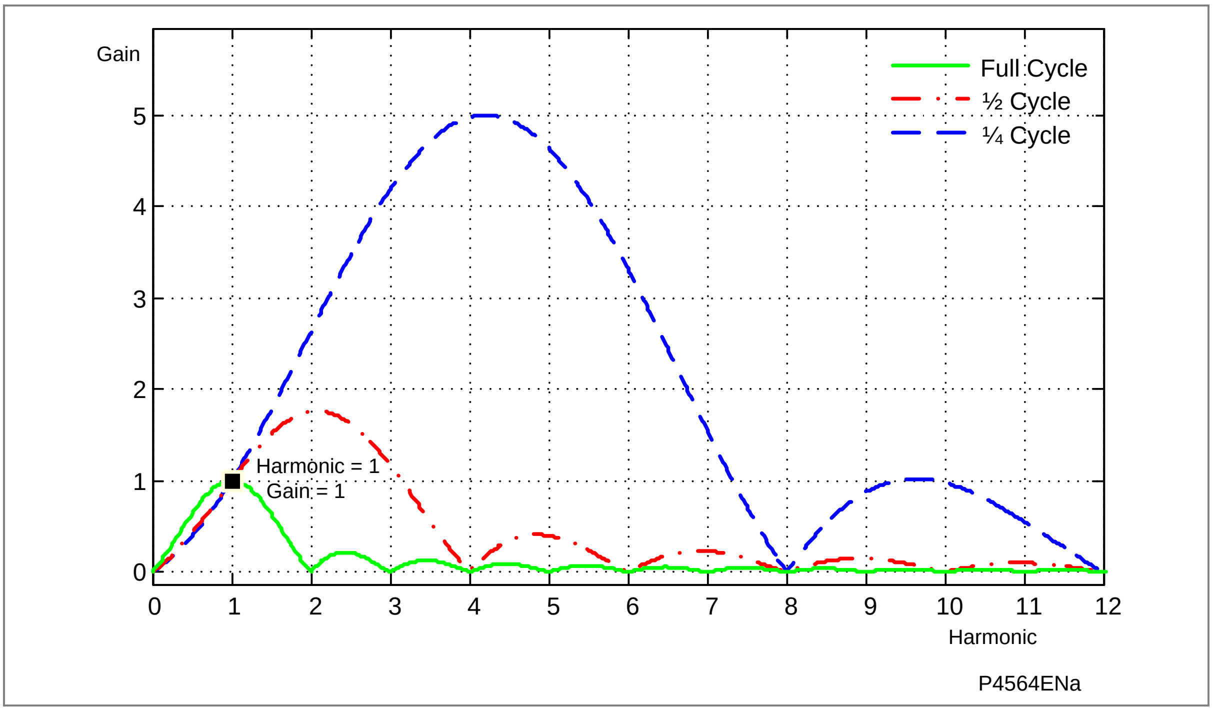


Figure 5: Filter frequency response

CONFIGURATION

CHAPTER 5

1 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 Px40 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 consists of the following sections:

2 USING THE HMI PANEL

2.1 Navigating 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 by means of a range of menu options. The information is displayed on the LCD.

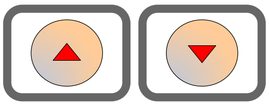
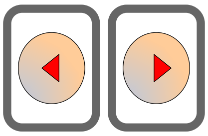
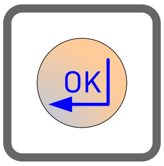
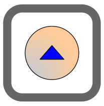
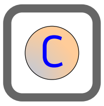
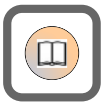
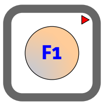
Keys	Description	Function
	Up and down Cursor keys	To change the menu level or change between settings in a particular column, or changing values within a cell
	Left and right cursor keys	To change default display, change between column headings, or changing values within a cell
	ENTER key	For changing 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 return to column header from any menu cell
	Function keys	For executing user programmable functions

Table 1: Key descriptions

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

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.

Figure 1 shows how to navigate the menu items in the form of a menu navigation map.

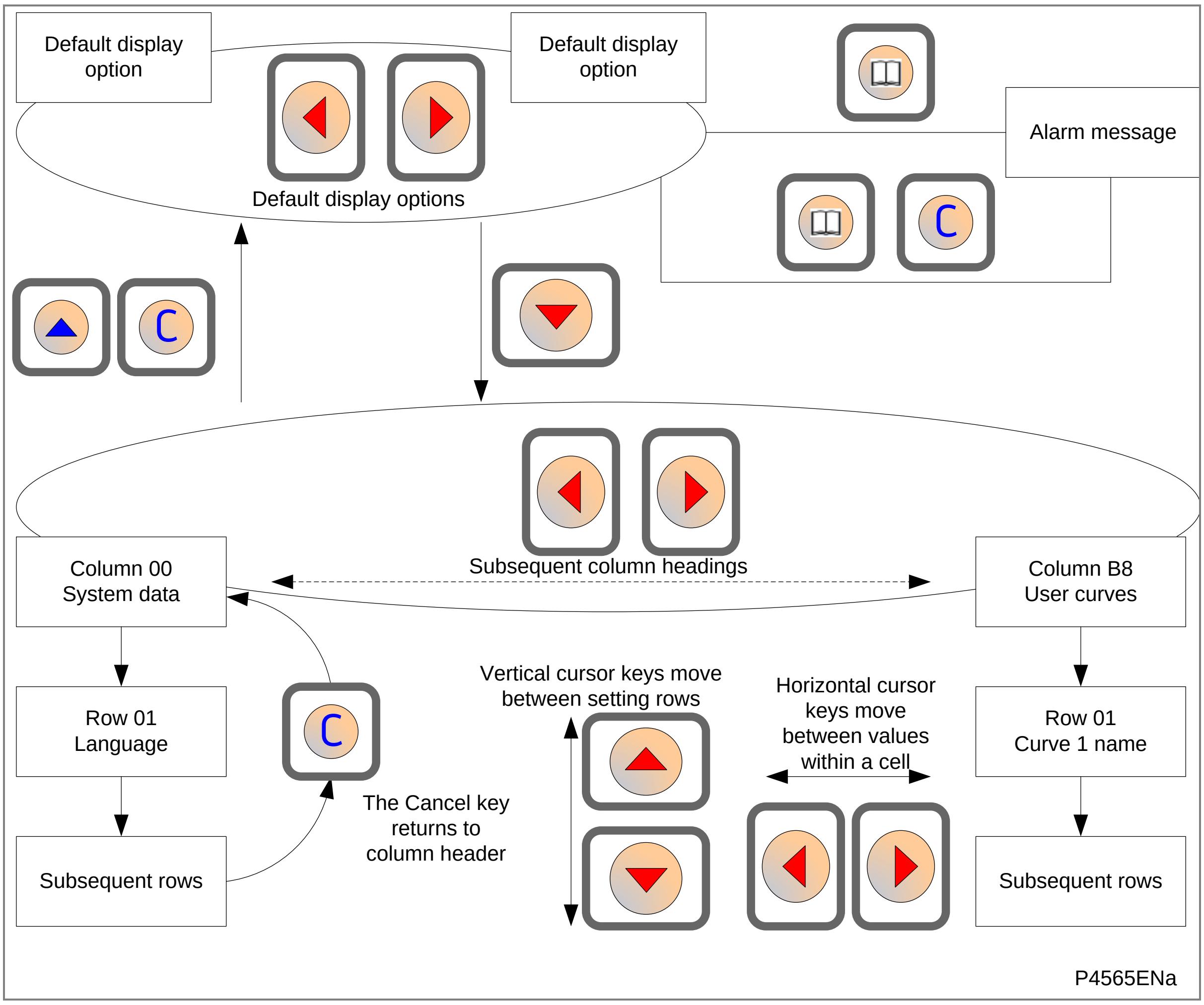


Figure 1: Menu Navigation

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
```

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

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

Date and time
For example:

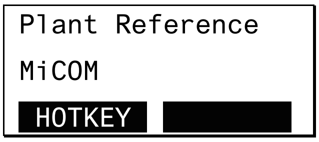
```
11:09:15
23 Nov 2010
HOTKEY
```

Description (user-defined)
For example:

```
Description
MiCOM P543
HOTKEY
```

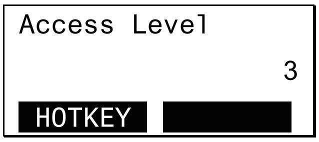
Plant reference (user-defined)

For example:



Access Level

For example:



In addition to the above, there are also displays for the system voltages, currents, power and frequency.

Figure 2 depicts the navigation between default displays.

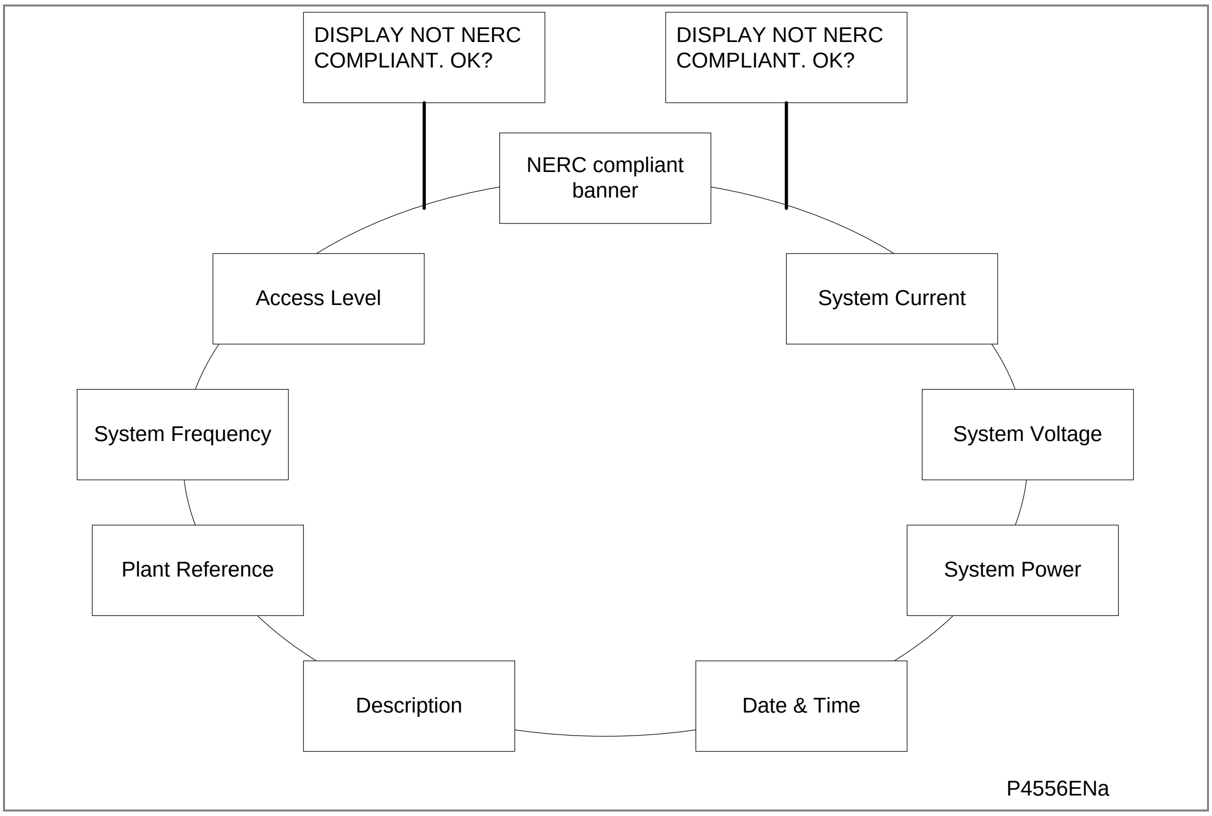


Figure 2: Default display navigation

The right cursor key takes you to the next menu option in a clockwise direction, whereas the left cursor key takes you to the next menu option in an anti-clockwise direction.

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: The unit is delivered with the NERC-compliant default display. Please see the Cyber Security chapter for further details*
>
> *Note: Whenever the unit 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.*

2.4 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** key to 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 if so what 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 System data > Password. If the keypad is inactive for 15 minutes, the password protection of the front panel user interface reverts to the default access level.
5. To manually reset the password protection to the default level, select System data > Password, then press the clear key instead of entering a password.

2.5 Reading and Clearing of 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.

2.6 Menu Structure

Settings, commands, records and measurements are stored inside the unit in non-volatile memory in a local database. When using the Human Machine Interface (HMI) it is convenient to visualize 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

Table 2 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)	Icat Magnitude (Row 01)	…
Password (Row 02)	Menu Cell Ref (Row 02)	Icat Phase Angle (Row 02)	…
Sys Fn Links Row 03)	Time & Date (Row 03)	Ifrd Magnitude (Row 03)	…
…	…	…	…

Table 2: Menu structure

It is more 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**
Icat Magnitude	02	01	First setting within third column
Icat Phase Angle	02	02	Second setting within third column
Ifdr Magnitude	02	03	Third setting within third column
…	…	…	

Table 3: Settings table example

The first three column headers are common throughout the entire Px40 series. 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 Px40 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 documentation and not make any assumptions

2.7 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 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 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.

> ***Notes**: 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*

2.8 Direct Access (The Hotkey Menu)

It can be quite an onerous process to configure settings using the HMI panel, especially for settings and commands that need to be executed 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 via these direct access keys are:

- Setting group selection
- Control Inputs
- CB Control functions

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.

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".

CB 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.

The availability of the above three 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'.

Hotkey display

In general, the layout of a typical display of the hotkey menu is as follows:

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

Accessing the Hotkey Menu

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 left and right cursor keys to scroll between the other available options, then use the hotkeys to control the function currently displayed. If neither of the cursor keys is pressed within 20 seconds of entering a hotkey sub menu, the unit reverts to the default display.

Press Clear key to return to the default menu from any page of the hotkey menu.

> *Note: More detailed information about the above three functions is available in the Operations chapter.*

The CB control menu

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
```

2.9 Function keys

Most devices have 10 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 energized 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 battery backed memory. If the auxiliary supply is interrupted, the status of all the function keys is restored. If the battery is missing or discharged, the function key DDB signals are set to logic 0 once the auxiliary supply is restored. The IED only recognizes 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 recognized in PSL. This feature avoids accidental double presses.

3 USING MICOM S1 AGILE

MiCOM S1 Agile is application software specifically designed to interface with General Electric protection devices. This section provides a brief overview of MiCOM S1 Agile and is intended to get you up and running.

For more detailed documentation, please refer to the demo included with the MiCOM S1 AGILE software package and the online help system. Further information is also available in the DNP3.0 Configurator Guide S1V2DNP/EN HI.

3.1 Platform Requirements

MiCOM S1 Agile requires the following hardware platform.

Minimum

- 1 GHz processor
- 256 MB RAM
- Windows™ XP
- Resolution 800 x 600 (256 colors)
- 1 GB free hard disk space

Recommended

- 2 GHz processor
- 1 GB RAM
- WindowsTM XP
- Resolution 1024 x 768
- 5 GB free hard disk space

3.2 Connecting to the Unit using MiCOM S1 Agile

This section is intended as a quick start guide to using MiCOM S1 Agile and assumes you have a copy installed on your PC. See the MiCOM S1 Agile program online help for more detailed information.

1. Connect a serial cable between the port on the front panel of the IED and the PC.
2. To start MiCOM S1 Studio, select **Programs > MiCOM S1 Agile > MiCOM S1 Agile**.
3. Click **Quick Connect** and select **Create a New System**.
4. The new system file is placed in a default path in the **Path to System** field. You can change this path if desired.
5. Enter the name of the system in the **Name** field (you can add a brief description of the system using the **Comment** field, if required).
6. Click **OK**.
7. Select the device type **Px40 Series**
8. Select the communications port **Front port**, **Rear port** or **Ethernet port**.
9. Once connected, select the language for the settings file, the device name, then click Finish. The configuration is updated.
10. In the Agile Explorer window, select **Device > Supervise Device…** to control the unit functions directly.

3.3 Off-line use of MiCOM S1 Agile

MiCOM S1 Agile can also be used as an off-line tool to prepare settings, without access to the unit.

1. If creating a new system, in the Studio Explorer, select **Create new system**.
2. Right click the new system and select **New substation**.
3. Right-click the new substation and select **New voltage level**.
4. Right-click the new voltage level and select **New bay**.
5. Right-click the new bay and select **New device**.
6. Select a device type from the list, and enter the unit type. Click **Next**.
7. Enter the full model number and click **Next**.
8. Select the Language and Model, then click **Next**.
9. Enter a unique device name, then click **Finish**.
10. Right-click the Settings folder and select New File. A default file 000 is added.
11. Right-click file 000 and select click **Open**. You can now edit the settings.

Notes: *You can add a device at any level, whether it is a system, substation, voltage or bay.*

If the device type you want doesn't appear in the list, you will have to import a device data model. Refer to section 3.4 for details.

3.4 Importing Device Data Models

To use MiCOM S1 Agile as an off-line tool to prepare settings etc., it is necessary to install the data models for the products that you wish to work with. Data models are installed using the Data Model Manager.

1. Before running the Data Model Manager, you must close MiCOM S1 Agile.
2. To start the Data Model Manager, select **Programs > Alstom Grid > MiCOM S1 Agile > Data Model Manager**.
3. You will be prompted to add data models. A dialog provides a list of locations from where the data models are to be retrieved.
4. You must now re-start MiCOM S1 Agile to use the new data models.

Note: *Each product version has a number of data models, all of which are large, and hence download times can be lengthy. We recommend that you select only the data models you need in order to keep download times reasonable.*

4 CONFIGURING THE ETHERNET INTERFACE

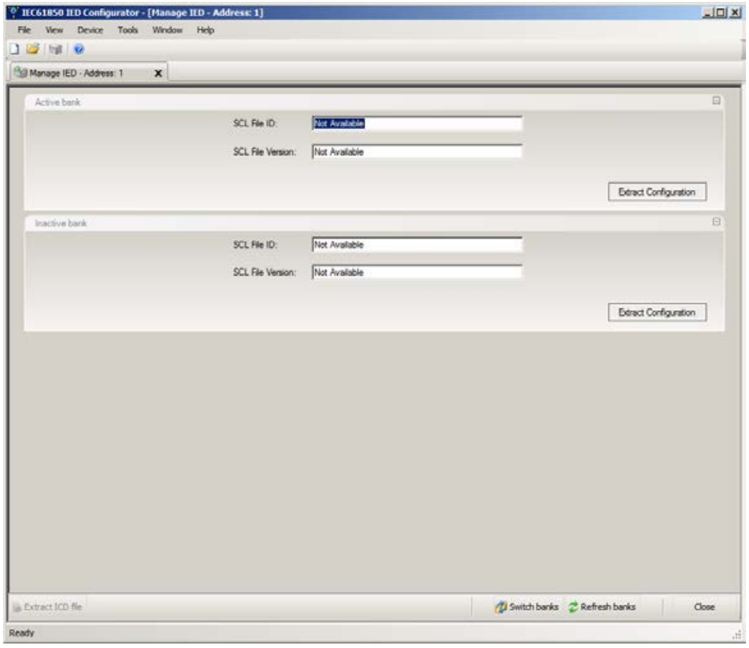
The way in which you configure the Ethernet interface depends on the particular type of interface you have. If you have a DNP3.0 interface, use the DNP setting file to configure the Ethernet interface. Otherwise you should use the IED configurator tool in MiCOM S1 Agile.

To launch MiCOM S1 Agile you need to connect to the front serial port.

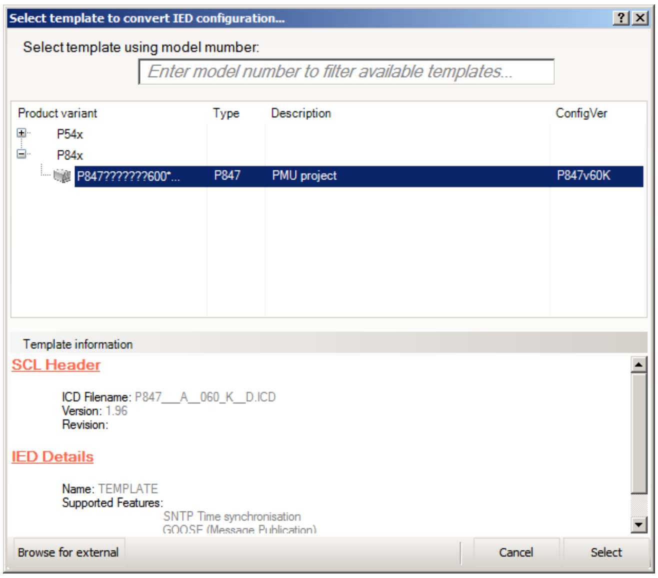
Note: Further information is available in the Communications chapter

4.1 Configuring the Ethernet Interface for IEC 61850

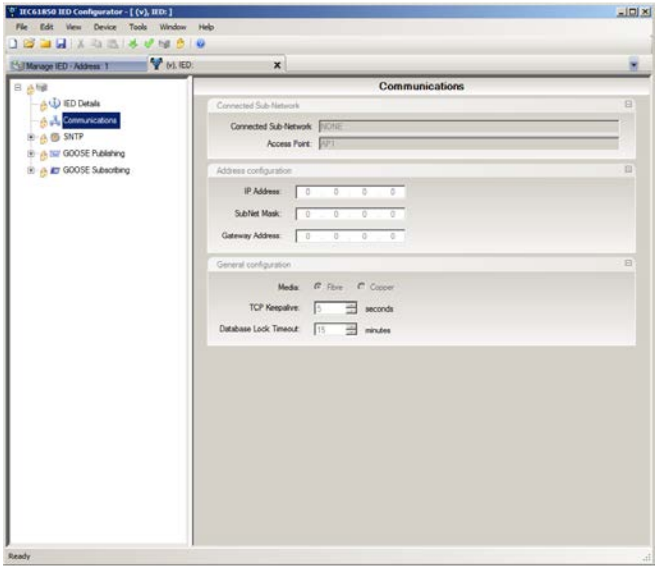
1. Open MiCOM S1 Agile:
2. Select **Tools > IEC61850 IED Configurator**
3. Select **Device > Manage IED**
4. Select **Px40**
5. Enter the address of the IED you want to manage (this will always be '1' if you are connected via the front port)
6. Click **Next**. The following screen appears



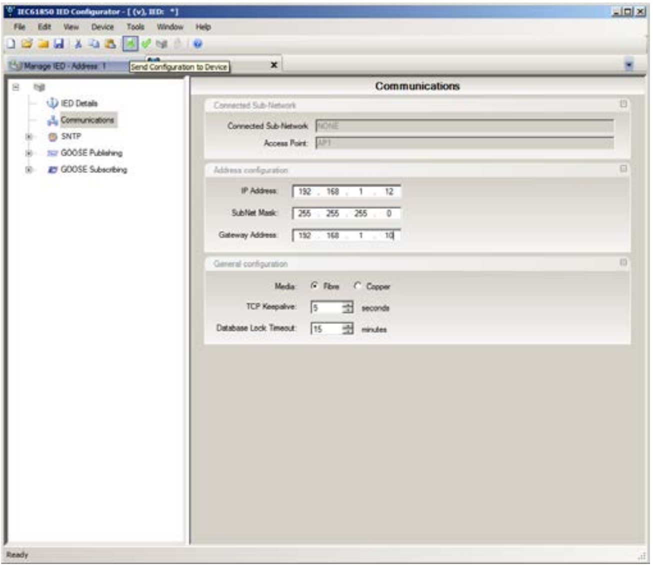
7. Select **Extract Configuration, Active Bank**



8. Select the model. The IP address data is then revealed:

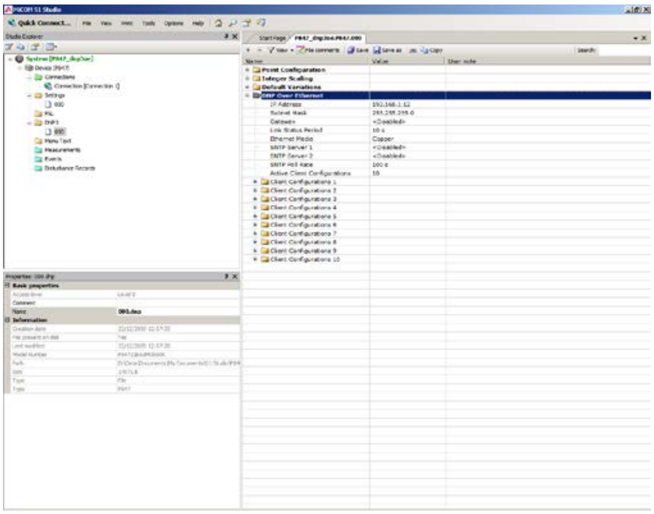


9. To change the address values, select **View > Enter Manual Editing Mode**
10. Enter the required IP configuration and select the green download button:

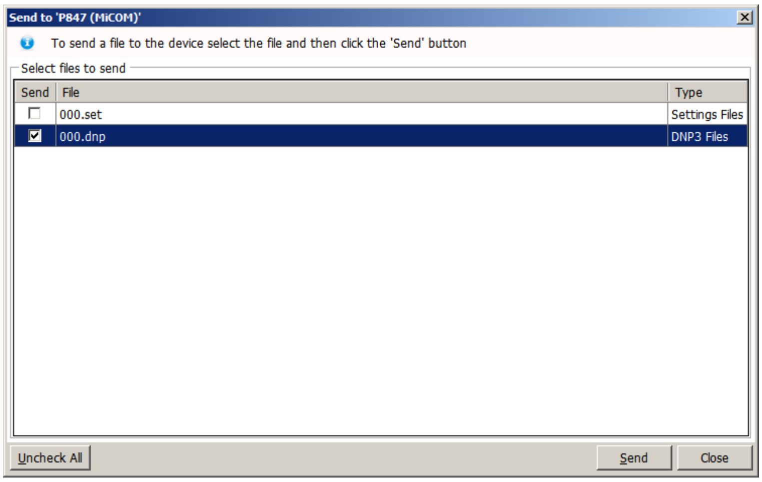


4.2 Configuring the Ethernet Interface for DNP3.0

1. Open MiCOM S1 Agile:
2. Select the device DNP3.0 file (which has been created by the DNP3.0 configurator)



3. Set the values, save them, and then send the DNP3.0 file to the device



5 CONFIGURING THE REDUNDANT ETHERNET BOARD

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 within a network is usually associated with a subnet mask that defines which network the device resides. A subnet mask takes the same form of an IP address.

For example: `255.255.255.0`

Both the IED and the REB (Redundant Ethernet Board) each have their own IP address. Figure 3 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 network.

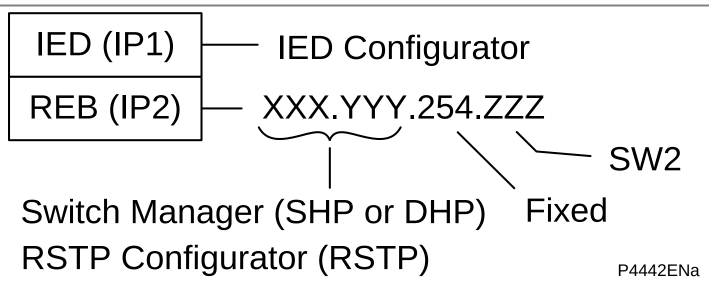


Figure 3: IED and REB IP address configuration

5.1 Configuring the IED IP address

The IP address of the IED is configured using the IED Configurator software in S1 Agile.

For IEC 61850, the IED IP address is set using the IEC 61850 IED Configurator.

For DNP3 over Ethernet, the IED IP address is managed directly through the DNP3 file.

There are 254 addresses available, which are configurable in the last octet. These are within the range 01 to 254 decimal, which is equivalent 01 to FE hexadecimal, or 00000001 to 11111110 binary.

As with all IP networks, the first and last addresses (00 and FF) should not be used as these are reserved for the network address and broadcast address respectively.

> *Note: In the IED Configurator, ensure that the port type is set to "Copper" (even if redundant fibres are being used)*

5.2 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.

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.

Configuring the Third Octet of the Board IP Address

The third octet is fixed at 254 (FE hex, 11111110 binary, regardless of the protocol.

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.

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.
5. Lift the upper and lower flaps. Remove the six screws securing the front panel and pull the front panel outwards.
6. Press the levers either side of the connector to disconnect the ribbon cable from the front panel.
7. Remove the redundant Ethernet board. Set the last octet of IP address using the DIP switches. The available range is 1 to 127.
8. Once you have set the IP address, reassemble the IED, following theses instructions in the reverse order.

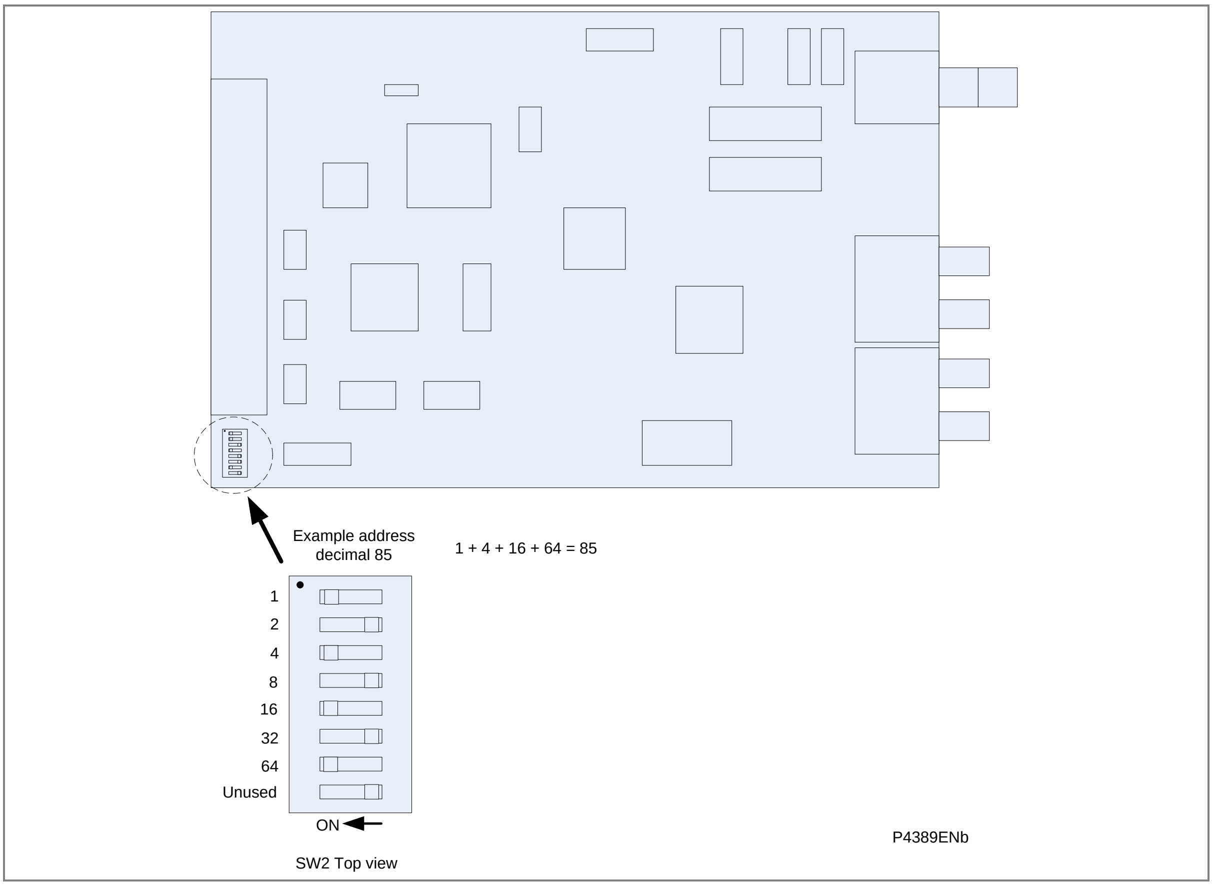


Figure 4: REB address switches (SW2)

Caution	**This hardware configuration should ideally take place before the unit is installed. If this is not possible, this must be carried out by authorized installation engineers.**

5.3 RSTP Configuration

If you are using RSTP, you will need the RSTP configurator software. This is available from General Electric on request.

The RSTP Configurator software is used to identify a device, configure the IP address, configure the SNTP IP address and configure RSTP settings.

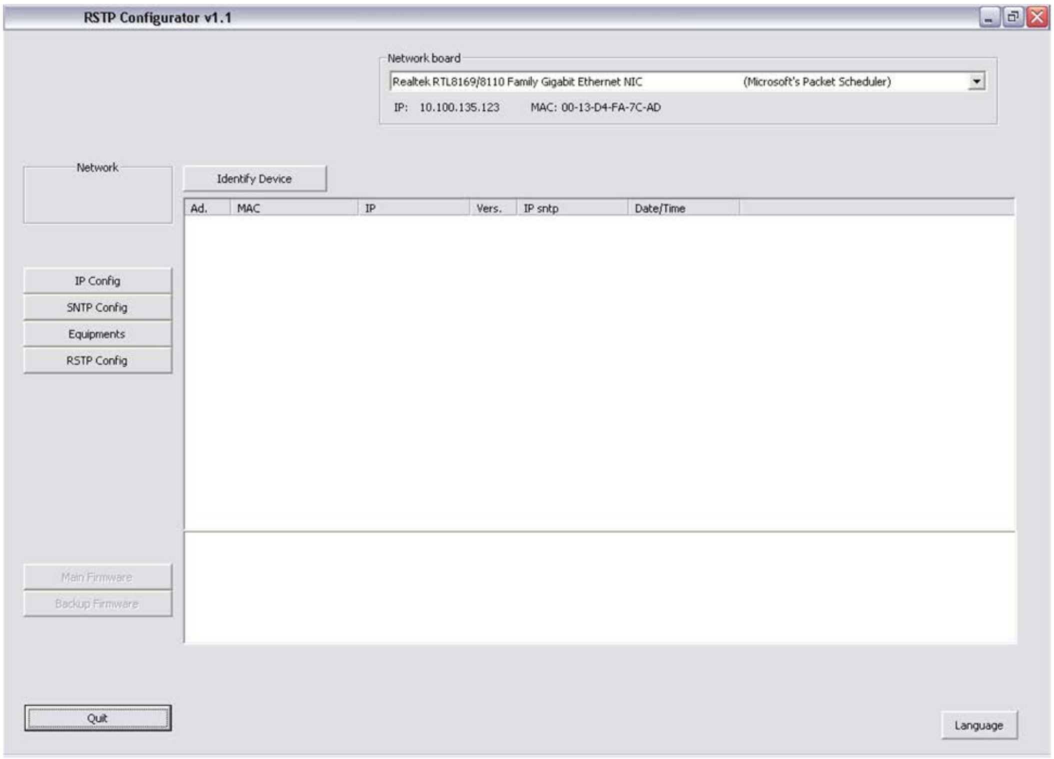
Installing RSTP Configurator

1. Double click **WinPcap_4_0.exe** to install WinPcap.
2. Double click **Alstom Grid-RSTP Configurator.msi** to install the RSTP Configurator.
3. The setup wizard appears. Click **Next** and follow the on-screen instructions to run the installation.

Starting the RSTP Configurator

1. To start the RSTP Configurator, select **Programs > RSTP Configurator > RSTP Configurator**.
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 of the RSTP Configurator appears. The Network Board drop-down list shows the Network Board, IP Address and MAC Address of the PC in which the RSTP Configurator is running.



Device Identification

1. To configure the REB, go to the main window and click **Identify Device**.
2. The REB connected to the PC is identified and its details are listed as shown below.

- Device address
- MAC address
- Version number of the firmware
- SNTP IP address
- Date & time of the real-time clock, from the board.

*Note: Due to the time needed to establish the RSTP protocol, it is necessary to wait 25 seconds between connecting the PC to the IED and clicking the **Identify Device** button.*

IP Address Configuration

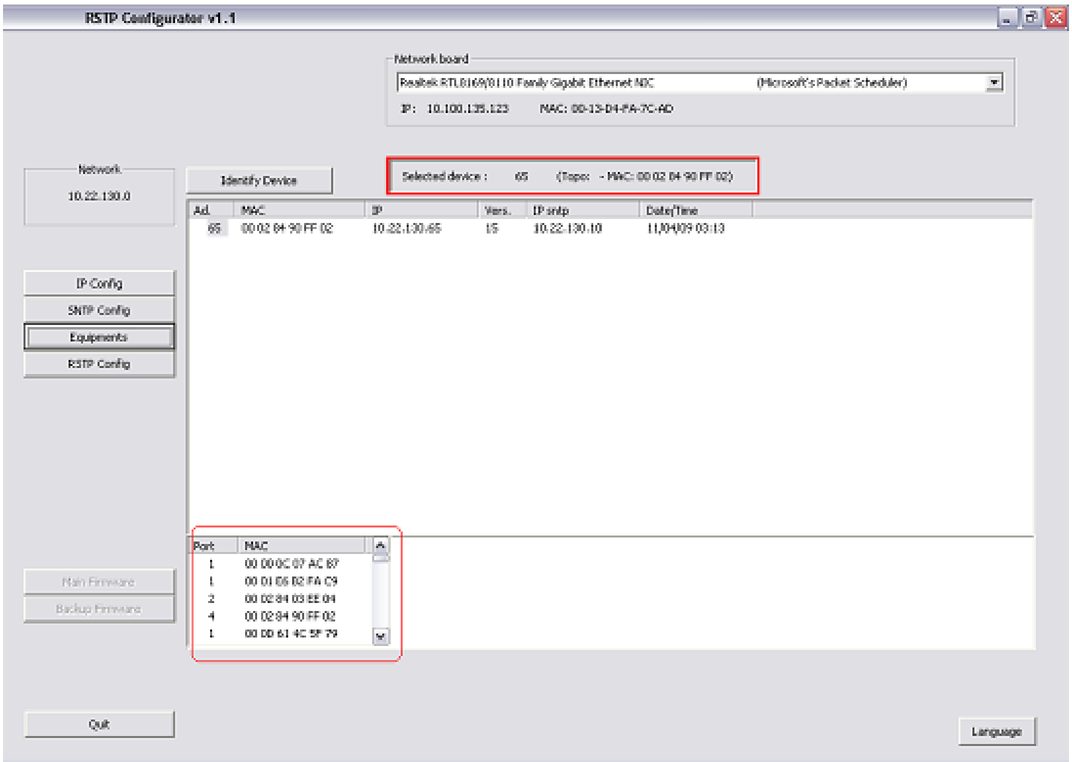
1. To change the network address component of the IP address, go to the main window and click the **IP Config** button. The Device setup screen appears. The first three octets of the board IP address can be configured. Note: the last octet is set using the DIP switches (SW2) next to the ribbon connector.
2. Enter the required board IP address and click OK. The board network address is updated and displayed in the main window.

SNTP IP Address Configuration

1. To Configure SNTP server IP address, go to the main window and click the SNTP Config button. The Device setup screen appears.
2. Enter the required SNTP MAC and server IP address, then click **OK**. The updated SNTP server IP address appears in the main screen.

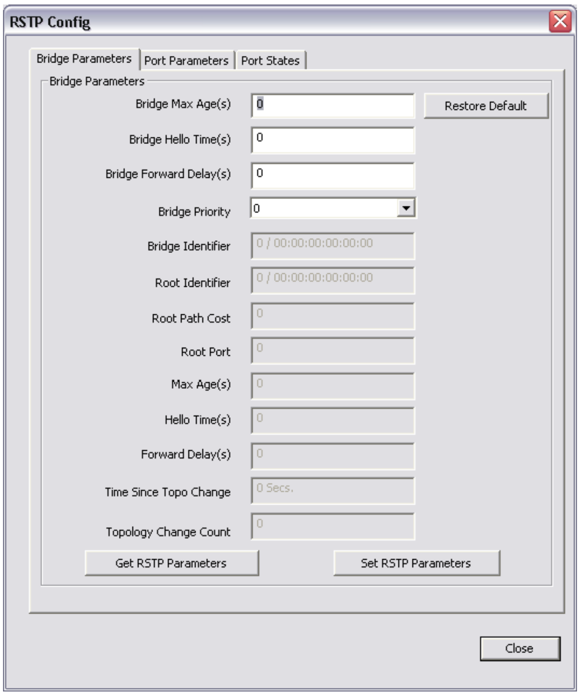
Equipment

1. To view the MAC addresses learned by the switch, go to the main window and click the Identify Device button. The selected device MAC address then appears highlighted.
2. Click the **Equipment** button. The list of MAC addresses learned by the switch and the corresponding port number are displayed.



RSTP Parameters

1. To view or configure the RSTP Bridge Parameters, go to the main window and 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.

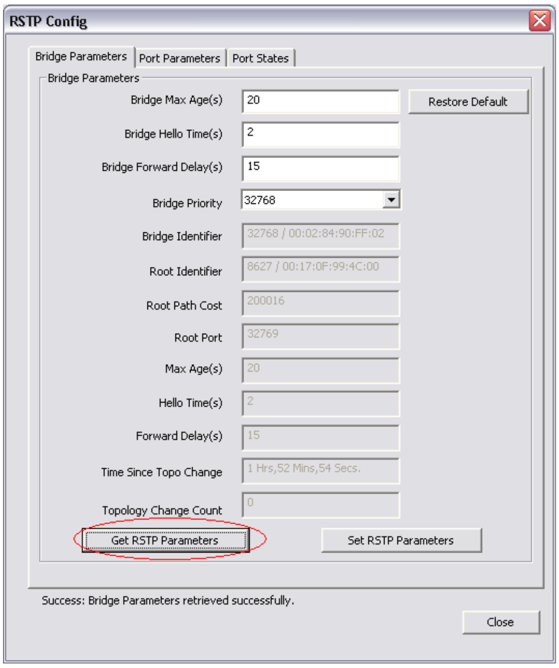


3. To view the available parameters in the board that is connected, click the **Get RSTP Parameters** button.
4. To set the configurable parameters such as **Bridge Max Age**, **Bridge Hello Time**, **Bridge Forward Delay**, and **Bridge Priority**, modify the parameter values and click **Set RSTP Parameters** as below:

S.No	Parameter	Default value (seconds)	Minimum value (seconds)	Maximum value (seconds)
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

Bridge Parameters

1. To read the RSTP bridge parameters from the board, go to the main window and 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.

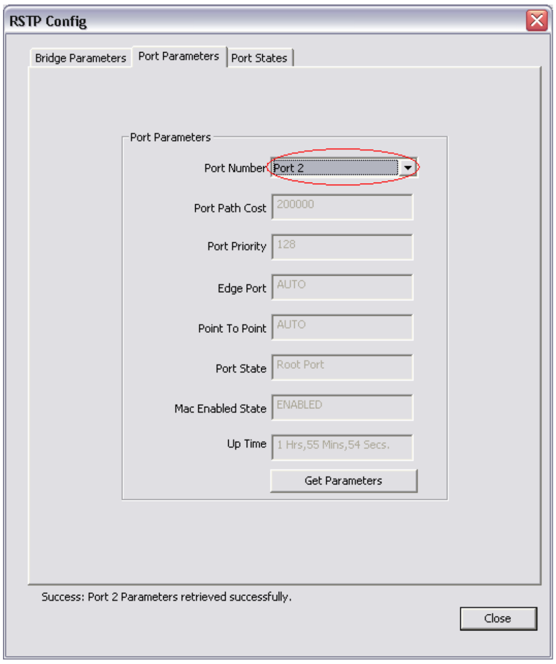


3. To modify the RSTP parameters, enter the values and click **Set RSTP Parameters**.
4. To restore the default values, click **Restore Default** and click **Set RSTP Parameters**.
5. The grayed parameters are read-only and cannot be modified.

Port Parameters

This function is useful if you need to view the parameters of each port.

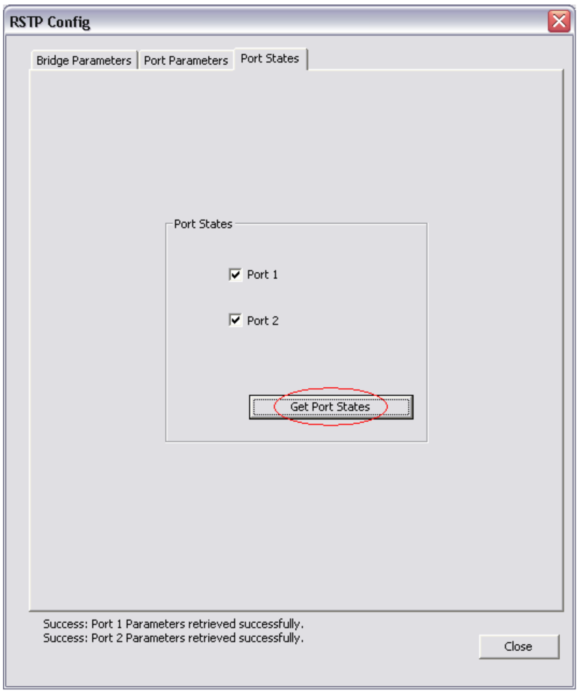
1. From the main window, click the device address to select the device and the **RSTP Config** window appears.
2. Select the **Port Parameters** tab, then click **Get Parameters** to read the port parameters.
3. Alternatively, select the port numbers to read the parameters.



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.



6 CONFIGURING THE DATA PROTOCOLS

Depending on the model, various protocols can be used with the serial rear ports. However, only one 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

6.1 Courier Configuration

To use the rear port with Courier, you can configure the settings using the HMI panel. Courier can be used with either a copper connection or a fibre connection.

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 0 and 254 for the IED address. It is important that no two IEDs have the same address.

```
COMMUNICATIONS
RP1 Address
                255
```

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 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 64kbps.

```
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.*

6.2 DNP3.0 configuration

To use the rear port with DNP3.0, you can configure the settings using the HMI panel. DNP3.0 can be used with either a copper connection or a fibre connection.

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 IED 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 1200bits/s, 2400bits/s, 4800bits/s, 9600bits/s, 19200bits/s and 38400bits/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 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 synchronization request from the master by the IED. It can be set to enabled or disabled. If enabled it allows the DNP3.0 master to synchronize the time.

```
COMMUNICATIONS
RP1 Time sync
Enabled
```

6.3 IEC 60870-5-103 Configuration

To use the rear port with IEC 60870-5-103, you can configure the settings using the HMI panel. IEC 60870-5-103 can be used with either a copper connection or a fibre connection.

The device operates as a slave in the system, responding to commands from a master station.

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 IED 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 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 energizing 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.
Command Blocking	When the command blocking DDB signal is active high, either by energizing an opto input or control input, all remote commands will be ignored (i.e. CB Trip/Close, change setting group etc.). When in this mode the device returns a “negative acknowledgement of command” message to the master station.

6.4 IEC 61850 Configuration

The only IEC 61850 configuration changes you can make with the HMI panel is to turn GOOSE on or off.

6.5 DNP3.0 configuration using MiCOM S1 Studio

A PC support package for DNP3.0 is available as part of 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.

6.6 IEC 61850 configuration

You cannot configure the device for IEC 61850 using the HMI panel on the product. For this you must use the IED Configurator.

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 even test (using simulation tools), a substation’s entire protection scheme before the products are even installed into the substation.

To help with this process, MiCOM S1 Agile provides an IED 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 MiCOM IEDs, 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: To help the user, some configuration data is available in the **IED CONFIGURATOR** column, allowing read-only access to basic configuration data.*

6.6.1 IEC 61850 Configuration banks

To help version management and minimize down-time during system upgrades and maintenance, the MiCOM IEDs have 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 IED Configurator tool can be used to transmit a command, which authorizes 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 **IED CONFIGURATOR** column of the HMI.

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

6.6.2 IEC 61850 Network connectivity

Configuration of the IP parameters and SNTP time synchronization parameters is performed by the IED Configurator tool. If these parameters are not available using an SCL file, they must be configured manually.

As the IP addressing will be completely detached and independent from any public network, it is up to the company's system administrator to establish the IP addressing strategy. Every IP address on the network must be unique. This applies to all devices on the network. Duplicate IP addresses will result in conflict and must be avoided. The IED will check for a conflict on every IP configuration change and at power up. An alarm will be raised 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.

SETTINGS AND RECORDS

CHAPTER 6

1 OVERVIEW

The product is an intelligent electronic device (IED) that must be configured to the system and application using appropriate settings. The IED is supplied preconfigured with factory default settings, but you need to set the parameters according to your application. The IED also supplies measurements of system parameters, which are not settable.

This chapter contains tables and descriptions of all the unit's settings and measurement parameters. It consists of the following sections:

2 SETTINGS DESCRIPTIONS

2.1 Setting Categories

Due to the complex functionality of the unit, it contains a large number of settings, which can be configured using the buttons and the liquid crystal display (LCD) on the front panel of the unit, or by the supplied application software, which can be accessed by connecting the unit to a PC. These settings are arranged in a hierarchical menu structure.

There are two categories of menu settings relevant to the user:

- Control and Support Settings
- Protection Group Settings

Wit the exception of the Disturbance Recorder, Control and Support settings are stored and used by the unit immediately after they are entered.

For Protection Group Settings and the Disturbance Recorder, the IED stores the new setting values in a temporary ‘scratchpad’ memory. Once the new settings have been confirmed, the device activates all the new settings together. This provides extra security so that several setting changes, made in a group of protection settings, all take effect at the same time.

2.2 Menu Structure

Settings, commands, records and measurements are stored inside the unit in non-volatile memory in a local database. When using the Human Machine Interface (HMI) it is convenient to visualize 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

Table 1 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)	Icat Magnitude (Row 01)	…
Password (Row 02)	Menu Cell Ref (Row 02)	Icat Phase Angle (Row 02)	…
Sys Fn Links Row 03)	Time & Date (Row 03)	Ifdr Magnitude (Row 03)	…
…	…	…	…

Table 1: Menu structure

It is more 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**
Icat Magnitude	02	01	First setting within third column
Icat Phase Angle	02	02	Second setting within third column
Ifdr Magnitude	02	03	Third setting within third column
…	…	…	

Table 2: Settings table example

The first three column headers are common throughout the entire Px40 series. 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 Px40 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 documentation and not make any assumptions

2.3 Rationalizing the Unit Configuration

The unit is a multi-function device that supports numerous different protection, control and communication features. To simplify the setting of the unit, there is a CONFIGURATION settings column, which can be used to enable or disable many of the unit's functions. The settings associated with any disabled function do not appear in the menu. To disable a function, you change the relevant cell in the CONFIGURATION column from **Enabled** to **Disabled**.

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

It is possible to copy the contents of one of the setting groups to that of another group. To do this, set the **Copy from** cell to the setting group to be copied then set the **Copy to** cell to the protection group where the copy is to be placed. The copied settings are initially placed in the temporary scratchpad and are only used after they have been confirmed.

3 CONTROL AND SUPPORT SETTINGS

These settings are used to configure the control and support features that do not need to adapt according to changing system conditions. These settings are part of the main menu and are used to configure the global configuration. This category of settings includes the following Courier columns:

Column Header	Column No.
SYSTEM DATA	00
VIEW RECORDS	01
MEASUREMENTS 1	02
MEASUREMENTS 2	03
MEASUREMENTS 3	04
MEASUREMENTS 4	05
CB CONDITION	06
CB CONTROL	07
DATE AND TIME	08
CONFIGURATION	09
CT AND VT RATIOS	0A
RECORD CONTROL	0B
DISTURB RECORDER	0C
MEASURE'T SETUP	0D
COMMUNICATIONS	0E
COMMISSION TESTS	0F
CB MONITOR SETUP	10
OPTO CONFIG	11
CONTROL INPUTS	12
CTRL I/P CONFIG	13
INTERMICOM COMMS	15
INTERMICOM CONF	16
FUNCTION KEYS	17
IED CONFIGURATOR	19
PROT COMMS/ IM64	20
SECURITY CONFIG	25
CTRL I/P LABELS	29
PSL DATA	B7
USER CURVES DATA	B8

Table 3: Control and support settings columns

3.1 Setting and Viewing System Data

The SYSTEM DATA column provides general system settings and status information.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
SYSTEM DATA	0	0	0	
This column contains general system settings				
Language	0	1	English	0 = English, 1 = Francais, 2 = Deutsch, 3 = Espanol
Sets the required language to be used by the device				
Password	0	2	0	ASCII 33 to 122
Plain text password entry cell				
Sys Fn Links	0	3	0	Bit 0 = Trip led self reset (1 = enable self reset), Bit 1 = Not Used, Bit 2 = Not Used, Bit 3 = Not Used, Bit 4 = Not Used, Bit 5 = Not Used, Bit 6 = Not Used or Bit 7 = Not Used
Setting to allow the fixed function trip LED to be self resetting (set to 1 to extinguish the LED after a period of healthy restoration of load current).				
Description	0	4	MiCOMho P44T	32 to 163 step 1
Editable 16 character description of the unit				
Plant Reference	0	5	MiCOM	32 to 163 step 1
Editable 16 character plant description				
Model Number	0	6	Model Number	<Model number>
Displays the model number				
Serial Number	0	8	Serial Number	<Serial number>
Displays the serial number				
Frequency	0	9	50	50 to 60 step 10
Sets the nominal system frequency				
Comms Level	0	0A	1	<conformance level displayed>
Displays the conformance of the IED to the Courier Level 2 comms.				
Relay Address	0	0B	255	0 to 255 step 1
Sets the first rear port IED address.				
Plant Status	0	0C	0	16-bit binary flag
Displays the circuit breaker plant status.				
Control Status	0	0D	0	Not used
Not used				
Active Group	0	0E	1	1 to 4 step 1
Displays the active settings group				
CB Trip/Close	0	10	No Operation	0 = No Operation, 1 = Trip, 2 = Close
Supports trip and close commands if enabled in the Circuit Breaker Control menu. Visible to LCD+Front Port				
CB Trip/Close	0	10	No Operation	0 = No Operation, 1 = Trip, 2 = Close
Supports trip and close commands if enabled in the Circuit Breaker Control menu. Visible to Rear Port				
Software Ref. 1	0	11	0	<Software Ref. 1>
Displays the IED software version including protocol and IED model.				
Software Ref. 2	0	12	0	<Software Ref. 2>
Displays the software version of the Ethernet card				
Opto I/P Status	0	20	0	32-bit binary flag: 0 = energized, 1 = de-energized
Displays the status of all available opto inputs fitted.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Relay O/P Status	0	21	0	32-bit binary flag: 0 = operated state 1 = non-operated state
Displays the status of all available output relays fitted.				
Alarm Status	0	22	0	0=Setting Group via opto invalid, 1=Test Mode Enabled, 2=Static Test Mode, 3=Loop Back Test Enabled, 4=IM64 Test Enabled, 5=VTS Indication, 6=MF out of Range, 7=WPC config wrong, 8=Train T conf. wr, 9=PantoFlash alarm, 10=CB Fail Alarm 11=CB Monitor Alarm, 12=CB Lockout Alarm , 13=CB Status Alarm, 14=CB Failed to Trip, 15=CB Failed to Close, 16=Control CB Unhealthy, 17=Control No Checksync, 18=Autoclose Lockout/RLY BAR, 19=No Healthy (AR), 20=No Check Sync / AR Fail, 21=System Split Alarm, 22=GPS Alarm, 23=Signaling failure alarm, 24=Signaling Propagation Delay Alarm, 25=Unused, 26=IM64 Scheme Fail alarm, 27=IEEE C37.94 Communications Alarms, 28=Unused, 29=Aid1 Channel Out, 30=Aid2 Channel Out, 31=Frequency out of range
Displays the status of the first 32 alarms as a binary string. Includes fixed and user settable alarms. Data type G96				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Alarm Status (Copy of 0022)	0	50	0	0=Setting Group via opto invalid, 1=Test Mode Enabled, 2=Static Test Mode, 3=Loop Back Test Enabled, 4=IM64 Test Enabled, 5=VTS Indication, 6=MF out of Range, 7=WPC config wrong, 8=Train T conf. wr, 9=PantoFlash alarm, 10=CB Fail Alarm, 11=CB Monitor Alarm, 12=CB Lockout Alarm , 13=CB Status Alarm, 14=CB Failed to Trip, 15=CB Failed to Close, 16=Control CB Unhealthy, 17=Control No Checksync, 18=Autoclose Lockout/RLY BAR, 19=No Healthy (AR), 20=No Check Sync / AR Fail, 21=System Split Alarm, 22=GPS Alarm, 23=Signaling failure alarm, 24=Signaling Propagation Delay Alarm, 25=Unused, 26=IM64 Scheme Fail alarm, 27=IEEE C37.94 Communications Alarms, 28=Unused, 29=Aid1 Channel Out, 30=Aid2 Channel Out, 31=Frequency out of range
32 bit field gives status of first 32 alarms. Includes fixed and user settable alarms.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Alarm Status 2	0	51	0	0=Unused, 1=Unused, 2=Unused, 3=Unused, 4=Unused, 5=Unused, 6=Unused, 7=Control No Checksync, 8=Autoclose Lockout/RLY BAR, 9=No Healthy (AR), 10=No Check Sync / AR Fail, 11=Invalid AR Mode, 12=Incompatible relays, 13=In Valid Message Format, 14=Copro Main Prot. Fail, 15=Configuration Error, 16=Re-Configuration Error, 17=Unused, 18=Max Prop Delay Alarm, 19=Unused, 20=Unused, 21=Unused, 22=Unused, 23=Unused, 24=SR User Alarm 1, 25=SR User Alarm 2, 26=SR User Alarm 3, 27=SR User Alarm 4, 28=MR User Alarm 5, 29=MR User Alarm 6, 30=MR User Alarm 7, 31=MR User Alarm 8
Displays the status of the next 32 alarms as a binary string. Data type G128				
Alarm Status 3	0	52	0	0=Battery Fail, 1=Field Volt Fail, 2=Rear Comm 2 Fail, 3=GOOSE IED Absent, 4=NIC Not Fitted, 5=NIC No Response, 6=NIC Fatal Error, 7=NIC Soft. Reload, 8=Bad TCP/IP Cfg., 9=Bad OSI Config., 10=NIC Link Fail, 11=NIC SW Mis-Match, 12=IP Addr Conflict, 13=IM Loopback, 14=IM Message Fail, 15=IM Data CD Fail, 16=IM Channel Fail, 17=Backup Setting, 18=Unused, 19=Backup Curve, 20 to 31= Unused
Displays the status of the next 32 alarms as a binary string. Data type G228				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Access Level	0	D0	0	0 = Read Some, 1 = Read All, 2 = Read All + Write Some, 3 = Read All + Write All
Displays the current access level. Level 0 - No password required - Read access to Security features, Model Number, Serial Number, S/W version, Description, Plant reference, Security code (UI Only), Encryption key (UI Only), User Banner and security related cells (BF12 - BF14). Level 1 - Password 1, 2 or 3 required - Read access to all data and settings. Write access to Primary/Secondary selector, Level 1 password setting, Password reset cell and log extraction cells (record selector) Level 2 - Password 2 or 3 required - Read access to all data and settings. Write access to Reset demands and counters and Level 2 password setting. Level 3 - Password 3 required - Read access to all data and settings. Write access to All settings including Level 3 password setting, PSL, IED Config, Security settings (port disabling etc)				
Password Level 1	0	D2	0	ASCII 33 to 122
Allows user to change password level 1. (8 characters)				
Password Level 2	0	D3	AAAA	ASCII 33 to 122
Allows user to change password level 2. (8 characters)				
Password Level 3	0	D4	AAAA	ASCII 33 to 122
Allows user to change password level 3. (8 characters)				
Security Feature	0	DF	1	1
Displays the level of cyber security implemented, 1 = phase 1.				
Password	0	E1	0	ASCII 33 to 122
Encrypted password entry cell. Not visible via UI				
Password Level 1	0	E2	0	ASCII 33 to 122
Allows user to change Encrypted password level 1. (8 characters) Not visible via UI				
Password Level 2	0	E3	0	ASCII 33 to 122
Allows user to change Encrypted password level 2. (8 characters) Not visible via UI				
Password Level 3	0	E4	0	ASCII 33 to 122
Allows user to change Encrypted password level 3. (8 characters) Not visible via UI				

Table 4: SYSTEM DATA column

3.2 Viewing Event and Fault Records

The device records and time tags events (1024) and stores them in battery-backed memory. This lets you establish the sequence of events that occurred following a particular power system condition, switching sequence etc. When the available space is exhausted, the oldest event is automatically overwritten by the new one.

The VIEW RECORDS column displays details of these Event, Fault and Maintenance records. Most of the items in this column are for information purposes and cannot be set, however there are settings, which allow you to select the records to be viewed.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
VIEW RECORDS	1	0	0	
This column contains record configuration				
Select Event [0...n]	1	1	0	0 to 1023 step 1
This selects the required event record. A value of 0 corresponds to the latest event and so on.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Menu Cell Ref	1	2	(From Record)	
Indicates the type of event				
Time & Date	1	3	(From Record)	
Time & Date Stamp for the event given by the internal Real Time Clock.				
Event Text	1	4	0	
Up to 32 Character description of the Event (refer to following sections).				
Event Value	1	5	0	
Up to 32 Bit Binary Flag or integer representative of the Event (refer to following sections).				
Select Fault [0...n]	1	6	0	0 to 14 step 1
Setting range from 0 to 14. This selects the required fault record from the possible 15 that may be stored. A value of 0 corresponds to the latest fault and so on.				
Faulted Phase	1	7	0	0x0001 = Start CAT, 0x0002 = Start FDR, 0x0004 = Unused, 0x0008 = Start GND, 0x0010 = Trip CAT, 0x0020 = Trip FDR, 0x0040 = Unused, 0x0080 = Trip GND
Displays the faulted phase. Started phases + tripped phases				
Start Elements 1	1	8	0	0x0000,0x0001=General Start, 0x0000,0x0002=Start Def, 0x0000,0x0004=Start Z1, 0x0000,0x0008=Start Z2, 0x0000,0x0010=Start Z3, 0x0000,0x0020=Start ZP, 0x0000,0x0040=Start Z4, 0x0000,0x0080=Start I>1, 0x0000,0x0100=Start I>2, 0x0000,0x0200=Start I>3, 0x0000,0x0400=Start I>4, 0x0000,0x0800=Unused, 0x0000,0x1000=Unused, 0x0000,0x2000=Unused, 0x0000,0x4000=Unused, 0x0000,0x8000=Unused, 0x0001,0x0000=Unused, 0x0002,0x0000=Unused, 0x0004,0x0000=Unused, 0x0008,0x0000=Thermal Alarm, 0x0010,0x0000=Unused, 0x0020,0x0000=Unused, 0x0040,0x0000=Panto F.Start, 0x0080,0x0000=Unused, 0x0100,0x0000=Unused, 0x0200,0x0000=Unused, 0x0400,0x0000=Unused, 0x0800,0x0000=Unused, 0x1000,0x0000=Unused, 0x2000,0x0000=Unused, 0x4000,0x0000=Unused, 0x8000,0x0000=Unused,
Displays the status of the first 32 start signals.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Start Elements 2	1	9	0	0x0000,0x0001=Start V<1, 0x0000,0x0002=Start V<2, 0x0000,0x0004=Start V<Cat, 0x0000,0x0008=Start V<Fdr, 0x0000,0x0010=Unused, 0x0000,0x0020=Start V>1, 0x0000,0x0040=Start V>2, 0x0000,0x0080=Start V>Cat, 0x0000,0x0100=Start V>Fdr, 0x0000,0x0200=Unused, 0x0000,0x0400=Unused, 0x0000,0x0800=Unused, 0x0000,0x1000=Unused, 0x0000,0x2000=Unused,
Displays the status of the second 32 start signals.				
Trip Elements(1)	1	0A	0	0x0000,0x0001=Any Trip, 0x0000,0x0002=Trip Def, 0x0000,0x0004=Unused, 0x0000,0x0008=PIT, 0x0000,0x0010=Trip Z1, 0x0000,0x0020=Trip Z2, 0x0000,0x0040=Trip Z3, 0x0000,0x0080=Trip ZP, 0x0000,0x0100=Trip Z4, 0x0000,0x0200=Aid 1 Dist Trip, 0x0000,0x0400=Unused, 0x0000,0x0800=Unused, 0x0000,0x1000=Aided 1 WI, 0x0000,0x2000=Aid 2 Dist Trip, 0x0000,0x4000=Unused, 0x0000,0x8000=Unused, 0x0001,0x0000=Aided 2 WI, 0x0002,0x0000=TOR, 0x0004,0x0000=SOTF, 0x0008,0x0000=Unused, 0x0010,0x0000=Unused, 0x0020,0x0000=Unused, 0x0040,0x0000=Unused, 0x0080,0x0000=Unused, 0x0100,0x0000=Unused, 0x0200,0x0000=Unused, 0x0400,0x0000=Unused, 0x0800,0x0000=Unused, 0x1000,0x0000=Unused, 0x2000,0x0000=Unused, 0x4000,0x0000=Unused, 0x8000,0x0000=Unused,
Displays the status of the first 32 trip signals.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Trip Elements(2)	1	0B	0	0x0000,0x0001=Trip I>1, 0x0000,0x0002=Trip I>2, 0x0000,0x0004=Trip I>3, 0x0000,0x0008=Trip I>4, 0x0000,0x0010=Unused, 0x0000,0x0020=Unused, 0x0000,0x0040=Unused, 0x0000,0x0080=Unused, 0x0000,0x0100=Unused, 0x0000,0x0200=Unused, 0x0000,0x0400=Unused, 0x0000,0x0800=Unused, 0x0000,0x1000=Unused, 0x0000,0x2000=Trip Thermal, 0x0000,0x4000=Unused, 0x0000,0x8000=Unused, 0x0001,0x0000=Unused, 0x0002,0x0000=Trip V< 1, 0x0004,0x0000=Trip V< 2, 0x0008,0x0000=Trip V< CAT, 0x0010,0x0000=Trip V< FDR, 0x0020,0x0000=Unused, 0x0040,0x0000=Trip V> 1, 0x0080,0x0000=Trip V> 2, 0x0100,0x0000=Trip V> CAT, 0x0200,0x0000=Trip V> FDR, 0x0400,0x0000=Unused, 0x0800,0x0000=Unused, 0x1000,0x0000=Unused, 0x2000,0x0000=Unused, 0x4000,0x0000=Unused, 0x8000,0x0000=Unused
Displays the status of the second 32 trip signals.				
Fault Alarms	1	0C	0	0x0000,0x0001=CB Fail 1, 0x0000,0x0002=CB Fail 2, 0x0000,0x0004=A/R Trip 1, 0x0000,0x0008=A/R Trip 2, 0x0000,0x0010=A/R Trip 3, 0x0000,0x0020=A/R Trip 4, 0x0000,0x0040=A/R Trip 5, 0x0000,0x0080=VTS, 0x0000,0x0100=Unused, 0x0000,0x0200=Unused, 0x0000,0x0400=Unused, 0x0000,0x0800=Unused, 0x0000,0x1000=Unused, 0x0000,0x2000=Unused,
Displays the status of the fault alarm signals.				
Fault Time	1	0D	0	
Displays fault time and date.				
Active Group	1	0E	0	
Displays active setting group				
System Frequency	1	0F	0	
Displays the system frequency				
Fault Duration	1	10	0	
Displays time from the start or trip until the undercurrent elements indicate the CB is open				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
CB Operate Time	1	11	0	
Displays time from protection trip to undercurrent elements indicating the CB is open				
Relay Trip Time	1	12	0	
Displays time from protection start to protection trip				
Fault Location	1	13	0	
Displays fault location in metres.				
Fault Location	1	14	0	
Displays fault location in miles.				
Fault Location	1	15	0	
Displays fault location in ohms.				
Fault Location	1	16	0	
Displays fault location in percentage.				
Start Elements 3	1	1A	0	0x0000,0x0001 = Unused, 0x0000,0x0002 = Unused, 0x0000,0x0004 = Unused, 0x0000,0x0008 = Unused, 0x0000,0x0010 = Unused, 0x0000,0x0020 = Unused,
Displays the status of the third 32 start signals.				
Trip Elements(3)	1	1C	0	0x0000,0x0001 = Unused, 0x0000,0x0002 = Unused, 0x0000,0x0004 = Unused, 0x0000,0x0008 = Unused, 0x0000,0x0010 = Unused,
Displays the status of the third 32 trip signals.				
Icat Prefault Mag	1	20	0	
Measured parameter				
Icat Prefault Ang	1	21	0	
Measured parameter				
Ifdr Prefault Mag	1	22	0	
Measured parameter				
Ifdr Prefault Ang	1	23	0	
Measured parameter				
Idef Prefault Mag	1	26	0	
Measured parameter				
Idef Prefault Ang	1	27	0	
Measured parameter				
Vcat Prefault Mag	1	30	0	
Measured parameter				
Vcat Prefault Ang	1	31	0	
Measured parameter				
Vfdr Prefault Mag	1	32	0	
Measured parameter				
Vfdr Prefault Ang	1	33	0	
Measured parameter				
Icat Fault Mag	1	40	0	

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Measured parameter				
Icat Fault Ang	1	41	0	
Measured parameter				
Ifdr Fault Mag	1	42	0	
Measured parameter				
Ifdr Fault Ang	1	43	0	
Measured parameter				
Idef Fault Mag	1	46	0	
Measured parameter				
Idef Fault Ang	1	47	0	
Measured parameter				
Vcat Fault Mag	1	50	0	
Measured parameter				
Vcat Fault Ang	1	51	0	
Measured parameter				
Vfdr Fault Mag	1	52	0	
Measured parameter				
Vfdr Fault Ang	1	53	0	
Measured parameter				
Idef Diff	1	54	0	
Measured parameter				
Idef Bias	1	56	0	
Measured parameter				
IA Differential	1	67	0	
Measured parameter				
IA Bias	1	70	0	
Measured parameter				
Ch 1 Prop Delay	1	73	0	
Measured parameter				
Ch 2 Prop Delay	1	74	0	
Measured parameter				
Select Maint [0...n]	1	F0	0	0 to 9 step 1
This selects the required maintenance report from those stored. A value of 0 corresponds to the latest report and so on.				
Maint Text	1	F1	0	
Up to 16 Character description of the occurrence (refer to following sections).				
Maint Type	1	F2	0	
These cells are numbers representative of the occurrence. They form a specific error code which should be quoted in any related correspondence to Report Data.				
Maint Data	1	F3	0	
These cells are numbers representative of the occurrence. They form a specific error code which should be quoted in any related correspondence to Report Data.				
Evt Iface Source	1	FA	0	0
Interface on which the event was logged				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Evt Access Level	1	FB	0	0
Any security event that indicates that it came from an interface action, such as disabling a port, will also record the access level of the interface that initiated the event. This will be recorded in the 'Event State' field of the event.				
Evt Extra Info	1	FC	0	0
This cell provides supporting information for the event and can vary between the different event types.				
Evt Unique Id	1	FE	0	0
Each event will have a unique event id. The event id is a 32 bit unsigned integer that is incremented for each new event record and is stored in the record in battery-backed memory (BBRAM). The current event id must be non-volatile so as to preserve it during power cycles, thus it too will be stored in BBRAM. The event id will wrap back to zero when it reaches its maximum (4,294,967,295). The event id will be used by PC based utilities when organising extracted logs from IED's.				
Reset Indication	1	FF	No	0 = No or 1 = Yes
This serves to reset the trip LED indications provided that the relevant protection element has reset.				

Table 5: VIEW RECORDS column

3.3 Measurements 1

The MEASUREMENTS 1 column lets you view the measurement quantities. These may include various Magnitudes, Phase Angles, RMS values and Frequencies.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
MEASUREMENTS 1	2	0	0	
This column contains measurement parameters				
Icat Magnitude	2	1	0	Not Settable
Icat Magnitude				
Icat Phase Angle	2	2	0	Not Settable
Icat Phase Angle				
Ifdr Magnitude	2	3	0	Not Settable
Ifdr Magnitude				
Ifdr Phase Angle	2	4	0	Not Settable
Ifdr Phase Angle				
IN Derived Mag	2	7	0	Not Settable
IN Derived Mag				
IN Derived Angle	2	8	0	Not Settable
IN Derived Angle				
Idef Magnitude	2	9	0	Not Settable
Idef Magnitude				
Idef Phase Angle	2	0A	0	Not Settable
IIdef Phase Angle				
Icat RMS	2	10	0	Not Settable
Icat RMS				
Ifdr RMS	2	11	0	Not Settable
Ifdr RMS				
Vcat-fdr Magnitude	2	14	0	Not Settable
Vcat-fdr Magnitude				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Vcat-fdr Phase Angle	2	15	0	Not Settable
Vcat-fdr Phase Angle				
Vcat Magnitude	2	1A	0	Not Settable
Vcat Magnitude				
Vcat Phase Angle	2	1B	0	Not Settable
Vcat Phase Angle				
Vfdr Magnitude	2	1C	0	Not Settable
Vfdr Magnitude				
Vfdr Phase Angle	2	1D	0	Not Settable
Vfdr Phase Angle				
Vcat RMS	2	27	0	Not Settable
Vcat RMS				
Vfdr RMS	2	28	0	Not Settable
Vfdr RMS				
Frequency	2	2D	0	Not Settable
Frequency				
C/S Voltage Mag	2	2E	0	Not Settable
C/S Voltage Mag				
C/S Voltage Ang	2	2F	0	Not Settable
C/S Voltage Ang				
C/S Bus-Line Ang	2	30	0	Not Settable
C/S Bus-Line Ang				
Slip Frequency	2	31	0	Not Settable
Slip Frequency				

Table 6: MEASUREMENTS 1 column

3.4 Measurements 2

The MEASUREMENTS 2 column works in a similar manner to the Measurements 1 settings, but may provide a different choice of measurement settings.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
MEASUREMENTS 2	3	0	0	
This column contains measurement parameters				
Cat Phase Watts	3	1	0	Not Settable
Cat Phase Watts				
Fdr Phase Watts	3	2	0	Not Settable
Fdr Phase Watts				
Cat Phase VArs	3	4	0	Not Settable
Cat Phase VArs				
Fdr Phase VArs	3	5	0	Not Settable
Fdr Phase VArs				
Cat Phase VA	3	7	0	Not Settable

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Cat Phase VA				
Fdr Phase VA	3	8	0	Not Settable
Fdr Phase VA				
Total Phase Watts	3	0A	0	Not Settable
Total Phase Watts				
Total Phase VArs	3	0B	0	Not Settable
Total Phase VArs				
Total Phase VA	3	0C	0	Not Settable
Total Phase VA				
Total Power Factor	3	0E	0	Not Settable
Total Power Factor				
Cat Power Factor	3	0F	0	Not Settable
Cat Power Factor				
Fdr Power Factor	3	10	0	Not Settable
Fdr Power Factor				
Total WHours Fwd	3	12	0	Not Settable
Total Watt - Hours (Forward)				
Total WHours Rev	3	13	0	Not Settable
Total Watts - Hours (Reverse)				
Total VArHours Fwd	3	14	0	Not Settable
Total VAr - Hours (Forward)				
Total VArHours Rev	3	15	0	Not Settable
Total VAr - Hours (Reverse)				
Total W Fix Demand	3	16	0	Not Settable
Total Watts - Fixed Demand				
Total VArs Fix Dem	3	17	0	Not Settable
Total VArs - Fixed Demand				
Icat Fixed Demand	3	18	0	Not Settable
Icat Fixed Demand				
Ifdr Fixed Demand	3	19	0	Not Settable
Ifdr Fixed Demand				
Total W Roll Dem	3	1B	0	Not Settable
Total Watts - Rolling Demand				
Total VArs RollDem	3	1C	0	Not Settable
Total VArs - Rolling Demand				
Icat Roll Demand	3	1D	0	Not Settable
Icat Roll Demand				
Ifdr Roll Demand	3	1E	0	Not Settable
Ifdr Roll Demand				
Total W Peak Dem	3	20	0	Not Settable
Total Watts - Peak Demand				
Total VAr Peak Dem	3	21	0	Not Settable
Total VArs - Peak Demand				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Icat Peak Demand	3	22	0	Not Settable
Icat Peak Demand				
Ifdr Peak Demand	3	23	0	Not Settable
Ifdr Peak Demand				
Reset Demand	3	25	No	0 = No or 1 = Yes
Reset Demand				
Thermal State	3	26	0	
Thermal State				
Reset Thermal	3	27	No	0 = No or 1 = Yes
Reset Thermal				

Table 7: MEASUREMENTS 2 column

3.5 Measurements 4

The MEASUREMENTS 4 column works in a similar manner to the Measurements 1 settings, but may provide a different choice of measurement settings.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
MEASUREMENTS 4	5	0	0	
This column contains measurement parameters				
Ch 1 Prop Delay	5	1	0	Not Settable
0				
Ch 2 Prop Delay	5	2	0	Not Settable
0				
Channel 1 Status	5	7	0	Bit 0=Unused, Bit 1=Unused, Bit 2=Unused, Bit 3=Unused, Bit 4=Mux Clk F Error, Bit 5=Signal Lost, Bit 6=Path Yellow, Bit 7=Mismatch RxN, Bit 8=Timeout, Bit 9=Message Level, Bit 10=Passthrough,
0				
Channel 2 Status	5	8	0	Bit 0=Unused, Bit 1=Unused, Bit 2=Unused, Bit 3=Unused, Bit 4=Mux Clk F Error, Bit 5=Signal Lost, Bit 6=Path Yellow, Bit 7=Mismatch RxN, Bit 8=Timeout, Bit 9=Message Level, Bit 10=Passthrough,
0				
IM64 Rx Status	5	9	0	Not Settable

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
0				
STATISTICS	5	10	0	0
0				
STATS RESET ON	5	11	0	0
0				
Date/Time	5	12	0	Not Settable
0				
Ch1 No.Vald Mess	5	13	0	Not Settable
0				
Ch1 No.Err Mess	5	14	0	Not Settable
0				
Ch1 No.Errored s	5	15	0	Not Settable
0				
Ch1 No.Sev Err s	5	16	0	Not Settable
0				
Ch1 No.Dgraded m	5	17	0	Not Settable
0				
Ch2 No.Vald Mess	5	18	0	Not Settable
0				
Ch2 No.Err Mess	5	19	0	Not Settable
0				
Ch2 No.Errored s	5	1A	0	Not Settable
0				
Ch2 No.Sev Err s	5	1B	0	Not Settable
0				
Ch2 No.Dgraded m	5	1C	0	Not Settable
0				
Max Ch 1 Prop Delay	5	26	0	Not Settable
0				
Max Ch 2 Prop Delay	5	27	0	Not Settable
0				
Clear Statistics	5	30	No	0 = No or 1 = Yes
0				

Table 8: MEASUREMENTS 4 column

3.6 Circuit Breaker Condition Monitoring

The device records statistics for each circuit breaker trip operation. The cells within the CB CONDITION column display statistics such as the number of trips, the total amount of broken current and the circuit breaker operate times. Most of these cells shown are counter values only, and cannot be set. The only settings possible are those that reset the counters back to zero.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
CB CONDITION	6	0	0	

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
This column contains CB Condition Monitoring Measured Parameters				
CB Cat Operations	6	2	0	Not Settable
Displays the total number of Cat phase trips issued by the IED				
CB Fdr Operations	6	3	0	Not Settable
Displays the total number of Fdr phase trips issued by the IED				
Total Icat Broken	6	5	0	Not Settable
Displays the total fault current interrupted by the IED for the Cat phase.				
Total Ifdr Broken	6	6	0	Not Settable
Displays the total fault current interrupted by the IED for the Fdr phase.				
CB Operate Time	6	8	0	Not Settable
Displays the calculated CB operating time.				
Reset CB Data	6	9	No	0 = No or 1 = Yes
Reset the CB condition counters.				
CB Monitoring	6	10	0	0=I^ Maint Alarm 1=I^ Lockout Alarm 2=CB OPs Maint 3=CB OPs Lock 4=CB Time Maint 5=CB Time Lockout 6=Fault Freq Lock
Displays the status of the CB Condition monitoring alarms				

Table 9: CB CONDITION column

3.7 Circuit Breaker Control

The CB CONTROL column contains settings for controlling the Circuit Breaker and monitoring its state. It also contains various statistics relating to the autoreclose function, and settings for controlling them and resetting from lockout conditions.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
CB CONTROL	7	0	0	
This column controls the circuit Breaker Control configuration				
CB Control by	7	1	Disabled	0 = Disabled, 1 = Local, 2 = Remote, 3 = Local+Remote, 4 = Opto, 5 = Opto+local, 6 = Opto+Remote, 7 = Opto+Rem+local
Selects the type of circuit breaker control to be used				
Close Pulse Time	7	2	0.5	0.1s to 50s step 0.01s
Defines the duration of the close pulse within which CB should close when close command is issued. If CB fails to close after elapse of this time, CB close fail alarm is set.				
Trip Pulse Time	7	3	0.5	0.1s to 50s step 0.01s
Defines the duration of the trip pulse within which CB should trip when manual or protection trip command is issued. If CB does not trip within set Trip Pulse Time, CB failed to trip alarm is set.				
Man Close Delay	7	5	10	0.01s to 600s step 0.01s
This defines the delay time before the close pulse is executed.				
CB Healthy Time	7	6	5	0.01s to 9999s step 0.01s
Settable time delay for manual closure with this circuit breaker check. If the circuit breaker does not indicate a healthy condition in this time period following a close command then the IED will lockout and alarm. CB Healthy is required for manual and auto reclosure.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Check Sync Time	7	7	5	0.01s to 9999s step 0.01s
A user settable time delay is included for manual closure with System Check Synchronizing. If the System Check Synchronizing criteria are not satisfied in this time period following a close command the IED will lockout and alarm.				
CB mon LO reset	7	8	No	0 = No or 1 = Yes
Command to reset the CB monitoring Lockout Alarm				
Rst CB mon LO by	7	9	CB Close	0 = User Interface or 1 = CB Close
This setting is used to decide preferred option to reset a lockout condition caused by CB monitoring conditions either by a manual circuit breaker close command or via the user interface.				
CB mon LO RstDly	7	0A	5	0.1s to 600s step 0.01s
If Rst CB mon LO by is set to CB close then CB mon LO RstDly timer allows reset of CB lockout state after set time delay				
Autoreclose Mode	7	0B	No Operation	0 = No Operation, 1 = In Service, 2 = Out of Service
Command to changes state of Auto-Reclose, In Service or Out of Service				
AR Status	7	0E	0	0 = Out of Service or 1 = In Service
Status of the Auto Reclose - In Service / Out of service				
CB Status Input	7	11	52B Single pole	0 = None 1 = 52A all pole 2 = 52B all pole 3 = 52A & 52B all pole 4 = 52A single pole 5 = 52B single pole 6 = 52A & 52B single pole
Setting to define the type of circuit breaker contacts that will be used for the circuit breaker control logic. Form A contacts match the status of the circuit breaker primary contacts, form B are opposite to the breaker status. When single pole is selected, individual contacts must be assigned in the Programmable Scheme Logic for phase Cat and phase Fdr. Setting all pole means that only a single contact is used, common to all poles.				
CB Status Time	7	7F	5	0.1s to 5s step 0.01s
Under healthy conditions the circuit breaker auxiliary contacts will be in opposite states. Should both sets of contacts be open or closed, it indicates that either the contacts, or the wiring, or the circuit breaker are defective and an alarm will be issued after CB Status Time delay. The time delay is set to avoid unwanted operation during normal switching duties.				
Reset AROK Ind	7	82	No	0 = No or 1 = Yes
If Res AROK by UI is set to Enabled, this command provides a pulse to reset the successful AR indication for both CB's				
Reset CB LO	7	83	No	0 = No or 1 = Yes
If Res LO by UI is set to Enabled, this command provides a pulse to reset the lockout for CB. Note: This requires the condition that caused the lockout to have been cleared.				
CB Total Shots	7	85	0	Not Settable
Indicates the total number of CB reclosures				
CB SUCC SPAR	7	86	0	Not Settable
Indicates the total number of CB successful single pole reclosures				
CB SUCCAPARShot1	7	87	0	Not Settable
Indicates the total number of CB successful all pole reclosures at 1st shot				
CB SUCCAPARShot2	7	88	0	Not Settable
Indicates the total number of CB successful all pole reclosures at 2nd shot				
CB SUCCAPARShot3	7	89	0	Not Settable
Indicates the total number of CB successful all pole reclosures at 3rd shot				
CB SUCCAPARShot4	7	8A	0	Not Settable
Indicates the total number of CB successful 3 pole reclosures at 4th shot				
CB Failed Shots	7	8B	0	Not Settable
Indicates the total number of CB failed reclose cycles				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Reset CB Shots	7	8C	No	0 = No or 1 = Yes
This command resets all CB shots counters to zero				
Res AROK by UI	7	96	Enabled	0 = Disabled or 1 = Enabled
If Enabled, this allows the successful auto-reclose signal to be reset by user interface command Reset AROK Ind.				
Res AROK by NoAR	7	97	Disabled	0 = Disabled or 1 = Enabled
If Enabled, allows the successful autoreclose signal to be reset by autoreclosing being disabled				
Res AROK by Ext	7	98	Disabled	0 = Disabled or 1 = Enabled
If Enabled, allows successful autoreclose signal reset by external DDB input Ext Rst CBx AROK via PSL.				
Res AROK by TDly	7	99	Disabled	0 = Disabled or 1 = Enabled
If Enabled, allows successful autoreclose signal to reset after time AROK Reset Time				
Res AROK by TDly	7	9A	1	1s to 9999s step 1s
Reset time for successful autoreclose signal if Res AROK by TDly is set to Enabled				
Res LO by CB IS	7	9B	Enabled	0 = Disabled or 1 = Enabled
If Enabled, allows reset of CB lockout state when CB is "In Service" (i.e. CB is closed for time > CB IS Time)				
Res LO by UI	7	9C	Enabled	0 = Disabled or 1 = Enabled
If Enabled, allows reset of each CB lockout state by UI command				
Res LO by NoAR	7	9D	Disabled	0 = Disabled or 1 = Enabled
If Enabled, allows reset of CB lockout state by selecting autoreclosing disabled				
Res LO by ExtDDB	7	9E	Disabled	0 = Disabled or 1 = Enabled
If Enabled, allows reset of CB lockout state by external DDB input Ext Rst CBx AROK via PSL.				
Res LO by TDelay	7	9F	Disabled	0 = Disabled or 1 = Enabled
If Enabled, allows reset of CB lockout state after time LO Reset Time				
LO Reset Time	7	A0	1	1s to 9999s step 1s
Reset time for CB lockout if Res LO by TDelay is set to Enabled				

Table 10: CB CONTROL column

3.8 Date and Time

The DATE AND TIME column displays all the settings and data relating to the date and time, as well as battery status.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
DATE AND TIME	8	0	0	
This column contains Date and Time stamp settings				
Date/Time	8	1	0	
Displays the IED's current date and time.				
Date	8	N/A	1 Jan 1994	
Displays the date. Front Panel Menu only				
Time	8	N/A	00:00	
Displays the time. Front Panel Menu only				
IRIG-B Sync	8	4	Disabled	0 = Disabled or 1 = Enabled
Enable IRIG-B time synchronization.				
IRIG-B Status	8	5	0	0 = Card Not Fitted, 1 = Card Failed, 2 = Signal Healthy, 3 = No Signal

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Displays the status of IRIG-B				
Battery Status	8	6	0	0 = Dead or 1 = Healthy
Displays whether the battery is healthy or not				
Battery Alarm	8	7	Enabled	0 = Disabled or 1 = Enabled
Enables or disables battery alarm. The battery alarm needs to be disabled when a battery is removed or not used				
SNTP Status	8	13	0	0 = Disabled, 1 = Trying server 1, 2 = Trying server 2, 3 = Server 1 OK, 4 = Server 2 OK, 5 = No response, 6 = No valid clock
IEC61850 or DNP3.0 over Ethernet versions only. Displays information about the SNTP time synchronization status				
LocalTime Enable	8	20	Flexible	0 = Disabled, 1 = Fixed or 2 = Flexible
Setting to turn on/off local time adjustments. Disabled - No local time zone will be maintained. Time synchronization from any interface will be used to directly set the master clock and all displayed (or read) times on all interfaces will be based on the master clock with no adjustment. Fixed - A local time zone adjustment can be defined using the LocalTime offset setting and all interfaces will use local time except SNTP time synchronization and IEC 61850 timestamps. Flexible - A local time zone adjustment can be defined using the LocalTime offset setting and each interface can be assigned to the UTC zone or local time zone with the exception of the local interfaces which will always be in the local time zone and IEC 61850/SNTP which will always be in the UTC zone.				
LocalTime Offset	8	21	0	-720 to 720 step 15
Setting to specify an offset of -12 to +12 hrs in 15 minute intervals for local time zone. This adjustment is applied to the time based on the master clock which is UTC/GMT				
DST Enable	8	22	Enabled	0 = Disabled or 1 = Enabled
Setting to turn on/off daylight saving time adjustment to local time.				
DST Offset	8	23	60	30 to 60 step 30
Setting to specify daylight saving offset which will be used for the time adjustment to local time.				
DST Start	8	24	Last	0 = First, 1 = Second, 2 = Third, 3 = Fourth or 4 = Last
Setting to specify the week of the month in which daylight saving time adjustment starts				
DST Start Day	8	25	Sunday	0 = Sunday, 1 = Monday, 2 = Tuesday, 3 = Wednesday, 4 = Thursday, 5 = Friday or 6 = Saturday
Setting to specify the day of the week in which daylight saving time adjustment starts				
DST Start Month	8	26	March	0 = January, 1 = February, 2 = March, 3 = April, 4 = May, 5 = June, 6 = July, 7 = August, 8 = September, 9 = October, 10 = November or 11 = December
Setting to specify the month in which daylight saving time adjustment starts				
DST Start Mins	8	27	60	0 to 1425 step 15
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	8	28	Last	0 = First, 1 = Second, 2 = Third, 3 = Fourth or 4 = Last
Setting to specify the week of the month in which daylight saving time adjustment ends				
DST End Day	8	29	Sunday	0 = Sunday, 1 = Monday, 2 = Tuesday, 3 = Wednesday, 4 = Thursday, 5 = Friday or 6 = Saturday
Setting to specify the day of the week in which daylight saving time adjustment ends				
DST End Month	8	2A	October	0 = January, 1 = February, 2 = March, 3 = April, 4 = May, 5 = June, 6 = July, 7 = August, 8 = September, 9 = October, 10 = November or 11 = December
Setting to specify the month in which daylight saving time adjustment ends				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
DST End Mins	8	2B	60	0 to 1425 step 15
Setting to specify the time of day in which daylight saving time adjustment ends. This is set relative to 00:00 hrs on the selected day when time adjustment is to end				
RP1 Time Zone	8	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	8	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	8	32	UTC	0 = UTC or 1 = Local
DNP3.0 over Ethernet versions only. Setting to specify if time synchronisation received will be local or universal time co-ordinated.				
Tunnel Time Zone	8	33	UTC	0 = UTC or 1 = Local
Ethernet versions only for tunnelled courier. Setting to specify if time synchronization received will be local or universal time co-ordinated				

Table 11: DATE AND TIME column

3.9 Configuration

The settings in this column are mainly concerned with switching on or off the protection functions. If a protection function is enabled, the settings associated with this function will appear in the HMI panel menu. If it is disabled, the settings associated with that function are not shown in the HMI panel menu.

The CONFIGURATION column is also used to enabling, disabling and activating Protection Setting Groups and controlling the visibility/invisibility of columns such as Control Inputs in order to simplify the menu.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
CONFIGURATION	9	0	0	
This column contains all the general configuration options				
Restore Defaults	9	1	No Operation	0 = No Operation, 1 = All Settings, 2 = Setting Group 1, 3 = Setting Group 2, 4 = Setting Group 3, 5 = Setting Group 4
Setting to restore a setting group to factory default settings. To restore the default values to the settings in any Group settings, set the ‘restore defaults’ cell to the relevant Group number. Alternatively it is possible to set the ‘restore defaults’ cell to ‘all settings’ to restore the default values to all of the IED’s settings, not just the Group settings. The default settings will initially be placed in the scratchpad and will only be used by the IED after they have been confirmed by the user. Note: Restoring defaults to all settings includes the rear communication port settings, which may result in communication via the rear port being disrupted if the new (default) settings do not match those of the master station.				
Setting Group	9	2	Select via Menu	0 = Select via Menu or 1 = Select via PSL
Allows setting group changes to be initiated via Opto Input or via Menu				
Active Settings	9	3	Group 1	0 = Group 1, 1 = Group 2, 2 = Group 3, 3 = Group 4
Selects the active setting group.				
Save Changes	9	4	No Operation	0 = No Operation, 1 = Save, 2 = Abort
Saves all IED settings.				
Copy From	9	5	Group 1	0 = Group 1, 1 = Group 2, 2 = Group 3, 3 = Group 4
Allows displayed settings to be copied from a selected setting group				
Copy To	9	6	No Operation	0 = No Operation, 1 = Group 1, 2 = Group 2, 3 = Group 3
Allows displayed settings to be copied to a selected setting group				
Setting Group 1	9	7	Enabled	0 = Disabled or 1 = Enabled

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Settings Group 1. If the setting group is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this setting.				
Setting Group 2	9	8	Disabled	0 = Disabled or 1 = Enabled
Settings Group 2. If the setting group is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this setting.				
Setting Group 3	9	9	Disabled	0 = Disabled or 1 = Enabled
Settings Group 3. If the setting group is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this setting.				
Setting Group 4	9	0A	Disabled	0 = Disabled or 1 = Enabled
Settings Group 4. If the setting group is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this setting.				
Distance	9	0B	Enabled	0 = Disabled or 1 = Enabled
Only in models with Distance option. To enable (activate) or disable (turn off) the Distance Protection: ANSI 21/21N.				
Operation Mode	9	0D	Single Phase	0 = Single Phase or 1 = Autotransformer
To select the operation mode between Autotransformer enable (activate) or Single Phase enable (turn off).				
Defrost Prot	9	0E	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Defrost Protection.				
Overcurrent	9	10	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Phase Overcurrent Protection function. I> stages: ANSI 50/51/67				
Panto Flash Over	9	11	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Panto Flash Over Protection function.				
High Z Delta I	9	14	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the High Impedance Delta I function				
Thermal Overload	9	17	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Thermal Overload Protection function. ANSI 49.				
Volt Protection	9	1D	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Voltage Protection (under/overvoltage/remote) function. V<, V>, Cp V> stages: ANSI 27/59/59R.				
CB Fail	9	20	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Circuit Breaker Fail Protection function: ANSI 50BF.				
Supervision	9	21	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Supervision (VTS) functions: ANSI 47/27/46.				
System Checks	9	23	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the System Checks (Check Sync. and Voltage Monitor) function: ANSI 25.				
Auto-Reclose	9	24	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the Auto-reclose function. ANSI 79.				
Input Labels	9	25	Visible	0 = Invisible or 1 = Visible
Sets the Input Labels menu visible further on in the IED settings menu.				
Output Labels	9	26	Visible	0 = Invisible or 1 = Visible
Sets the Output Labels menu visible further on in the IED settings menu.				
CT & VT Ratios	9	28	Visible	0 = Invisible or 1 = Visible
Sets the Current & Voltage Transformer Ratios menu visible further on in the IED settings menu.				
Record Control	9	29	Visible	0 = Invisible or 1 = Visible
Sets the Record Control menu visible further on in the IED settings menu.				
Disturb Recorder	9	2A	Visible	0 = Invisible or 1 = Visible
Sets the Disturbance Recorder menu visible further on in the IED settings menu.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Measure't Setup	9	2B	Visible	0 = Invisible or 1 = Visible
Sets the Measurement Setup menu visible further on in the IED settings menu.				
Comms Settings	9	2C	Visible	0 = Invisible or 1 = Visible
Sets the Communications Settings menu visible further on in the IED settings menu. These are the settings associated with the 1st and 2nd rear communications ports				
Commission Tests	9	2D	Visible	0 = Invisible or 1 = Visible
Sets the Commissioning Tests menu visible further on in the IED settings menu.				
Setting Values	9	2E	Primary	0 = Primary or 1 = Secondary
This affects all protection settings that are dependent upon CT and VT ratios. All subsequent settings input must be based in terms of this reference.				
Control Inputs	9	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	9	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	9	36	Visible	0 = Invisible or 1 = Visible
Sets the Control Input Labels menu visible further on in the IED setting menu.				
Direct Access	9	39	Enabled	0= Disabled, 1 = Enabled, 2 = Hotkey only, or 3 = CB Ctrl Only
Defines what CB control direct access is allowed. The front direct access keys that are used as a short cut function of the menu may be: Disabled – No function visible on the LCD. Enabled – All control functions mapped to the Hotkeys and Control Trip/Close are available. Hotkey Only – Only control functions mapped to the Hotkeys are available on the LCD. CB Ctrl Only – Only Control Trip/Control Close command will appear on the IED’s LCD.				
InterMiCOM	9	40	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) EIA (RS) 232 InterMiCOM (integrated teleprotection).				
InterMiCOM 64	9	41	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) InterMiCOM64 (integrated 56/64kbit/s teleprotection).				
Function Key	9	50	Visible	0 = Invisible or 1 = Visible
Sets the Function Key menu visible further on in the IED setting menu.				
RP1 Read Only	9	FB	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) Read Only Mode of Rear Port 1.				
RP2 Read Only	9	FC	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) Read Only Mode of Rear Port 2.				
NIC Read Only	9	FD	Disabled	0 = Disabled or 1 = Enabled
Ethernet versions only. To enable (activate) or disable (turn off) Read Only Mode of Network Interface Card.				
LCD Contrast	9	FF	11	0 to 31 step 1
Sets the LCD contrast.				

Table 12: CONFIGURATION column

> *Note:* *When you select 'restore defaults to all settings', this includes the rear communication port settings. This will result disrupt communication via the rear port if the new (default) settings do not match those of the master station.*

3.10 CT and VT Ratios

The CT AND VT RATIOS column contains the settings for defining the main system current and voltage transformers, such as the primary and secondary voltage and current ratings.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
CT AND VT RATIOS	0A	0	0	
This column contains settings for Current and Voltage Transformer ratios				
Main VT Primary	0A	1	110	100 V to 1 MV step 1 V
Sets the main voltage transformer input primary voltage.				
Main VT Sec'y	0A	2	110	80 V to 140 V step 1 V
Sets the main voltage transformer input secondary voltage.				
CS VT Primary	0A	3	110	100 V to 1 MV step 1 V
Sets the System Check Synchronism voltage transformer input primary voltage.				
CS VT Secondary	0A	4	110	80 V to 140 V step 1 V
Sets the System Check Synchronism voltage transformer input secondary voltage.				
Phase CT Primary	0A	7	1	1A to 30kA step 1A
Sets the phase current transformer input primary current rating.				
Phase CT Sec'y	0A	8	1	1A or 5A
Sets the phase current transformer input secondary current rating.				
Def CT Primary	0A	9	1	1A to 30kA step 1A
Sets the defrost current transformer input primary current rating.				
Def CT Sec'y	0A	0A	1	1A or 5A
Sets the defrost current transformer input secondary current rating.				
CS Input	0A	0F	CAT	0 = CAT, 1 = FDR, 2 = CAT+FDR,
Selects the System Check Synchronism Input voltage measurement.				
Main VT Location	0A	10	Line	0 = Line or 1 = Bus
Selects the main voltage transformer location.				
CT Polarity	0A	11	Standard	0 = Standard or 1 = Inverted
To invert polarity (180 °) of the CT				
Def CT Polarity	0A	12	Standard	0 = Standard or 1 = Inverted
To invert polarity (180 °) of the DEF CT				

Table 13: CT AND VT RATIOS column

3.11 Record Control

The RECORD CONTROL column contains settings that enable or disable the recording of events and faults. You can also allow or disallow individual Digital Data Bus signals (DDB lines) from being included as a recorded event.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
RECORD CONTROL	0B	0	0	
This column contains settings for Record Controls				
Alarm Event	0B	4	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event is generated for alarms				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Relay O/P Event	0B	5	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any change in logic output state.				
Opto Input Event	0B	6	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any change in logic input state.				
General Event	0B	7	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no General Events are generated				
Fault Rec Event	0B	8	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any fault that produces a fault record				
Maint Rec Event	0B	9	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any occurrence that produces a maintenance record.				
Protection Event	0B	0A	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that any operation of protection elements will not be logged as an event				
DDB 31 - 0	0B	40	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 63 - 32	0B	41	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 95 - 64	0B	42	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 127 - 96	0B	43	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 159 - 128	0B	44	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 191 - 160	0B	45	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 223 - 192	0B	46	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 255 - 224	0B	47	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 287 - 256	0B	48	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
DDB 319 - 288	0B	49	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 351 - 320	0B	4A	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 383 - 352	0B	4B	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 415 - 384	0B	4C	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 447 - 416	0B	4D	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 479 - 448	0B	4E	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 511 - 480	0B	4F	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 543 - 512	0B	50	0xFFFFC7FF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 575 - 544	0B	51	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 607 - 576	0B	52	0xFFFFFBBF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 639 - 608	0B	53	0xFFEF7BDE	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 671 - 640	0B	54	0xF7777FFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 703 - 672	0B	55	0xFF7777FF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 735 - 704	0B	56	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 767 - 736	0B	57	0xDC00001D	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 799 - 768	0B	58	0xEEEFFFDD	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 831 - 800	0B	59	0xFFFFFFFE	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 863 - 832	0B	5A	0xFFDFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 895 - 864	0B	5B	0xF7FFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 927 - 896	0B	5C	0xFF8787FF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 959 - 928	0B	5D	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 991 - 960	0B	5E	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1023 - 992	0B	5F	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1055 - 1024	0B	60	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1087 - 1056	0B	61	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
DDB 1119 - 1088	0B	62	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1151 - 1120	0B	63	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1183 - 1152	0B	64	0x00FFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1215 - 1184	0B	65	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1247 - 1216	0B	66	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1279 - 1248	0B	67	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1311 - 1280	0B	68	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1343 - 1312	0B	69	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1375 - 1344	0B	6A	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1407 - 1376	0B	6B	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1439 - 1408	0B	6C	0xD3FFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1471 - 1440	0B	6D	0xFFFFF9F3	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1503 - 1472	0B	6E	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1535 - 1504	0B	6F	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1567 - 1536	0B	70	0x990CF27F	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1599 - 1568	0B	71	0xFFFFFFFA	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1631 - 1600	0B	72	0xFFFFFFF1	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1663 - 1632	0B	73	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1695 - 1664	0B	74	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1727 - 1696	0B	75	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1759 - 1728	0B	76	0x00000000	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1760 - 1791	0B	77	0x00000000	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1792 - 1823	0B	78	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1824 - 1855	0B	79	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1856 - 1887	0B	7A	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
DDB 1888 - 1919	0B	7B	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1920 - 1951	0B	7C	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1952 - 1983	0B	7D	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1984 - 2015	0B	7E	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 2016 - 2047	0B	7F	0xFFFFFFFF	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Table 14: RECORD CONTROL column

3.12 Disturbance Recorder Settings (Oscillography)

The DISTURB RECORDER column is used to set the parameters for the Disturbance Recorder, including the record duration and trigger position, selection of analogue and digital signals to record, and the signal sources that trigger the recording.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
DISTURB RECORDER	0C	0	0	
This column contains settings for the Disturbance Recorder				
Duration	0C	1	1.5	0.1s to 10.5s step 0.01s
This sets the overall recording time.				
Trigger Position	0C	2	33.3	0 to 100 step 0.1
This sets the trigger point as a percentage of the duration. For example, the default settings show that the overall recording time is set to 1.5 s with the trigger point being at 33.3% of this, giving 0.5 s pre-fault and 1s post fault recording times.				
Trigger Mode	0C	3	Single	0 = Single or 1 = Extended
If set to single mode, if a further trigger occurs whilst a recording is taking place, the recorder will ignore the trigger. However, if this has been set to Extended, the post trigger timer will be reset to zero, thereby extending the recording time.				
Analog Channel 1	0C	4	Vcat	0=Icat, 1=Ifdr, 2=Idef, 3=Vcat, 4=Vfdr, 5=V Checksync, 6=Max Ih(2), 7=Unused
Selects any available analogue input to be assigned to this channel.				
Analog Channel 2	0C	5	Unused	0=Icat, 1=Ifdr, 2=Idef, 3=Vcat, 4=Vfdr, 5=V Checksync, 6=Max Ih(2), 7=Unused
Selects any available analogue input to be assigned to this channel.				
Analog Channel 3	0C	6	VChecksync	0=Icat, 1=Ifdr, 2=Idef, 3=Vcat, 4=Vfdr, 5=V Checksync, 6=Max Ih(2), 7=Unused
Selects any available analogue input to be assigned to this channel.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Analog Channel 4	0C	7	Icat	0=Icat, 1=Ifdr, 2=Idef, 3=Vcat, 4=Vfdr, 5=V Checksync, 6=Max Ih(2), 7=Unused
Selects any available analogue input to be assigned to this channel.				
Analog Channel 5	0C	8	Unused	0=Icat, 1=Ifdr, 2=Idef, 3=Vcat, 4=Vfdr, 5=V Checksync, 6=Max Ih(2), 7=Unused
Selects any available analogue input to be assigned to this channel.				
Analog Channel 6	0C	9	Idef	0=Icat, 1=Ifdr, 2=Idef, 3=Vcat, 4=Vfdr, 5=V Checksync, 6=Max Ih(2), 7=Unused
Selects any available analogue input to be assigned to this channel.				
Analog Channel 7	0C	0A	Max Ih(2)	0=Icat, 1=Ifdr, 2=Idef, 3=Vcat, 4=Vfdr, 5=V Checksync, 6=Max Ih(2), 7=Unused
Selects any available analogue input to be assigned to this channel.				
Analog Channel 8	0C	0B	Unused	0=Icat, 1=Ifdr, 2=Idef, 3=Vcat, 4=Vfdr, 5=V Checksync, 6=Max Ih(2), 7=Unused
Selects any available analogue input to be assigned to this channel.				
Digital Input 1	0C	0C	Relay 1	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 1 Trigger	0C	0D	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 2	0C	0E	Relay 2	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 2 Trigger	0C	0F	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 3	0C	10	Relay 3	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 3 Trigger	0C	11	Trigger L/H	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 4	0C	12	Relay 4	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 4 Trigger	0C	13	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 5	0C	14	Relay 5	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 5 Trigger	0C	15	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 6	0C	16	Relay 6	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 6 Trigger	0C	17	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 7	0C	18	Relay 7	See Data Types - G32

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 7 Trigger	0C	19	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 8	0C	1A	Relay 8	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 8 Trigger	0C	1B	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 9	0C	1C	Relay 9	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 9 Trigger	0C	1D	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 10	0C	1E	Relay 10	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 10 Trigger	0C	1F	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 11	0C	20	Relay 11	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 11 Trigger	0C	21	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 12	0C	22	Relay 12	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 12 Trigger	0C	23	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 13	0C	24	Relay 13	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 13 Trigger	0C	25	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 14	0C	26	Relay 14	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 14 Trigger	0C	27	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 15	0C	28	Opto Input 1	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 15 Trigger	0C	29	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 16	0C	2A	Opto Input 2	See Data Types - G32

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 16 Trigger	0C	2B	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 17	0C	2C	Opto Input 3	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 17 Trigger	0C	2D	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 18	0C	2E	Opto Input 4	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 18 Trigger	0C	2F	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 19	0C	30	Opto Input 5	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 19 Trigger	0C	31	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 20	0C	32	Opto Input 6	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 20 Trigger	0C	33	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 21	0C	34	Opto Input 7	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 21 Trigger	0C	35	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 22	0C	36	Opto Input 8	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 22 Trigger	0C	37	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 23	0C	38	Opto Input 9	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 23 Trigger	0C	39	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 24	0C	3A	Opto Input 10	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 24 Trigger	0C	3B	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 25	0C	3C	Opto Input 11	See Data Types - G32

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 25 Trigger	0C	3D	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 26	0C	3E	Opto Input 12	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 26 Trigger	0C	3F	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 27	0C	40	Opto Input 13	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 27 Trigger	0C	41	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 28	0C	42	Opto Input 14	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 28 Trigger	0C	43	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 29	0C	44	Opto Input 15	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 29 Trigger	0C	45	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 30	0C	46	Opto Input 16	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 30 Trigger	0C	47	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 31	0C	48	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 31 Trigger	0C	49	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 32	0C	4A	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Input 32 Trigger	0C	4B	No Trigger	0 = No Trigger, 1 = Trigger L/H, 2 = Trigger H/L
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				
Digital Input 33	0C	70	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 34	0C	71	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 35	0C	72	Not Used	See Data Types - G32

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 36	0C	73	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 37	0C	74	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 38	0C	75	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 39	0C	76	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 40	0C	77	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 41	0C	78	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 42	0C	79	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 43	0C	7A	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 44	0C	7B	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 45	0C	7C	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 46	0C	7D	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 47	0C	7E	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 48	0C	7F	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 49	0C	80	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 50	0C	81	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 51	0C	82	Not Used	See Data Types - G32

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 52	0C	83	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 53	0C	84	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 54	0C	85	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 55	0C	86	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 56	0C	87	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 57	0C	88	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 58	0C	89	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 59	0C	8A	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 60	0C	8B	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 61	0C	8C	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 62	0C	8D	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 63	0C	8E	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				
Digital Input 64	0C	8F	Not Used	See Data Types - G32
The digital channels may monitor any of the opto isolated inputs or output contacts, in addition to a number of internal IED digital signals, such as protection starts, LEDs etc.				

Table 15: DISTURB RECORDER column

3.13 Measurement Setup

The MEASURE'T SETUP column allows you to set up the way quantities are measured displayed. For example, whether they are displayed as primary or secondary quantities, how monitoring periods are defined and how distance units are selected.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
MEASURE'T SETUP	0D	0	0	
This column contains settings for the measurement setup				
Default Display	0D	1	Description	0 = User Banner, 1 = Vcat, Vfdr, Icat, and Ifdr, 2 = Power, 3 = Date and Time, 4 = Description, 5 = Plant Reference, 6 = Frequency, 7 = Access Level
This setting can be used to select the default display from a range of options, note that it is also possible to view the other default displays whilst at the default level using the left and right cursor keys. However once the 15 minute timeout elapses the default display will revert to that selected by this setting.				
Local Values	0D	2	Primary	0 = Primary or 1 = Secondary
This setting controls whether measured values via the front panel user interface and the front courier port are displayed as primary or secondary quantities.				
Remote Values	0D	3	Primary	0 = Primary or 1 = Secondary
This setting controls whether measured values via the rear communication port are displayed as primary or secondary quantities.				
Measurement Ref	0D	4	Vcat	0 = Vcat, 1 = Vfdr, 2 = Icat, 3 = Ifdr
Using this setting the phase reference for all angular measurements by the IED can be selected. This reference is for Measurements 1. Measurements 3 uses always Icat local as a reference.				
Measurement Mode	0D	5	0	0 to 3 step 1
This setting is used to control the signing of the real and reactive power quantities.				
Fix Dem Period	0D	6	30	1 to 99 step 1
This setting defines the length of the fixed demand window				
Roll Sub Period	0D	7	30	1 to 99 step 1
These two settings are used to set the length of the window used for the calculation of rolling demand quantities				
Num Sub Periods	0D	8	1	1 to 15 step 1
This setting is used to set the resolution of the rolling sub window				
Distance Unit	0D	9	Miles	0 = Kilometres or 1 = Miles
This setting is used to select the unit of distance for fault location purposes, note that the length of the line is preserved when converting from km to miles and vice versa				
Fault Location	0D	0A	Distance	0 = Distance, 1 = Ohms, 2 = % of Line
The calculated fault location can be displayed using one of several options selected using this setting				
Remote 2 Values	0D	0B	Primary	0 = Primary or 1 = Secondary
The setting defines whether the values measured via the Second Rear Communication port are displayed in primary or secondary terms.				

Table 16: MEASURE'T SETUP column

3.14 Communications Settings

The settings in the COMMUNICATIONS column are used to set the serial communication parameters for the rear serial port(s). It cannot be used to set Ethernet parameters, although some Ethernet-related information, such as the NIC MAC and IP addresses are displayed.

Further details are given in the Communications chapter.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
COMMUNICATIONS	0E	0	0	
This column contains general communications settings				
RP1 Protocol	0E	1	0	0 = Courier, 1 = IEC870-5-103, 3 = DNP3.0
Indicates the communications protocol that will be used on the rear communications port.				
RP1 Address	0E	2	255	0 to 255 step 1
Courier or IEC60870-5-103 versions only. Sets the address of Rear Port 1				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
RP1 Address	0E	2	1	0 to 65519 step 1
DNP3.0 versions only. Sets the address of Rear Port 1				
RP1 InactivTimer	0E	3	15	1 to 30 step 1
Defines the period of inactivity before IED reverts to its default state				
RP1 Baud Rate	0E	4	19200 bits/s	0 = 9600 bits/s or 1 = 19200 bits/s
IEC60870-5-103 versions only. This cell controls the communication speed between IED and master station. It is important that both IED and master station are set at the same speed setting.				
RP1 Baud Rate	0E	4	19200 bits/s	0 = 1200 bits/s, 1 = 2400 bits/s, 2 = 4800 bits/s, 3 = 9600 bits/s, 4 = 19200 bits/s, 5 = 38400 bits/s
DNP3.0 versions only. This cell controls the communication speed between IED and master station. It is important that both IED and master station are set at the same speed setting.				
RP1 Parity	0E	5	None	0 = Odd, 1 = Even, 2 = None
DNP3.0 versions only. This cell controls the parity format used in the data frames. It is important that both IED and master station are set with the same parity setting.				
RP1 Meas Period	0E	6	10	1s to 60s step 1s
IEC60870-5-103 versions only. This cell controls the time interval that the IED will use between sending measurement data to the master station.				
RP1 PhysicalLink	0E	7	Copper	0 = Copper or 1 = Fibre Optic
This cell defines whether an electrical EIA(RS) 485 or fiber optic connection is being used for communication between the master station and IED. This cell is only visible if a fibre optic board is fitted.				
RP1 Time Sync	0E	8	Disabled	0 = Disabled or 1 = Enabled
DNP3.0 versions only. If set to Enabled the master station can be used to synchronize the time on the IED. If set to Disabled either the internal free running clock or IRIG-B input are used.				
RP1 CS103Blocking	0E	0A	Disabled	0 = Disabled, 1 = Monitor Blocking or 2 = Command Blocking
IEC60870-5-103 versions only. There are three settings associated with this cell: Disabled - No blocking selected. Monitor Blocking - When the monitor blocking DDB Signal is active high, either by energizing an opto input or control input, reading of the status information and disturbance records is not permitted. When in this mode the IED returns a “termination of general interrogation” message to the master station. Command Blocking - When the command blocking DDB signal is active high, either by energizing an opto input or control input, all remote commands will be ignored (i.e. CB Trip/Close, change setting group etc.). When in this mode the IED returns a “negative acknowledgement of command” message to the master station.				
RP1 Card Status	0E	0B	0	0 = K Bus OK, 1 = EIA485 OK or 2 = Fibre Optic OK
Displays the status of the card in RP1				
RP1 Port Config	0E	0C	K Bus	0 = K Bus or 1 = EIA485 (RS485)
Courier versions only. This cell defines whether an electrical KBus or EIA(RS)485 is being used for communication between the master station and IED.				
RP1 Comms Mode	0E	0D	IEC60870 FT1.2	0 = IEC60870 FT1.2 Frame or 1 = 10-bit no parity
Courier versions only. The choice is either IEC 60870 FT1.2 for normal operation with 11-bit modems, or 10-bit no parity.				
RP1 Baud Rate	0E	0E	19200 bits/s	0 = 9600 bits/s, 1 = 19200 bits/s, 2 = 38400 bits/s
Courier versions only. This cell controls the communication speed between IED and master station. It is important that both IED and master station are set at the same speed setting.				
Meas Scaling	0E	0F	Normalised	0 = Normalised, 1 = Primary, 2 = Secondary
DNP 3.0 versions only. Setting to report analogue values in terms of primary, secondary or normalized (with respect to the CT/VT ratio setting) values.				
Message Gap	0E	10	0	0 to 50 step 1
DNP 3.0 versions only. This setting allows the master station to have an interframe gap.				
DNP Need Time	0E	11	10	1 to 30 step 1
DNP 3.0 versions only. The duration of time waited before requesting another time sync from the master.				
DNP App Fragment	0E	12	2048	100 to 2048 step 1

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
DNP 3.0 versions only. The maximum message length (application fragment size) transmitted by the IED.				
DNP App Timeout	0E	13	2	1s to 120s step 1s
DNP 3.0 versions only. Duration of time waited, after sending a message fragment and awaiting a confirmation from the master.				
DNP SBO Timeout	0E	14	10	1s to 10s step 1s
DNP 3.0 versions only. Duration of time waited, after receiving a select command and awaiting an operate confirmation from the master.				
DNP Link Timeout	0E	15	0	0s to 120s step 1s
DNP 3.0 versions only. Duration of time that the IED will wait for a Data Link Confirm from the master. A value of 0 means data link support disabled and 1 to 120 seconds is the timeout setting.				
NIC Protocol	0E	1F	IEC61850	IEC61850 or DNP3.0
IEC61850 versions only. Indicates that IEC 61850 will be used on the rear Ethernet port.				
NIC Mac Address	0E	22	0	
IEC61850 versions only. Indicates the MAC address of the rear Ethernet port.				
NIC Tunl Timeout	0E	64	5	1 to 30 step 1
IEC61850 versions only. Duration of time waited before an inactive tunnel to MiCOM S1 Studio is reset.				
NIC Link Report	0E	6A	Alarm	0 = Alarm, 1 = Event, 2 = None
IEC61850 versions only. Configures how a failed/unfitted network link (copper or fiber) is reported: Alarm - an alarm is raised for a failed link Event - an event is logged for a failed link None - nothing reported for a failed link				
REAR PORT2 (RP2)	0E	80	0	
RP2 versions only.				
RP2 Protocol	0E	81	Courier	0
RP2 versions only. Indicates the communications protocol that will be used on the rear communications port.				
RP2 Card Status	0E	84	0	0 = Unsupported, 1 = Card Not Fitted, 2 = EIA232 OK, 3 = EIA485 OK, 4 = K Bus OK
RP2 versions only. Displays the status of the card in RP2				
RP2 Port Config	0E	88	EIA232 (RS232)	0 = EIA232 (RS232), 1 = EIA485 (RS485), 2 = K-Bus
RP2 versions only. This cell defines whether an electrical EIA(RS)232, EIA(RS)485 or KBus is being used for communication.				
RP2 Comms Mode	0E	8A	IEC60870 FT1.2	0 = IEC60870 FT1.2 Frame or 1 = 10-bit no parity
RP2 versions only. The choice is either IEC 60870 FT1.2 for normal operation with 11-bit modems, or 10-bit no parity.				
RP2 Address	0E	90	255	0 to 255 step 1
RP2 versions only. This cell sets the unique address for the IED such that only one IED is accessed by master station software.				
RP2 InactivTimer	0E	92	15	1 to 30 step 1
RP2 versions only. This cell controls how long the IED will wait without receiving any messages on the rear port before it reverts to its default state, including resetting any password access that was enabled.				
RP2 Baud Rate	0E	94	19200 bits/s	0 = 9600 bits/s, 1 = 19200 bits/s, 2 = 38400 bits/s
RP2 versions only. This cell controls the communication speed between IED and master station. It is important that both IED and master station are set at the same speed setting.				
NIC Protocol	0E	A0	DNP 3.0	IEC61850 or DNP3.0
DNP 3.0 over Ethernet versions only. Indicates that DNP 3.0 will be used on the rear Ethernet port.				
IP Address	0E	A1	0.0.0.0	

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
DNP 3.0 over Ethernet versions only. Indicates the IP address of the IED				
Subnet Mask	0E	A2	0.0.0.0	
DNP 3.0 over Ethernet versions only. Indicates the Subnet address				
NIC MAC Address	0E	A3	Ethernet MAC Address	
DNP 3.0 over Ethernet versions only. Indicates the MAC address of the rear Ethernet port.				
Gateway	0E	A4	0.0.0.0	
DNP 3.0 over Ethernet versions only. Indicates the Gateway address				
DNP Time Sync	0E	A5	Disabled	0 = Disabled or 1 = Enabled
DNP 3.0 over Ethernet versions only. If set to ‘Enabled’ the DNP3.0 master station can be used to synchronize the time on the IED. If set to ‘Disabled’ either the internal free running clock, or IRIG-B input are used.				
Meas Scaling	0E	A6	Primary	0 = Normalised, 1 = Primary, 2 = Secondary
DNP 3.0 over Ethernet versions only. Setting to report analogue values in terms of primary, secondary or normalized (with respect to the CT/VT ratio setting) values.				
NIC Tunl Timeout	0E	A7	5	1 to 30 step 1
DNP 3.0 over Ethernet versions only. Duration of time waited before an inactive tunnel to MiCOM S1 Studio is reset.				
NIC Link Report	0E	A8	Alarm	0 = Alarm, 1 = Event, 2 = None
DNP 3.0 over Ethernet versions only. Configures how a failed/unfitted network link (copper or fiber) is reported: Alarm - an alarm is raised for a failed link Event - an event is logged for a failed link None - nothing reported for a failed link				
SNTP PARAMETERS	0E	AA	0	
DNP 3.0 over Ethernet versions only				
SNTP Server 1	0E	AB	0.0.0.0	
DNP 3.0 over Ethernet versions only. Indicates the SNTP Server 1 address.				
SNTP Server 2	0E	AC	0.0.0.0	
DNP 3.0 over Ethernet versions only. Indicates the SNTP Server 2 address.				
SNTP Poll Rate	0E	AD	64	
DNP 3.0 over Ethernet versions only. Duration of SNTP poll rate in seconds.				
DNP Need Time	0E	B1	10	1 to 30 step 1
DNP 3.0 versions only. The duration of time waited before requesting another time sync from the master.				
DNP App Fragment	0E	B2	2048	100 to 2048 step 1
DNP 3.0 versions only. The maximum message length (application fragment size) transmitted by the IED.				
DNP App Timeout	0E	B3	2	1s to 120s step 1s
DNP 3.0 versions only. Duration of time waited, after sending a message fragment and awaiting a confirmation from the master.				
DNP SBO Timeout	0E	B4	10	1s to 10s step 1s
DNP 3.0 versions only. Duration of time waited, after receiving a select command and awaiting an operate confirmation from the master.				

Table 17: COMMUNICATIONS column

3.15 Commissioning Tests

The COMMISSION TESTS column contains cells that allow the status of the opto-isolated inputs, output relay contacts, internal digital data bus (DDB) signals and user-programmable LEDs to be monitored. Additionally there are settings to test the operation of the output contacts, user-programmable LEDs and, where available, the auto-reclose cycles.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
COMMISSION TESTS	0F	0	0	
This column contains commissioning test settings				
Opto I/P Status	0F	1	0	
This menu cell displays the status of the available IED's opto-isolated inputs as a binary string, a '1' indicating an energized opto-isolated input and a '0' a de-energized one.				
Relay O/P Status	0F	2	0	
This menu cell displays the status of the digital data bus (DDB) signals that result in energization of the available output relays as a binary string, a '1' indicating an operated state and '0' a non-operated state. When the 'Test Mode' cell is set to 'Enabled' the 'Relay O/P Status' cell does not show the current status of the output relays and hence can not be used to confirm operation of the output relays. Therefore it will be necessary to monitor the state of each contact in turn.				
Test Port Status	0F	3	0	
This menu cell displays the status of the eight digital data bus (DDB) signals that have been allocated in the 'Monitor Bit' cells.				
Monitor Bit 1	0F	5	1060	0 to 2047 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 2	0F	6	1062	0 to 2047 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 3	0F	7	1064	0 to 2047 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 4	0F	8	1066	0 to 2047 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 5	0F	9	1068	0 to 2047 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 6	0F	0A	1070	0 to 2047 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 7	0F	0B	1072	0 to 2047 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 8	0F	0C	1074	0 to 2047 step 1
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Test Mode	0F	0D	Disabled	0 = Disabled, 1 = Test Mode, 2 = Contacts Blocked
The Test Mode menu cell is used to allow secondary injection testing to be performed on the IED without operation of the trip contacts. It also enables a facility to directly test the output contacts by applying menu controlled test signals. To select test mode the Test Mode menu cell should be set to 'Test Mode', which takes the IED out of service . It also causes an alarm condition to be recorded and the yellow 'Out of Service' LED to illuminate and an alarm message 'Prot'n. Disabled' is given. In IEC 60870-5-103 builds changes the Cause of Transmission, COT, to Test Mode. To enable testing of output contacts the Test Mode cell should be set to Contacts Blocked. This blocks the protection from operating the contacts and enables the test pattern and contact test functions which can be used to manually operate the output contacts. This mode also blocks maintenance, counters and freezes any information stored in the Circuit Breaker Condition column. Also in IEC 60870-5-103 builds changes the Cause of Transmission, COT, to Test Mode. Once testing is complete the cell must be set back to 'Disabled' to restore the IED back to service.				
Test Pattern	0F	0E	0x0	0=Not Operated or 1=Operated
This cell is used to select the output relay contacts that will be tested when the 'Contact Test' cell is set to 'Apply Test'.				
Contact Test	0F	0F	No Operation	0 = No Operation, 1 = Apply Test, 2 = Remove Test

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
When the 'Apply Test' command in this cell is issued the contacts set for operation (set to '1') in the 'Test Pattern' cell change state. After the test has been applied the command text on the LCD will change to 'No Operation' and the contacts will remain in the Test State until reset issuing the 'Remove Test' command. The command text on the LCD will again revert to 'No Operation' after the 'Remove Test' command has been issued. Note: When the 'Test Mode' cell is set to 'Enabled' the 'Relay O/P Status' cell does not show the current status of the output relays and hence can not be used to confirm operation of the output relays. Therefore it will be necessary to monitor the state of each contact in turn.				
Test LEDs	0F	10	No Operation	0 = No Operation or 1 = Apply Test
When the 'Apply Test' command in this cell is issued, the eighteen user-programmable LEDs will illuminate for approximately 2 seconds before they extinguish and the command text on the LCD reverts to 'No Operation'.				
Test Autoreclose	0F	11	No Operation	0 = No Operation, 1 = Trip 3 Pole, 2 = Trip Pole A, 3 = Trip Pole B, 4 = Trip Pole C
This is a command used to simulate a single or three pole tripping in order to test Auto-reclose cycle.				
Static Test Mode	0F	12	Disabled	0 = Disabled or 1 = Enabled
When Static test is Enabled, delta phase selectors and the delta directional line are bypassed to allow the user to test the IED with older injection test sets that are incapable of simulating real dynamic step changes in current and voltage. Resulting trip times will be slower, as extra filtering of distance comparators is also switched-in.				
Loopback Mode	0F	13	Disabled	0 = Disabled, 1 = External, 2 = Internal
Setting that allows communication loopback testing.				
IM64 TestPattern	0F	14	0	0 to 16 step 1
This cell is used to set the DDB signals included in the User Defined Inter-IED Commands IM64 when the 'IM64 Test Mode' cell is set to 'Enable'.				
IM64 Test Mode	0F	15	Disabled	0 = Disabled or 1 = Enabled
When the Enable command in this cell is issued the DDB set for operation (set to '1') in the 'Test Pattern' cell change state.				
Red LED Status	0F	1A	0	
This cell is an eighteen bit binary string that indicates which of the user-programmable LEDs on the IED are illuminated with the Red LED input active when accessing the IED from a remote location, a '1' indicating a particular LED is lit and a '0' not lit.				
Green LED Status	0F	1B	0	
This cell is an eighteen bit binary string that indicates which of the user-programmable LEDs on the IED are illuminated with the Green LED input active when accessing the IED from a remote location, a '1' indicating a particular LED is lit and a '0' not lit.				
DDB 31 - 0	0F	20	0	
Displays the status of DDB signals				
DDB 63 - 32	0F	21	0	
Displays the status of DDB signals				
DDB 95 - 64	0F	22	0	
Displays the status of DDB signals				
DDB 127 - 96	0F	23	0	
Displays the status of DDB signals				
DDB 159 - 128	0F	24	0	
Displays the status of DDB signals				
DDB 191 - 160	0F	25	0	
Displays the status of DDB signals				
DDB 223 - 192	0F	26	0	
Displays the status of DDB signals				
DDB 255 - 224	0F	27	0	
Displays the status of DDB signals				
DDB 287 - 256	0F	28	0	
Displays the status of DDB signals				
DDB 319 - 288	0F	29	0	

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Displays the status of DDB signals				
DDB 351 - 320	0F	2A	0	
Displays the status of DDB signals				
DDB 383 - 352	0F	2B	0	
Displays the status of DDB signals				
DDB 415 - 384	0F	2C	0	
Displays the status of DDB signals				
DDB 447 - 416	0F	2D	0	
Displays the status of DDB signals				
DDB 479 - 448	0F	2E	0	
Displays the status of DDB signals				
DDB 511 - 480	0F	2F	0	
Displays the status of DDB signals				
DDB 543 - 512	0F	30	0	
Displays the status of DDB signals				
DDB 575 - 544	0F	31	0	
Displays the status of DDB signals				
DDB 607 - 576	0F	32	0	
Displays the status of DDB signals				
DDB 639 - 608	0F	33	0	
Displays the status of DDB signals				
DDB 671 - 640	0F	34	0	
Displays the status of DDB signals				
DDB 703 - 672	0F	35	0	
Displays the status of DDB signals				
DDB 735 - 704	0F	36	0	
Displays the status of DDB signals				
DDB 767 - 736	0F	37	0	
Displays the status of DDB signals				
DDB 799 - 768	0F	38	0	
Displays the status of DDB signals				
DDB 831 - 800	0F	39	0	
Displays the status of DDB signals				
DDB 863 - 832	0F	3A	0	
Displays the status of DDB signals				
DDB 895 - 864	0F	3B	0	
Displays the status of DDB signals				
DDB 927 - 896	0F	3C	0	
Displays the status of DDB signals				
DDB 959 - 928	0F	3D	0	
Displays the status of DDB signals				
DDB 991 - 960	0F	3E	0	
Displays the status of DDB signals				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
DDB 1023 - 992	0F	3F	0	
Displays the status of DDB signals				
DDB 1055 - 1024	0F	40	0	
Displays the status of DDB signals				
DDB 1087 - 1056	0F	41	0	
Displays the status of DDB signals				
DDB 1119 - 1088	0F	42	0	
Displays the status of DDB signals				
DDB 1151 - 1120	0F	43	0	
Displays the status of DDB signals				
DDB 1183 - 1152	0F	44	0	
Displays the status of DDB signals				
DDB 1215 - 1184	0F	45	0	
Displays the status of DDB signals				
DDB 1247 - 1216	0F	46	0	
Displays the status of DDB signals				
DDB 1279 - 1248	0F	47	0	
Displays the status of DDB signals				
DDB 1311 - 1280	0F	48	0	
Displays the status of DDB signals				
DDB 1343 - 1312	0F	49	0	
Displays the status of DDB signals				
DDB 1375 - 1344	0F	4A	0	
Displays the status of DDB signals				
DDB 1407 - 1376	0F	4B	0	
Displays the status of DDB signals				
DDB 1439 - 1408	0F	4C	0	
Displays the status of DDB signals				
DDB 1471 - 1440	0F	4D	0	
Displays the status of DDB signals				
DDB 1503 - 1472	0F	4E	0	
Displays the status of DDB signals				
DDB 1535 - 1504	0F	4F	0	
Displays the status of DDB signals				
DDB 1567 - 1536	0F	50	0	
Displays the status of DDB signals				
DDB 1599 - 1568	0F	51	0	
Displays the status of DDB signals				
DDB 1631 - 1600	0F	52	0	
Displays the status of DDB signals				
DDB 1663 - 1632	0F	53	0	
Displays the status of DDB signals				
DDB 1695 - 1664	0F	54	0	

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Displays the status of DDB signals				
DDB 1727 - 1696	0F	55	0	
Displays the status of DDB signals				
DDB 1759 - 1728	0F	56	0	
Displays the status of DDB signals				
DDB 1791 - 1760	0F	57	0	
Displays the status of DDB signals				
DDB 1823 - 1792	0F	58	0	
Displays the status of DDB signals				
DDB 1855 - 1824	0F	59	0	
Displays the status of DDB signals				
DDB 1887 - 1856	0F	5A	0	
Displays the status of DDB signals				
DDB 1919 - 1888	0F	5B	0	
Displays the status of DDB signals				
DDB 1951 - 1920	0F	5C	0	
Displays the status of DDB signals				
DDB 1983 - 1952	0F	5D	0	
Displays the status of DDB signals				
DDB 2015 - 1984	0F	5E	0	
Displays the status of DDB signals				
DDB 2047 - 2016	0F	5F	0	
Displays the status of DDB signals				

Table 18: COMMISSION TESTS column

3.16 Circuit Breaker Condition Monitor Setup

The CB MONITOR SETUP column contains settings for defining the way the CB condition monitoring is set up. It includes the setup of the ruptured current facility and those features that can be set to raise an alarm, or lockout the CB.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
CB MONITOR SETUP	10	0	0	
This column contains Circuit Breaker monitoring parameters				
Broken I^	10	1	2	1 to 2 step 0.1
This sets the factor to be used for the cumulative I^ counter calculation that monitors the cumulative severity of the duty placed on the interrupter. This factor is set according to the type of Circuit Breaker used				
I^ Maintenance	10	2	Alarm Disabled	0 = Alarm Disabled or 1 = Alarm Enabled
Setting which determines if an alarm will be raised or not when the cumulative I^ maintenance counter threshold is exceeded.				
I^ Maintenance	10	3	1000	1 to 25000 step 1
Setting that determines the threshold for the cumulative I^ maintenance counter monitors.				
I^ Lockout	10	4	Alarm Disabled	0 = Alarm Disabled or 1 = Alarm Enabled
Setting which determines if an alarm will be raised or not when the cumulative I^lockout counter threshold is exceeded.				
I^ Lockout	10	5	2000	1 to 25000 step 1

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Setting that determines the threshold for the cumulative I^ lockout counter monitor. Set that should maintenance not be carried out, the IED can be set to lockout the auto-reclose function on reaching a second operations threshold.				
No. CB Ops Maint	10	6	Alarm Disabled	0 = Alarm Disabled or 1 = Alarm Enabled
Setting to activate the number of circuit breaker operations maintenance alarm.				
No. CB Ops Maint	10	7	10	1 to 10000 step 1
Sets the threshold for number of circuit breaker operations maintenance alarm, indicating when preventative maintenance is due.				
No. CB Ops Lock	10	8	Alarm Disabled	0 = Alarm Disabled or 1 = Alarm Enabled
Setting to activate the number of circuit breaker operations lockout alarm.				
No. CB Ops Lock	10	9	20	1 to 10000 step 1
Sets the threshold for number of circuit breaker operations lockout. The IED can be set to lockout the auto-reclose function on reaching a second operations threshold.				
CB Time Maint	10	0A	Alarm Disabled	0 = Alarm Disabled or 1 = Alarm Enabled
Setting to activate the circuit breaker operating time maintenance alarm.				
CB Time Maint	10	0B	0.1	0.005s to 0.5s step 0.001s
Setting for the circuit operating time threshold which is set in relation to the specified interrupting time of the circuit breaker.				
CB Time Lockout	10	0C	Alarm Disabled	0 = Alarm Disabled or 1 = Alarm Enabled
Setting to activate the circuit breaker operating time lockout alarm.				
CB Time Lockout	10	0D	0.2	0.005s to 0.5s step 0.001s
Setting for the circuit breaker operating time threshold which is set in relation to the specified interrupting time of the circuit breaker. The IED can be set to lockout the auto-reclose function on reaching a second operations threshold.				
Fault Freq Lock	10	0E	Alarm Disabled	0 = Alarm Disabled or 1 = Alarm Enabled
Enables the excessive fault frequency alarm.				
Fault Freq Count	10	0F	10	1 to 9999 step 1
Sets a circuit breaker frequent operations counter that monitors the number of operations over a set time period				
Fault Freq Time	10	10	3600	0s to 9999s step 1s
Sets the time period over which the circuit breaker operations are to be monitored. Should the set number of trip operations be accumulated within this time period, an alarm can be raised. Excessive fault frequency/trips can be used to indicate that the circuit may need maintenance attention (e.g. Tree-felling or insulator cleaning).				

Table 19: CB MONITOR SETUP column

3.17 Opto-input Configuration

The OPTO CONFIG is column lets you define the opto-input configuration settings, including setting nominal voltage values for each opto-input, setting filters to reduce wiring noise as well as pick-up and drop-off characteristics for the opto-inputs.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
OPTO CONFIG	11	0	0	
This column contains opto-input configuration settings				
Global Nominal V	11	1	24/27V	0 = 24-27V, 1 = 30-34V, 2 = 48-54V, 3 = 110-125V, 4 = 220-250V or 5 = Custom
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Opto Input 1	11	2	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 2	11	3	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 3	11	4	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 4	11	5	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 5	11	6	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 6	11	7	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 7	11	8	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 8	11	9	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 9	11	0A	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 10	11	0B	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 11	11	0C	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 12	11	0D	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				

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

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Opto Input 25	11	1A	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 26	11	1B	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 27	11	1C	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 28	11	1D	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 29	11	1E	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 30	11	1F	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 31	11	20	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Input 32	11	21	24/27V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting. The number of inputs may be up to 32, depending on the IED and I/O configuration.				
Opto Filter Cntl	11	60	0xFEB7FB	32-bit binary setting: 0 = Off, 1= Energized
Selects each input with a pre-set filter of ½ cycle that renders the input immune to induced noise on the wiring. The number of available bits may be 16, 24 or 32, depending on the I/O configuration.				
Characteristic	11	80	Standard 60%-80%	0 = Standard 60% to 80% or 1 = 50% to 70%
Selects the pick-up and drop-off characteristics of the opto's. Selecting the standard setting means they nominally provide a Logic 1 or On value for Voltages ≥80% of the set lower nominal voltage and a Logic 0 or Off value for the voltages ≤60% of the set higher nominal voltage.				

Table 20: OPTO CONFIG column

3.18 Control Inputs

The control inputs are logical switches internal to the IED, which can be used to trigger any function to which they are connected as part of the PSL. The CONTROL INPUT column contains commands that set or reset these control inputs.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
CONTROL INPUTS	12	0	0	
This column contains settings for the type of control input (32 in all)				
Ctrl I/P Status	12	1	0	Binary Flag (32 bits) Indexed String (0 = Reset, 1 = Set)
Cell that is used to set (1) and reset (0) the selected Control Input by simply scrolling and changing the status of selected bits. This command will be then recognized and executed in the PSL. Alternatively, each of the 32 Control input can also be set and reset using the individual menu setting cells as follows:				
Control Input 1	12	2	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 1 set/ reset.				
Control Input 2	12	3	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 2 set/ reset.				
Control Input 3	12	4	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 3 set/ reset.				
Control Input 4	12	5	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 4 set/ reset.				
Control Input 5	12	6	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 5 set/ reset.				
Control Input 6	12	7	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 6 set/ reset.				
Control Input 7	12	8	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 7 set/ reset.				
Control Input 8	12	9	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 8 set/ reset.				
Control Input 9	12	0A	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 9 set/ reset.				
Control Input 10	12	0B	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 10 set/ reset.				
Control Input 11	12	0C	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 11 set/ reset.				
Control Input 12	12	0D	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 12 set/ reset.				
Control Input 13	12	0E	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 13 set/ reset.				
Control Input 14	12	0F	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 14 set/ reset.				
Control Input 15	12	10	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 15 set/ reset.				
Control Input 16	12	11	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 16 set/ reset.				
Control Input 17	12	12	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 17 set/ reset.				
Control Input 18	12	13	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 18 set/ reset.				
Control Input 19	12	14	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 19 set/ reset.				
Control Input 20	12	15	No Operation	0 = No Operation, 1 = Set , 2 = Reset

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Setting to allow Control Inputs 20 set/ reset.				
Control Input 21	12	16	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 21 set/ reset.				
Control Input 22	12	17	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 22 set/ reset.				
Control Input 23	12	18	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 23 set/ reset.				
Control Input 24	12	19	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 24 set/ reset.				
Control Input 25	12	1A	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 25 set/ reset.				
Control Input 26	12	1B	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 26 set/ reset.				
Control Input 27	12	1C	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 27 set/ reset.				
Control Input 28	12	1D	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 28 set/ reset.				
Control Input 29	12	1E	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 29 set/ reset.				
Control Input 30	12	1F	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 30 set/ reset.				
Control Input 31	12	20	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 31 set/ reset.				
Control Input 32	12	21	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 32 set/ reset.				

Table 21: CONTROL INPUTS column

3.19 Control Input Configuration

The CONTROL I/P CONFIG column contains a setting to allow the control inputs to be individually assigned to Hotkeys and allows you to define the operating mode for each of the Control Inputs. There are four possible operating modes; On/Off, Set/Reset, In/Out, and Enabled/Disabled.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
CTRL I/P CONFIG	13	0	0	
This column contains settings for the type of control input (32 in all)				
Hotkey Enabled	13	1	0xFFFFFFFF	0xFFFFFFFF to 32 step 1
Setting to allow the control inputs to be individually assigned to the Hotkey menu by setting ‘1’ in the appropriate bit in the Hotkey Enabled cell. The hotkey menu allows the control inputs to be set, reset or pulsed without the need to enter the CONTROL INPUTS column.				
Control Input 1	13	10	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’. A latched control input will remain in the set state until a reset command is given, either by the menu or the serial communications. A pulsed control input, however, will remain energized for 10 ms after the set command is given and will then reset automatically (i.e. no reset command required).				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Ctrl Command 1	13	11	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 2	13	14	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 2	13	15	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 3	13	18	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 3	13	19	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 4	13	1C	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 4	13	1D	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 5	13	20	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 5	13	21	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 6	13	24	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 6	13	25	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 7	13	28	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 7	13	29	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 8	13	2C	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 8	13	2D	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 9	13	30	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Ctrl Command 9	13	31	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 10	13	34	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 10	13	35	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 11	13	38	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 11	13	39	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 12	13	3C	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 12	13	3D	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 13	13	40	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 13	13	41	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 14	13	44	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 14	13	45	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 15	13	48	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 15	13	49	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 16	13	4C	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 16	13	4D	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 17	13	50	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Ctrl Command 17	13	51	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 18	13	54	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 18	13	55	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 19	13	58	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 19	13	59	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 20	13	5C	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 20	13	5D	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 21	13	60	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 21	13	61	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 22	13	64	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 22	13	65	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 23	13	68	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 23	13	69	Set/Reset	0 = On/Off, 1 = Set/Reset, 2 = In/Out, 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 24	13	6C	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				
Ctrl Command 24	13	6D	Set/Reset	0 = On/Off or 1 = Set/Reset or 2 = In/Out or 3 = Enabled/Disabled
Allows the SET / RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON / OFF, IN / OUT etc.				
Control Input 25	13	70	Latched	0 = Latched or 1 = Pulsed
Configures the control inputs as either ‘latched’ or ‘pulsed’.				

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

Table 22: CONTROL I/P CONFIG column

3.20 Serial InterMiCOM Communications

The INTERMICOM COMMS column is used to set up the physical RS485 serial communication link for interMiCOM communications and to display status and statistical information relating to the communication. This column is only applicable to copper transmission media.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
INTERMICOM COMMS	15	0	0	
This column is only visible if the model number supports InterMiCOM and second rear comms board is fitted.				
IM Output Status	15	1	Data	
Displays the status of each InterMiCOM output signal.				
IM Input Status	15	2	Data	
Displays the status of each InterMiCOM input signal, with IM1 signal starting from the right. When loop back mode is set, all bits will display zero.				
Source Address	15	10	1	0 to 10 step 1
Setting for the unique IED address that is encoded in the InterMiCOM sent message.				
Received Address	15	11	2	0 to 10 step 1
The aim of setting addresses is to establish pairs of IED's which will only communicate with each other. Should an inadvertent channel misrouting or spurious loopback occur, an error will be logged, and the erroneous received data will be rejected. As an example, in a 2 ended scheme the following address setting would be correct: Local IED: Source Address = 1, Receive Address = 2 Remote IED: Source Address = 2, Receive Address = 1				
Baud Rate	15	12	9600	0 = 600, 1 = 1200, 2 = 2400, 3 = 4800, 4 = 9600 or 5 = 19200
Setting of the signalling speed in terms of number of bits per second. The speed will match the capability of the MODEM or other characteristics of the channel provided.				
Ch Statistics	15	20	Invisible	0 = Invisible, 1 = Visible
Settings that makes visible or invisible Channel Statistics on the LCD. The statistic is reset by either IED's powering down or using the 'Reset Statistics' cell.				
Rx Direct Count	15	21	0	
Displays the number of valid Direct Tripping messages since last counter reset.				
Rx Perm Count	15	22	0	
Displays the number of valid Permissive Tripping messages since last counter reset.				
Rx Block Count	15	23	0	
Displays the number of valid Blocking messages since last counter reset.				
Rx NewDataCount	15	24	0	
Displays the number of different messages (change events) since last counter reset.				
Rx ErroredCount	15	25	0	
Displays the number of invalid received messages since last counter reset.				
Lost Messages	15	26	0	
Displays the difference between the number of messages that were supposed to be received (based on set Baud Rate) and actual valid received messages since last reset.				
Elapsed Time	15	30	0	
Displays the time in seconds since last counter reset.				
Reset Statistics	15	31	No	0 = No, 1 = Yes
Command that allows all Statistics and Channel Diagnostics to be reset.				
Ch Diagnostics	15	40	Invisible	0 = Invisible, 1 = Visible
Setting that makes visible or invisible Channel Diagnostics on the LCD. The diagnostic is reset by either IED's powering down or using the 'Reset Statistics' cell.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Data CD Status	15	41	0	0 = OK, 1 = Fail, 2 = SCC Absent
Indicates when the DCD line (pin 1 on EIA232 Connector) is energized. OK = DCD is energized FAIL = DCD is de-energized Absent = 2nd Rear port board is not fitted				
FrameSync Status	15	42	0	0 = OK, 1 = Fail, 2 = SCC Absent
Indicates when the message structure and synchronization is valid. OK = Valid message structure and synchronization FAIL = Synchronization has been lost Absent = 2nd Rear port board is not fitted Unavailable = Hardware error present				
Message Status	15	43	0	0 = OK, 1 = Fail, 2 = SCC Absent
Indicates when the percentage of received valid messages has fallen below the ‘IM Msg Alarm Lvl’ setting within the alarm time period. OK = Acceptable ratio of lost messages FAIL = Unacceptable ratio of lost messages Absent = 2nd Rear port board is not fitted Unavailable = Hardware error present				
Channel Status	15	44	0	0 = OK, 1 = Fail, 2 = SCC Absent
Indicates the state of the InterMiCOM communication channel. OK = Channel healthy FAIL = Channel failure Absent = 2nd Rear port board is not fitted Unavailable = Hardware error present				
IM H/W Status	15	45	0	0 = OK, 1 = Fail, 2 = SCC Absent, 3 = SCC Read Error, 4 = SCC Write Error
Indicates the state of InterMiCOM hardware OK = InterMiCOM hardware healthy Read or Write Error = InterMiCOM failure Absent = 2nd Rear port is not fitted or failed to initialize.				
Loopback Mode	15	50	Disabled	0 = Disabled, 1 = Internal or 2 = External
Setting to allow testing of the InterMiCOM channel. When ‘Internal’ is selected, only the local InterMiCOM software functionality is tested, whereby the IED will receive its own sent data. ‘External’ setting allows a hardware and software check, with an external link required to jumper the sent data onto the receive channel. During normal service condition Loopback mode must be disabled.				
Test Pattern	15	51	0xFF	8 bits
Allows specific bit statuses to be inserted directly into the InterMiCOM message, to substitute real data. This is used for testing purposes.				
Loopback Status	15	52	0	0 = OK, 1 = Fail, 2 = SCC Absent
Indicates the status of the InterMiCOM loopback mode OK = Loopback software (and hardware) is working correctly FAIL = Loopback mode failure Unavailable = Hardware error present.				

Table 23: INTERMICOM COMMS column

3.21 Serial InterMiCOM Configuration

The INTERMICOM CONF column contains settings to configure parameters relating to the operating mode and the way in which the IED handles the messages transferred over the serial link. This column is only applicable to copper transmission media.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
INTERMICOM CONF	16	0	0	
This column is only visible if the model number supports InterMiCOM and second rear comms board is fitted.				
IM Msg Alarm Lvl	16	1	25	0 to 100 step 0.1
Setting that is used to alarm for poor channel quality. If during the fixed 1.6s window the ratio of invalid messages to the total number of messages that should be received (based upon the ‘Baud Rate’ setting) exceeds the above threshold, a ‘Message Fail’ alarm will be issued.				
IM1 Cmd Type	16	10	Blocking	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_1 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
IM1 FallBackMode	16	11	Default	0 = Default or 1 = Latched
Setting that defines the status of IM1 signal in case of heavy noise and message synchronization being lost. If set to ‘Latching’ the last valid IM1 status will be maintained until the new valid message is received. If set to ‘Default’, the IM1 status, pre-defined by the user in ‘IM1 DefaultValue’ cell will be set. A new valid message will replace ‘IM1 DefaultValue’, once the channel recovers.				
IM1 DefaultValue	16	12	1	0 to 1 step 1
Setting that defines the IM1 fallback status.				
IM1 FrameSyncTim	16	13	1.5	0.01s to 1s step 0.001s
Time delay after which ’IM1 DefaultValue’ is applied, providing that no valid message is received in the meantime.				
IM2 Cmd Type	16	18	Blocking	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_2 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
IM2 FallBackMode	16	19	Default	0 = Default or 1 = Latched
Setting that defines the status of IM2 signal in case of heavy noise and message synchronization being lost. If set to ‘Latching’ the last valid IM2 status will be maintained until the new valid message is received. If set to ‘Default’, the IM2 status, pre-defined by the user in ‘IM2 DefaultValue’ cell will be set. A new valid message will replace ‘IM2 DefaultValue’, once the channel recovers.				
IM2 DefaultValue	16	1A	1	0 to 1 step 1
Setting that defines the IM2 fallback status.				
IM2 FrameSyncTim	16	1B	1.5	0.01s to 1s step 0.001s
Time delay after which ’IM2 DefaultValue’ is applied, providing that no valid message is received in the meantime.				
IM3 Cmd Type	16	20	Blocking	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_3 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
IM3 FallBackMode	16	21	Default	0 = Default or 1 = Latched
Setting that defines the status of IM3 signal in case of heavy noise and message synchronization being lost. If set to ‘Latching’ the last valid IM3 status will be maintained until the new valid message is received. If set to ‘Default’, the IM3 status, pre-defined by the user in ‘IM3 DefaultValue’ cell will be set. A new valid message will replace ‘IM3 DefaultValue’, once the channel recovers.				
IM3 DefaultValue	16	22	1	0 to 1 step 1
Setting that defines the IM3 fallback status.				
IM3 FrameSyncTim	16	23	1.5	0.01s to 1s step 0.001s
Time delay after which ’IM3 DefaultValue’ is applied, providing that no valid message is received in the meantime.				
IM4 Cmd Type	16	28	Blocking	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_4 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
IM4 FallBackMode	16	29	Default	0 = Default or 1 = Latched
Setting that defines the status of IM4 signal in case of heavy noise and message synchronization being lost. If set to ‘Latching’ the last valid IM4 status will be maintained until the new valid message is received. If set to ‘Default’, the IM4 status, pre-defined by the user in ‘IM4 DefaultValue’ cell will be set. A new valid message will replace ‘IM4 DefaultValue’, once the channel recovers.				
IM4 DefaultValue	16	2A	1	0 to 1 step 1
Setting that defines the IM4 fallback status.				
IM4 FrameSyncTim	16	2B	1.5	0.01s to 1s step 0.001s
Time delay after which ’IM4 DefaultValue’ is applied, providing that no valid message is received in the meantime.				
IM5 Cmd Type	16	30	Direct	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_5 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
IM5 FallBackMode	16	31	Default	0 = Default or 1 = Latched
Setting that defines the status of IM5 signal in case of heavy noise and message synchronization being lost. If set to ‘Latching’ the last valid IM5 status will be maintained until the new valid message is received. If set to ‘Default’, the IM5 status, pre-defined by the user in ‘IM5 DefaultValue’ cell will be set. A new valid message will replace ‘IM5 DefaultValue’, once the channel recovers.				
IM5 DefaultValue	16	32	0	0 to 1 step 1
Setting that defines the IM5 fallback status.				
IM5 FrameSyncTim	16	33	1.5	0.01s to 1s step 0.001s
Time delay after which ‘IM5 DefaultValue’ is applied.				
IM6 Cmd Type	16	38	Direct	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_6 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
IM6 FallBackMode	16	39	Default	0 = Default or 1 = Latched
Setting that defines the status of IM6 signal in case of heavy noise and message synchronization being lost. If set to ‘Latching’ the last valid IM6 status will be maintained until the new valid message is received. If set to ‘Default’, the IM6 status, pre-defined by the user in ‘IM6 DefaultValue’ cell will be set. A new valid message will replace ‘IM6 DefaultValue’, once the channel recovers.				
IM6 DefaultValue	16	3A	0	0 to 1 step 1
Setting that defines the IM6 fallback status.				
IM6 FrameSyncTim	16	3B	1.5	0.01s to 1s step 0.001s
Time delay after which ‘IM6 DefaultValue’ is applied.				
IM7 Cmd Type	16	40	Direct	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_7 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
IM7 FallBackMode	16	41	Default	0 = Default or 1 = Latched
Setting that defines the status of IM7 signal in case of heavy noise and message synchronization being lost. If set to ‘Latching’ the last valid IM7 status will be maintained until the new valid message is received. If set to ‘Default’, the IM7 status, pre-defined by the user in ‘IM7 DefaultValue’ cell will be set. A new valid message will replace ‘IM7 DefaultValue’, once the channel recovers.				
IM7 DefaultValue	16	42	0	0 to 1 step 1
Setting that defines the IM7 fallback status.				
IM7 FrameSyncTim	16	43	1.5	0.01s to 1s step 0.001s
Time delay after which ‘IM7 DefaultValue’ is applied.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
IM8 Cmd Type	16	48	Direct	0 = Disabled, 1 = Direct or 2 = Blocking
Setting that defines the operative mode of the InterMiCOM_8 signal. Selecting the channel response for this bit to Blocking allows fastest signalling, whereas setting to Direct offers higher security at the expense of speed. Selecting the channel response for this bit to Permissive offers higher dependability				
IM8 FallBackMode	16	49	Default	0 = Default or 1 = Latched
Setting that defines the status of IM8 signal in case of heavy noise and message synchronization being lost. If set to 'Latching' the last valid IM8 status will be maintained until the new valid message is received. If set to 'Default', the IM8 status, pre-defined by the user in 'IM8 DefaultValue' cell will be set. A new valid message will replace 'IM8 DefaultValue', once the channel recovers.				
IM8 DefaultValue	16	4A	0	0 to 1 step 1
Setting that defines the IM8 fallback status.				
IM8 FrameSyncTim	16	4B	1.5	0.01s to 1s step 0.001s
Time delay after which 'IM8 DefaultValue' is applied.				

Table 24: INTERMICOM CONF column

3.22 Function Keys

The function keys produce logical inputs that are fed into the unit's PSL. These inputs can be used to trigger any function to which they are connected as part of the PSL. The settings in the FUNCTION KEYS column allow you to enable or disable each function key, to set internal labels, and to set the operating mode to Normal or Toggled.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
FUNCTION KEYS	17	0	0	
This column contains the function key definitions				
Fn Key Status	17	1	0	
Displays the status of each function key.				
Fn Key 1	17	2	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The 'Lock' setting allows a function key output that is set to toggle mode to be locked in its current active state.				
Fn Key 1 Mode	17	3	Normal	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In 'Toggle' mode, a single key press will set/latch the function key output as 'high' or 'low' in programmable scheme logic. This feature can be used to enable/disable IED functions. In the 'Normal' mode the function key output will remain 'high' as long as key is pressed.				
Fn Key 1 Label	17	4	Function Key 1	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 2	17	5	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The 'Lock' setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 2 Mode	17	6	Normal	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In 'Toggle' mode, a single key press will set/latch the function key output as 'high' or 'low' in programmable scheme logic. This feature can be used to enable/disable IED functions. In the 'Normal' mode the function key output will remain 'high' as long as key is pressed.				
Fn Key 2 Label	17	7	Function Key 1	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 3	17	8	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The 'Lock' setting allows a function key output that is set to toggle mode to be locked in its current active position.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Fn Key 3 Mode	17	9	Normal	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In 'Toggle' mode, a single key press will set/latch the function key output as 'high' or 'low' in programmable scheme logic. This feature can be used to enable/disable IED functions. In the 'Normal' mode the function key output will remain 'high' as long as key is pressed.				
Fn Key 3 Label	17	0A	Function Key 1	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 4	17	0B	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The 'Lock' setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 4 Mode	17	0C	Normal	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In 'Toggle' mode, a single key press will set/latch the function key output as 'high' or 'low' in programmable scheme logic. This feature can be used to enable/disable IED functions. In the 'Normal' mode the function key output will remain 'high' as long as key is pressed.				
Fn Key 4 Label	17	0D	Function Key 1	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 5	17	0E	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The 'Lock' setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 5 Mode	17	0F	Normal	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In 'Toggle' mode, a single key press will set/latch the function key output as 'high' or 'low' in programmable scheme logic. This feature can be used to enable/disable IED functions. In the 'Normal' mode the function key output will remain 'high' as long as key is pressed.				
Fn Key 5 Label	17	10	Function Key 1	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 6	17	11	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The 'Lock' setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 6 Mode	17	12	Normal	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In 'Toggle' mode, a single key press will set/latch the function key output as 'high' or 'low' in programmable scheme logic. This feature can be used to enable/disable IED functions. In the 'Normal' mode the function key output will remain 'high' as long as key is pressed.				
Fn Key 6 Label	17	13	Function Key 1	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 7	17	14	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The 'Lock' setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 7 Mode	17	15	Normal	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In 'Toggle' mode, a single key press will set/latch the function key output as 'high' or 'low' in programmable scheme logic. This feature can be used to enable/disable IED functions. In the 'Normal' mode the function key output will remain 'high' as long as key is pressed.				
Fn Key 7 Label	17	16	Function Key 1	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				
Fn Key 8	17	17	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The 'Lock' setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn Key 8 Mode	17	18	Normal	0 = Normal or 1 = Toggled
Sets the function key in toggle or normal mode. In 'Toggle' mode, a single key press will set/latch the function key output as 'high' or 'low' in programmable scheme logic. This feature can be used to enable/disable IED functions. In the 'Normal' mode the function key output will remain 'high' as long as key is pressed.				
Fn Key 8 Label	17	19	Function Key 1	32 to 163 step 1
Allows the text of the function key to be changed to something more suitable for the application.				

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

Table 25: FUNCTION KEYS column

3.23 IED CONFIGURATOR - IEC 61850 Configuration

The contents of the IED CONFIGURATOR column are mostly data cells, which display information relating to the IEC61850 configuration. In order to edit the configuration, you need to use the IED Configurator tool in the MiCOM S1 Agile application software. There are however two commands to switch the configuration banks and to restore the MCL (MiCOM Configuration Language). There is also a setting to switch GOOSE on or off.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
IED CONFIGURATOR	19	0	0	
This column contains IED Configurator settings				
Switch Conf.Bank	19	5	No Action	0 = No Action or 1 = Switch banks
Setting which allows the user to switch between the current configuration, held in the Active Memory Bank (and partly displayed below), to the configuration sent to and held in the Inactive Memory Bank.				
Restore MCL	19	0A	No Action	0 = No Action or 1 = Restore MCL
Setting which allows the user to restore MCL or no action.				
Active Conf.Name	19	10	0	
IEC61850 versions only. The name of the configuration in the Active Memory Bank, usually taken from the SCL file.				
Active Conf.Rev	19	11	0	
IEC61850 versions only. Configuration Revision number of the configuration in the Active Memory Bank, usually taken from the SCL file.				
Inact.Conf.Name	19	20	0	
IEC61850 versions only. The name of the configuration in the Inactive Memory Bank, usually taken from the SCL file.				
Inact.Conf.Rev	19	21	0	
IEC61850 versions only. Configuration Revision number of the configuration in the Inactive Memory Bank, usually taken from the SCL file.				
IP PARAMETERS	19	30	0	
IEC61850 versions only.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
IP address	19	31	0	
IEC61850 versions only. Displays the unique network IP address that identifies the IED.				
Subnet mask	19	32	0	
IEC61850 versions only. Displays the sub-network the IED is connected to.				
Gateway	19	33	0	
IEC61850 versions only. Displays the IP address of the gateway (proxy) that the IED is connected to, if any.				
SNTP PARAMETERS	19	40	0	
IEC61850 versions only.				
SNTP Server 1	19	41	0	
IEC61850 versions only. Displays the IP address of the primary SNTP server.				
SNTP Server 2	19	42	0	
IEC61850 versions only. Displays the IP address of the secondary SNTP server.				
IEC61850 SCL	19	50	0	
IEC61850 versions only.				
IED Name	19	51	0	
IEC61850 versions only. 8 character IED name, which is the unique name on the IEC 61850 network for the IED, usually taken from the SCL file.				
IEC61850 GOOSE	19	60	0	
IEC61850 versions only.				
GoEna	19	70	0x00000000	0 = Disabled or 1 = Enabled
IEC61850 versions only. Setting to enable GOOSE publisher settings.				
Test Mode	19	71	0x00000000	0 = Disabled, 1 = Pass Through, 2 = Forced
IEC61850 versions only. The Test Mode cell allows the test pattern to be sent in the GOOSE message, for example for testing or commissioning. When 'Disabled' is selected, the test flag is not set. When 'Pass Through' is selected, the test flag is set, but the data in the GOOSE message is sent as normal. When 'Forced' is selected, the test flag is set, and the data sent in the GOOSE message is as per the 'VOP Test Pattern' setting below. Once testing is complete the cell must be set back to 'Disabled' to restore the GOOSE scheme back to normal service.				
Ignore Test Flag	19	73	No	0 = No or 1 = Yes
IEC61850 versions only. The Test Mode cell allows the test pattern to be sent in the GOOSE message, for example for testing or commissioning. When 'Disabled' is selected, the test flag is not set. When 'Pass Through' is selected, the test flag is set, but the data in the GOOSE message is sent as normal. When 'Forced' is selected, the test flag is set, and the data sent in the GOOSE message is as per the 'VOP Test Pattern' setting below. Once testing is complete the cell must be set back to 'Disabled' to restore the GOOSE scheme back to normal service.				

Table 26: IED CONFIGURATOR column

3.24 PROT.COMMS/IM64 - Fibre Teleprotection

The settings in the PROT COMMS/IM64 column are used to configure InterMiCOM64 (IM64) Teleprotection. InterMiCOM^{64} is a fibre-based teleprotection scheme, described in detail in the Operation and Application chapters of this service manual.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
PROT COMMS/ IM64	20	0	0	
This column contains settings for IM64 Configuration				
Scheme Setup	20	1	2 Terminal	0 = 3 Terminal, 1 = 2 Terminal, 2 = Dual Redundant
Settings to determine how many IED ends are connected in the differential zone or how many IED's are connected to the teleprotection scheme for the protected line, with two or three ends possible. For a plain two terminal line, there is an additional option to use dual communication channels, to implement redundancy (i.e. employ a parallel "hot-standby" path).				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Address	20	2	0-0	0=0-0, 1=1-A, 2=2-A, 3=3-A, 4=4-A, 5=5-A, 6=6-A, 7=7-A, 8=8-A, 9=9-A, 10=10-A, 11=11-A, 12=12-A, 13=13-A, 14=14-A, 15=15-A, 16=16-A, 17=17-A, 18=18-A, 19=19-A, 20=20-A, 21=21-A, 22=22-A, 23=23-A, 24=24-A, 25=25-A, 26=26-A, 27=27-A, 28=28-A, 29=29-A, 30=30-A, 31=31-A, 32=32-A, 33=1-B, 34=2-B, 35=3-B, 36=4-B, 37=5-B, 38=6-B, 39=7-B, 40=8-B, 41=9-B, 42=10-B, 43=11-B, 44=12-B, 45=13-B, 46=14-B, 47=15-B, 48=16-B, 49=17-B, 50=18-B, 51=19-B, 52=20-B, 53=21-B, 4=22-B, 55=23-B, 56=24-B, 57=25-B, 58=26-B, 59=27-B, 60=28-B, 61=29-B, 62=30-B, 63=31-B, 64=32-B, 65=1-C, 66=2-C, 67=3-C, 68=4-C, 69=5-C, 70=6-C, 71=7-C, 72=8-C, 73=9-C, 74=10-C, 75=11-C, 76=12-C, 77=13-C, 78=14-C, 79=15-C, 80=16-C, 81=17-C, 82=18-C, 83=19-C, 84=20-C, 85=21-C, 86=22-C, 87=23-C, 88=24-C, 89=25-C, 90=26-C, 91=27-C, 92=28-C, 93=29-C, 94=30-C, 95=31-C, 96=32-C
In 3 terminal schemes, communicating groups of three IED's may be configured. See below.				
Address	20	3	0-0	0=0-0, 1=1-A, 2=2-A, 3=3-A, 4=4-A, 5=5-A, 6=6-A, 7=7-A, 8=8-A, 9=9-A, 10=10-A, 11=11-A, 12=12-A, 13=13-A, 14=14-A, 15=15-A, 16=16-A, 17=17-A, 18=18-A, 19=19-A, 20=20-A, 21=21-A, 22=22-A, 23=23-A, 24=24-A, 25=25-A, 26=26-A, 27=27-A, 28=28-A, 29=29-A, 30=30-A, 31=31-A, 32=32-A, 33=1-B, 34=2-B, 35=3-B, 36=4-B, 37=5-B, 38=6-B, 39=7-B, 40=8-B, 41=9-B, 42=10-B, 43=11-B, 44=12-B, 45=13-B, 46=14-B, 47=15-B, 48=16-B, 49=17-B, 50=18-B, 51=19-B, 52=20-B, 53=21-B, 54=22-B, 55=23-B, 56=24-B, 57=25-B, 58=26-B, 59=27-B, 60=28-B, 61=29-B, 62=30-B, 63=31-B, 64=32-B,
Setting for the unique IED address that is encoded in the InterMiCOM64 sent message. The aim of setting the address is to establish pairs of IED's which will only communicate with each other. Should an inadvertent fiber/MUX misrouting or spurious loopback occur, an error will be logged, and the erroneous received data will be rejected. As an example, in a 2 ended scheme the following address setting would be correct: Local IED: 1-A Remote IED: 1-B Address 0-0 is a universal address, whereby any IED will be free to communicate with any other (equivalent to disabling of the unique addressing). When PROT COMMS/IM64 is set to loop back mode, the address 0-0 will replace any existing address in the IED.				
Comms Mode	20	10	Standard	0 = Standard or 1 = IEEE C37.94
Setting that defines the data format that will be transmitted on the fiber outputs from the IED. If the Multiplexer accepts direct fiber inputs according to IEEE C37.94, the 'IEEE C37.94' setting is selected. For a direct fiber link between IED's, and where the MUX connection is in electrical format (G.703 or V.35 or X.21), the 'Standard' message format needs to be set. For a setting change to take effect, rebooting of the IED will be required. The Comm Mode setting applies to both channels.				
Baud Rate Ch1	20	11	64kbits/s	0 = 64kbits/s or 1 = 56kbits/s
Channel 1 data rate setting for signalling between ends. The setting will depend on the MUX electrical interface, set 64kbit/s for G.703 and X.21, or generally 56kbit/s for V.35. For direct fiber connection between IED's, 64kbit/s will offer slightly faster data transmission. The setting is invisible when IEEE C37.94 Comm Mode is selected.				
Baud Rate Ch2	20	12	64kbits/s	0 = 64kbits/s or 1 = 56kbits/s
Channel 2 data rate setting for signalling between ends. The setting will depend on the MUX electrical interface, set 64kbit/s for G.703 and X.21, or generally 56kbit/s for V.35. For direct fiber connection between IED's, 64kbit/s will offer slightly faster data transmission. The setting is invisible when IEEE C37.94 Comm Mode is selected.				
Clock Source Ch1	20	13	Internal	0 = Internal or 1 = External
Setting that defines which clock source is used to synchronize data transmissions over channel 1. The setting will depend on communications configuration and external clock source availability. If IED's are connected direct fiber over channel 1, 'Internal' setting should be selected. If channel 1 is routed via a multiplexer, either setting may be required (see Application Notes).				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Clock Source Ch2	20	14	Internal	0 = Internal or 1 = External
Setting that defines which clock source is used to synchronize data transmissions over channel 2. The setting will depend on communications configuration and external clock source availability. If IED's are connected direct fiber over channel 2, 'Internal' setting should be selected. If channel 2 is routed via a multiplexer, either setting may be required (see Application Notes).				
Ch1 N*64kbits/s	20	15	1	0 = Auto, 1 = 1, 2 = 2, 3 = 3, 4 = 4, 5 = 5, 6 = 6, 7 = 7, 8 = 8, 9 = 9, 10 = 10, 11 = 11 or 12 = 12
Setting for channel 1 when connected to MUX. When set to 'Auto' IED will configure itself to match the multiplexer. The setting is visible only when IEEE C37.94 Comm Mode is selected.				
Ch2 N*64kbits/s	20	16	1	0 = Auto, 1 = 1, 2 = 2, 3 = 3, 4 = 4, 5 = 5, 6 = 6, 7 = 7, 8 = 8, 9 = 9, 10 = 10, 11 = 11 or 12 = 12
Setting for channel 2 when connected to MUX. When set to 'Auto' IED will configure itself to match the multiplexer. The setting is visible only when IEEE C37.94 Comm Mode is selected.				
Comm Fail Timer	20	18	10	0.1s to 600s step 0.1s
Time delay after which the 'Channel Fail Alarm' will be issued providing that no messages were received during the 'Channel Timeout' period or the 'Alarm Level' is exceeded.				
Comm Fail Mode	20	19	Ch 1 or 2 Fail	0 = Ch 1 Failure 1 = Ch 2 Failure 2 = Ch 1 or 2 Fail 3 = Ch 1 and 2 Fail
Fail mode setting that triggers the 'Channel Fail Alarm', providing that the Dual Redundancy or 3 ended scheme is set. Normally the alarm would be raised for any loss of an operational channel (logical OR combination). However, when IED's in a 3 ended scheme are deliberately operated in Chain topology AND logic may be used, for indication when the scheme becomes finally inoperative, with no self-healing (signal rerouting) mode possible.				
Channel Timeout	20	1E	0.1	0.1s to 10s step 0.1s
A rolling time window beyond which any of the 8 IM signals that are set to 'Default' will be replaced by the corresponding 'IM_X Default Value' setting, providing that no valid message is received on that channel in the meantime. The 'Chnl Fail Alarm' timer will be also initiated. If only one channel is used, each out of 16 IM signals available that is set to 'Default' will convert to corresponding 'IM_X Default Value' If a Dual redundant or 3 ended scheme is selected, each out of 8 IM signals available that is set to 'Default' will convert to corresponding 'IM_X Default Value', but only for the affected channel.				
IM Msg Alarm Lvl	20	1F	25	0 to 100 step 0.1
Setting that is used to alarm for poor channel quality. If during a fixed 100 ms rolling window the number of invalid messages divided by the total number of messages that should be received (based upon the 'Baud Rate' setting) increase above the threshold, a 'Channel Fail Alarm' timer will be initiated.				
Prop Delay Stats	20	20	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) the alarms of Maximum propagation delay time				
MaxCh 1 PropDelay	20	21	0.015	0.001s to 0.05s step 0.001s
When the protection communications are enabled, the overall propagation delay divided by 2 is calculated and the maximum value is determined and displayed in Measurements 4 column. This value is displayed and compared against this setting. If the setting is exceeded, an alarm MaxCh1 PropDelay (DDB 1386) is raised.				
MaxCh 2 PropDelay	20	22	0.015	0.001s to 0.05s step 0.001s
When the protection communications are enabled, the overall propagation delay divided by 2 is calculated and the maximum value is determined and displayed in Measurements 4 column. This value is displayed and compared against this setting. If the setting is exceeded, an alarm MaxCh2 PropDelay (DDB 1387) is raised.				
IM1 Cmd Type	20	30	Permissive	0 = Direct or 1 = Permissive
Setting that defines the operative mode of the received InterMiCOM_1 signal. When 'Direct' tripping is chosen, for security reasons 2 consecutive valid messages have to be received before a change in the signal status will be acknowledged. That will impose an additional 1-2 ms delay comparing to 'Permissive' mode. Set 'Direct' in Direct Transfer Tripping (Intertripping) applications. Set 'Permissive' to accommodate any Permissive or Blocking scheme.				
IM1 FallBackMode	20	31	Default	0 = Default or 1 = Latched

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Setting that defines the status of IM1 signal in case of heavy noise and message synchronization being lost. If set to Latching the last valid IM1 status will be maintained until the new valid message is received. If set to Default, the IM1 status, pre-defined by the user in IM1 Default Value cell will be set. A new valid message will replace IM1 Default Value, once the channel recovers.				
IM1 DefaultValue	20	32	0	0 to 1 step 1
Setting that defines the IM1 fallback status.				
IM2 Cmd Type	20	34	Permissive	0 = Direct or 1 = Permissive
Setting that defines the operative mode of the received InterMiCOM_2 signal. When 'Direct' tripping is chosen, for security reasons 2 consecutive valid messages have to be received before a change in the signal status will be acknowledged. That will impose an additional 1-2 ms delay comparing to 'Permissive' mode. Set 'Direct' in Direct Transfer Tripping (Intertripping) applications. Set 'Permissive' to accommodate any Permissive or Blocking scheme.				
IM2 FallBackMode	20	35	Default	0 = Default or 1 = Latched
Setting that defines the status of IM2 signal in case of heavy noise and message synchronization being lost. If set to Latching the last valid IM2 status will be maintained until the new valid message is received. If set to Default, the IM2 status, pre-defined by the user in IM2 Default Value cell will be set. A new valid message will replace IM2 Default Value, once the channel recovers.				
IM2 DefaultValue	20	36	0	0 to 1 step 1
Setting that defines the IM2 fallback status.				
IM3 Cmd Type	20	38	Permissive	0 = Direct or 1 = Permissive
Setting that defines the operative mode of the received InterMiCOM_3 signal. When 'Direct' tripping is chosen, for security reasons 2 consecutive valid messages have to be received before a change in the signal status will be acknowledged. That will impose an additional 1-2 ms delay comparing to 'Permissive' mode. Set 'Direct' in Direct Transfer Tripping (Intertripping) applications. Set 'Permissive' to accommodate any Permissive or Blocking scheme.				
IM3 FallBackMode	20	39	Default	0 = Default or 1 = Latched
Setting that defines the status of IM3 signal in case of heavy noise and message synchronization being lost. If set to Latching the last valid IM3 status will be maintained until the new valid message is received. If set to Default, the IM3 status, pre-defined by the user in IM3 Default Value cell will be set. A new valid message will replace IM3 Default Value, once the channel recovers.				
IM3 DefaultValue	20	3A	0	0 to 1 step 1
Setting that defines the IM3 fallback status.				
IM4 Cmd Type	20	3C	Permissive	0 = Direct or 1 = Permissive
Setting that defines the operative mode of the received InterMiCOM_4 signal. When 'Direct' tripping is chosen, for security reasons 2 consecutive valid messages have to be received before a change in the signal status will be acknowledged. That will impose an additional 1-2 ms delay comparing to 'Permissive' mode. Set 'Direct' in Direct Transfer Tripping (Intertripping) applications. Set 'Permissive' to accommodate any Permissive or Blocking scheme.				
IM4 FallBackMode	20	3D	Default	0 = Default or 1 = Latched
Setting that defines the status of IM4 signal in case of heavy noise and message synchronization being lost. If set to Latching the last valid IM4 status will be maintained until the new valid message is received. If set to Default, the IM4 status, pre-defined by the user in IM4 Default Value cell will be set. A new valid message will replace IM4 Default Value, once the channel recovers.				
IM4 DefaultValue	20	3E	0	0 to 1 step 1
Setting that defines the IM4 fallback status.				
IM5 Cmd Type	20	40	Permissive	0 = Direct or 1 = Permissive
Setting that defines the operative mode of the received InterMiCOM_5 signal. When 'Direct' tripping is chosen, for security reasons 2 consecutive valid messages have to be received before a change in the signal status will be acknowledged. That will impose an additional 1-2 ms delay comparing to 'Permissive' mode. Set 'Direct' in Direct Transfer Tripping (Intertripping) applications. Set 'Permissive' to accommodate any Permissive or Blocking scheme.				
IM5 FallBackMode	20	41	Default	0 = Default or 1 = Latched

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Setting that defines the status of IM5 signal in case of heavy noise and message synchronization being lost. If set to Latching the last valid IM5 status will be maintained until the new valid message is received. If set to Default, the IM5 status, pre-defined by the user in IM5 Default Value cell will be set. A new valid message will replace IM5 Default Value, once the channel recovers.				
IM5 DefaultValue	20	42	0	0 to 1 step 1
Setting that defines the IM5 fallback status.				
IM6 Cmd Type	20	44	Permissive	0 = Direct or 1 = Permissive
Setting that defines the operative mode of the received InterMiCOM_6 signal. When 'Direct' tripping is chosen, for security reasons 2 consecutive valid messages have to be received before a change in the signal status will be acknowledged. That will impose an additional 1-2 ms delay comparing to 'Permissive' mode. Set 'Direct' in Direct Transfer Tripping (Intertripping) applications. Set 'Permissive' to accommodate any Permissive or Blocking scheme.				
IM6 FallBackMode	20	45	Default	0 = Default or 1 = Latched
Setting that defines the status of IM6 signal in case of heavy noise and message synchronization being lost. If set to Latching the last valid IM6 status will be maintained until the new valid message is received. If set to Default, the IM6 status, pre-defined by the user in IM6 Default Value cell will be set. A new valid message will replace IM6 Default Value, once the channel recovers.				
IM6 DefaultValue	20	46	0	0 to 1 step 1
Setting that defines the IM6 fallback status.				
IM7 Cmd Type	20	48	Permissive	0 = Direct or 1 = Permissive
Setting that defines the operative mode of the received InterMiCOM_7 signal. When 'Direct' tripping is chosen, for security reasons 2 consecutive valid messages have to be received before a change in the signal status will be acknowledged. That will impose an additional 1-2 ms delay comparing to 'Permissive' mode. Set 'Direct' in Direct Transfer Tripping (Intertripping) applications. Set 'Permissive' to accommodate any Permissive or Blocking scheme.				
IM7 FallBackMode	20	49	Default	0 = Default or 1 = Latched
Setting that defines the status of IM7 signal in case of heavy noise and message synchronization being lost. If set to Latching the last valid IM7 status will be maintained until the new valid message is received. If set to Default, the IM7 status, pre-defined by the user in IM7 Default Value cell will be set. A new valid message will replace IM7 Default Value, once the channel recovers.				
IM7 DefaultValue	20	4A	0	0 to 1 step 1
Setting that defines the IM7 fallback status.				
IM8 Cmd Type	20	4C	Permissive	0 = Direct or 1 = Permissive
Setting that defines the operative mode of the received InterMiCOM_8 signal. When 'Direct' tripping is chosen, for security reasons 2 consecutive valid messages have to be received before a change in the signal status will be acknowledged. That will impose an additional 1-2 ms delay comparing to 'Permissive' mode. Set 'Direct' in Direct Transfer Tripping (Intertripping) applications. Set 'Permissive' to accommodate any Permissive or Blocking scheme.				
IM8 FallBackMode	20	4D	Default	0 = Default or 1 = Latched
Setting that defines the status of IM8 signal in case of heavy noise and message synchronization being lost. If set to Latching the last valid IM8 status will be maintained until the new valid message is received. If set to Default, the IM8 status, pre-defined by the user in IM8 Default Value cell will be set. A new valid message will replace IM8 Default Value, once the channel recovers.				
IM8 DefaultValue	20	4E	0	0 to 1 step 1
Setting that defines the IM8 fallback status.				

Table 27: PROT COMMS/IM64 column

3.25 Cyber Security Configuration

The SECURITY CONFIG column contains all settings related to the NERC-compliant cyber security features. These include settings to do with password control as well as settings to allow the possibility of disabling physical ports.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
SECURITY CONFIG	25	0	0	0
This column contains settings for Security Config				
User Banner	25	1	ACCESS ONLY FOR AUTHORISED USERS	ASCII 32 to 234
NERC compliant user IED description				
Attempts Limit	25	2	3	0 to 3 step 1
Defines the maximum number of failed password attempts.				
Attempts Timer	25	3	2	1 to 3 step 1
Defines the time duration used for detection of maximum failed password attempts				
Blocking Timer	25	4	5	1 to 30 step 1
Defines the time duration for which the user is blocked after exceeding the maximum attempts limit				
Front Port	25	5	Enabled	0 = Disabled or 1 = Enabled
Enable/disable of Physical Front Port				
Rear Port 1	25	6	Enabled	0 = Disabled or 1 = Enabled
Enable/disable of Physical Rear Port 1				
Rear Port 2	25	7	Enabled	0 = Disabled or 1 = Enabled
Enable/disable of Physical Rear Port 2				
Ethernet Port	25	8	Enabled	0 = Disabled or 1 = Enabled
Enable/disable of Physical Ethernet Port				
Courier Tunnel	25	9	Enabled	0 = Disabled or 1 = Enabled
Enable/disable of Logical Tunnelled courier Port				
IEC61850	25	0A	Enabled	0 = Disabled or 1 = Enabled
Enable/disable of Logical IEC61850 Port				
DNP3 OE	25	0B	Enabled	0 = Disabled or 1 = Enabled
Enable/disable of Logical DNP3 OverEthernet Port				
Attempts Remain	25	11	0	0
Number of password attempts remaining				
Blk Time Remain	25	12	0	0
Blocking time remaining				
Fallback Level	25	20	0	0 = Password Level 0, 1 = Password Level 1, 2 = Password Level 2, 3 = Password Level 3
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	0	0
16 character security code required when requesting a recovery password.				

Table 28: SECURITY CONFIG column

3.26 Control Input Labels

Each control input may have a 16 character label associated with it. The CTRL I/P LABELS column contains settings that allow you to specify these labels.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
CTRL I/P LABELS	29	0	0	
This column contains settings for Control Input Labels				
Control Input 1	29	1	Control Input 1	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 2	29	2	Control Input 2	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 3	29	3	Control Input 3	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 4	29	4	Control Input 4	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 5	29	5	Control Input 5	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 6	29	6	Control Input 6	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 7	29	7	Control Input 7	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 8	29	8	Control Input 8	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 9	29	9	Control Input 9	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 10	29	0A	Control Input 10	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 11	29	0B	Control Input 11	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 12	29	0C	Control Input 12	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 13	29	0D	Control Input 13	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 14	29	0E	Control Input 14	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 15	29	0F	Control Input 15	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 16	29	10	Control Input 16	32 to 163 step 1

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 17	29	11	Control Input 17	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 18	29	12	Control Input 18	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 19	29	13	Control Input 19	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 20	29	14	Control Input 20	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 21	29	15	Control Input 21	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 22	29	16	Control Input 22	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 23	29	17	Control Input 23	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 24	29	18	Control Input 24	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 25	29	19	Control Input 25	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 26	29	1A	Control Input 26	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 27	29	1B	Control Input 27	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 28	29	1C	Control Input 28	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 29	29	1D	Control Input 29	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 30	29	1E	Control Input 30	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 31	29	1F	Control Input 31	32 to 163 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 32	29	20	Control Input 32	32 to 163 step 1

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				

Table 29: CTRL I/P LABELS column

3.27 PSL Data

The PSL DATA column contains cells that display information relating to the PSL scheme used in each of the settings groups. The items that can be displayed are the PSL reference, ID, and the Date and Time that the scheme was downloaded to the device or the default was restored.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
PSL DATA	B7	0	0	
0				
Grp1 PSL Ref	B7	1	0	
User settable PSL reference during PSL file download				
Date/Time	B7	2	0	
Date and Time of when PSL file was downloaded or when firmware was downloaded/default settings restored				
Grp1 PSL ID	B7	3	0	
CRC of Group 1 PSL file				
Grp2 PSL Ref	B7	11	0	
User settable PSL reference during PSL file download				
Date/Time	B7	12	0	
Date and Time of when PSL file was downloaded or when firmware was downloaded/default settings restored				
Grp2 PSL ID	B7	13	0	
CRC of Group 2 PSL file				
Grp3 PSL Ref	B7	21	0	
User settable PSL reference during PSL file download				
Date/Time	B7	22	0	
Date and Time of when PSL file was downloaded or when firmware was downloaded/default settings restored				
Grp3 PSL ID	B7	23	0	
CRC of Group 3 PSL file				
Grp4 PSL Ref	B7	31	0	
User settable PSL reference during PSL file download				
Date/Time	B7	32	0	
Date and Time of when PSL file was downloaded or when firmware was downloaded/default settings restored				
Grp4 PSL ID	B7	33	0	
CRC of Group 4 PSL file				

Table 30: PSL DATA column

3.28 User Curves Data

The USER CURVES DATA column contains cells that display information relating to the user curves. The items that can be displayed are the curve name and version and the date and time it was created. The only settable items are the curve versions (1.0 for Operate and 1.1 for Reset) and a command for restoring the default curve.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
USER CURVES DATA	B8	0	0	
This column contains settings for User Curve Data				
Curve 1 Name	B8	1	Default Curve 1	
Name entered when curve downloaded				
Date & Time	B8	2	0	
Date and Time of when curve was downloaded or when firmware was downloaded/default settings restored				
Curve 1 ID	B8	3	0	
CRC of curve 1				
UserCurve 1 Type	B8	4	Operate 1.0	0 = Operate 1.0 or 1 = Reset 1.1
Defines the user curve template, either operate or reset				
Curve 2 Name	B8	11	Default Curve 2	
Name entered when curve downloaded				
Date & Time	B8	12	0	
Date and Time of when curve was downloaded or when firmware was downloaded/default settings restored				
Curve 2 ID	B8	13	0	
CRC of curve 2				
UserCurve 2 Type	B8	14	Operate 1.0	0 = Operate 1.0 or 1 = Reset 1.1
Defines the user curve template, either operate or reset				
Curve 3 Name	B8	21	Default Curve 3	
Name entered when curve downloaded				
Date & Time	B8	22	0	
Date and Time of when curve was downloaded or when firmware was downloaded/default settings restored				
Curve 3 ID	B8	23	0	
CRC of curve 3				
UserCurve 3 Type	B8	24	Reset 1.1	0 = Operate 1.0 or 1 = Reset 1.1
Defines the user curve template, either operate or reset				
Curve 4 Name	B8	31	Default Curve 4	
Name entered when curve downloaded				
Date & Time	B8	32	0	
Date and Time of when curve was downloaded or when firmware was downloaded/default settings restored				
Curve 4 ID	B8	33	0	
CRC of curve 4				
UserCurve 4 Type	B8	34	Reset 1.1	0 = Operate 1.0 or 1 = Reset 1.1
Defines the user curve template, either operate or reset				
Restore Def Crv	B8	F0	0	0 = No Operation, 1 = Default Curve 1, 2 = Default Curve 2, 3 = Default Curve 3, 4 = Default Curve 4
0				

Table 31: USER CURVES DATA column

4 PROTECTION GROUP SETTINGS

There are four groups of protection settings, with each group containing the same setting cells. This allows you to have four different configuration schemes. Only one group of protection settings can be selected as the active group. The active group is used by the protection elements. GROUP 1 is the default group.

The protection settings can be enabled or disabled by a setting in the CONFIGURATION column. This acts like a master switch, so if a setting is disabled, it is made invisible on the HMI panel and can no longer be set. The setting cells that are enabled in the CONFIGURATION column are visible in all GROUP settings.

Column Header	Column No.
GROUP 1 LINE PARAMETERS	30
GROUP 1 DISTANCE SETUP	31
GROUP 1 DIST. ELEMENTS	32
GROUP 1 DEFROST PROT.	33
GROUP 1 SCHEME LOGIC	34
GROUP 1 OVERCURRENT	35
GROUP 1 PANTO FLASH OVER	36
GROUP 1 THERMAL OVERLOAD	3C
GROUP 1 VOLTAGE PROTECTION	42
GROUP1 CB FAIL & P.DEAD	45
GROUP 1 SUPERVISION	46
GROUP 1 SYSTEM CHECKS	48
GROUP 1 AUTORECLOSE	49
GROUP 1 INPUT LABELS	4A
GROUP 1 OUTPUT LABELS	4B

Table 32: Protection Group settings columns

The above columns are also applicable to Settings Groups 2, 3 and 4 but with the addresses as follows:

- GROUP 2: Column address starts at 50
- GROUP 3: Column address starts at 70
- GROUP 4: Column address starts at 90

4.1 Line Parameters

The GROUP 1 LINE PARAMETERS column is used to enter the settings used by the fault locator as the base data for input to the distance to fault algorithm, and also as the reference for all distance zones when the Distance set up is preferred in the 'Simple' setting mode. It also accommodates the system phase rotation and defines the single or three pole tripping mode.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 LINE PARAMETERS	30	0	0	
This column contains settings for Line Parameters				
Line Length (metres)	30	1	100000	300 to 1000000 step 10
Setting of the protected line/cable length in km. This setting is available if MEASURE'T SETUP column is selected as Visible in the CONFIGURATION column and if Distance unit in the MEASURE'T SETUP column is selected as kilometres				
Line Length (miles)	30	2	62.1	0.2 to 625 step 0.005 / 0.01
Setting of the protected line/cable length in miles. This setting is available if Distance unit in the MEASURE'T SETUP column is selected as miles. Dual step size is provided, for cables/short lines up to 10 miles the step size is 0.005 miles, 0.01 miles otherwise				
CAT Impedance	30	3	10	0.05/In to 500/(In*% reach) step 0.01/In (Ohms)
Setting for protected catenary positive sequence impedance in either primary or secondary terms, depending on the Setting Values reference chosen in the CONFIGURATION column. The set value is used for Fault locator, and for all distance zone reaches calculation.				
CAT Angle	30	4	70	20 to 90 step 1
Setting of the catenary angle (catenary positive sequence impedance angle).				
FDR Impedance	30	5	10	0.05/In to 500/(In*% reach) step 0.01/In (Ohms)
Setting for protected feeder positive sequence impedance in either primary or secondary terms, depending on the Setting Values reference chosen in the CONFIGURATION column. The set value is used for Fault locator, and for all distance zone reaches calculation.				
FDR Angle	30	6	70	20 to 90 step 1
Setting of the feeder angle (feeder positive sequence impedance angle).				
CAT-FDR Impedance	30	8	10	0.05/In to 500/(In*% reach) step 0.01/In (Ohms)
Setting for protected catenary-feeder positive sequence impedance in either primary or secondary terms, depending on the Setting Values reference chosen in the CONFIGURATION column. The set value is used for Fault locator, and for all distance zone reaches calculation.				
CAT-FDR Angle	30	9	70	20 to 90 step 1
Setting of the catenary-feeder angle (feeder positive sequence impedance angle).				
Tripping Mode	30	0C	All Pole	0 = All Pole, 1 = Single and All Pole
This setting is used to select the tripping mode. The selection Single and All pole allows single pole tripping for single phase to ground faults, whilst selection All pole converts any trip command(s) to All pole tripping.				

Table 33: GROUP 1 LINE PARAMETERS column

4.2 Distance Setup

The GROUP 1 DISTANCE SETUP column is used to set up the parameters required for distance protection, where applicable.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 DISTANCE SETUP	31	0	0	
This column contains settings for Distance Setup				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
PHASE DISTANCE	31	10	0	
This is a sub heading				
Phase Chars.	31	11	Disable	0 = Disabled, 1 = Quadrilateral
Setting to disable (turn off) phase distance protection or to set Quad operating characteristic: ANSI 21. The chosen setting is applicable to all phase distance zones.				
Zone 1 Ph Status	31	20	Disable	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) Zone 1 for phase faults. This setting is invisible if ‘Phase Char.’ is disabled.				
Zone 2 Ph Status	31	30	Disable	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) Zone 2 for phase faults. This setting is invisible if ‘Phase Char.’ is disabled.				
Zone 3 Ph Status	31	40	Disable	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) Zone 3 for phase faults. This setting is invisible if ‘Phase Char.’ is disabled.				
Zone 3 Ph Dir.	31	42	Offset	0 = Forward, 1 = Offset, 2 = Reverse
To directionalise Zone 3, forward, offset or reverse, for phase faults. By default, Zone 3 phase characteristic is offset (partly reverse directional), thus self polarized. If set forward or reverse, Zone 3 characteristic becomes memory/cross polarized like all other zones.				
Zone P Ph Status	31	50	Disabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) Zone P for phase faults. This setting is invisible if ‘Phase Char.’ is disabled.				
Zone P Ph Dir.	31	51	Forward	0 = Forward, 1 = Reverse, 2 = Offset
To directionalise Zone P, forward, reverse or offset, for phase faults. By default, Zone P phase characteristic is Forward, thus memory/cross polarized like all other zones. Likewise if set reverse. If Zone P phase characteristic is offset (partly reverse directional), self polarization is used.				
Zone 4 Ph Status	31	60	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) Zone 4 for phase faults. This setting is invisible if ‘Phase Char.’ is disabled.				
GROUND DISTANCE	31	70	0	
This is a sub heading				
Ground Chars.	31	71	Quad	0 = Disabled, 1 = Quadrilateral
Setting to disable (turn off) ground distance protection or to set Quad operating characteristic: ANSI 21N. The chosen setting is applicable to all ground distance zones.				
Zone 1 Gnd Stat.	31	80	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) Zone 1 for ground faults. This setting is invisible if ‘Ground Char.’ is disabled.				
Zone 2 Gnd Stat.	31	90	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) Zone 2 for ground faults. This setting is invisible if ‘Ground Char.’ is disabled.				
Zone 3 Gnd Stat.	31	A0	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) Zone 3 for ground faults. This setting is invisible if ‘Ground Char.’ is disabled.				
Zone 3 Gnd Dir.	31	A2	Offset	0 = Forward, 1 = Offset, 2 = Reverse
To directionalise Zone 3, forward, offset or reverse, for ground faults. By default, Zone 3 ground characteristic is offset (partly reverse directional), thus self polarized. If set forward or reverse, Zone 3 characteristic becomes memory/cross polarized like all other zones.				
Zone P Gnd Stat.	31	B0	Disabled	0 = Disabled, 1 = Normal Mode or 2= WPC Mode

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
To disable (turn off) or if enable (activate), choose between distance Zone P for ground faults (normal mode) or Zone for Wrong phase Coupling Protection function. This setting is invisible if 'Ground Char.' is disabled.				
Zone P Gnd Dir.	31	B1	Forward	0 = Forward, 1 = Reverse, 2 = Offset
To directionalise Zone P, forward, reverse or offset, for ground faults. By default, Zone P ground characteristic is Forward, thus memory/cross polarized like all other zones. Likewise if set reverse. If Zone P phase characteristic is offset (partly reverse directional), self polarization is used.				
Zone 4 Gnd Stat.	31	C0	Enabled	0 = Disabled or 1 = Enabled
To enable (activate) or disable (turn off) Zone 4 for ground faults. This setting is invisible if 'Ground Char.' is disabled.				
Digital Filter	31	D0	Standard	0 = Standard or 1 = Special Applics.
Setting to enable (activate) 'Standard' or 'Special Application' filters. 'Standard' filters are the default setting and should be applied in the majority of applications. It is only the case when the fault currents and voltages may become very distorted by non-fundamental harmonics that extra filtering is necessary to avoid transient over-reach. In such system conditions the 'Special Applications' setting should be applied.				
CVT Filters	31	D1	Disabled	0 = Disabled, 1 = Passive, 2 = Active
Setting that accommodates the type of voltage transformer being used to prevent transient over-reach and preserve sub-cycle operating time whenever possible. In case of conventional wound VTs, the transients due to voltage collapse during faults are very small and no extra filtering is required, therefore the setting should be 'Disabled' as per default. For a CVT with active Ferro resonance damping, the voltage distortions may be severe and risk transient over-reach. For that reason, the 'CVT Filters' should be set to 'Active'. Trip times increase proportionally (subcycle up to SIR = 2, gradually lengthening for SIR up to 30). For a CVT with passive Ferro resonance damping, the voltage distortions are generally small up to SIR of 30. For such applications, 'CVT Filters' should be set 'Passive'. The IED calculates the SIR and will take marginally longer to trip if the infeed is weak (exceeds the IED's SIR setting).				
SIR Setting	31	D2	30	5 to 60 step 1
Setting that determines when extra filtering will be applied. If on fault inception the calculated SIR exceeds the 'SIR Setting' the IED will marginally slow down, as otherwise there would be a risk of over-reach. This setting is visible only when 'CVT Filters' is set to 'Passive'.				
Load Blinders	31	D3	Disabled	0 = Disabled or 1 = Enabled
Setting used to activate (enable) or turn off (disable) load blinders. Load blinders, when enabled, have two main purposes: to prevent tripping due to load encroachment under heavy load condition and detect very slow moving power swings.				
Z< Blinder Imp	31	D4	15	0.1/In Ω to 500/In Ω step 0.01/In Ω
Setting of radius of under-impedance circle.				
Load/B Angle	31	D5	45	15 to 65 step 1
Angle setting for the two blinder lines boundary with the gradient of the rise or fall with respect to the resistive axis.				
Load Blinder V<	31	D6	15	1V to 70V step 0.5V
Load blinder phase to ground under-voltage setting that overrides the blinder if the measured voltage in the affected phase falls below setting. Also overrides blinding of phase-phase loops where the phase-phase voltage falls below $\sqrt{3}$ x (V< setting).				
Dist. Polarizing	31	D7	1	0.2 to 5 step 0.1
The setting defines the composition of polarizing voltage as a mixture of 'Self' and 'Memory' polarizing voltage. 'Self' polarized voltage is fixed to 1pu and could be mixed with 'Memory' polarizing voltage ranging from 0.2pu up to 5pu. The default setting of 1 means that half of the polarizing voltage is made up from 'Self' and the other half from clean 'Memory' voltage.				
DELTADIRECTIONAL	31	E0	0	
This is a sub heading				
Dir. Status	31	E1	Enabled	0 = Disabled or 1 = Enabled
Setting used to enable or disable Delta Direction: ANSI 78DCB/78DCUB. To enable or disable the delta direction decision used by distance elements. If disabled, the IED uses conventional (non delta) directional lines.				
Dir. Char Angle	31	E3	60	0 to 90 step 1
Setting for the IED characteristic angle used for the delta directional decision.				
Z2 Op.Mode dx/dt	31	F1	Without	0 = Without, 1 = AND or 2 = OR

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Setting used to choose the operation mode of Train Start-Up detection in distance Zone 2.				
Z2Delta I(di/dt)	31	F2	Block	0 = Block or 1 = Enabled
Setting used to enable or block the Delta di/dt element operation in Zone 2.				
Z2Delta V(dv/dt)	31	F3	Block	0 = Block or 1 = Enabled
Setting used to enable or block the Delta dv/dt element operation in Zone 2.				
Z2D.phi(dphi/dt)	31	F4	Block	0 = Block or 1 = Enabled
Setting used to enable or block the Delta dphi/dt element operation in Zone 2.				
Z3 Op.Mode dx/dt	31	F5	Without	0 = Without, 1 = AND or 2 = OR
Setting used to choose the operation mode of Train Start-Up detection in distance Zone 2.				
Z3Delta I(di/dt)	31	F6	Block	0 = Block or 1 = Enabled
Setting used to enable or block the Delta di/dt element operation in Zone 3.				
Z3Delta V(dv/dt)	31	F7	Block	0 = Block or 1 = Enabled
Setting used to enable or block the Delta dv/dt element operation in Zone 3.				
Z3D.phi(dphi/dt)	31	F8	Block	0 = Block or 1 = Enabled
Setting used to enable or block the Delta dphi/dt element operation in Zone 3.				
Delta Imin	31	F9	0.2 In	0.1 In to 10 In step 0.01 In
Setting used to set the minimum current trigger for Train Start-Up detection.				
Delta I	31	FA	0.1A	0.1 In to 10 In step 0.01 In
Setting used to set the threshold for current change detection.				
Delta V	31	FB	4 V	0.5V to 30V step 0.1V
Setting used to set the threshold for voltage drop detection.				
Delta Phi	31	FC	30 deg	5 to 90 step 1
Setting used to set the threshold for angle change detection.				
Delta Phi	31	FC	30 deg	5 to 90 step 1
Setting used to set the threshold for angle change detection.				

Table 34: GROUP 1 DISTANCE SETUP column

4.3 Distance Elements

In advanced mode, the GROUP 1 DIST. ELEMENTS column is used to individually set parameters such as the reaches, line angles and compensation factors:

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 DIST. ELEMENTS	32	0	0	
This column contains settings for Distance Elements				
PHASE DISTANCE	32	1	0	
This is a sub heading				
Z1 Ph. Reach	32	2	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z1 reach.				
Z1 Ph. Angle	32	3	70	20 to 90 step 1
Setting of line angle for zone 1.				
R1 Phase RH Res.	32	6	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z1 right resistive reach. This setting is only visible if Quad is selected.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
R1 Phase LH Res.	32	7	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z1 left resistive reach. This setting is only visible if Quad is selected.				
Z1 Tilt Top Line	32	8	-3	-30 to 30 step 1
Setting of Z1 top reactance line gradient to avoid over-reach for resistive phase faults under heavy load. Minus angle tilts the reactance line downwards.				
Z1 Sensit. Iph>1	32	9	0.075	0.05*In to 2*In step 0.005*In
Current sensitivity setting for Z1 that must be exceeded in faulted phases if Z1 is to operate.				
Z2 Ph. Reach	32	10	15	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z2 reach.				
Z2 Ph. Angle	32	11	70	20 to 90 step 1
Setting of line angle for zone 2.				
R2 Phase RH Res.	32	14	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z2 right resistive reach. This setting is only visible if Quad is selected.				
R2 Phase LH Res.	32	15	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z2 left resistive reach. This setting is only visible if Quad is selected.				
Z2 Tilt Top Line	32	16	-3	-30 to 30 step 1
Setting of Z2 top reactance line gradient.				
Z2 Sensit. Iph>2	32	17	0.075	0.05*In to 2*In step 0.005*In
Zone 2 current sensitivity.				
Z3 Ph. Reach	32	20	25	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z3 reach.				
Z3 Ph. Angle	32	21	70	20 to 90 step 1
Setting of line angle for zone 3.				
Z3' Ph Rev Reach	32	22	1	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z3 offset (reverse) reach. This setting is only visible if ‘Z3 Offset’ is enabled in ‘GROUP x DISTANCE SETUP’.				
R3 Phase RH Res.	32	25	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z3 right resistive reach. This setting is only visible if Quad is selected.				
R3 Phase LH Res.	32	26	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z3 left resistive reach. This setting is only visible if Quad is selected.				
Z3 Tilt Top Line	32	27	-3	-30 to 30 step 1
Setting of Z3 top reactance line gradient.				
Z3 Sensit. Iph>3	32	28	0.05	0.05*In to 2*In step 0.005*In
Zone 3 current sensitivity.				
ZP Ph. Reach	32	30	20	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for ZP reach.				
ZP Ph. Angle	32	31	70	20 to 90 step 1
Setting of line angle for zone P.				
ZP' Ph Rev Reach	32	32	1	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for ZP reach.				
RP Phase RH Res.	32	33	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for ZP right resistive reach. This setting is only visible if Quad is selected.				
RP Phase LH Res.	32	35	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for ZP left resistive reach. This setting is only visible if Quad is selected.				
ZP Tilt Top Line	32	36	-3	-30 to 30 step 1

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Setting of ZP top reactance line gradient.				
ZP Sensit. Iph>P	32	37	0.05	0.05*In to 2*In step 0.005*In
Zone P current sensitivity.				
Z4 Ph. Reach	32	40	15	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z4 reach. This is a common setting for Z4 time delayed and Z4 high speed elements used in blocking schemes and for current reversal guard.				
Z4 Ph. Angle	32	41	70	20 to 90 step 1
Setting of line angle for zone 4.				
R4 Phase RH Res.	32	42	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z4 right resistive reach. This setting is only visible if Quad is selected.				
R4 Phase LH Res.	32	43	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z4 left resistive reach. This setting is only visible if Quad is selected.				
Z4 Tilt Top Line	32	45	-3	-30 to 30 step 1
Setting of Z4 top reactance line gradient.				
Z4 Sensit. Iph>4	32	46	0.05	0.05*In to 2*In step 0.005*In
Zone P current sensitivity.				
GROUND DISTANCE	32	50	0	
This is a sub heading				
Z1 Gnd. Reach	32	51	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z1 reach.				
Z1 Gnd. Angle	32	52	70	20 to 90 step 1
Setting of line angle (positive sequence) for zone 1.				
Z1 Tilt Top Line	32	54	-3	-30 to 30 step 1
Setting of the zone 1 tilt angle. Minus angle tilts the reactance line downwards This setting is visible only when the above setting is visible.				
R1 Gnd RH Res.	32	59	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z1 ground right resistive reach. This setting is only visible if Quad is selected.				
R1 Gnd LH Res.	32	5A	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z1 ground left resistive reach. This setting is only visible if Quad is selected.				
Z1 Sensit Ignd>1	32	5B	0.075	0.05*In to 2*In step 0.005*In
Current sensitivity setting for Z1 that must be exceeded in faulted phase and the neutral if Z1 is to operate.				
Z2 Gnd. Reach	32	60	15	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z2 reach.				
Z2 Gnd. Angle	32	61	70	20 to 90 step 1
Setting of line angle (positive sequence) for zone 2.				
Z2 Tilt Top Line	32	64	-3	-30 to 30 step 1
Setting of the zone 2 tilt angle. Minus angle tilts the reactance line downwards This setting is visible only when the above setting is visible.				
R2 Gnd RH Res.	32	69	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z2 ground right resistive reach. This setting is only visible if Quad is selected.				
R2 Gnd LH Res.	32	6A	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z2 ground left resistive reach. This setting is only visible if Quad is selected.				
Z2 Sensit Ignd>2	32	6B	0.075	0.05*In to 2*In step 0.005*In
Zone 2 current sensitivity.				
Z3 Gnd. Reach	32	70	25	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z3 reach.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Z3 Gnd. Angle	32	71	70	20 to 90 step 1
Setting of line angle (positive sequence) for zone 3.				
Z3' Gnd Rev Rch	32	72	1	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z3 offset (reverse) reach. This setting is only visible if 'Z3 Offset' is enabled in 'GROUP x DISTANCE SETUP'.				
Z3 Tilt Top Line	32	74	-3	-30 to 30 step 1
Setting of the Z3 tilt angle. Minus angle tilts the reactance line downwards This setting is visible only when the above setting is visible.				
R3 Gnd RH Res.	32	79	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z3 ground right resistive reach. This setting is only visible if Quad is selected.				
R3 Gnd LH Res.	32	7A	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z3 ground left resistive reach. This setting is only visible if Quad is selected.				
Z3 Sensit Ignd>3	32	7C	0.05	0.05*In to 2*In step 0.005*In
Zone 3 current sensitivity.				
ZP Gnd. Reach	32	80	20	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for ZP reach.				
ZP Gnd. Angle	32	81	70	20 to 90 step 1
Setting of line angle (positive sequence) for zone P.				
ZP' Gnd Rev Rch	32	82	1	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z3 resistive reach that defines Quad's left hand line. This is settable only if Ground Chars. is Quad and Z3 offset is enabled otherwise is fixed to 25% of the right hand blinder.				
ZP Tilt Top Line	32	84	-3	-30 to 30 step 1
Setting of the ZP tilt angle. Minus angle tilts the reactance line downwards This setting is visible only when the above setting is visible.				
RP Gnd RH Res.	32	89	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for ZP ground right resistive reach. This setting is only visible if Quad is selected.				
RP Gnd LH Res.	32	8A	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for ZP ground left resistive reach. This setting is only visible if Quad is selected.				
ZP Sensit Ignd>P	32	8B	0.05	0.05*In to 2*In step 0.005*In
Zone P current sensitivity.				
Z4 Gnd. Reach	32	90	15	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z4 reach. This is a common setting for Z4 time delayed and Z4 high speed elements used in blocking schemes and for current reversal guard.				
Z4 Gnd. Angle	32	91	70	20 to 90 step 1
Setting of line angle (positive sequence) for zone 4.				
Z4 Tilt Top Line	32	94	-3	-30 to 30 step 1
Setting of the Z4 tilt angle. Minus angle tilts the reactance line downwards This setting is visible only when the above setting is visible.				
R4 Gnd RH Res.	32	99	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z4 ground right resistive reach. This setting is only visible if Quad is selected.				
R4 Gnd LH Res.	32	9A	8	0.05/In Ω to 500/In Ω step 0.01/In Ω
Setting for Z4 ground left resistive reach. This setting is only visible if Quad is selected.				
Z4 Sensit Ignd>4	32	9B	0.05	0.05*In to 2*In step 0.005*In
Zone 4 current sensitivity.				
WPC Line Angle	32	A0	125	90 to 180 step 1
Zone 4 Current Sensitivity.				
WPC RH Angle	32	A1	100	90 to 175 step 1
Zone 4 Current Sensitivity.				
WPC LH Angle	32	A2	150	95 to 180 step 1

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Zone 4 Current Sensitivity.				
ZWPC Min	32	A3	10	2/In Ω to 15/In Ω step 0.01/In Ω
Zone 4 Current Sensitivity.				
ZWPC Max	32	A4	30	20/In Ω to 60/In Ω step 0.01/In Ω
Zone 4 Current Sensitivity.				
Mem Volt Dura	32	B0	32	16 to 32 step 1
This setting sets the length of the voltage memory cycles.				

Table 35: GROUP 1 DIST. ELEMENTS column

4.4 Defrost Protection

The device provides a defrost protection with differential characteristics. The GROUP 1 DEFROST PROT. column is used to set the associated parameters.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 DEFROST PROT.	33	0	0	
This column contains settings for Defrost Elements				
Defrost Diff	33	1	Enabled	0 = Disabled, 1 = Enabled
Setting that defines defrost prot. operating status. Depending on this setting, Defrost Prot. will be enabled permanently.				
Idef > Is1	33	2	0.5	0.08*In to 1.00*In step 0.01*In
This setting defines the bias current threshold, above which the higher percentage bias k1 is used.				
Idef > Is2	33	3	1.25	0.10*In to 1.50*In step 0.05*In
This setting defines the bias current threshold, above which the higher percentage bias k2 is used.				
Idef > K1	33	4	0	0 to 150 step 5
The lower percentage bias setting used when the bias current is below Is2..				
Idef > K2	33	5	40	0 to 150 step 5
The higher percentage bias setting used to improve IED stability under heavy through fault current conditions.				
Idef Time Delay	33	6	0	0s to 100s step 0.01s
Setting for the time-delay for the definite time setting if selected for defrost prot. element.				

Table 36: GROUP 1 DEFROST PROTECTION ELEMENTS column

4.5 Scheme Logic (Basic and Aided Scheme Logic)

The GROUP 1 SCHEME LOGIC column is used to:

- Set operating mode and associated timers for each distance zone when distance operates in the basic scheme
- Select aided schemes via one or two available signalling channels
- Define operating zones during Trip On Close (TOC)

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 SCHEME LOGIC	34	0	0	
This column contains settings for Distance Scheme Logic				
BASIC SCHEME	34	1	0	
This is a sub heading				
BasicScheme Mode	34	2	Standard	0 = Standard or 1 = Alternative
If set to Alternative, all enabled zone timers will start when fault impedance enters any enabled zone resulting in Improved operating times for evolving faults. If set to Standard, only the zones detecting the fault would start their own timers.				
Zone 1 Tripping	34	8	Ground Only	0 = Disabled, 1 = Phase only, 2 = Ground only, 3 = Phase And Ground
Setting to select for which types of fault Zone 1 elements will be applied.				
tZ1 Ph Delay	34	9	0	0s to 10s step 0.01s
Time delay for Z1 phase element.				
tZ1 Gnd Delay	34	0A	0	0s to 10s step 0.01s
Time delay for Z1 ground element.				
Zone 2 Tripping	34	10	Ground Only	0 = Disabled, 1 = Phase only, 2 = Ground only, 3 = Phase And Ground
Setting to select for which types of fault Zone 2 elements will be applied.				
tZ2 Ph Delay	34	11	0.2	0s to 10s step 0.01s
Time delay for Z2 phase element.				
tZ2 Gnd Delay	34	12	0.2	0s to 10s step 0.01s
Time delay for Z2 ground element.				
tZ2L Ph. Delay	34	13	2	0s to 10s step 0.01s
Longer time delay for Z2 phase element.				
tZ2L Gnd. Delay	34	14	2	0s to 10s step 0.01s
Longer time delay for Z2 ground element.				
Zone 3 Tripping	34	18	Ground Only	0 = Disabled, 1 = Phase only, 2 = Ground only, 3 = Phase And Ground
Setting to select for which types of fault Zone 3 elements will be applied.				
tZ3 Ph Delay	34	19	0.6	0s to 10s step 0.01s
Time delay for Z3 phase element.				
tZ3 Gnd Delay	34	1A	0.6	0s to 10s step 0.01s
Time delay for Z3 ground element.				
tZ3L Ph. Delay	34	1B	6	0s to 10s step 0.01s
Longer time delay for Z3 phase element.				
tZ3L Gnd. Delay	34	1C	6	0s to 10s step 0.01s
Longer time delay for Z3 ground element.				
Zone P Tripping	34	20	Ground Only	0 = Disabled, 1 = Phase only, 2 = Ground only, 3 = Phase And Ground
Setting to select for which types of fault Zone P elements will be applied.				
tZP Ph Delay	34	21	0.4	0s to 10s step 0.01s
Time delay for ZP phase element.				
tZP Gnd Delay	34	22	0.4	0s to 10s step 0.01s
Time delay for ZP ground element.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
tZP WPC Delay	34	23	0	0s to 10s step 0.01s
Time delays for ZP WPC Mode.				
Zone 4 Tripping	34	28	Ground Only	0 = Disabled, 1 = Phase only, 2 = Ground only, 3 = Phase And Ground
Setting to select for which types of fault Zone 4 elements will be applied.				
tZ4 Ph Delay	34	29	1	0s to 10s step 0.01s
Time delay for Z4 phase element.				
tZ4 Gnd Delay	34	2A	1	0s to 10s step 0.01s
Time delay for Z4 ground element.				
AIDED SCHEME 1	34	40	0	
This is a sub heading				
Aided 1 Selection	34	41	Disabled	0 = Disabled, 1 = PUR, 2 = PUR Unblocking, 3 = POR, 4 = POR Unblocking, 5 = Blocking 1, 6 = Blocking 2, 7 = Prog. Unblocking, 8 = Programmable
Selection of the generic scheme type for aided channel 1. Note: POR is equivalent to POTT (permissive overreach transfer trip), PUR is equivalent to PUTT (permissive underreach transfer trip).				
Aided 1 Distance	34	42	Ground Only	0 = Disabled, 1 = Phase only, 2 = Ground only, 3 = Phase And Ground
Setting to select whether distance elements should key the scheme selected as per the previous setting. If set to Disabled, no distance zones interact with this aided scheme, and basic scheme tripping only applies.				
Aided 1 Dist dly	34	43	0	0s to 1s step 0.002s
Trip time delay for Aided 1 Distance schemes.				
tRev. Guard	34	4A	0.02	0s to 0.15s step 0.002s
Setting for the current reversal guard timer. Intended to keep stability on a healthy line, whilst breakers open on a faulted parallel line to clear the fault. This setting is visible only when over-reaching or Blocking schemes are selected.				
Unblocking Delay	34	4B	0.05	0s to 0.1s step 0.002s
Time delay after Loss of Guard until unblocking occurs. After the set delay, the IED will respond as though an aided signal has been received from the remote end. This setting is visible only when PUR Unblocking, POR Unblocking or Programmable Unblocking schemes are chosen.				
Send on Trip	34	4C	Aided / Z1	0 = Aided / Z1, 1 = Any Trip, 2 = None
Setting that defines the reinforced trip signal for POR Aided 1 scheme. If selected to: None: No reinforced signal is issued Aided/Z1: The reinforced signal is issued with aided trip or with Z1 if aided distance scheme is enabled Any Trip: Signal is reinforced with Any trip (DDB 522)				
Weak Infeed	34	50	Disabled	0 = Disabled, 1 = Echo, 2 = Echo and Trip
Setting that defines Aided 1 scheme operation in case of weak infeed conditions, where no protection elements detect the fault at the local end, but an aided channel has been received from the remote end. Setting “Echo” will allow the received signal to be returned to the remote IED, “Trip” will allow local end tripping after a set delay.				
WI Single Pole Trip	34	51	Disabled	0 = Disabled or 1 = Enabled
Setting that defines the Weak Infeed tripping mode. When disabled, any WI trip will be converted to a 3 phase trip.				
WI V< Threshold	34	52	45	10V to 70V step 5V

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Setting of Weak Infeed level detector. If phase - ground voltage in any phase drops below the threshold and with insufficient phase current for the protection to operate, the end is declared as a weak infeed terminal.				
WI Trip Delay	34	53	0.06	0s to 1s step 0.002s
Setting for the weak infeed trip time delay.				
Custom Send Mask	34	58	1	0 = Z1 Gnd., 1 = Z2 Gnd., 2 = Z4 Gnd., 3 = Z1 Ph., 4 = Z2 Ph., 5 = Z4 Ph., 6 = DEF Fwd., 7 = DEF Rev., 8 = Dir Comp Fwd., 9 = Dir Comp Rev
Logic Settings that determine the element or group of elements that are sending a permissive signal to the other line end. For the signal to be sent, the element must operate and a corresponding bit in the matrix must be set to 1 (High). The above mapping is part of a custom made Aided 1 scheme, and unlike all other schemes that are factory tested, the customer must take the responsibility for testing and the operation of the scheme. This setting is visible only if a Programmable or Prog. Unblocking scheme is selected.				
Custom Time PU	34	59	0	0s to 1s step 0.002s
Pick up time delay of DDB signal 'Aid1 CustomT in', available in the PSL logic. Once the time delay elapses, the DDB signal 'Aid1 CustomT out' will become high.				
Custom Time DO	34	5A	0	0s to 1s step 0.002s
Drop off time delay of DDB signal 'Aid1 CustomT in'. Once the time delay elapses, the DDB signal 'Aid1 CustomT out' will become low. Note: The timer is a combined hard coded PU/DO timer for Custom Aided scheme 1.				
AIDED SCHEME 2	34	60	0	
This is a sub heading				
Aided 2 Selection	34	61	Disabled	0 = Disabled, 1 = PUR, 2 = PUR Unblocking, 3 = POR, 4 = POR Unblocking, 5 = Blocking 1, 6 = Blocking 2, 7 = Prog. Unblocking, 8 = Programmable
Selection of the generic scheme type for aided channel 2. Note: POR is equivalent to POTT (permissive overreach transfer trip), PUR is equivalent to PUTT (permissive underreach transfer trip).				
Aided 2 Distance	34	62	Disabled	0 = Disabled, 1 = Phase only, 2 = Ground only, 3 = Phase And Ground
Setting to select whether distance elements should key the scheme selected as per the previous setting. If set to Disabled, no distance zones interact with this aided scheme, and basic scheme tripping only applies.				
Aided 2 Dist dly	34	63	0.02	0s to 1s step 0.002s
Trip time delay for Aided 2 Distance schemes.				
tRev. Guard	34	6A	0.02	0s to 0.15s step 0.002s
Setting for the current reversal guard timer. Intended to keep stability on a healthy line, whilst breakers open on a faulted parallel line to clear the fault. This setting is visible only when over-reaching or Blocking schemes are selected.				
Unblocking Delay	34	6B	0.05	0s to 0.1s step 0.002s
Time delay after Loss of Guard until unblocking occurs. After the set delay, the IED will respond as though an aided signal has been received from the remote end. This setting is visible only when PUR Unblocking, POR Unblocking or Programmable Unblocking schemes are chosen.				
Send on Trip	34	6C	Aided / Z1	0 = Aided / Z1, 1 = Any Trip, 2 = None

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Setting that defines the reinforced trip signal for POR Aided 2 scheme. If selected to: None: No reinforced signal is issued Aided/Z1: The reinforced signal is issued with aided trip or with Z1 if aided distance scheme is enabled Any Trip: Signal is reinforced with Any trip (DDB 522)				
Weak Infeed	34	70	Disabled	0 = Disabled, 1 = Echo, 2 = Echo and Trip
Setting that defines Aided 2 scheme operation in case of weak infeed conditions, where no protection elements detect the fault at the local end, but an aided channel has been received from the remote end. Setting “Echo” will allow the received signal to be returned to the remote IED, “Trip” will allow local end tripping after a set delay.				
WI Single Pole Trip	34	71	Disabled	0 = Disabled or 1 = Enabled
Setting that defines the Weak Infeed tripping mode. When disabled, any WI trip will be converted to a 3 phase trip.				
WI V< Threshold	34	72	45	10V to 70V step 5V
Setting of Weak Infeed level detector. If phase - ground voltage in any phase drops below the threshold and with insufficient phase current for the protection to operate, the end is declared as a weak infeed terminal.				
WI Trip Delay	34	73	0.06	0s to 1s step 0.002s
Setting for the weak infeed trip time delay.				
Custom Send Mask	34	78	1	0 = Z1 Gnd., 1 = Z2 Gnd., 2 = Z4 Gnd., 3 = Z1 Ph., 4 = Z2 Ph., 5 = Z4 Ph., 6 = DEF Fwd., 7 = DEF Rev., 8 = Dir Comp Fwd., 9 = Dir Comp Rev
Logic Settings that determine the element or group of elements that are sending a permissive signal to the other line end. For the signal to be sent, the element must operate and a corresponding bit in the matrix must be set to 1 (High). The above mapping is part of a custom made Aided 2 scheme, and unlike all other schemes that are factory tested, the customer must take the responsibility for testing and the operation of the scheme. This setting is visible only if a Programmable or Prog. Unblocking scheme is selected.				
Custom Time PU	34	79	0	0s to 1s step 0.002s
Pick up time delay of DDB signal ‘Aid2 CustomT in’, available in the PSL logic. Once the time delay elapses, the DDB signal ‘Aid2 CustomT out’ will become high.				
Custom Time DO	34	7A	0	0s to 1s step 0.002s
Drop off time delay of DDB signal ‘Aid2 CustomT in’. Once the time delay elapses, the DDB signal ‘Aid2 CustomT out’ will become low. Note: The timer is a combined hard coded PU/DO timer for Custom Aided scheme 2.				
TRIP ON CLOSE	34	80	0	
This is a sub heading				
SOTF Status	34	81	Enabled PoleDead	0 = Disabled, 1 = Enabled PoleDead, 2 = Enabled ExtPulse, 3 = En Pdead + Pulse
Setting that enables note (turns on) or disables (turns off) a special protection logic which can apply upon line energization. SOTF = Switch on to Fault. Note: SOTF can be enabled in three different manners: 1. Enabled Pole Dead. By using pole dead logic detection logic 2. Enabled ExtPulse. By using an external pulse 3. En Pdead + Pulse. By using both				
SOTF Delay	34	82	110	0.2s to 1000s step 0.05s
The SOTF Delay is a pick up time delay that starts after opening all 3 poles of a CB. If the CB is then closed after the set time delay has expired, SOTF protection will be active. SOTF provides enhanced protection for manual closure of the breaker (not for auto-reclosure). This setting is visible only if Pole Dead or Pdead + Pulse are selected to enable SOTF.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
SOTF Tripping	34	83	1	0 = Zone 1, 1 = Zone 2, 2 = Zone 3, 3 = Zone 4, 4 = Zone 5 or 5 = CNV
Logic Settings that determine the Distance zones that are allowed to operate instantaneously upon line energization. If, for example, Bit 1 is set to 1 (High), Z2 will operate without waiting for the usual tZ2 time delay should a fault lie within Z2 upon CB closure. It also allows a user to map 'Currents No Volt' option for fast fault clearance upon line energization. SOTF tripping is 3 phase and auto-reclose will be blocked.				
TOR Status	34	84	Enabled	0 = Disabled or 1 = Enabled
Setting that enables (turns on) or disables (turns off) special protection following auto-reclosure. When set Enabled, TOR will be activated after the 'TOC Delay' has expired, ready for application when an auto-reclose shot occurs. TOR = Trip on (auto)Reclose.				
TOR Tripping	34	85	1	0 = Zone 1, 1 = Zone 2, 2 = Zone 3, 3 = Zone 4, 4 = Zone 5 or 5 = CNV
Logic Settings that determine the Distance zones that are allowed to operate instantaneously upon line energization. If, for example, Bit 1 is set to 1 (High), Z2 will operate without waiting for the usual tZ2 time delay should a fault lie within Z2 upon CB closure. It also allows a user to map 'Currents No Volt' option for fast fault clearance upon line reclosure on a permanent fault. TOR tripping is 3 phase and auto-reclose will be blocked.				
TOC Reset Delay	34	86	0.5	0.1s to 2s step 0.1s
The TOC Reset Delay is a user settable time window during which TOC protection is available. The time window starts timing upon CB closure and it is common for SOTF and TOR protection. Once this timer expires after a successful (re)closure, all protection reverts to normal.				
SOTF Pulse	34	87	0.5	0.1s to 10s step 0.01s
The SOTF Pulse is a user settable time window during which the SOTF protection is available. This setting is visible only if ExtPulse or Pdead + Pulse are selected to enable SOTF				
TOC Delay	34	88	0.2	0.05s to 0.2s step 0.01s
The TOC Delay is a user settable time delay following the CB opening after which the TOR becomes active (enabled). The time must be set in conjunction with the Dead Time setting of the Auto-reclose so that the setting must not exceed the minimum Dead Time setting since both timers start instantaneously.				
Z1 EXTENSION	34	B0	0	
This is a sub heading				
Z1 Ext Status	34	B1	Disabled	0 = Disabled, 1 = Enabled, 2 = En. on Ch1 Fail, 3 = En. on Ch2 Fail, 4 = En. All Ch Fail, 5 = En. Any Ch Fail
Setting that enables (turns on) or disables (turns off) the Zone 1 Extension scheme. When Enabled, extended Zone 1 will apply unless the Reset Zone 1 Extension DDB signal is energized. Otherwise, it is possible to enable Z1X when aided scheme channel(s) fail.				
Z1 Ext Phs	34	B2	150	100 to 200 step 1
Extended Z1X phase reach as a percentage of the Z1 phase reach. (Phase resistive reach for Z1X is the same as for Zone 1.)				
Z1 Ext Gnd	34	B3	150	100 to 200 step 1
Extended Z1X ground reach as a percentage of Z1 ground reach. (Ground resistive reach and residual compensation for Z1X is the same as for Zone 1.)				

Table 37: GROUP 1 SCHEME LOGIC column

4.6 Phase Overcurrent Protection

The device provides four stage non-directional and directional phase segregated overcurrent protection with independent time delay characteristics. The GROUP 1 OVERCURRENT column is used to set the associated parameters.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 OVERCURRENT	35	0	0	
This column contains settings for Overcurrent				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
I>1 Status	35	1	Enabled	0 = Disabled, 1 = Enabled, 2 = Enabled VTS
Setting that defines first stage overcurrent operating status. Depending on this setting, I>1 will be enabled permanently or in case of Voltage Transformer Supervision (fuse fail) operation				
I>1 Function	35	2	IEC S Inverse	0 = DT, 1 = IEC S Inverse, 2 = IEC V Inverse, 3 = IEC E Inverse, 4 = UK LT Inverse, 5 = IEEE M Inverse, 6 = IEEE V Inverse, 7 = IEEE E Inverse, 8 = US Inverse, 9 = US ST Inverse, 10=Default Curve 1, 11=Default Curve 2, 12=Default Curve 3, 13=Default Curve 4
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Directional	35	3	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for first stage element.				
I>1 Current Set	35	4	1	0.08*In to 4*In step 0.01In
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	35	5	1	0s to 100s step 0.01s
Setting for the time-delay for the definite time setting if selected for first stage element. The setting is visible only when DT function is selected.				
I>1 TMS	35	6	1	0.025 to 1.2 step 0.005
Setting for the time multiplier setting to adjust the operating time of the IEC IDMT characteristic.				
I>1 Time Dial	35	7	1	0.01 to 100 step 0.01
Setting for the time multiplier setting to adjust the operating time of the IEEE/US IDMT curves. The Time Dial (TD) is a multiplier on the standard curve equation, in order to achieve the required tripping time. The reference curve is based on TD = 1. Care: Certain manufacturer's use a mid-range value of TD = 5 or 7, so it may be necessary to divide by 5 or 7 to achieve parity.				
I>1 Reset Char	35	8	DT	0 = DT or 1 = Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	35	9	0	0s to 100s step 0.01s
Setting that determines the reset/release time for definite time reset characteristic				
I>2 Status	35	0A	Disabled	0 = Disabled, 1 = Enabled, 2 = Enabled VTS
Setting that defines second stage overcurrent operating status. Depending on this setting, I>2 will be enabled permanently or in case of Voltage Transformer Supervision (fuse fail) operation				
I>2 Function	35	0B	IEC S Inverse	0 = DT, 1 = IEC S Inverse, 2 = IEC V Inverse, 3 = IEC E Inverse, 4 = UK LT Inverse, 5 = IEEE M Inverse, 6 = IEEE V Inverse, 7 = IEEE E Inverse, 8 = US Inverse, 9 = US ST Inverse, 10=Default Curve 1, 11=Default Curve 2, 12=Default Curve 3, 13=Default Curve 4
Setting for the tripping characteristic for the second stage overcurrent element.				
I>2 Directional	35	0C	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for second stage element.				
I>2 Current Set	35	0D	1	0.08*In to 4*In step 0.01In
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	35	0E	1	0s to 100s step 0.01s
Setting for the time-delay for the definite time setting if selected for second stage element. The setting is visible only when DT function is selected.				
I>2 TMS	35	0F	1	0.025 to 1.2 step 0.005
Setting for the time multiplier setting to adjust the operating time of the IEC IDMT characteristic.				
I>2 Time Dial	35	10	1	0.01 to 100 step 0.01
Setting for the time multiplier setting to adjust the operating time of the IEEE/US IDMT curves. The Time Dial (TD) is a multiplier on the standard curve equation, in order to achieve the required tripping time. The reference curve is based on TD = 1. Care: Certain manufacturer's use a mid-range value of TD = 5 or 7, so it may be necessary to divide by 5 or 7 to achieve parity.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
I>2 Reset Char	35	11	DT	0 = DT or 1 = Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>2 tRESET	35	12	0	0s to 100s step 0.01s
Setting that determines the reset/release time for definite time reset characteristic				
I>3 Status	35	13	Disabled	0 = Disabled, 1 = Enabled, 2 = Enabled VTS
Setting that defines third stage overcurrent operating status. Depending on this setting, I>3 will be enabled permanently or in case of Voltage Transformer Supervision (fuse fail) operation				
I>3 Directional	35	14	Directional Fwd	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for the third stage overcurrent element.				
I>3 Current Set	35	15	10	0.08*In to 32*In step 0.01In
Pick-up setting for third stage overcurrent element.				
I>3 Time Delay	35	16	0	0s to 100s step 0.01s
Setting for the operating time-delay for third stage overcurrent element.				
I>4 Status	35	18	Disabled	0 = Disabled, 1 = Enabled, 2 = Enabled VTS
Setting that defines fourth stage overcurrent operating status. Depending on this setting, I>4 will be enabled permanently or in case of Voltage Transformer Supervision (fuse fail) operation				
I>4 Directional	35	19	Non-Directional	0 = Non-Directional, 1 = Directional Fwd, 2 = Directional Rev
This setting determines the direction of measurement for the fourth stage overcurrent element.				
I>4 Current Set	35	1A	10	0.08*In to 32*In step 0.01In
Pick-up setting for fourth stage overcurrent element.				
I>4 Time Delay	35	1B	0	0s to 100s step 0.01s
Setting for the operating time-delay for fourth stage overcurrent element.				
I> Char Angle	35	1C	-45	-95 to 95 step 1
Setting for the IED characteristic angle used for the directional decision. The setting is visible only when 'Directional Fwd' or 'Directional Rev' is set.				
I> Blocking	35	1D	0xF	0 = VTS Blocks I>1, 1 = VTS Blocks I>2, 2 = VTS Blocks I>3, 3 = VTS Blocks I>4
Logic Settings that determine whether blocking signals from VT supervision affect certain overcurrent stages. VTS Block – only affects directional overcurrent protection. With the relevant bit set to 1, operation of the Voltage Transformer Supervision (VTS), will block the stage. When set to 0, the stage will revert to Non-directional upon operation of the VTS. If I> Status is set 'Enabled VTS', no blocking should be selected in order to provide fault clearance by overcurrent protection during the VTS condition.				
I>1 Usr Rst Char	35	20	DT	0 = DT, 1=Default Curve 1, 2=Default Curve 2, 3=Default Curve 3, 4=Default Curve 4
Setting to determine the type of reset/release characteristic of the User defined curves.				
I>2 Usr Rst Char	35	25	DT	0 = DT, 1=Default Curve 1, 2=Default Curve 2, 3=Default Curve 3, 4=Default Curve 4
Setting to determine the type of reset/release characteristic of the User defined curves.				

Table 38: GROUP 1 OVERCURRENT column

4.7 Panto Flash Over

The GROUP 1 PANTO FLASH OVER column is used to set the panto flash over protection parameters. The panto flash over function can be selected to give only alarm or trip or even alarm and trip.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 PANTO FLASH OVER	36	00	0	
PantoFlash Stat.	36	01	Disabled	0 = Disabled or 1 = Enabled
Setting that defines panto flash over protection operating status. Depending on this setting, Panto Flash Over Protection will be enabled permanently.				
Panto V< Set	36	02	38.1 V	10V to 40V step 0.1V
Sets the pick-up setting for the panto flash over undervoltage element.				
Panto AlarmDelay	36	03	10s	0s to 100s step 0.01s
Setting that defines the operating time delay for the panto flash over definite time undervoltage element.				
Panto V> Set	36	04	77 V	40V to 110V step 1V
Sets the pick-up setting for the panto flash over overvoltage element.				
Panto Trip Delay	36	05	10s	0s to 100s step 0.01s
Setting that defines the operating time delay for the panto flash over definite time overvoltage element.				

Table 39: GROUP 1 OVERCURRENT column

4.8 Thermal Overload

The GROUP 1 THERMAL OVERLOAD column is used to set the thermal overload protection parameters. The thermal overload function can be selected as a single time constant or dual time constant characteristic, dependent on the type of plant to be protected.

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

Table 40: GROUP 1 THERMAL OVERLOAD column

4.9 High Impedance Delta

The GROUP 1 HIGH Z DELTA I column is used to set the high impedance protection parameters.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 HIGH Z DELTA I	40	00		
This column contains settings for high impedance delta I protection for railway lines				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
HZ Delta I mag.	40	01	0.2	0.1*In to 10*In step 0.01In
This setting determines the pick-up setting for high impedance delta I protection.				
HZ Delta I angle	40	02	30	1 to 90 step 1
Setting of the change in current angle over a period of time				
HZ Delta I Delay	40	03	0.2	0s to 10s step 0.01s
Setting for the operating time delay for the detection of high impedance delta I function				
HZ Delta I Sens.	40	04	0.5	0.05*In to 2*In step 0.005In
This setting determines the minimum pick-up setting for high impedance delta I protection.				
HZ Delta V Sens.	40	05	0.1	0.05*Vn to 0.5*Vn step 0.005Vn
This setting determines the minimum pick-up setting for high impedance delta I protection.				
HZ Delta Ireact.	40	06	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the high resistance delta current protection using forward and reverse reactance of the line.				
HZD ZGND Forw	40	07	8	0.05/In Ω to 750/In Ω step 0.01/In Ω
This is the setting of the phase to ground reactance reach in the forward direction up to which the operation of high impedance delta I function will be inhibitted.				
HZD ZGND Rev	40	08	8	0.05/In Ω to 750/In Ω step 0.01/In Ω
This is the setting of the phase to ground reactance reach in the reverse direction up to which the operation of high impedance delta I function will be inhibitted.				
HZ DeltaI V Mode	40	09	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the minimum voltage reading affecting high resistance delta current protection function.				
HZ DeltaI HarmRe	40	10	0.1	0.1*In to 20*In step 0.01In
Setting to select the delta I Magnitude in case either 3rd or 5th harmonic content above a set threshold is detected				
HZ DeltI 3rdHarm	40	12	Disabled	0 = Disabled, 1 = Restrained, 2 =Blocking
Setting the mode in which the user can select to use the 3rd harmonic detection result on catenary or feeder				
HZ DeltI 5thHarm	40	13	Disabled	0 = Disabled, 1 = Restrained, 2 =Blocking
Setting the mode in which the user can select to use the 5th harmonic detection result on catenary or feeder				

4.10 Voltage Protection

The GROUP 1 VOLT PROTECTION column is used to set the parameters for overvoltage, undervoltage, and compensated overvoltage protection. There are two stages, which can be configured separately, allowing completely independent operation for each stage.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 VOLT PROTECTION	42	0	0	
This column contains settings for Voltage protection				
UNDER VOLTAGE	42	1	0	
This is a sub heading				
V< Measur't Mode	42	2	V<1 & V<2 Ph-N	0 = V<1 & V<2 Ph-Ph, 1 = V<1 & V<2 Ph-N, 2 = V<1Ph-Ph V<2Ph-N, 3 = V<1Ph-N V<2Ph-Ph
Sets the combination of measured input voltage that will be used for the undervoltage elements. Note: If any stage is disabled, the associated text in the setting menu cell setting will remain visible but will not affect the operation of the stage that is enabled.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
V< Operate Mode	42	3	V<1 & V<2 Any Ph	0 = V<1 & V<2 Any Ph, 1 = V<1 & V<2 All Ph, 2 = V<1AnyPh V<2 All Ph, 3 = V<1 All Ph V<2AnyPh
Setting that determines whether any phase or all three phases has to satisfy the undervoltage criteria before a decision is made. Note: If any stage is disabled, the associated text in the setting menu cell setting will remain visible but will not affect the operation of the stage that is enabled.				
V<1 Function	42	4	DT	0 = Disabled, 1 = DT or 2 = IDMT
Setting for the tripping characteristic of the first stage undervoltage element.				
V<1 Voltage Set	42	5	80	10V to 120V step 1V
Sets the pick-up setting for first stage undervoltage element.				
V<1 Time Delay	42	6	10	0s to 100s step 0.01s
Setting for the operating time-delay for the first stage definite time undervoltage element.				
V<1 TMS	42	7	1	0.5 to 100 step 0.5
Setting for the time multiplier setting to adjust the operating time of the IDMT characteristic.				
V<1 Poledead Inh	42	8	Enabled	0 = Disabled or 1 = Enabled
If the cell is enabled, the relevant stage will become inhibited by the pole dead logic. This logic produces an output when it detects either an open circuit breaker via auxiliary contacts feeding the IED opto inputs or it detects a combination of both undercurrent and undervoltage on any one phase. It allows the undervoltage protection to reset when the circuit breaker opens to cater for line or bus side VT applications.				
V<2 Status	42	9	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the second stage undervoltage element.				
V<2 Voltage Set	42	0A	60	10V to 120V step 1V
This setting determines the pick-up setting for second stage undervoltage element.				
V<2 Time Delay	42	0B	5	0s to 100s step 0.01s
Setting for the operating time-delay for the second stage definite time undervoltage element.				
V<2 Poledead Inh	42	0C	Enabled	0 = Disabled or 1 = Enabled
If the cell is enabled, the relevant stage will become inhibited by the pole dead logic. This logic produces an output when it detects either an open circuit breaker via auxiliary contacts feeding the IED opto inputs or it detects a combination of both undercurrent and undervoltage on any one phase. It allows the undervoltage protection to reset when the circuit breaker opens to cater for line or bus side VT applications.				
OVERVOLTAGE	42	0D	0	
This is a sub heading				
V> Measur't Mode	42	0E	V>1 & V>2 Ph-N	0 = V>1 & V>2 Ph-Ph, 1 = V>1 & V>2 Ph-N, 2 = V>1Ph-Ph V>2Ph-N, 3 = V>1Ph-N V>2Ph-Ph
Sets the combination of measured input voltage that will be used for the overvoltage elements. Note: If any stage is disabled, the associated text in the setting menu cell setting will remain visible but will not affect the operation of the stage that is enabled.				
V> Operate Mode	42	0F	V>1 & V>2 Any Ph	0 = V>1 & V>2 Any Ph, 1 = V>1 & V>2 All Ph, 2 = V>1AnyPh V>2 All Ph, 3 = V>1 All Ph V>2 AnyPh
Setting that determines whether any phase or all three phases has to satisfy the overvoltage criteria before a decision is made. Note: If any stage is disabled, the associated text in the setting menu cell setting will remain visible but will not affect the operation of the stage that is enabled.				
V>1 Function	42	10	DT	0 = Disabled, 1 = DT or 2 = IDMT
Setting for the tripping characteristic of the first stage overvoltage element.				
V>1 Voltage Set	42	11	130	60V to 185V step 1V
Sets the pick-up setting for first stage overvoltage element.				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
V>1 Time Delay	42	12	10	0s to 100s step 0.01s
Setting for the operating time-delay for the first stage definite time overvoltage element.				
V>1 TMS	42	13	1	0.5 to 100 step 0.5
Setting for the time multiplier setting to adjust the operating time of the IDMT characteristic.				
V>2 Status	42	14	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the second stage overvoltage element.				
V>2 Voltage Set	42	15	150	60V to 185V step 1V
This setting determines the pick-up setting for the second stage overvoltage element.				
V>2 Time Delay	42	16	0.5	0s to 100s step 0.01s
Setting for the operating time-delay for the second stage definite time overvoltage element.				

Table 41: GROUP 1 VOLT PROTECTION column

4.11 Circuit Breaker Fail and Pole Dead Detection Function

The GROUP 1 CB FAIL & P. DEAD column is used to set the parameters for Circuit Breaker Failure and Pole Dead detection.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 CB FAIL & P.DEAD	45	0	0	
This column contains settings for Circuit Fail and Under Current				
BREAKER FAIL	45	1	0	
This is a sub heading				
CB Fail 1 Status	45	2	Enabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the first stage of the circuit breaker function.				
CB Fail 1 Timer	45	3	0.2	0s to 100s step 0.01s
Setting for the circuit breaker fail timer stage 1, during which breaker opening must be detected. There are timers per phase to cope with evolving faults, but the timer setting is common.				
CB Fail 2 Status	45	4	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the second stage of the circuit breaker function.				
CB Fail 2 Timer	45	5	0.4	0s to 100s step 0.01s
Setting for the circuit breaker fail timer stage 2, during which breaker opening must be detected.				
Non I Prot Reset	45	6	Prot Reset & I<	0 = I< Only, 1 = CB Open & I<, 2 = Prot Reset & I<
Setting which determines the elements that will reset the circuit breaker fail time for voltage protection function initiated circuit breaker fail conditions.				
Ext Prot Reset	45	7	Prot Reset & I<	0 = I< Only, 1 = CB Open & I<, 2 = Prot Reset & I<, 3 = Prot Reset or I<, 4 = Rst or CBOp & I<
Setting which determines the elements that will reset the circuit breaker fail time for external protection function initiated circuit breaker fail conditions.				
WI Prot Reset	45	8	Disabled	0 = Disabled or 1 = Enabled
When Enabled, CB Fail timers will be reset by drop off of a weak infeed trip condition, providing that WI trip logic is activated.				
ExtTrip Only Init	45	9	Disabled	0 = Disabled or 1 = Enabled
When Enabled, CB Fail timers will only be initiated by External Trip inputs.				
UNDER CURRENT	45	0A	0	
This is a sub heading				
I< Current Set	45	0B	0.05	0.02*In to 3.2*In step 0.01*In

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Setting that determines the circuit breaker fail timer reset current for overcurrent based protection circuit breaker fail initiation. This setting is also used in the pole dead logic to determine the status of the pole (dead or live).				
POLEDEAD VOLTAGE	45	0E	0	
This is a sub heading				
V<	45	10	38.1	10V to 40V step 0.1V
Under voltage level detector for pole dead detection				

Table 42: GROUP 1 CB FAIL & P.DEAD column

4.12 Supervision

The GROUP 1 SUPERVISION column is used to set the parameters for the Supervision functions. The Supervision column includes Voltage Transformer Supervision (VTS), Current Transformer Supervision (CTS), Inrush Detection and special Weak Infeed Blocking.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 SUPERVISION	46	0	0	
This column contains settings for Voltage and Current Supervision				
VTS Mode	46	1	Measured + MCB	0 = Measured + MCB, 1 = Measured Only, 2 = MCB Only
Setting that determines the method to be used to declare VT failure.				
VTS Status	46	2	Blocking	0 = Disabled, 1 = Blocking, 2 = Indication
This setting determines whether the following operations will occur upon detection of VTS. • VTS set to provide alarm indication only. • Optional blocking of voltage dependent protection elements. • Optional conversion of directional overcurrent elements to non-directional protection (available when set to blocking mode only). These settings are found in the function links cell of the relevant protection element columns in the menu.				
VTS Reset Mode	46	3	Auto	0 = Manual or 1 = Auto
The VTS block will be latched after a user settable time delay 'VTS Time Delay'. Once the signal has latched then two methods of resetting are available. The first is manually via the front panel interface (or remote communications) and secondly, when in 'Auto' mode, provided the VTS condition has been removed and the 3 phase voltages have been restored above the phase level detector settings for more than 240 ms.				
VTS Time Delay	46	4	5	1s to 10s step 0.1s
Setting that determines the operating time-delay of the element upon detection of a voltage supervision condition.				
VTS I> Inhibit	46	5	10	0.08*In to 32*In step 0.01In
The setting is used to override a voltage supervision block in the event of a phase fault occurring on the system that could trigger the voltage supervision logic.				
Inrush Detection	46	0E	Disabled	0 = Disabled or 1 = Enabled
This setting is to enable/disable the Inrush Detection used for the Distance protection.				
I>2nd Harmonic	46	0F	20	10 to 100 step 5
If the level of second harmonic in any phase current or neutral current exceeds the setting, inrush conditions will be recognized by changing the status of four DDB signals from low to high in the Programmable Scheme Logic (PSL). The user then has a choice to use them further in the PSL in accordance with the application.				
I>3rd Harmonic	46	10	15	5 to 100 step 1
Setting the ratio of 3rd harmonic content on catenary or feeder to be used in HZDI or PSL				
I>5th Harmonic	46	11	15	5 to 100 step 1
Setting the ratio of 5th harmonic content on catenary or feeder to be used in HZDI or PSL				

Table 43: GROUP 1 SUPERVISION column

4.13 System Checks (Check Sync. Function)

The GROUP 1 SYSTEM CHECKS column is used to set the parameters for the Check Synchronism function. It contains settings to configure Voltage Monitoring, System Checks and Manual System Checks for manual closure of the Circuit Breaker.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 SYSTEM CHECKS	48	0	0	
This column contains settings for System Checks				
VOLTAGE MONITORS	48	14	0	
This is a sub heading				
Live Line	48	85	32	5 to 132 step 0.5
Line is considered Live with voltage above this setting.				
Dead Line	48	86	13	5 to 132 step 0.5
Line is considered Dead with voltage below this setting.				
Live Bus	48	87	32	5 to 132 step 0.5
Bus is considered Live with voltage above this setting.				
Dead Bus	48	88	13	5 to 132 step 0.5
Bus is considered Dead with voltage below this setting.				
CS UV	48	8B	54	5 to 120 step 0.5
Check Synch Undervoltage setting decides that System Check Synchronism logic for CB1 will be blocked if V< is one of the selected options in setting CB1 CS Volt.Blk (48 8E), and either line or bus voltage is below this setting. System Check Synchronism for CB2 will be blocked if V< is one of the selected options in setting CB2 CS Volt. Blk (48 9C), and either line or bus voltage is below this setting.				
CS OV	48	8C	130	60 to 200 step 0.5
Check Synch Overvoltage setting decides that System Check Synchronism logic for CB1 is blocked if V> is one of the selected options in setting CB1 CS Volt.Blk (48 8E), and either line or bus voltage is above this setting. System Check Synchronism for CB2 is blocked if V> is one of the selected options in setting CB2 CS Volt. Blk (48 9C), and either line or bus voltage is above this setting.				
System Checks	48	8D	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable both stages of system checks for reclosing. If System Checks is set to Disabled, all other menu settings associated with synchronism checks become invisible, and a DDB (880) signal SysChks Inactive is set.				
CS Voltage Block	48	8E	V<	0 = None, 1 = V<, 2 = V>, 3 = Vdiff>, 4 = V< and V>, 5 = V< and Vdiff>, 6 = V> and Vdiff>, 7 = V< V> and Vdiff>
Setting to determine which, if any, conditions should block synchronism check (undervoltage V<, overvoltage V>, and/or voltage differential Vdiff etc) for the line and bus voltages.				
CS1 Status	48	8F	Enabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the stage 1 synchronism check elements for auto-reclosing and manual closing of CB.				
CS1 Angle	48	90	20	0 to 90 step 1
Maximum permitted phase angle between Line and Bus 1 voltages for first stage synchronism check element to reclose CB.				
CS1 VDiff	48	91	6.5	1 to 120 step 0.5

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Check Synch Voltage differential setting decides that stage 1 System Check Synchronism logic is blocked if Vdiff> is one of the selected options in setting CS Voltage Block (48 8E), and voltage magnitude difference between line and bus 1 voltage is above this setting.				
CS1 Slip Ctrl	48	92	Enabled	0 = Disabled or 1 = Enabled
Setting to enable or disable blocking of synchronism check stage 1 for reclosing CB by excessive frequency difference (slip) between line and bus voltages (refer to setting CS1 Slip Freq).				
CS1 Slip Freq	48	93	0.05	0.005 to 2 step 0.005
If CS1 Slip Ctrl is enabled, synchronism check stage 1 is blocked for reclosing CB if measured frequency difference between line and bus voltages is greater than this setting.				
CS2 Status	48	94	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable the stage 2 synchronism check elements for auto-reclosing and manual closing CB.				
CS2 Angle	48	95	20	0 to 90 step 1
Maximum permitted phase angle between Line and Bus 1 voltages for second stage synchronism check element to reclose CB				
CS2 VDiff	48	96	6.5	1 to 120 step 0.5
Check Synch Voltage differential setting decides that stage 2 System Check Synchronism logic is blocked if Vdiff> is one of the selected options in setting CS Voltage Block (48 8E), and voltage magnitude difference between line and bus 1 voltage is above this setting.				
CS2 Slip Ctrl	48	97	Enabled	0 = Disabled or 1 = Enabled
Setting to enable or disable blocking of synchronism check stage 2 for reclosing CB by excessive frequency difference (slip) between line and bus voltages (refer to setting CS2 Slip Freq)				
CS2 Slip Freq	48	98	0.05	0.005 to 2 step 0.005
If CS2 Slip Ctrl is enabled, synchronism check stage 2 is blocked for reclosing CB if measured frequency difference between line and bus voltages is greater than this setting.				
CS2 Adaptive	48	99	Disabled	0 = Disabled or 1 = Enabled
Setting to enable or disable Adaptive CB closing with System Check Synchronism stage 2 closing for CB: logic uses set CB Cl Time to issue CB close command at such a time that the predicted phase angle difference when CB main contacts touch is as close as possible to 0 degrees. If Adaptive closing is disabled, the logic issues CB close command as soon as phase angle comes within set limit at CB CS2 Angle .				
CB Cl Time	48	9A	0.05	0.01 to 0.5 step 0.001
This sets CB closing time, from receipt of CB close command until main contacts touch.				
MAN SYS CHECKS	48	B0	0	
This is a sub heading				
CBM SC required	48	B2	Disabled	0 = Disabled or 1 = Enabled
This setting determines whether a system check (e.g. live bus / dead line etc) is required for any manual (operator-controlled) closure of CB. If Enabled, system check is required for closure. If Disabled, system check is not required.				
CBM SC CS1	48	B3	Disabled	0 = Disabled or 1 = Enabled
This setting enables CB to close by manual control when the system satisfies all the System Check Synchronism Stage 1 conditions as listed under the setting CS1 Status in the SYSTEM CHECKS column.				
CBM SC CS2	48	B4	Disabled	0 = Disabled or 1 = Enabled
This setting enables CB1 to close by manual control when the system satisfies all the System Check Synchronism Stage 2 conditions as listed under the setting CS2 Status in the SYSTEM CHECKS column.				
CBM SC DLLB	48	B5	Disabled	0 = Disabled or 1 = Enabled
This setting enables CB to close by manual control when the dead line & live bus1 conditions are satisfied as set in the SYSTEM CHECKS column.				
CBM SC LLDB	48	B6	Disabled	0 = Disabled or 1 = Enabled
This setting enables CB to close by manual control when the live line & dead bus1 conditions are satisfied as set in the SYSTEM CHECKS column.				
CBM SC DLDB	48	B7	Disabled	0 = Disabled or 1 = Enabled
This setting enables CB to close by manual control when the dead line & dead bus1 conditions are satisfied as set in the SYSTEM CHECKS column.				

Table 44: GROUP 1 SYSTEM CHECKS column

4.14 Auto-Reclose Function

The GROUP 1 AUTORECLOSE column is used to set the parameters for the Autoreclose function. Auto reclose is provided for both single and dual circuit breaker variants.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 AUTORECLOSE	49	0	0	
This column contains settings for Autoreclose				
AR Mode	49	51	AR AP	0 = AR SP, 1 = AR S/AP, 2 = AR AP or 3 = AR Opto
This setting determines which auto-reclose modes are permitted for the circuit breaker : single phase (AR SP) only, both single phase and All phase (AR S/AP), All phase only (AR AP), or the auto-reclosing mode is controlled by opto input signals (AR Opto) mapped via DDB's (1497) AR Mode SP and (1498) AR Mode SP.				
AR Shots	49	59	1	1 to 4 step 1
This setting determines how many reclose attempts (shots) are permitted for any single fault incident before it is treated as persistent and auto-reclosing is locked out. For example if AR Shots = 2, a second reclose attempt is initiated if the protection retrips during the reclaim time following one reclose attempt, but locks out if the protection retrips during the reclaim time after a second reclose attempt.				
AR Skip Shot 1	49	5A	Disabled	0 = Disabled or 1 = Enabled
If set to “Enable”, allows the first programmed reclose attempt (“shot”) to be omitted if the “Skip Shot 1” input is high when the Increment is triggered at the start of an autoreclose cycle:				
Discrim Time	49	5D	0.1	0.005s to 5s step 0.005s
Discrim Time = Discriminating Time. This is a setting which determines whether a fault on another phase (evolving or developing fault) after single phase trip and auto-reclose has been initiated by a single phase fault stops the single phase cycle and starts a three phase auto-reclose cycle provided this second fault (evolving fault) occurs BEFORE the Discrimination Time elapsed. It forces a lockout if second fault (evolving fault) occurs AFTER Discrimination Time has elapsed but before Single Phase Dead Time elapses.				
CB IS Time	49	60	5	0.1s to 200s step 0.1s
CB IS Time = CB In Service Time. This is a timer setting for which a CB must remain closed (and optionally the line be live) before it is considered to be In Service.				
CB IS MemoryTime	49	61	0.5	0.01s to 1s step 0.01s
CB IS Memory Time is a timer setting which allows a CB In Service state to be remembered for a short period following changeover of the CB auxiliary switch contacts to a CB Open state. This may occasionally be necessary for a few types of CB with exceptionally fast acting auxiliary switch contacts which allow the auto-reclose scheme logic to detect the CB opening before it detects an associated protection operation.				
DT Start by Prot	49	62	Protection Reset	0 = Protection Reset, 1 = Protection Op or 2 = Disable
DT Start by Prot = Dead Time Start By Protection action. If DT Start by Prot is set to Disable, a dead time start is not directly affected by protection operation or reset, but is enabled by other conditions or events (see settings: 3PDTStart WhenLD and DTStart by CB Op). If DT Start by Prot is set to Protection Op, the dead time starting is enabled when the auto-reclose initiation signal is received from the protection. If DT Start by Prot is set to Protection Reset, the dead time starting is inhibited until the auto-reclose initiation signal from the protection resets.				
APDTStart WhenLD	49	63	Disabled	0 = Disabled or 1 = Enabled
APDTStart When LD = All phase auto-reclose dead time starts when the line has gone dead. If Enabled, the line is required to go dead before a All phase auto-reclose dead time can start. If Disabled, dead time can start when other selected conditions are satisfied, irrespective of line volts.				
DTStart by CB Op	49	64	Disabled	0 = Disabled or 1 = Enabled
If Enabled, a dead time start is permitted only when the CB has tripped. If Disabled, a dead time start is permitted when other selected conditions are satisfied, irrespective of the CB position.				
Dead Line Time	49	66	5	1s to 9999s step 1s
When 3PDTStart When LD is Enabled, and the line does not go dead within the set Dead Line Time period, then the logic will force the auto-reclose sequence to lockout after expiry of this time.				
SP AR Dead Time	49	67	0.5	0s to 10s step 0.01s
Dead time setting for single phase auto-reclose.				
AP AR DT Shot 1	49	68	0.3	0.01s to 300s step 0.01s
Dead time setting for All phase auto-reclose (first shot).				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
AP AR DT Shot 2	49	69	60	1s to 9999s step 1s
Dead time setting for All phase auto-reclose (2nd shot).				
AP AR DT Shot 3	49	6A	60	1s to 9999s step 1s
Dead time setting for All phase auto-reclose (3rd shot).				
AP AR DT Shot 4	49	6B	60	1s to 9999s step 1s
Dead time setting for All phase auto-reclose (4th shot).				
SPAR ReclaimTime	49	6D	60	1s to 600s step 1s
Reclaim time setting following single phase auto-reclosure.				
AP AR ReclaimTime	49	6E	180	1s to 600s step 1s
Reclaim time setting following All phase auto-reclosure.				
AR CBHealthyTime	49	6F	5	0.01s to 9999s step 0.01s
Settable time delay for autoreclosure with this circuit breaker check. If the circuit breaker does not indicate a healthy condition in this time period following an auto close command then the IED will lockout and alarm. CB Healthy is required for manual and auto reclosures.				
AR CheckSyncTime	49	70	5	0.01s to 9999s step 0.01s
A user settable time delay is included for autoreclosure with System Check Synchronizing. If the System Check Synchronizing criteria are not satisfied in this time period following a close command the IED will lockout and alarm.				
Z1 AR	49	72	Initiate AR	0 = Initiate AR or 1 = Block AR
Setting that determines impact of instantaneous zone 1 on AR operation. Set Initiate AR if the trip should initiate a cycle, and Block AR if an instantaneous zone 1 trip should cause lockout. (Only in models with distance option)				
Dist Aided AR	49	74	Initiate AR	0 = Initiate AR or 1 = Block AR
Setting that determines impact of the aided distance schemes tripping on AR operation. (Only in models with distance option)				
Z2T AR	49	75	Block AR	0 = No Action, 1 = Initiate AR or 2 = Block AR
Setting that determines impact of time delayed zone 2 on AR operation. Set Initiate AR if the trip should initiate a cycle, and Block AR if a time delayed trip should cause lockout. Set No action if Zone 2 tripping should exert no specific logic control on the recloser. (Only in models with distance option)				
Z3T AR	49	76	Block AR	0 = No Action, 1 = Initiate AR or 2 = Block AR
Setting that determines impact of the Zone 3 tripping on AR operation. (Only in models with distance option)				
ZPT AR	49	77	Block AR	0 = No Action, 1 = Initiate AR or 2 = Block AR
Setting that determines impact of the Zone P tripping on AR operation. (Only in models with distance option)				
Z4T AR	49	78	Block AR	0 = No Action, 1 = Initiate AR or 2 = Block AR
Setting that determines impact of the Zone 4 tripping on AR operation. (Only in models with distance option)				
TOR AR	49	7B	Block AR	0 = Initiate AR or 1 = Block AR
Setting that determines impact of Trip On Reclose (TOR) on AR operation. (Only in models with distance option)				
I>1 AR	49	7C	No Action	0 = No Action, 1 = Initiate AR or 2 = Block AR
Setting that determines impact of first stage overcurrent protection on AR operation. Set Initiate AR if the trip should initiate a cycle and Block AR if trip should cause lockout. Set No action if trip should exert no specific logic control on the recloser. (Only in models with distance option)				
I>2 AR	49	7D	No Action	0 = No Action, 1 = Initiate AR or 2 = Block AR
Setting that determines impact of the second stage overcurrent protection on AR operation.				
I>3 AR	49	7E	No Action	0 = No Action, 1 = Initiate AR or 2 = Block AR
Setting that determines impact of the third stage overcurrent protection on AR operation.				
I>4 AR	49	7F	No Action	0 = No Action, 1 = Initiate AR or 2 = Block AR

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Setting that determines impact of the fourth stage overcurrent protection on AR operation.				
AR SYS CHECKS	49	A5	0	0 = No Action, 1 = Initiate AR or 2 = Block AR
This is a sub heading				
CB SC all	49	A6	Disabled	0 = Disabled or 1 = Enabled
This setting determines whether a system check (e.g. live bus / dead line etc) is required for any auto-reclose of CB. If Enabled, system check is required for some or all reclosures. If Disabled, system check is not required for any reclosures.				
CB SC Shot 1	49	A7	Disabled	0 = Disabled or 1 = Enabled
This setting determines whether a system check (e.g. live bus / dead line etc) is required for the first shot reclosure of CB. If Enabled, system check is required for the first shot reclosure. If Disabled, system check is not required for the first shot reclosure.				
CB SC ClsNoDly	49	A8	Disabled	0 = Disabled or 1 = Enabled
If CB SC ClsNoDly is Enabled, CB can reclose as leader as soon as the synchro check conditions are satisfied, without waiting for the dead time to elapse. This option is sometimes required for the second line end to reclose onto a line with delayed auto-reclosing (typical cycle: first line end recloses after the dead time with live bus & dead line, then the second line end recloses immediately with live bus & live line in synchronism).				
CB SC CS1	49	A9	Disabled	0 = Disabled or 1 = Enabled
This setting enables CB to auto-reclose as leader when the system satisfies all the System Check Synchronism Stage 1 criteria as defined under CB CS1 Status settings in the SYSTEM CHECKS column.				
CB SC CS2	49	AA	Disabled	0 = Disabled or 1 = Enabled
This setting enables CB to auto-reclose as leader when the system satisfies all the System Check Synchronism Stage 2 criteria as defined under the setting CB CS2 Status in the SYSTEM CHECKS column.				
CB SC DLLB	49	AB	Disabled	0 = Disabled or 1 = Enabled
This setting enables CB to auto-reclose as leader when the dead line & live bus1 conditions are satisfied as set in the SYSTEM CHECKS column.				
CB SC LLDB	49	AC	Disabled	0 = Disabled or 1 = Enabled
This setting enables CB to auto-reclose as leader when the live line & dead bus1 conditions are satisfied as set in the SYSTEM CHECKS column.				
CB SC DLDB	49	AD	Disabled	0 = Disabled or 1 = Enabled
This setting enables CB to auto-reclose as leader when the dead line & dead bus1 conditions are satisfied as set in the SYSTEM CHECKS column.				

Table 45: GROUP 1 AUTORECLOSE column

4.15 Input Labels

The GROUP 1 INPUT LABELS column is used to individually label each opto-input. The text is restricted to 16 characters and is available if ‘Input Labels’ are set to 'visible' in the CONFIGURATION column.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 INPUT LABELS	4A	0	0	
This column contains settings for Input Labels				
Opto Input 1	4A	1	Input L1	32 to 163 step 1
Label for Opto Input 1				
Opto Input 2	4A	2	Input L2	32 to 163 step 1
Label for Opto Input 2				
Opto Input 3	4A	3	Input L3	32 to 163 step 1
Label for Opto Input 3				
Opto Input 4	4A	4	Input L4	32 to 163 step 1
Label for Opto Input 4				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Opto Input 5	4A	5	Input L5	32 to 163 step 1
Label for Opto Input 5				
Opto Input 6	4A	6	Input L6	32 to 163 step 1
Label for Opto Input 6				
Opto Input 7	4A	7	Input L7	32 to 163 step 1
Label for Opto Input 7				
Opto Input 8	4A	8	Input L8	32 to 163 step 1
Label for Opto Input 8				
Opto Input 9	4A	9	Input L9	32 to 163 step 1
Label for Opto Input 9				
Opto Input 10	4A	0A	Input L10	32 to 163 step 1
Label for Opto Input 10				
Opto Input 11	4A	0B	Input L11	32 to 163 step 1
Label for Opto Input 11				
Opto Input 12	4A	0C	Input L12	32 to 163 step 1
Label for Opto Input 12				
Opto Input 13	4A	0D	Input L13	32 to 163 step 1
Label for Opto Input 13				
Opto Input 14	4A	0E	Input L14	32 to 163 step 1
Label for Opto Input 14				
Opto Input 15	4A	0F	Input L15	32 to 163 step 1
Label for Opto Input 15				
Opto Input 16	4A	10	Input L16	32 to 163 step 1
Label for Opto Input 16				
Opto Input 17	4A	11	Input L17	32 to 163 step 1
Label for Opto Input 17				
Opto Input 18	4A	12	Input L18	32 to 163 step 1
Label for Opto Input 18				
Opto Input 19	4A	13	Input L19	32 to 163 step 1
Label for Opto Input 19				
Opto Input 20	4A	14	Input L20	32 to 163 step 1
Label for Opto Input 20				
Opto Input 21	4A	15	Input L21	32 to 163 step 1
Label for Opto Input 21				
Opto Input 22	4A	16	Input L22	32 to 163 step 1
Label for Opto Input 22				
Opto Input 23	4A	17	Input L23	32 to 163 step 1
Label for Opto Input 23				
Opto Input 24	4A	18	Input L24	32 to 163 step 1
Label for Opto Input 24				

Table 46: GROUP 1 INPUT LABELS column

4.16 Output Labels

The GROUP 1 OUTPUT LABELS column is used to individually label each output relay. The text is restricted to 16 characters and is available if 'Input Labels' are set to 'visible' in the CONFIGURATION column.

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
GROUP 1 OUTPUT LABELS	4B	0	0	
This column contains settings for Output Relay Labels				
Relay 1	4B	1	Output R1	16 character custom name
Label for output relay 1				
Relay 2	4B	2	Output R2	16 character custom name
Label for output relay 2				
Relay 3	4B	3	Output R3	16 character custom name
Label for output relay 3				
Relay 4	4B	4	Output R4	16 character custom name
Label for output relay 4				
Relay 5	4B	5	Output R5	16 character custom name
Label for output relay 5				
Relay 6	4B	6	Output R6	16 character custom name
Label for output relay 6				
Relay 7	4B	7	Output R7	16 character custom name
Label for output relay 7				
Relay 8	4B	8	Output R8	16 character custom name
Label for output relay 8				
Relay 9	4B	9	Output R9	16 character custom name
Label for output relay 9				
Relay 10	4B	0A	Output R10	16 character custom name
Label for output relay 10				
Relay 11	4B	0B	Output R11	16 character custom name
Label for output relay 11				
Relay 12	4B	0C	Output R12	16 character custom name
Label for output relay 12				
Relay 13	4B	0D	Output R13	16 character custom name
Label for output relay 13				
Relay 14	4B	0E	Output R14	16 character custom name
Label for output relay 14				
Relay 15	4B	0F	Output R15	16 character custom name
Label for output relay 15				
Relay 16	4B	10	Output R16	16 character custom name
Label for output relay 16				
Relay 17	4B	11	Output R17	16 character custom name
Label for output relay 17				
Relay 18	4B	12	Output R18	16 character custom name
Label for output relay 18				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Relay 19	4B	13	Output R19	16 character custom name
Label for output relay 19				
Relay 20	4B	14	Output R20	16 character custom name
Label for output relay 20				
Relay 21	4B	15	Output R21	16 character custom name
Label for output relay 21				
Relay 22	4B	16	Output R22	16 character custom name
Label for output relay 22				
Relay 23	4B	17	Output R23	16 character custom name
Label for output relay 23				
Relay 24	4B	18	Output R24	16 character custom name
Label for output relay 24				
Relay 25	4B	19	Output R25	16 character custom name
Label for output relay 25				
Relay 26	4B	1A	Output R26	16 character custom name
Label for output relay 26				
Relay 27	4B	1B	Output R27	16 character custom name
Label for output relay 27				
Relay 28	4B	1C	Output R28	16 character custom name
Label for output relay 28				
Relay 29	4B	1D	Output R29	16 character custom name
Label for output relay 29				
Relay 30	4B	1E	Output R30	16 character custom name
Label for output relay 30				
Relay 31	4B	1F	Output R31	16 character custom name
Label for output relay 31				

MENU TEXT	Col	Row	Default Setting	Available Setting
Description				
Relay 32	4B	20	Output R32	16 character custom name
Label for output relay 32				

Table 47: GROUP 1 OUTPUT LABELS column

OPERATION

CHAPTER 7

1 OVERVIEW

This chapter explains the principles of the IED's individual protection functions. It consists of the following sections:

2 SETTING GROUPS

There are four groups of protection settings; each group contains the same setting cells. This allows four different sets of settings and PSL configurations. Only one group of protection settings can be selected as the active group. The active group is the group currently used by all protection elements. **GROUP 1** is the default active group.

There are four groups of protection settings, with each group containing the same setting cells. This allows a user to have four different sets of settings and PSL configurations. Only one group of protection settings can be selected as the active group. The active group is the group currently used by all protection elements. **GROUP 1** is the default active group.

2.1 Setting groups selection

The setting groups can be changed using opto inputs, a menu selection, the hotkey menu or function keys. In the **Configuration** column if **Setting Group - Select via PSL** is selected, any opto input or function key can be programmed in PSL to select the setting group as shown in Table 1. If **Setting Group - Select via Menu** is selected, in the **Configuration** column the **Active Settings – Group 1(2,3,4)** can be used to select the setting group as long as the setting group is enabled.

The setting group can be changed using the hotkey menu, if **Setting Group - Select via Menu** is selected.

Two DDB signals are available in PSL for selecting a setting group via an opto input or a function key. Table 1 shows the setting group that is active when the relevant DDB signals are activated.

DDB 542 SG Select x1	DDB 543 SG Select 1x	Selected Setting Group
0	0	1
1	0	2
0	1	3
1	1	4

Table 1: Setting group selection in PSL

Note: *Each setting group has its own PSL. Once a PSL has been designed it can be sent to any one of 4 setting groups in the IED. When downloading a PSL to the IED, enter the setting group to which it will be sent. This is also the case when extracting a PSL from the IED.*

3 LINE PARAMETERS

3.1 Tripping mode - selection of single or all poles tripping

This selects whether instantaneous trips are allowed as single pole or are always all poles.

Instantaneous protection elements are those normally set to trip with no intentional time delay. For example, distance Zone 1 and distance channel-aided scheme (optional).

The **Single and All Pole** setting allows single-pole tripping for single-phase-to-ground faults. The selection of **All Pole** converts any trip into two poles trip.

This functionality is shown in AR Figure 63 (logic diagram supplement).

4 DISTANCE PROTECTION

4.1 Distance protection introduction

P44T offers a comprehensive distance protection that comprises:

- Phase fault distance protection
- Earth fault distance protection
- Switch on to fault (SOTF) and trip on reclose (TOR)
- Aided schemes

These features are described in the following sections.

P44T distance protection has phase and ground elements. Ground elements are used for single feed systems, while phase and ground elements are required for autotransformer applications. Ground elements perform a loop impedance calculation with one of the current inputs; either feeder or catenary, while phase elements use both feeder and catenary current inputs.

For autotransformer applications, the relay has access to both catenary and feeder currents. Given the current distribution in these applications, and the impedance loops calculation in combination with the phase selector, both phase and ground elements shall be set with the same reach. Generally, the phase to ground elements will cover faults up to the first autotransformer location, while phase elements will cover faults beyond first autotransformer, this is because faults beyond the first autotransformer are balanced.

Distance protection tripping decision

P44T needs several conditions to be satisfied for Distance protection to trip. These are:

- The phase selector needs to identify the faulted phases and ensure that only the correct distance measuring zones can issue a trip. Possible phase selections are Cat-N, Fdr-N and Cat-Fdr.
- For the selected phase-to-ground elements, the phase current must exceed the minimum sensitivity threshold. For the selected phase-to-phase elements both the phase current and phase to phase current must exceed the minimum sensitivity threshold. The biased detector should be picked up for any ground fault distance element to operate.
- The faulted phase impedance must appear within a tripping (measuring) zone, corresponding to the phase selection. Five independent protection zones are provided. The tripping zones are quadrilateral and are selected independently for phase-to-phase and phase-to-ground faults.
- For directional zones, the directionality element (see section 4.4.1) must agree with the tripping zone. Zones 1, 2, 4 are always directional whereas Zone P and 3 are only directional if set as directional. In directional zones, the directionality element must agree with the tripping zone. For example, Zone 1 is a forward directional zone and must not trip for reverse faults. Therefore, a Zone 1 trip is only allowed if the directionality element issues a forward decision. Zone 4 is reverse-looking so needs a reverse decision by the directionality element.
- Zone P can be used also for Wrong Phase Coupling function if set (see section 5).
- The set time delay for the measuring zone must expire, with the fault impedance measured inside the zone characteristic for the duration. Typically, Zone 1 has no time delay (instantaneous), all other zones have time delays. Where channel-aided distance schemes are used, the time delay tZ2 for overreaching Zone 2 may be bypassed under certain conditions.

To achieve fast, sub-cycle operation, the phase selection, measuring zones and directionality algorithms run in parallel, with their outputs combined with an AND-gate.

This helps to avoid sequential measurement, which would slow the operation of the protection.

Phase and earth distance protection

Phase fault distance protection

P44T has 5 zones of phase fault protection. All zones are set with quadrilateral (polygon) characteristics and are invisible and disabled when run in classic mode (single-phase mode). Each zone can be set independently to be permanently disabled or permanently enabled.

The protection elements are directionalised as follows:

- Zones 1 and 2 - Directional forward zones

Note: *Zone 1 can be extended to Zone 1X when required in zone 1 extension schemes.*

- Zones 3 - Selectable as a directional (forward or reverse) or offset zone
- Zones P (programmable) - Selectable as a directional (forward or reverse), offset zone or Wrong Phase Coupling zone
- Zone 4 - Directional reverse zone

Note: *Each Zone can set reach and reach angle separately and can set its right and left hand resistive reach separately.*

Earth fault distance protection

P44T has 5 zones of earth (ground) fault protection. All zones are set with quadrilateral characteristics. Each zone can be set independently to be permanently disabled or permanently enabled.

The impedance plot, in the figure below, shows simplified polygon (quad) characteristics based on default distance settings and without dynamic expansion.

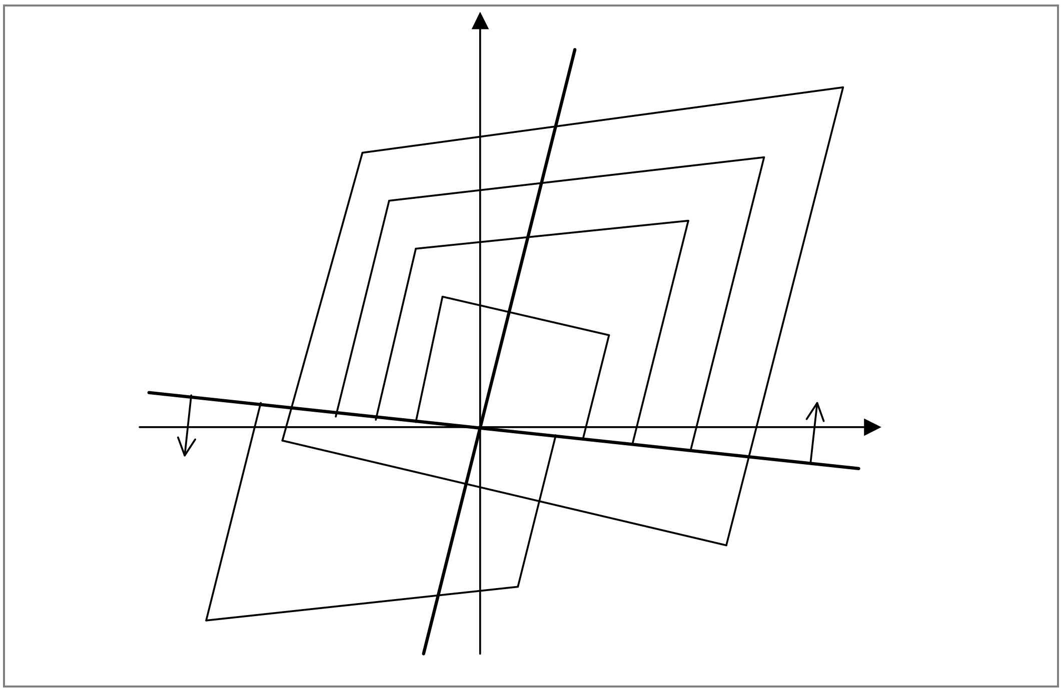


Figure 1: Simplified polygon characteristics

4.2 Phase selection

Phase selection allows the IED to identify exactly which phases are involved in the fault and allows the correct measuring zones to trip.

Operation of the distance elements is controlled by the Superimposed Current Phase Selector. Only elements associated with the fault type selected by the phase selector are allowed to operate during a period of two cycles following the phase selection. If these elements do not operate, all elements are enabled for the following five cycles, before the phase selector returns to its quiescent state.

Operation of an enabled distance element, during the two cycles or five-cycle period, causes the phase selector state to be maintained until the element resets. The one exception to this is when the phase selector decision changes while an element is operated. In this case, the selected elements are reset and the two cycle period restarts with the new selection.

Note: Any existing trip decision is not reset under this condition. After the first cycle following a selection, the phase selector is only permitted to change to a selection involving additional phases.

4.2.1 Theory of operation

The faulted phase are selected by comparing the magnitudes of the phase-to-phase superimposed currents. A single phase-to-ground fault produces the same superimposed current on two of these signals. A phase-to-phase fault produces one signal which is larger than the other two.

A superimposed current is large enough to be included in the selection if it is greater than 80% of the largest superimposed current.

A controlled decay of the superimposed threshold ensures that the phase selector resets correctly on fault clearance.

Phase selection can only be made when any superimposed current exceeds 5% of nominal current (In) as a default value.

Under normal power system conditions, the superimposed currents are made by subtracting the phase-phase current sample taken 96 samples (2 cycles) earlier from the present sample.

When a fault is detected, resulting in a phase selection being made, the previous memorized sample used in the superimposed current calculation is taken from a recycled buffer of previous samples. This ensures that, if the fault develops to include other phases, the original selection is not lost. The recycling of the prefault buffers continues until the phase selector resets, either because the fault is cleared or when the 5 cycle period has expired and no element has operated.

Under conditions on load with high levels of sub-synchronous frequencies, it is necessary to increase the ∆I phase selector threshold from its default (5% In) to prevent sporadic operation. This is automatically performed by the IED, which self-adjusts the threshold to prevent operation due to noise signals, while still maintaining high sensitivity to faults.

To test the distance elements using test sets, select **COMMISSIONING TESTS** > **Static Test** mode. When set, this disables phase selector control and forces the IED to use a conventional (non-delta) directional line.

4.3 Measuring zones – theory of operation

All distance zones in the IED are constructed with several (for quad characteristics) comparators. These comparators operate in the voltage domain and compare phase angles of two voltage values: S_1 and S_2. Using these angle comparators is significantly faster than calculating fault impedance and detecting if this impedance is within a characteristic.

4.3.1 Quadrilateral characteristic

Directional quadrilateral elements

The forward (reverse) quadrilateral directional elements consist of combinations of quadrilateral impedance characteristics with a settable reverse (forward) reach and a separate directional element (see section 4.4.1).

Directional quadrilateral

This characteristic is used for Zones 1, 2, 3 (optionally reversed), P (optionally reversed), and 4 (reversed).

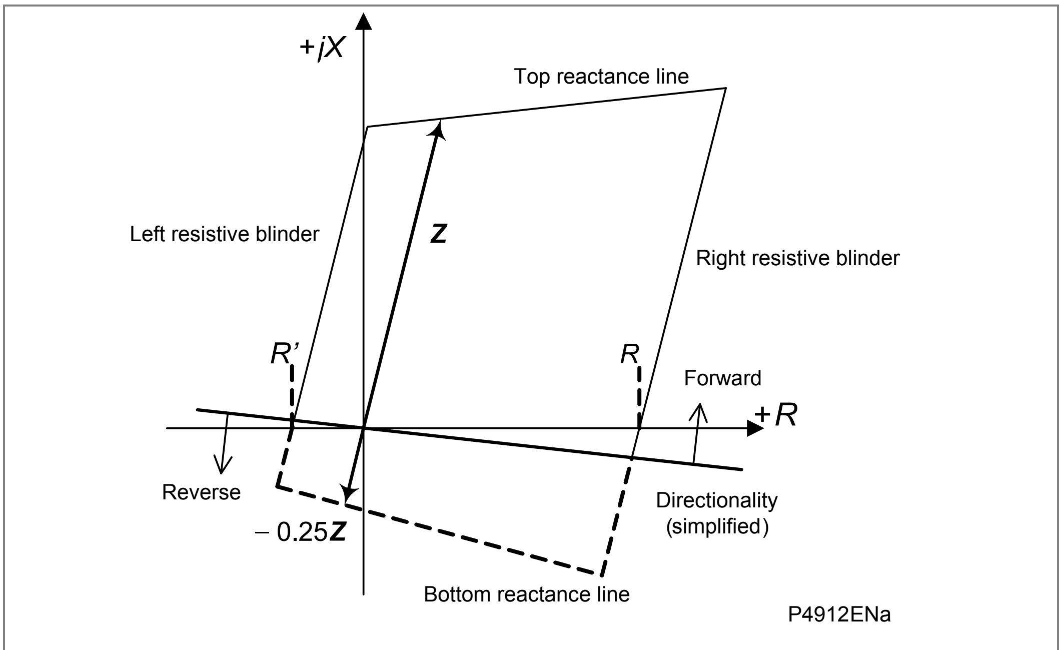


Figure 2: Quadrilateral characteristics (directional line shown simplified)

The directional quadrilateral is formed from two parallel reactance lines, two parallel resistive reach blinders, and is controlled by the delta or conventional directional line. The bottom reactance line is automatically set to 25% of the reactance reach and the left and right hand reach blinder are settable. The reactance line is arranged to operate for faults below the line, the blinders for faults within the resistive reach limits and the delta directional line for forward faults. The counter increments when all of these conditions are satisfied.

Offset quadrilateral

This characteristic is used for Zone 3, Zone P when the offset is enabled (by default the Z3 offset is enable).

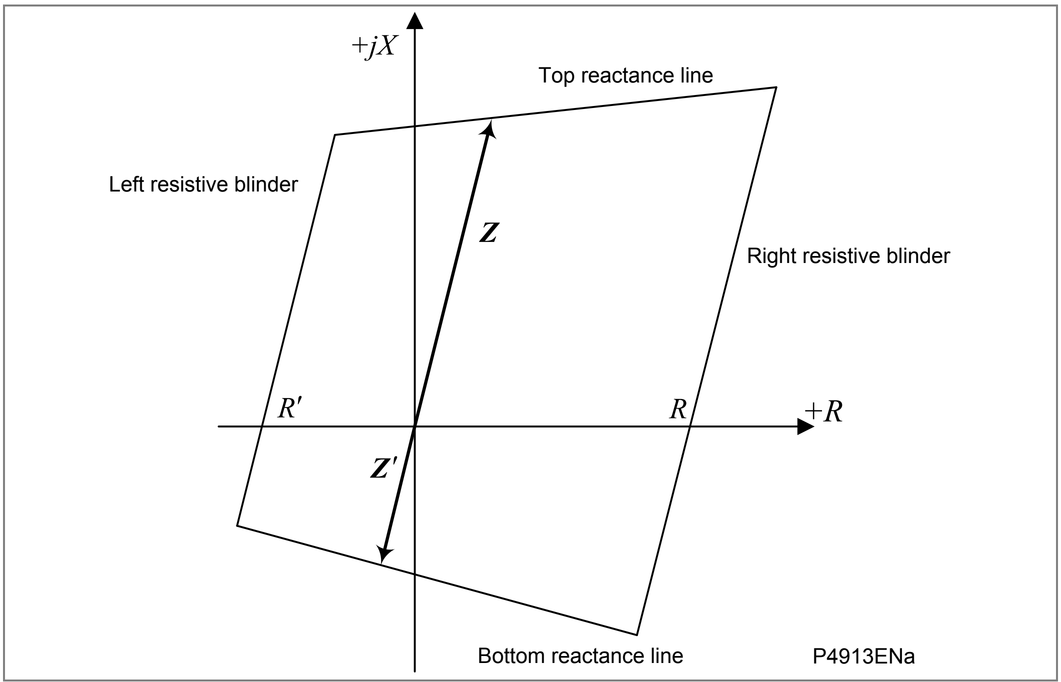


Figure 3: Offset quadrilateral for Zone 3, Zone P

The offset quadrilateral is formed from two reactance lines and two resistive reach blinders. The upper reactance line is arranged to operate for faults below it and the lower for faults above it. The right hand blinder is arranged to operate for faults to its left and the left hand blinder for faults to its right.

> *Note: In the advanced setting mode, both lines can be set independently.*

4.3.1.1 Phase elements

Reactance line - top line of quadrilateral

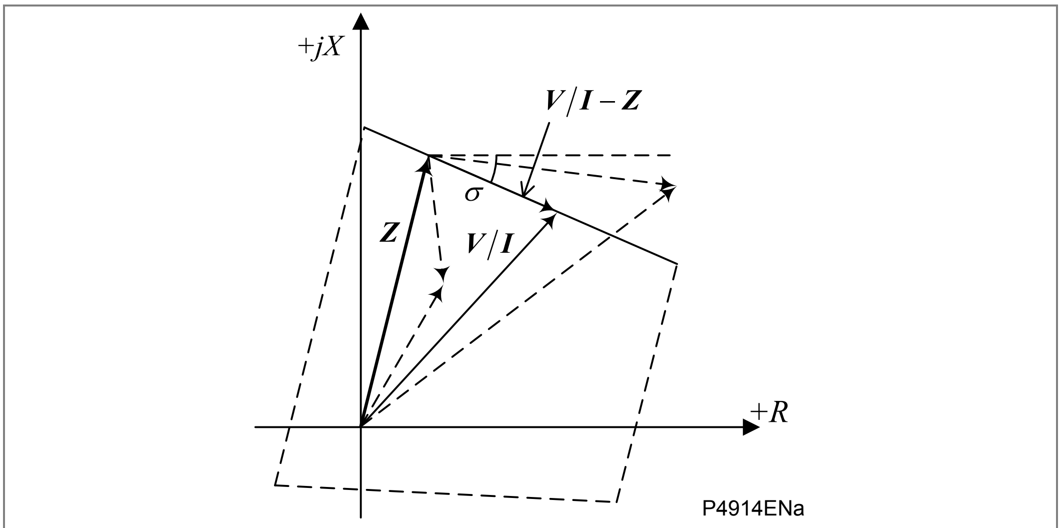


Figure 4: Reactance line - top line of quadrilateral

For all $\boldsymbol{V}/\boldsymbol{I}$ vectors below the top reactance line the following condition is true:

$\angle(\boldsymbol{V}/\boldsymbol{I}-\boldsymbol{Z}) \le \sigma$.

The same condition in the voltage domain is:

$\angle(\boldsymbol{V}-\boldsymbol{I}\cdot\boldsymbol{Z}) \le \angle(\boldsymbol{I}\cdot e^{j\sigma})$,

where $e^{j\sigma}$ denotes phase rotation of the settable angle σ.

The conversion from the impedance domain into the voltage domain is done this way and the following parameters are used.

$\boldsymbol{Z}$ is the impedance reach setting,

$\boldsymbol{V}$ is the distance protection voltage (i.e. $\mathbf{V}=\mathbf{V}_{Cat}-\mathbf{V}_{Fdr}$ for Cat-Fdr fault),

$\boldsymbol{I}$ is the distance protection current (i.e. $\mathbf{I}=\mathbf{I}_{Cat}-\mathbf{I}_{Fdr}$ for Cat-Fdr fault),

$\boldsymbol{V}/\boldsymbol{I}$ is the impedance measurement of the IED.

Since $\boldsymbol{Z}$ is the impedance reach , for all points inside the characteristic zone the following condition is true in impedance domain:

$$90° \le \angle(\boldsymbol{V}/\boldsymbol{I}) - \angle(\boldsymbol{V}/\boldsymbol{I}-\boldsymbol{Z}) \le -90°,$$ Equation

The above condition can be converted into the voltage domain by multiplying all parameters by the distance protection current $\boldsymbol{I}$

$$90° \le \angle\boldsymbol{V} - \angle(\boldsymbol{V}-\boldsymbol{I}\cdot\boldsymbol{Z}) \le -90°,$$ Equation

Finally, the two signals provided to the comparator are:

$$\boldsymbol{S}_1 = \boldsymbol{V}-\boldsymbol{I}\cdot\boldsymbol{Z},$$

$$\boldsymbol{S}_2 = \boldsymbol{I}\cdot e^{j\sigma}.$$

The impedance below the top reactance line is detected when the angle between the signals is less than 0°:

$$\angle\boldsymbol{S}_1 - \angle\boldsymbol{S}_2 < 0°.$$

Reactance line - bottom line of quadrilateral

The tilting of the phase elements bottom line is fixed at minus three degrees (-3°).

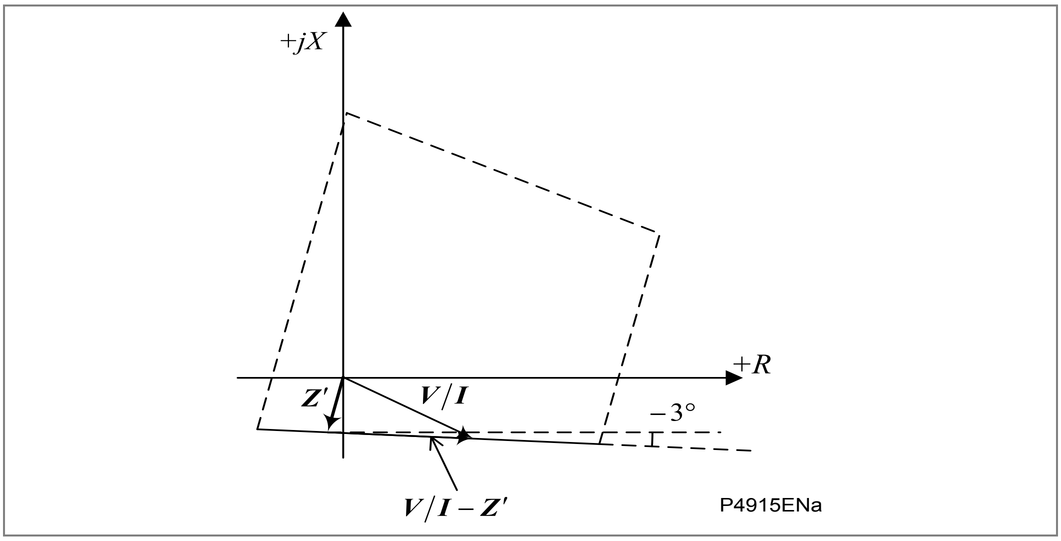


Figure 5: Reactance line - bottom line of quadrilateral

For an offset zone $\boldsymbol{Z}'$ is a settable reverse reach . For a directional zone $\boldsymbol{Z}'$ is 25% of the forward reach $\boldsymbol{Z}$:

$$\boldsymbol{Z}' = -0.25 \cdot \boldsymbol{Z}$$

The signals provided to the comparator are:

$$\boldsymbol{S}_1 = \boldsymbol{V} - \boldsymbol{I} \cdot \boldsymbol{Z}' ,$$

$$\boldsymbol{S}_2 = \boldsymbol{I} \cdot e^{-j3^\circ} ,$$

where e^{-j3° denotes phase rotation of -3°.

The impedance above the bottom reactance line is detected when the angle between the signals is greater than 0°:

$$\angle \boldsymbol{S}_1 - \angle \boldsymbol{S}_2 > 0^\circ .$$

Right hand resistive reach line

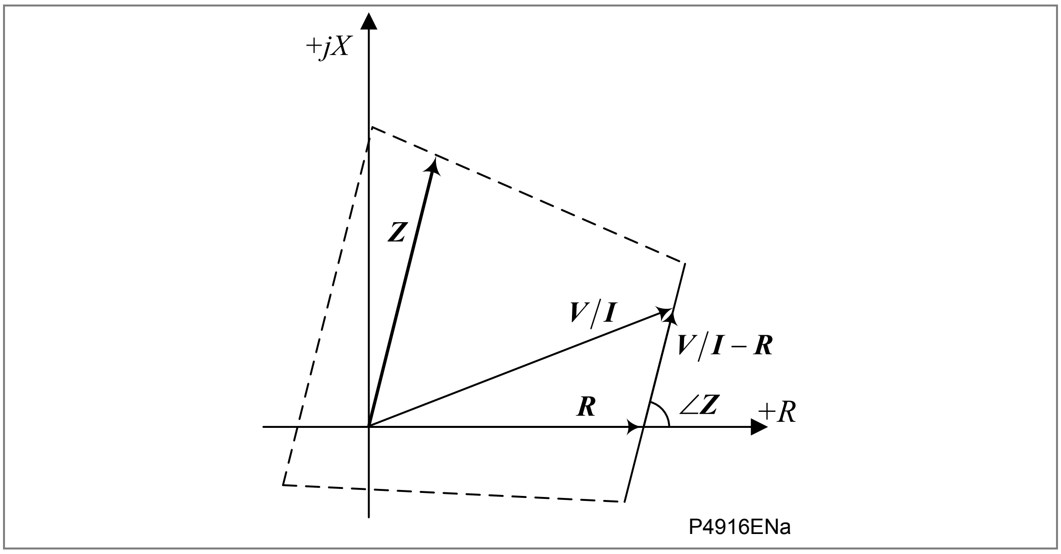


Figure 6: Right hand resistive reach line

For all $\boldsymbol{V}/\boldsymbol{I}$ vectors which are on the left side of the right blinder the following condition is true:

$\angle(\boldsymbol{V}/\boldsymbol{I} - \boldsymbol{R}) \geq \angle\boldsymbol{Z}$.

The same condition in the voltage domain is:

$\angle(\boldsymbol{V} - \boldsymbol{I}\cdot\boldsymbol{R}) \geq \angle(\boldsymbol{I}\cdot\boldsymbol{Z})$,

The conversion from the impedance domain into the voltage domain is done in the same way as explain before for the Reactance line - top line of quadrilateral.

Finally, the two signals provided to the comparator are:

$$\boldsymbol{S}_1 = \boldsymbol{V} - \boldsymbol{I}\cdot\boldsymbol{R},$$

$$\boldsymbol{S}_2 = \boldsymbol{I}\cdot\boldsymbol{Z}.$$

The impedance on the left side of the right hand resistive line is detected when the angle between the signals is greater than 0°:

$$\angle\boldsymbol{S}_1 - \angle\boldsymbol{S}_2 > 0°.$$

Quadrilateral phase resistive reaches

The setting **Rx Ph. Resistive** defines the complete loop resistive reach $\boldsymbol{R}_{LP}$ of the Distance Protection, see the following figure:

Left hand resistive reach line

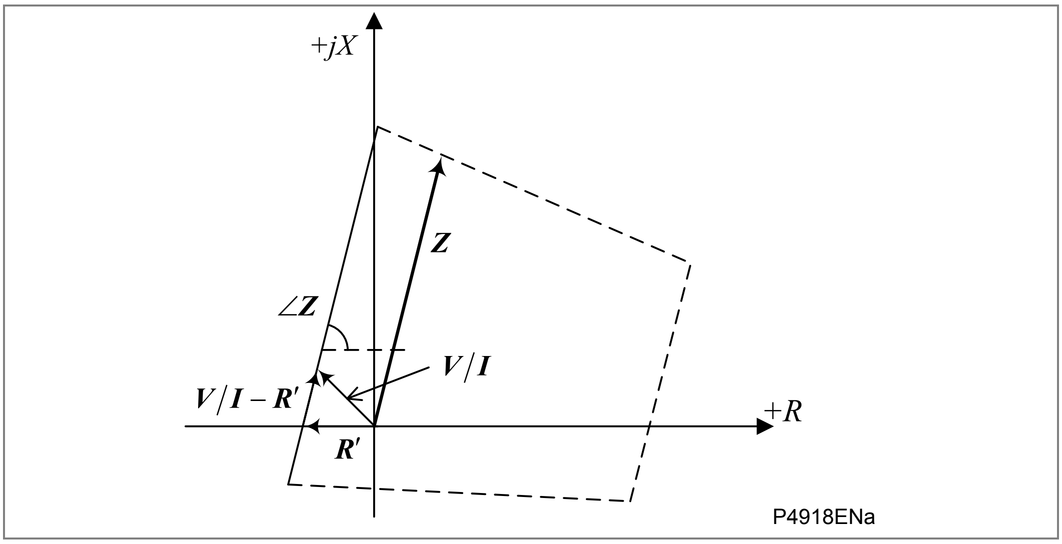


Figure 7: Right hand resistive reach line

For an offset zone $\boldsymbol{R}'$ is a settable reverse resistive reach …. For a directional zone $\boldsymbol{R}'$ is settable also.

The two signals provided to the comparator are:

$$\boldsymbol{S}_1 = \boldsymbol{V} - \boldsymbol{I}\cdot\boldsymbol{R}',$$

$$\boldsymbol{S}_2 = \boldsymbol{I}\cdot\boldsymbol{Z}.$$

The impedance on the right side of the left hand resistive line is detected when the angle between the signals is less than 0°:

$$\angle\boldsymbol{S}_1 - \angle\boldsymbol{S}_2 < 0°.$$

Summary for phase quadrilateral characteristic

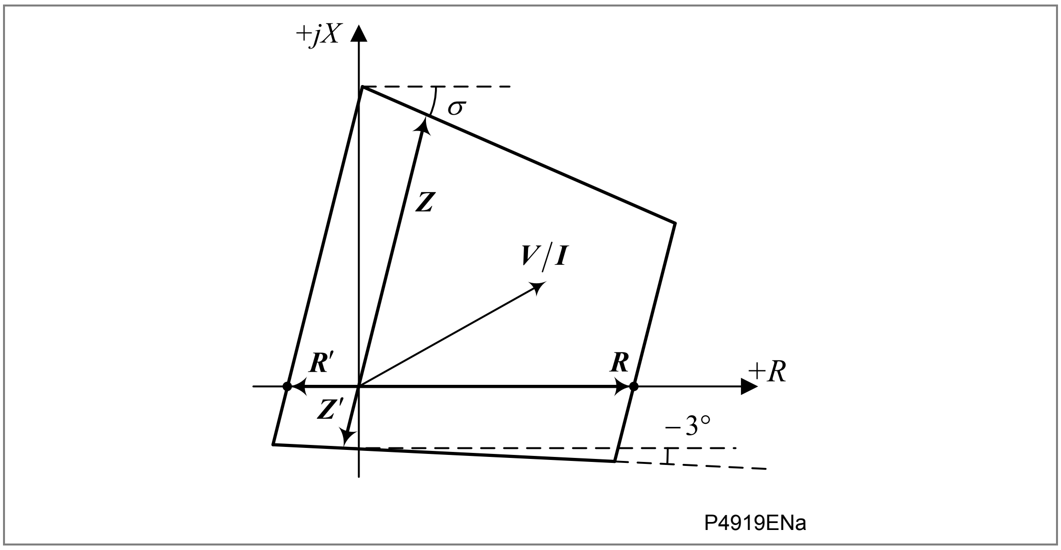


Figure 8: Phase quadrilateral summary

Comparators:

Forward or Offset Zone

Line	S_1	S_2	Condition
Top Line	$V - I \cdot Z$	$I \cdot e^{j\sigma}$	$\angle S_1 - \angle S_2 < 0°$
Bottom Line	$V - I \cdot Z'$	$I \cdot e^{-j3°}$	$\angle S_1 - \angle S_2 > 0°$
Right Line	$V - I \cdot R$	$I \cdot Z$	$\angle S_1 - \angle S_2 > 0°$
Left Line	$V - I \cdot R'$	$I \cdot Z$	$\angle S_1 - \angle S_2 < 0°$

Reverse Zone

Line	S_1	S_2	Condition
Top Line	$V + I \cdot Z$	$-I \cdot e^{j\sigma}$	$\angle S_1 - \angle S_2 < 0°$
Bottom Line	$V + I \cdot Z'$	$-I \cdot e^{-j3°}$	$\angle S_1 - \angle S_2 > 0°$
Right Line	$V + I \cdot R$	$-I \cdot Z$	$\angle S_1 - \angle S_2 > 0°$
Left Line	$V + I \cdot R'$	$-I \cdot Z$	$\angle S_1 - \angle S_2 < 0°$

Parameters

Parameter	Forward or Reverse Zone	Offset Zone
Z	**Zx Ph. Reach** ∠ **Zx Ph. Angle**	**Zx Ph. Reach** ∠ **Zx Ph. Angle**
Z'	0.25 * **Zx Ph. Reach** ∠ **Zx Ph. Angle** + 180°	**Zx' Ph Rev Reach** ∠ **Zx Ph. Angle** + 180°
R	**Rx RPh. Resistive** ∠ 0°	**Rx RPh. Resistive** ∠ 0°
R'	**Rx LPh. Resistive** ∠ 180°	**Rx' LPh. Res. Rev** ∠ 180°
σ	**Zx Tilt Top Line**	**Zx Tilt Top Line**

Table 2: Zone reach settings

4.3.1.2 Ground elements

Reactance line - top line of quadrilateral

The ground loops measure the fault impedance V/I, where V is the distance protection voltage (i.e. $\mathbf{V} = \mathbf{V}_{Cat}$ for Cat-N fault), I is the distance protection current ($\mathbf{I} = \mathbf{I}_{Cat}$ for Cat-N fault). The top line of the characteristic can be tilted by the following angle:

$$\angle\left(\frac{I_{fault}}{I}\right) + \sigma = \angle\left(\frac{I_{fault}}{I} \cdot e^{j \cdot \sigma}\right),$$

The quadrilateral characteristic top line is polarised by the fault phase current $\boldsymbol{I}_{ph}$.

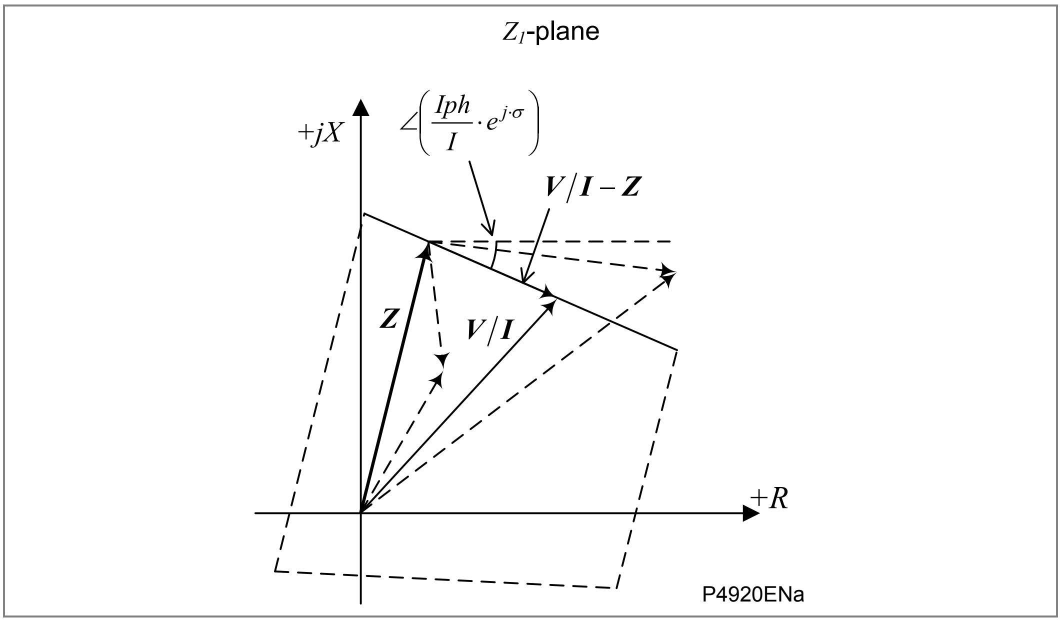


Figure 9: Reactance line - top line of quadrilateral

For all $\boldsymbol{V}/\boldsymbol{I}$ vectors below the top reactance line, the following condition is true:

$$\angle(\boldsymbol{V}/\boldsymbol{I}-\boldsymbol{Z})\leq\angle\left(\frac{\boldsymbol{I}_{ph}}{\boldsymbol{I}}\cdot e^{j\cdot\sigma}\right).$$

The same condition in the voltage domain is:

$$\angle(\boldsymbol{V}-\boldsymbol{I}\cdot\boldsymbol{Z})\leq\angle(\boldsymbol{I}_{ph}\cdot e^{j\cdot\sigma})$$

Since for a ground loop $\boldsymbol{V}=\boldsymbol{V}_{ph}$ and $\mathbf{I}=\mathbf{I}_{ph}$ provided, the signals fed into comparator are:

$$\boldsymbol{S}_1=\boldsymbol{V}_{ph}-\boldsymbol{I}_{ph}\cdot\boldsymbol{Z}_{replica},$$

$$\boldsymbol{S}_2=\boldsymbol{I}_{ph}\cdot e^{j\sigma},$$

where $\boldsymbol{Z}_{replica}$ is the replica forward reach

$$\mathbf{Z}_{replica}=\mathbf{Z}$$

The impedance below the top reactance line is detected when the angle between the signals is less than 0°:

$$\angle\boldsymbol{S}_1-\angle\boldsymbol{S}_2<0°$$

The following figure shows the Z_{LP}-plane representation of the characteristic:

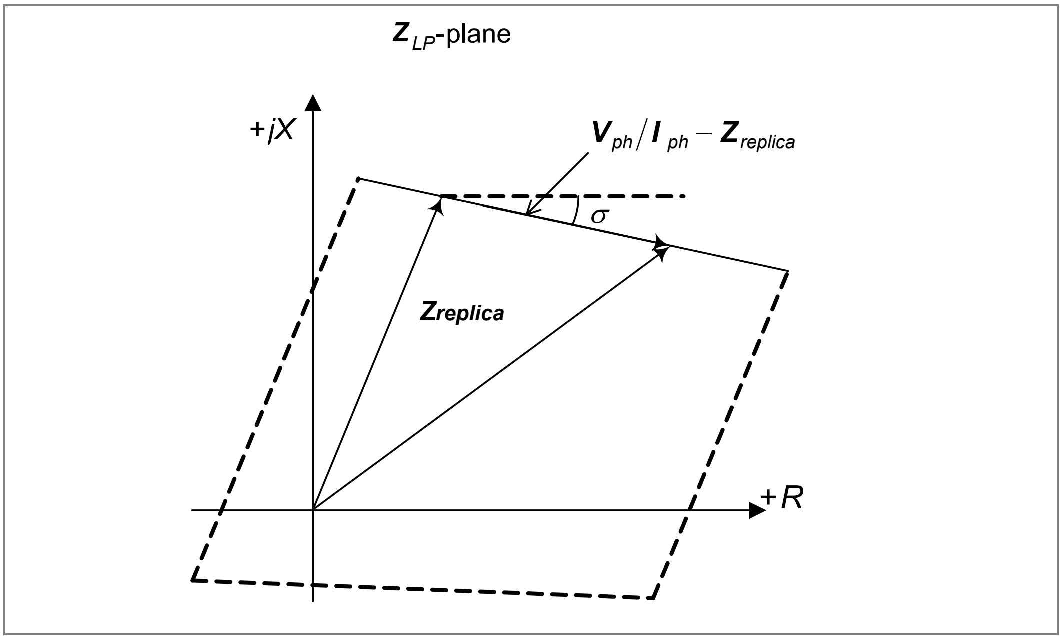


Figure 10: Reactance line - top line of quadrilateral

Note the following important points:

1. The top line tilting angle in Z_{LP}-plane characteristic is fixed at setting σ (**Zx Tilt Top Line**).
2. The top line tilting angle in Z_1-plane characteristic is fixed at setting σ (**Zx Tilt Top Line**).

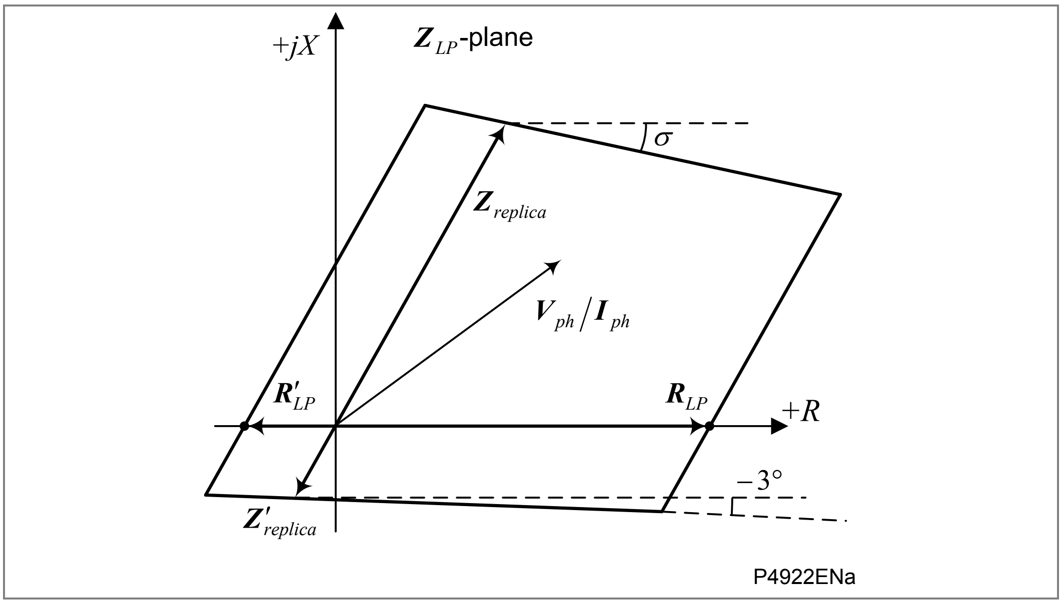


Figure 11: General characteristic in Z_{LP}-plane

Comparators:

Forward or Offset Zone

Line	S_1	S_2	Condition
Top Line	$V_{ph} - I_{ph} \cdot Z_{replica}$	$I_{ph} \cdot e^{j\sigma}$	$\angle S_1 - \angle S_2 < 0°$
Bottom Line	$V_{ph} - I_{ph} \cdot Z'_{replica}$	$I_{ph} \cdot e^{-j3°}$	$\angle S_1 - \angle S_2 > 0°$
Right Line	$V_{ph} - I_{ph} \cdot R_{LP}$	$I_{ph} \cdot Z_{replica}$	$\angle S_1 - \angle S_2 > 0°$
Left Line	$V_{ph} - I_{ph} \cdot R'_{LP}$	$I_{ph} \cdot Z_{replica}$	$\angle S_1 - \angle S_2 < 0°$

Reverse Zone

Line	S_1	S_2	Condition
Top Line	$V_{ph} + I_{ph} \cdot Z_{replica}$	$-I_{ph} \cdot e^{j\sigma}$	$\angle S_1 - \angle S_2 < 0°$
Bottom Line	$V_{ph} + I_{ph} \cdot Z'_{replica}$	$-I_{ph} \cdot e^{-j3°}$	$\angle S_1 - \angle S_2 > 0°$
Right Line	$V_{ph} + I_{ph} \cdot R_{LP}$	$-I_{ph} \cdot Z_{replica}$	$\angle S_1 - \angle S_2 > 0°$
Left Line	$V_{ph} + I_{ph} \cdot R'_{LP}$	$-I_{ph} \cdot Z_{replica}$	$\angle S_1 - \angle S_2 < 0°$

Replica reach impedances calculation:

$$Z_{replica} = Z$$

$$Z'_{replica} = Z'$$

Parameters

Parameter	Forward or Reverse Zone	Offset Zone
Z	**Zx Gnd. Reach** ∠ **Zx Gnd. Angle**	**Zx Gnd. Reach** ∠ **Zx Gnd. Angle**
Z'	0.25 * **Zx Gnd. Reach** ∠ **Zx Gnd. Angle** + 180°	**Zx' Gnd Rev Rch** ∠ **Zx Gnd. Angle** + 180°
R_{LP}	**Rx RGnd Resistive** ∠ 0°	**Rx Gnd Resistive** ∠ 0°
R'_{LP}	**Rx LGnd Resistive** ∠ 180°	**Rx' Gnd Res. Rev** ∠ 180°
σ	**Zx Tilt Top Line**	**Zx Tilt Top Line**

Table 3: Zone reach settings

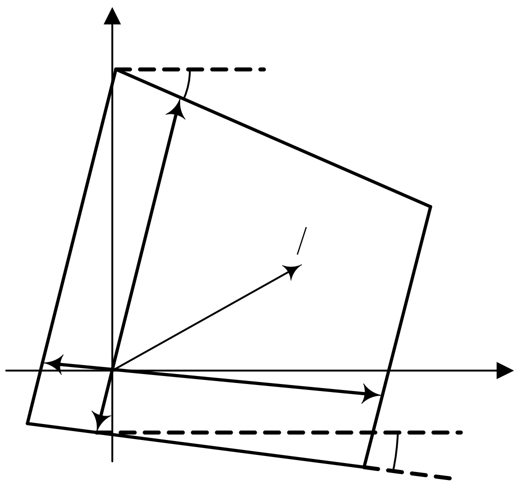


Figure 12: General characteristic in Z_1-plane

$$\boldsymbol{R} = \boldsymbol{R}_{LP} \cdot \frac{\boldsymbol{I}_{ph}}{\boldsymbol{I}}, \ \boldsymbol{R}' = \boldsymbol{R}'_{LP} \cdot \frac{\boldsymbol{I}_{ph}}{\boldsymbol{I}}$$

$$\mathbf{I} = \mathbf{I}_{ph}$$

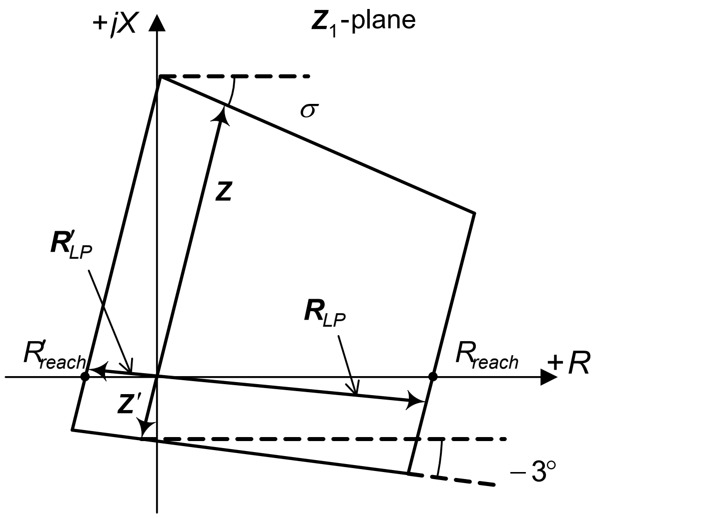


Figure 13: Simplified characteristic in Z_1-plane

$$R_{reach} = R_{LP} \cdot \frac{\sin(\angle\mathbf{Z} + \alpha)}{\sin(\angle\mathbf{Z})},$$

$$R'_{reach} = -R'_{LP} \cdot \frac{\sin(\angle\mathbf{Z} + \alpha)}{\sin(\angle\mathbf{Z})}$$

In typical cases the sine ratio coefficient is close to unity so the simplified equations can be used:

$$R_{reach} \approx R_{LP}$$

$$R'_{reach} \approx -R'_{LP}$$

4.4 Distance elements zone settings

For all applications the IED is using the **Advanced** setting mode, so the user has decided to set all the zones and must complete all the reach for each zone in the menu column **GROUP x DISTANCE ELEMENTS**.

> *Note: Distance zones are directionalized (where applicable) by a delta directional decision. The characteristic angle for this decision is set along with the Delta Directional configuration, in the **GROUP x DISTANCE SETUP** menu column. The default setting is 60º.*

4.4.1 Directionality – Delta and Conventional

The operation of the relay's quadrilateral elements are supervised by directional elements. The IED uses a delta directional technique whenever possible and if enabled. If no decision can be made by the delta directional algorithm, or if the delta directional status is set to disabled, the distance protection switches to the conventional directional technique with a proportion of memory (or cross-polarisation) of the voltage and actual voltage.

Delta directional decision

Delta directional looks at the relative phase angle of the superimposed current ∆I compared to the superimposed voltage ∆V, at the instant of fault initiation. The delta is only present when a fault occurs and a step change from the prefault steady-state load is generated by the fault.

Under healthy network conditions the system voltage is close to Vn nominal and load current flows. Under such steady-state conditions, if the voltage measured on each phase compared to a stored memory value taken from exactly two power system cycles previously (equal to 96 samples), the difference between them is zero. Zero voltage change (∆V = 0) and zero current change (∆I = 0), except when there are changes in load current.

When a fault occurs on the system, the delta changes measured are:

∆V = fault voltage (time "t") - prefault healthy voltage (t-96 samples)

∆I = fault current (time "t") - prefault load current (t-96 samples)

The delta measurements are a vector difference, resulting in a delta magnitude and angle. Under healthy system conditions the prefault values are those measured 2 cycles earlier. When a fault is detected the prefault values are retained for the duration of the fault.

The forward and reverse fault direction determination are explained in the following example: Consider a protected line section AB (Figure 14**).** With a fault external to the protected circuit, both forward and reverse directional measurements are demonstrated using the same fault. Figure 14 shows the difference between the unfaulted and faulted circuit is an equivalent circuit in which all signals are superimposed components. This shows that the superimposed components of current and voltages can be considered to be produced by an equivalent source of superimposed voltage at the fault point. The fault is represented by closing switch S, which connects the superimposed voltage source ∆E, whose magnitude is the change in voltage at the fault point. This causes a superimposed current ∆I to flow in the superimposed circuit.

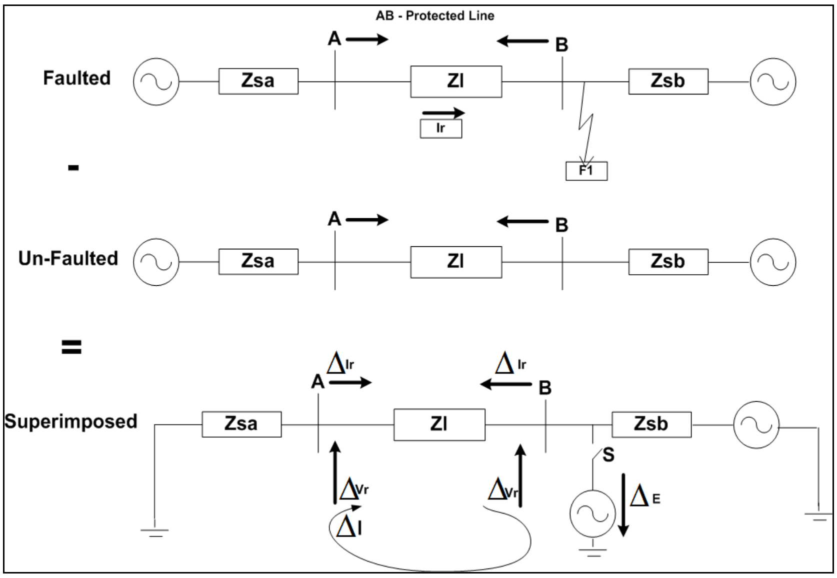


Figure 14: Superimposed Network

Looking closely at the equivalent circuit (Figure 15), in which all signals are superimposed components and solve the circuits for Ends A and B.

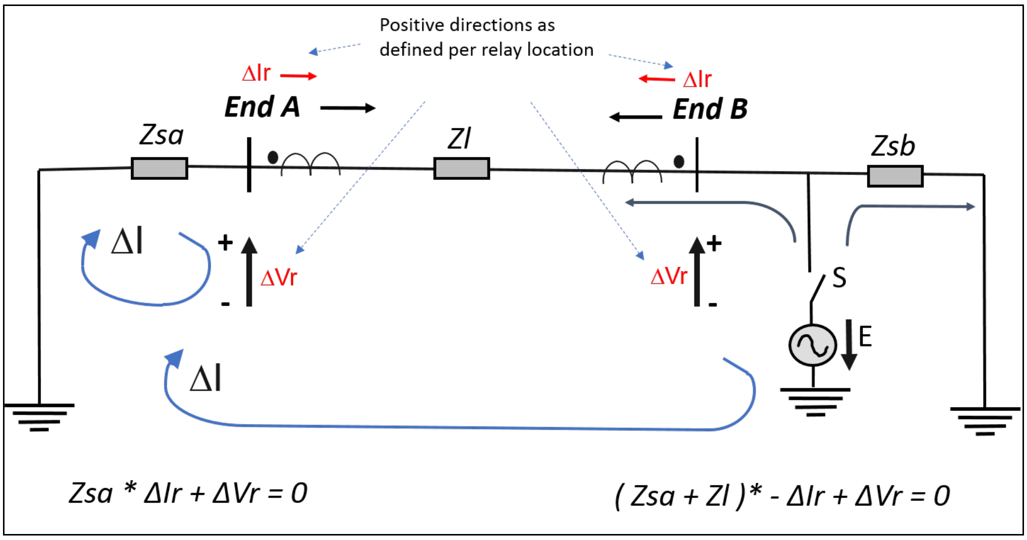


Figure 15: Superimposed network directionality

For End A:

Zsa * ΔIr + ΔVr = 0 ∴ ΔIr = -ΔVr/Zsa

Zsa being the source behind the relay location

Similarly for the relay at End B, this relationship is:

(Zsa + Zl)* - ΔIr + ΔVr = 0 ∴ ΔIr = ΔVr/(Zsa + ZL)

This means for a forward fault (End A), ΔIr lags -ΔVr according to the characteristic angle of the source impedance behind the relay location. This source impedance is settable with the relay characteristic angle (RCA) for the delta directional line with **Dir. Char Angle**. Figure 16 shows the delta directional characteristic with a source impedance setting of 60°.

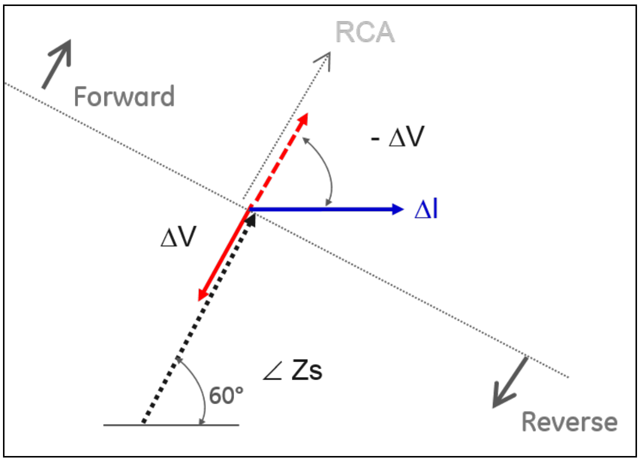


Figure 16: Delta directional forward

In summary:

Forward fault. Delta V is a decrease in voltage, so it is descending. Delta I is a forward current flow, so it is ascending. Where delta I and delta V are approximately in antiphase, the fault is forward. The exact angle relationship for the forward fault is: ΔV / ΔI = (Source impedance, Zs)

Reverse fault. Delta V is a decrease in voltage, so it is descending. Delta I is an outfeed flowing in the reverse direction, so it is also descending. Where delta I and delta V are approximately in phase, the fault is reverse. The exact angle relationship for the reverse fault is: ΔV / ΔI = (Remote Source impedance Zs' + ZL)

To facilitate testing of the distance elements using test sets, which do not provide a dynamic model to generate true fault delta conditions, select COMMISSIONING TESTS > Static Test. When Static Test mode is enabled, phase selector control is disabled, forcing the IED to use a conventional (non-delta) directional line.

Distance zone directionalizing uses fixed operating thresholds: ΔV=0.5V and ΔI=5%In.

Conventional directional decision

The directional elements are polarised by a mix of self (actual) and memory voltage**.** The polarising voltage always contains self-polarized voltage and a percentage of the prefault memory voltage. The setting **Dist. Polarizing** defines the proportion between self-polarising voltage and memory-polarising voltage. Figure 17 shows the conventional directional line, which has a fixed relay characteristic angle (RCA) of 60°.

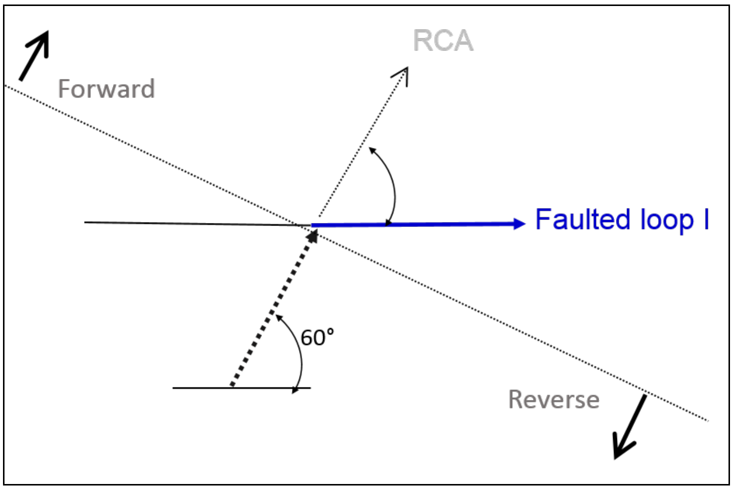


Figure 17 Conventional directional line

In simple terms, a conventional directional line is normally shown on a quadrilateral characteristic as the bottom limit of the characteristic, shown in Figure 18. Therefore, the actual protected area is the shaded area, shown below**.** The directional line is actually dynamic.

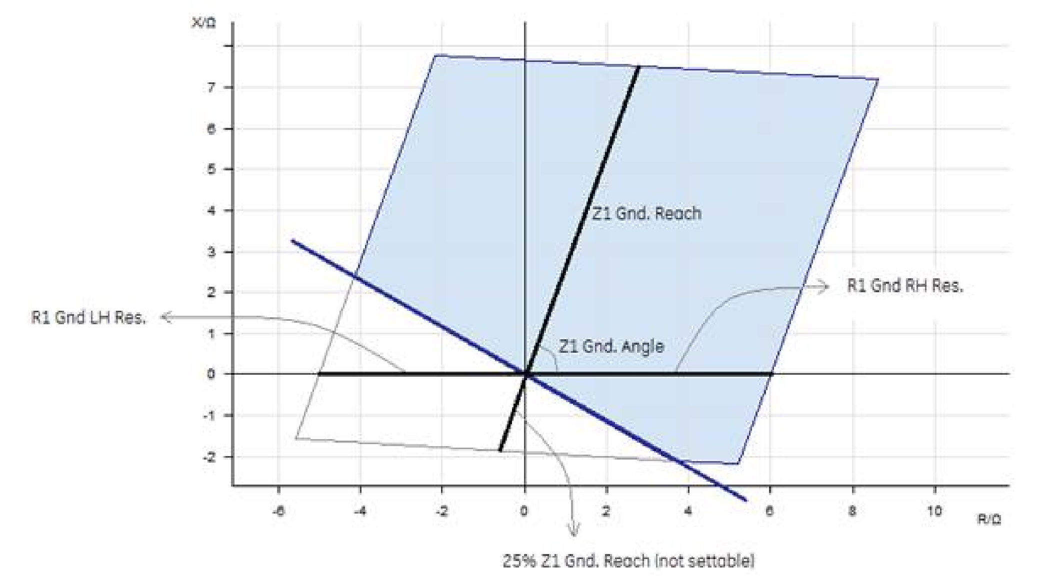


Figure 18: Conventional directional line—simple representation

The main reasons why the delta directional technique might not be able to make a decision are:

- The delta directional algorithm is disabled or **COMMISSION TESTS** > **Static Test** is set.
- The memory has elapsed or is not valid due to a SOTF condition
- There is no sufficient change in voltage and current (no delta measured)

The Conventional Directional technique uses the polarising voltage signal:

$$\mathbf{S}_1 = \mathbf{V} + p \cdot \mathbf{V}_{mem} \,.$$

When the memory time expired and no cross voltage available, it will be the 100% self polarising. it means:

$$\mathbf{S}_1 = \mathbf{V} + p \cdot \mathbf{V}_{mem} \;,\; p \cdot = 0 \text{ under this condition}$$

The second signal provided to the comparator is

$$\boldsymbol{S}_2 = \boldsymbol{I} \cdot e^{j \cdot 60^\circ} \,.$$

A forward fault is detected if the following condition is true:

$$-90^\circ < \angle \boldsymbol{S}_1 - \angle \boldsymbol{S}_2 < 90^\circ \,.$$

The RCA (Relay Characteristic Angle) of the Conventional Directional element is fixed at 60°.

4.4.2 Phase fault zone settings

By factory defaults, the top line of quadrilateral characteristics is not fixed as a horizontal reactance line. To account for phase angle tolerances in the line CT, VT and IED, the line is tilted downwards at a droop of -3°. This tilt down helps to prevent zone 1 overreach.

The top line tilt is settable and set by default to -3°.

The current sensitivity setting for each zone is used to set the minimum current that must flow in each of the faulted phases before a trip can occur. For example, if a phase Cat-

Fdr fault is present, the IED must measure both currents Icat and Ifdr above the minimum set sensitivity.

The default setting is 7.5% In for Zones 1 and 2, 5% In for other zones, ensuring that distance element operation is not constrained, right through to an SIR ratio of 60.

4.4.3 Ground fault zone settings

The Ground reach settings (Reach and Angle) are set according to the line impedance, so are generally identical to the Phase reach settings.

The top line of ground quadrilateral characteristics is not fixed as a horizontal reactance line. To account for phase angle tolerances in the line CT, VT and the IED, the line is tilted downwards at a "droop" of -3°. This tilt down helps to prevent zone 1 overreach:

- Zone 1 is allowed to tilt down to avoid overreaching for prefault power export;
- Zones 2 and 3 are allowed to tilt up to avoid underreaching for prefault power import.

The top line tilt is settable and set by default to -3°.

The current sensitivity setting for each zone is used to set the minimum current that must flow in the faulted phase and the neutral before a trip can occur. For example, if an Cat-ground fault is present, the IED must measure Icat fault current above the minimum set sensitivity.

The default setting is 7.5% In for Zones 1 and 2, and 5% In for other zones, ensuring that distance element operation is not constrained, right through to an SIR ratio of 60.

4.4.4 Distance zone sensitivities

The criteria used to calculate the setting value are needed for a minimum value of current flowing in the faulted loop and for the Zone reach point voltage, should be applied to ensure distance element accuracy.

. For Zones 3, P, and 4, the minimum current must be greater than 5% of the rated current and the minimum voltage at the Zone reach point must be 0.25 V. The current equating to the reach point criteria can be expressed as 0.25/Zone reach and the sensitivity can be expressed as:-

Sensitivity (Z3, ZP, Z4) = max (5%In, (0.25/Zone reach))

Zones 1 and 2 are set less sensitive than the reverse Zone 4. This ensures stability of the IED in either an overreaching or a blocking scheme. For Zones 1 and 2, the same criteria are applied as for Zones 3, P, and 4. Also a minimum sensitivity criterion is applied, depending on the Zone 4 sensitivity. The sensitivity must exceed 1.5 x Zone 4 sensitivity and can be expressed as:-

Sensitivity (Z1, Z2) = max (5%In, (0.25/Zone reach), (1.5 x Zone 4 sensitivity))

Or

Sensitivity (Z1, Z2) = max (5%In, (0.25/Zone reach), (1.5 x (0.25/Zone 4 reach)))

The dependency on the Zone 4 element always applies, even if Zone 4 is disabled.

The default reach setting for Zones 1, 2, and 4 are 80%, 120%, and 150% respectively. For these settings the zone-dependent terms can be reduced to:

0.25/Zone 1 reach = 0.25/(0.8 x line impedance)

0.25/Zone 2 reach = 0.25/(1.2 x line impedance)

1.5 x (0.25/Zone 4 reach) = 0.25/line impedance

In such cases, for Zone 1, the dominant Zone reach term is that of Zone 1 and the equation can be reduced to:

Sensitivity (Z1) = max (5%In, (0.25/(0.8 x line impedance)))

For lines with an impedance of less than 6.25 Ω the Zone 1 reach term dominates and the sensitivity is greater than 5% In. Above this line impedance the sensitivity is 5% In.

Similarly, for Zone 2, the dominant Zone reach term is that of Zone 4 and the equation can be reduced to:

Sensitivity (Z2) = max (5%In, (0.25/line impedance))

For lines with an impedance of less than 5 Ω the Zone reach term dominates and the sensitivity is greater than 5% In. Above this line impedance the sensitivity is 5% In.

4.5 Conventional voltage transformer and capacitor VT applications

The IED achieves fast trip times due to an optimized counting strategy. For faults on angle and up to 80% of the set reach of the zone, a counter increments quickly to reach the level at which a trip is issued. Near the characteristic boundary, the count increments more slowly to avoid transient overreach and to ensure boundary accuracy. This strategy is entirely sufficient where conventional wound voltage transformers are used. Therefore where capacitor-coupled voltage transformers (CVT) are not used, **CVT Filters** can be set to **Disabled**.

Where capacitor-coupled voltage transformers are used, for a close-up fault, the transient component can be very large in relation to the fundamental component of fault voltage. The IED has setting options to allow additional filtering to be switched-in when required. The filter options depend on the likely severity of the CVT transient. The two filtering methods are:

- CVTs with passive suppression of ferroresonance.
- CVTs with active suppression of ferroresonance.

4.5.1 CVTs with passive suppression of ferroresonance

Passive suppression uses an anti-resonance design and the resulting transient distortion is fairly small. Sometimes such suppression is classed as a type 2 CVT. In passive CVT applications, the affect on characteristic accuracy is generally negligible for source to line impedance ratios of less than 30 (SIR < 30). However, at high SIRs it is advisable to use the slower count strategy. This is done by setting **CVT Filters** to **Passive**.

By enabling this filter, the IED is not slowed unless the SIR is above that set. If the line terminal has an SIR below the setting, the IED can still trip subcycle. If the SIR is estimated higher than the setting, the instantaneous operating time is increased by about a quarter of a power frequency cycle. The IED estimates the SIR as the ratio of nominal rated voltage Vn to the size of the comparator vector IZ (in volts):

SIR = Vn/IZ

Where:

Vn = Nominal phase voltage of catenary or Feeder

I = Fault current

Z = Reach setting for the zone concerned

Therefore for slower counting I needs to be low, as restricted by a relatively weak infeed and Z needs to be small, as for a short line.

4.5.2 CVTs with active suppression of ferroresonance

Active suppression uses a tuned L-C circuit in the CVT. The damping of transients is not as efficient as for the passive designs. Such suppression is often termed a type 1 CVT. In active CVT applications, to ensure reach point accuracy, **CVT Filters** is set to **Active**. The IED then varies the count strategy according to the calculated SIR (= Vn / IZ). Subcycle tripping is maintained for lower SIRs, up to a ratio of 2. The instantaneous operating time is increased by about a quarter of a power frequency cycle at higher SIRs.

Transients caused by voltage dips, however severe, do not affect the IED's directional measurement because the IED uses voltage memory.

4.6 Load blinding (load avoidance)

Load blinders are provided for all phase and ground fault distance elements, to prevent misoperation (mal-tripping) for heavy load flow. The purpose is to configure a blinder envelope which surrounds the expected worst case load limits, and to block tripping for any impedance measured within the blinded region. Only a fault impedance which is outside of the load area is allowed to cause a trip. The blinder characteristics are shown in Figure 19.

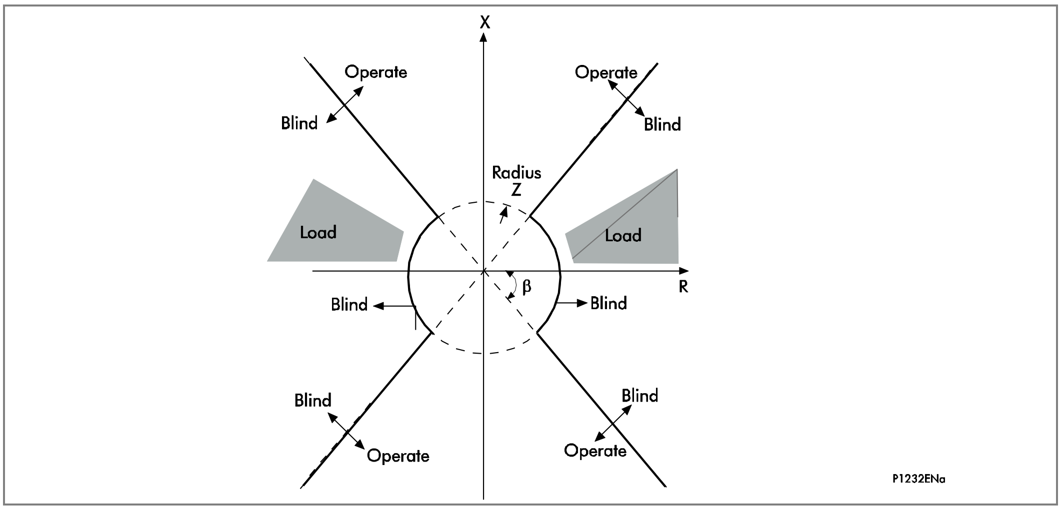


Figure 19: Load blinder characteristics

In Figure 19:

- Z denotes the Load/B Impedance setting. This sets the radius of the underimpedance circle.
- β denotes the Load/B Angle setting. This sets the angle of the two blinder boundary lines - the gradient of the rise or fall with respect to the resistive axis.

MiCOM P44T can allow the load blinder to be bypassed any time the measured voltage for the phase in question falls below an undervoltage V< setting. Under such circumstances, the low voltage could not be explained by normal voltage excursion tolerances on-load. A fault is definitely present on the phase in question, and it is acceptable to override the blinder action and allow the distance zones to trip according to the entire zone shape. The benefit is that the resistive coverage for faults near to the IED location can be higher.

4.7 Distance elements basic scheme setting

The configuration of which zones will trip, and the zone time delays is set in the menu column **GROUP x SCHEME LOGIC** (where x is the setting group). Phase and ground elements may have different time delays if required. The operation of distance zones according to their set time delays is called the Basic Scheme,. The basic scheme always runs, regardless of any channel-aided acceleration schemes which may be enabled .

The setting **BasicScheme Mode** defines how zone timers are initiated when some zones trip.

In the **Standard** mode a zone timer starts only when the corresponding distance zone start occurs, see Figure 20.

In the **Alternative** mode, any enabled Distance element sets **Any Distance Start** DDB. This starts all Zone timers (both Phase and Ground), see Figure 21. The timers are reset if **Any Distance Start** signal resets. If a distance element operates and its zone timer also operates, a trip is issued.

The **Alternative** mode is epecially suitable for evolving faults where the ground timers could reset and phase timers start.

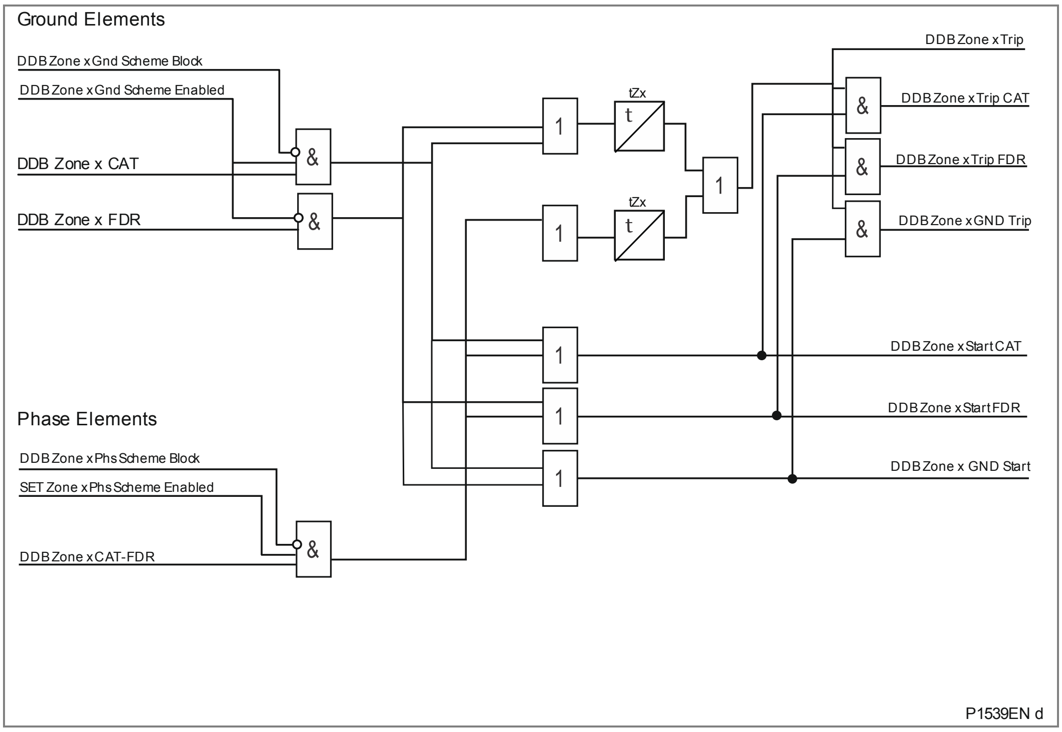


Figure 20: Basic scheme delayed trip

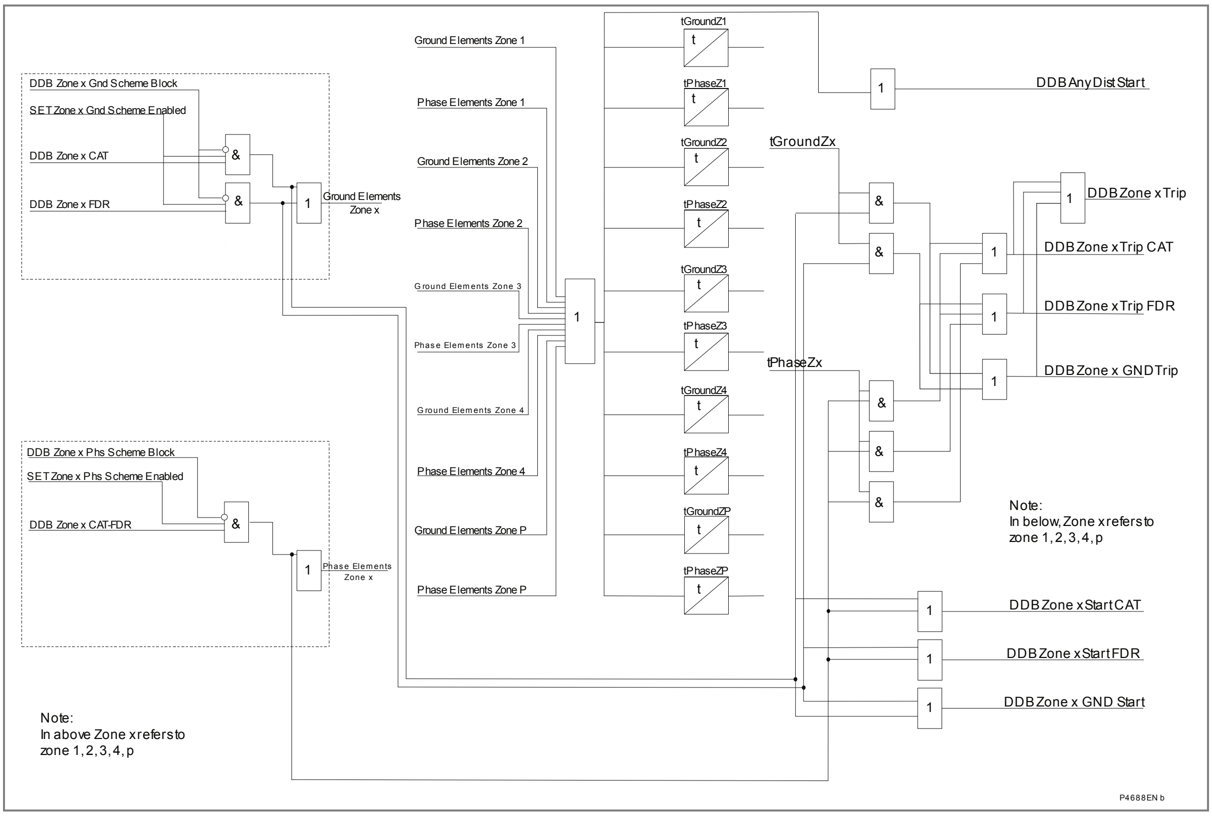


Figure 21: Alternative timer start scheme

By default distance start events are controlled by the inputs to the basic scheme, DDB 960-987. DDB 741-758 can also produce events but these are blocked by settings in the RECORD CONTROL column. The source of these start events can be referred depending on the customer's preference.

Signal	Zone 1	Zone 2	Zone 3	Zone P	Zone 4
Zone x Ground Block	384	386	388	390	392
Zone x Phase Block	385	387	389	391	393
Zone x Cat Element	960	966	972	978	984
Zone x Fdr Element	961	967	973	979	985
Zone x Cat-Fdr Element	963	969	975	981	987
Zone x Trip	608	613	618	623	628
Zone x Cat Trip	609	614	619	624	629
Zone x Fdr Trip	610	615	620	625	630
Zone x Cat Start	741	745	749	753	757
Zone x Fdr Start	742	746	750	754	758

Table 4: Zone settings

Note: The numbers in the table represent the DDB signals available in the PSL.

5 WRONG PHASE COUPLING

Electrical rail networks are designed to present a balance load to three phase grid feed systems. The figure below shows a typical two track electrified railway with 25 kV single phase and booster transformers, with each feeding station able to supply the whole network. In normal service, the coupling breaker at the mid-point station is open and each feeding station supplies the power up to that station. Under emergency conditions, only one feeding station is supplying the whole of the network and the coupling breaker is closed. If the coupling breaker is closed accidentally while both feeding stations are in service, connecting two asynchronous supplies would cause a short circuit. This is known as wrong phase coupling.

Zone P has a selection mode which enables protection for Wrong Phase Coupling (WPC). In the menu column **GROUP x DISTANCE SETUP** (where x is the setting group), the **Zone P Gnd Dir** setting can be set to WPC mode, operating with an impedance protection characteristic suitable for this condition.

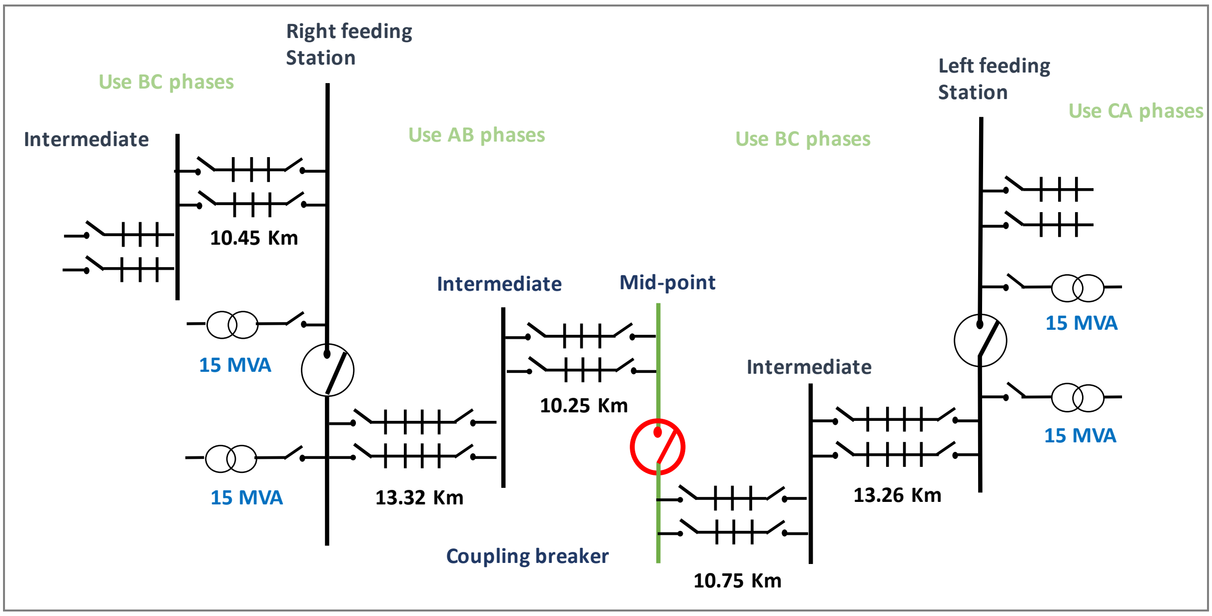


Figure 22: Typical two track electrified railway

5.1 Wrong Phase Coupling principle

Configuration of this zone is set in the menu column **GROUP x DIST. ELEMENTS** (where x is the setting group).

This element may require a different time delay. The time delay for Zone P, working as Wrong Phase Coupling, is under the Basic Scheme, **tZP WPC Delay**. The basic scheme always runs regardless of any channel-aided acceleration schemes which may be enabled.

WPC setting parameters are as follows:

- WPC line angle;
- Z WPC min;
- Z WPC max;
- WPC LH angle;
- WPC RH angle.

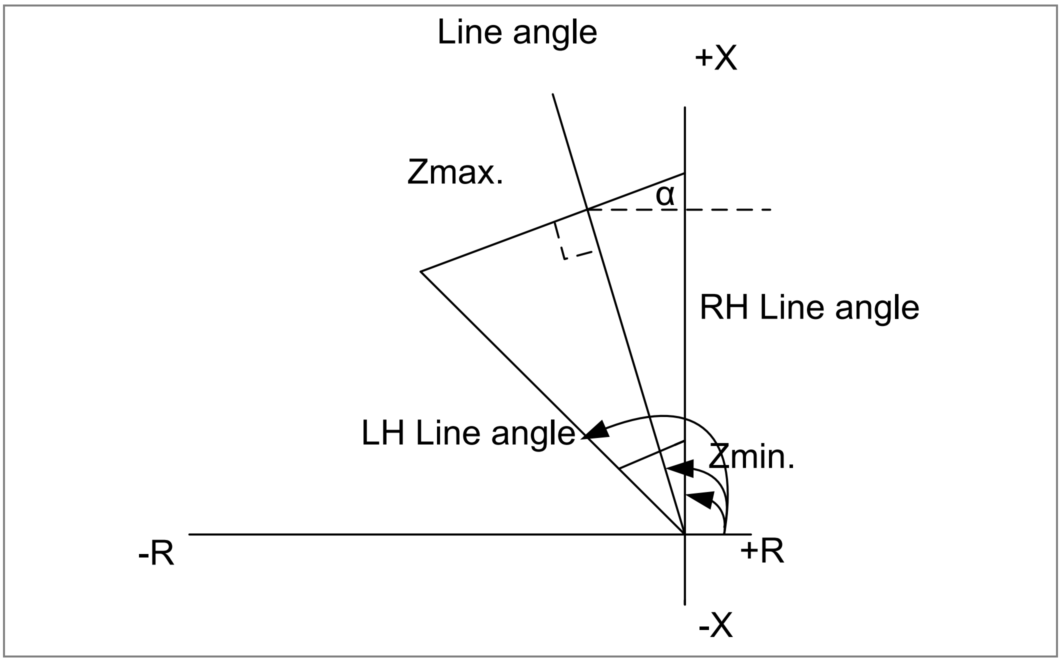


Figure 23: General characteristic of WPC zone

> *Note: The above settings should following the following condition limits:*
> *WPC LH angle > WPC Line angle > WPC RH angle*
> *If above is against, P44T relay will indicate an alarm:*
> *DDB 295 "WPC_config_wrong.*

The P44T WPC distance will issue a trip when meet the following conditions,

- The WPC option is set.
- No block
- Measure impedance meets the four conditions list in the table

Line	S_1	S_2	Condition
Top Line	$V - I * Z\max$	$I * e^{\alpha}$	$\angle S1 - \angle S2 < 0^0$
Bottom Line	$V - I * Z\min$	$I * e^{\alpha}$	$\angle S1 - \angle S2 > 0^0$
Right Line	(V / I)	e (β_{RH})	$\angle S1 - \angle S2 > 0^0$
Left Line	(V / I)	e (β_{LH})	$\angle S1 - \angle S2 < 0^0$

Table 5: WPC zone measure impedance

> *Note:* α *= WPC line angle -90.*

- Delay time is expired

The same as the existing distance zone, the WPC range distance also should have the count strategy, the Zmin and Zmax have the same 10% boundary, but the left hand and right hand angle should have +/-5 degree boundary as following:

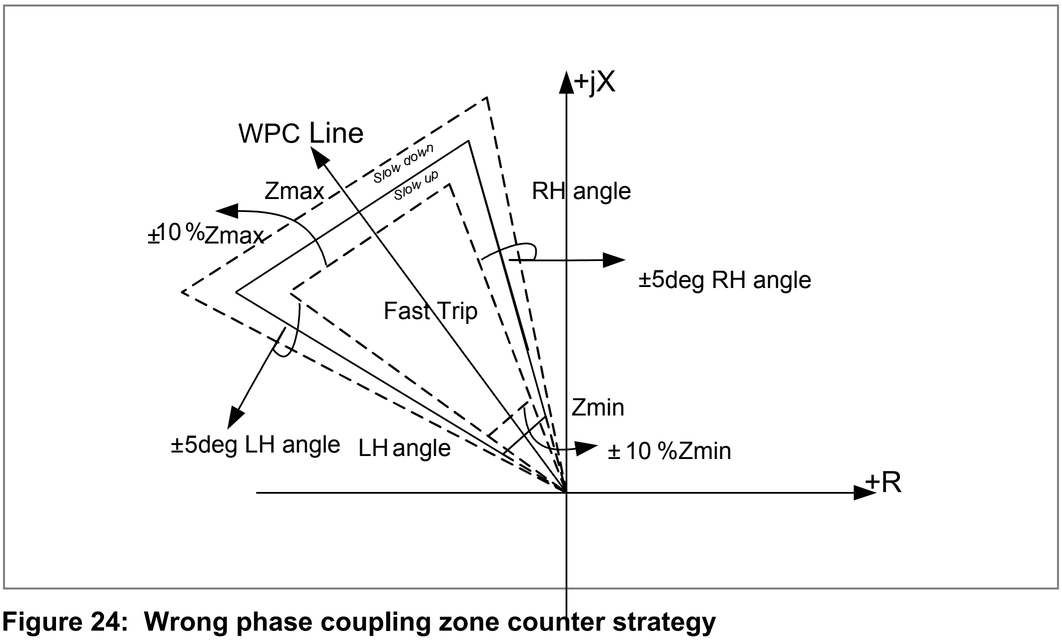


Figure 24: Wrong phase coupling zone counter strategy

6 COMMUNICATIONS BETWEEN IEDS

6.1 InterMiCOM P44y

6.1.1 Protection signaling

To achieve fast fault clearance and correct discrimination for faults anywhere in a high voltage power network, it is necessary to signal between the points at which protection IEDs are connected. The following two distinct types of protection signaling can be identified.

Unit protection schemes

In these schemes the signaling channel is used to convey analog data representative of the power system between IEDs. Typically current magnitude and/or phase information is communicated between line ends to enable a unit protection scheme to be implemented. These unit protection schemes are not covered by InterMiCOM or InterMiCOM^{64}. Instead, the MiCOM P54x range of current differential and phase comparison IEDs are available for unit applications.

Teleprotection - channel aided schemes

In channel-aided schemes the signaling channel is used to convey simple ON/OFF commands from a local protection device to a remote device to provide some additional information to be used in the protection scheme operation. The commands can be used to accelerate in-zone fault clearance or to prevent out-of-zone tripping, or both.

The InterMiCOM application is an effective replacement to the traditional hardwired logic and communication schemes used by protection IEDs for such teleprotection signaling.

The MiCOM Px4x series products have a grouping of internal digital signals known as the digital data bus, DDB, that are used to implement the protection scheme logic. A number of these DDB signals are reserved as inputs and outputs for the InterMiCOM application. These are mapped using the programmable scheme logic (PSL) support tool. The InterMiCOM application provides a means of transferring the status of these mapped DDB signals between the protection IEDs using dedicated full-duplex communications channels.

6.1.2 InterMiCOM variants

There are two different types of integrated InterMiCOM teleprotection available in the MiCOM P44T IEDs:

- An optical fiber implementation, InterMiCOM^{64} - designed, primarily, to work over fiber optic and multiplexed digital communications channels with data rates of 56/64 kbit/s. A total of 16 InterMiCOM^{64} commands (16 inputs and 16 outputs) are available in the P44T. These are arranged as two groups of 8 bits each, and are referred to as Channel 1 and Channel 2. Three InterMiCOM^{64} scheme arrangements are possible:
  - Two-terminal with a single communications link
  - Two-terminal with a dual redundant communications link (sometimes referred to as '**hot standby**')
  - Three terminal (or triangulated) scheme
- An electrical implementation of InterMiCOM, realised over an EIA(RS)232 medium typically for MODEM applications and referred to as MODEM InterMiCOM for ease of differentiation with InterMiCOM^{64}. MODEM InterMiCOM supports two-terminal applications with a single communications channel. Eight MODEM InterMiCOM commands can be transmitted between the line ends.

Provided the correct hardware options have been specified, it is possible to configure the P44T to operate using either InterMiCOM^{64} or MODEM InterMiCOM, or both. The selection is made under the CONFIGURATION column of the menu software.

6.1.3 InterMiCOM features

The different requirements of applications that use teleprotection signaling for direct acting, permissive, or blocking schemes are all catered for by InterMiCOM.

Communications are supervised and alarms and signal defaults can be defined to give controlled actions in the event of communications signals being distorted or unavailable.

Communications statistics and loopback features are available to help with commissioning and testing purposes.

Both InterMiCOM^{64} and MODEM InterMiCOM teleprotection provide the ideal means to configure schemes using the MiCOM P44T. Selection between the two depends on communications media availability, system configuration, distances, cost issues and utility practice.

6.1.4 Definition of teleprotection commands

Three generic types of teleprotection command can be defined. These are Intertripping, Permissive signaling, and Blocking. All teleprotection signals are initiated in a transmitting IEDs but, according to the application, the receiving IED may condition the signal according to the scheme requirements:

Intertripping: In intertripping (also called direct or transfer tripping) applications, the command is not supervised at the receiving end by any protection IED and its receipt causes direct circuit breaker operation. Since no checking of the received signal by another protection element is performed, it is essential that any noise on the signaling channel is not interpreted as being a valid signal when the command isn't being transmitted. For an intertripping scheme, therefore, the primary requirement of the signaling channel is security.

Permissive: In permissive applications, tripping is only permitted when the command coincides with a protection operation at the receiving end. Since the receiver applies a second independent check before tripping, the signaling channel for a permissive scheme does not have to be quite as secure as for an intertripping scheme, but it may need to be faster.

Blocking: In blocking applications, tripping occurs when a protection element picks up in a receiving IED while no signal is received from a remote IED. In such schemes, when the command is received, the protection element is blocked even if a protection element picks up. Since the signal is used to prevent tripping, it is a requirement that the signal should be available whenever possible, and that it should be received as quickly as possible. The requirements of a blocking channel are, therefore, to be fast and to be dependable.

Figure 25 shows the requirements for the three channel types.

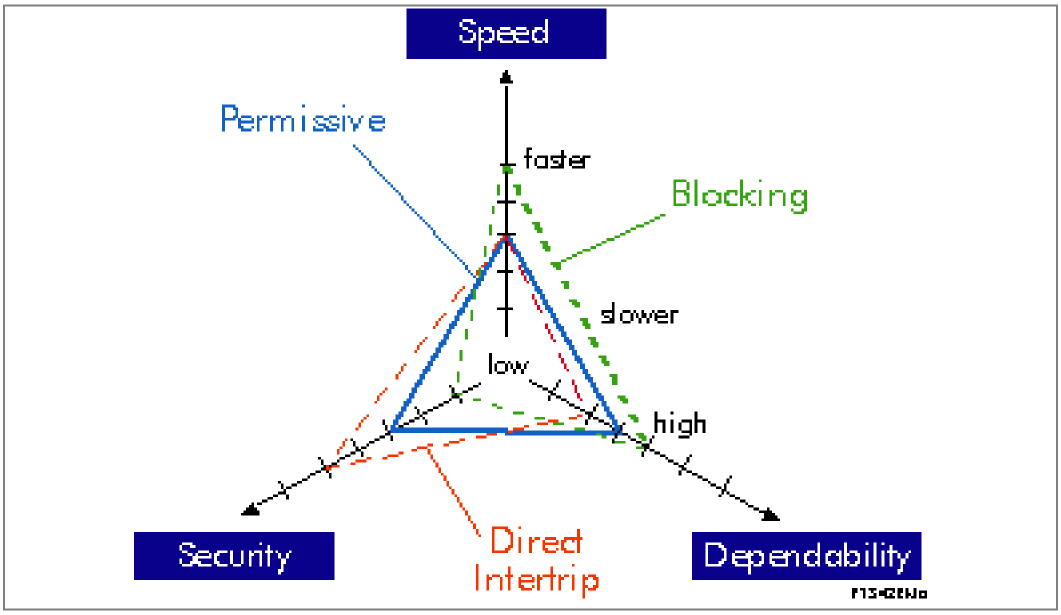


Figure 25: Pictorial comparison of operating modes

This diagram shows that a blocking signal should be fast and dependable; a direct intertrip signal should be very secure; and a permissive signal is an intermediate compromise of speed, security and dependability.

In MODEM InterMiCOM applications, selected signaling bits within each message can be conditioned to provide optimal characteristics for each of the three teleprotection command types.

In InterMiCOM^{64} applications, the framing and error checking of a single command message is sufficient to meet the security of a permissive application, while the speed is sufficiently fast to meet the needs of a blocking scheme. Accordingly in InterMiCOM^{64} applications, there is no differentiation between blocking commands or permissive commands, so that only signals being used for direct intertripping with higher security requirements need to be differentiated from those in permissive (or blocking) schemes.

6.2 MODEM InterMiCOM, EIA(RS)232 InterMiCOM or Copper InterMiCOM

6.2.1 Communications media

MODEM InterMiCOM is capable of transferring up to eight commands over one communication channel. Due to recent expansions in communication networks, most signaling channels are now digital schemes utilizing multiplexed communications links and for this reason, MODEM InterMiCOM provides a standard EIA(RS)232 output using digital signaling techniques. This digital signal can then be converted using suitable devices to a range of different communications media as required. The EIA(RS)232 output may alternatively be connected to MODEMs for use over analogue links.

Regardless of whether analogue or digital systems are being used, all the requirements of teleprotection commands are described by an international standard, IEC60834-1:1999, and MODEM InterMiCOM is compliant with the essential requirements of this standard. This standard describes the speed requirements of the commands as well as the security (defined in terms of probability of unwanted commands being received) and dependability (defined in terms of the probability of missing commands).

6.2.2 General features and implementation

InterMiCOM provides eight commands over a single communications link, with the mode of operation of each command being individually selectable within the **IM# Cmd Type** cell. **Blocking** mode provides the fastest signaling speed (available on commands 1 - 4), **Direct Intertrip** mode provides the most secure signaling (available on commands 1 - 8) and **Permissive** mode provides secure, dependable signaling (available on commands 5 - 8). Each command can also be disabled so that it has no effect in the logic of the IED.

Since many applications involve commands being sent over a multiplexed communications channel, it is necessary to ensure that only data from the correct IED is used. The IEDs in the scheme must be programmed with a unique pair of addresses that correspond with each other in the **Source Address** and **Receive Address** cells. For example, at the local end relay, if the **Source Address** is set to 1, the **Receive Address** at the remote end relay must also be set to 1. Similarly, if the remote end relay has a **Source Address** set to 2, the **Receive Address** at the local end must also be set to 2. The two pairs of addresses should be set to be different in any scheme to avoid the possibility of incorrect operation during inadvertent loopback connections, and any schemes sharing the same communications services should be set to have different address pairs to avoid any problems caused by inadvertent cross-channel connections.

Noise on the communications should not be interpreted as valid commands by the relay. For this reason, InterMiCOM uses a combination of unique pair addressing described above, basic signal format checking and an 8-bit Cyclic Redundancy Check (CRC) according to the security requirements of the commands. The CRC calculation is performed at both the sending and receiving end relays for each message and both must match to assure the security of the **Direct Intertrip** commands.

An alarm is provided if noise on the communications channel becomes excessive.

During periods of excessive noise, it is possible that the synchronization of the message structure will be lost and accurate decoding of the messages may not be possible. Predictable operation of InterMiCOM is assured during such noisy periods by means of the **IM# FallBackMode** cell. The status of the last received valid command can be maintained until a new valid message is received by setting the **IM# FallBackMode** cell to **Latched**. Alternatively, a known fallback state can be assigned to the command by setting the **IM# FallBackMode** cell to **Default**. In this latter case, the time period between communication disruption and the default state being restored will need to be set in the **IM# FrameSynTim** cell and the default value will need to be set in **IM# DefaultValue** cell. On subsequent receipt of a valid message, all the timer periods will be reset and the new valid command states will be used.

If there is a total communications failure, the relay will use the fallback (failsafe) strategy as described above. Total failure of the channel is considered when no message data is received for four power system cycles or if there is a loss of the DCD line.

6.2.3 EIA(RS)232 physical connections

MODEM InterMiCOM on the Px4x relays is implemented using a 9-pin D-type female connector (labeled SK5) located at the bottom of the 2nd Rear communication board. This connector on the Px40 relay is wired in DTE (Data Terminating Equipment) mode, as shown in the following table.

Pin	Acronym	InterMiCOM Usage
1	DCD	**Data Carrier Detec**t is only used when connecting to modems otherwise this should be tied high by connecting to terminal 4
2	RxD	**Receive Data**
3	TxD	**Transmit Data**
4	DTR	**Data Terminal Ready** is permanently tied high by the hardware since InterMiCOM requires a permanently open communication channel

Pin	Acronym	InterMiCOM Usage
5	GND	**Signal Ground**
6	Not used	-
7	RTS	**Ready To Send** is permanently tied high by the hardware since InterMiCOM requires a permanently open communication channel
8	Not used	-
9	Not used	-

Table 6: EIA(RS)232 physical connections

Depending on whether a direct or modem connection between the two relays in the scheme is being used, the required pin connections are described as follows.

6.2.4 Direct connection

EIA(RS)232 is only suitable for short transmission distances due to the signaling levels used and the connection shown below is limited to less than 15m. This limit may be overcome by introducing suitable signal converters as described in the following sections:

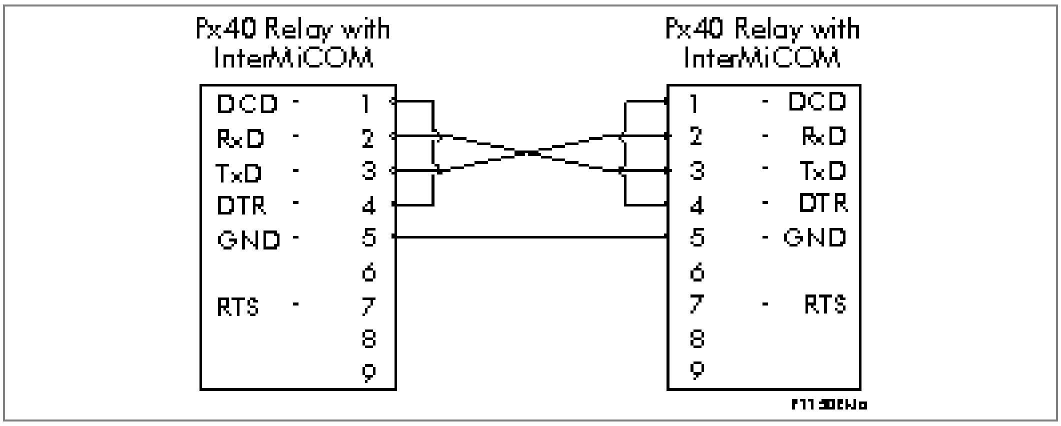


Figure 26: Direct connection within the local substation

The connection configuration shown in Figure 26 should also be used when connecting to equipment that does not implement control the DCD line.

6.2.5 EIA(RS)232 modem connection

To achieve longer distance communication, modems may be used, in which the case the following connections should be made.

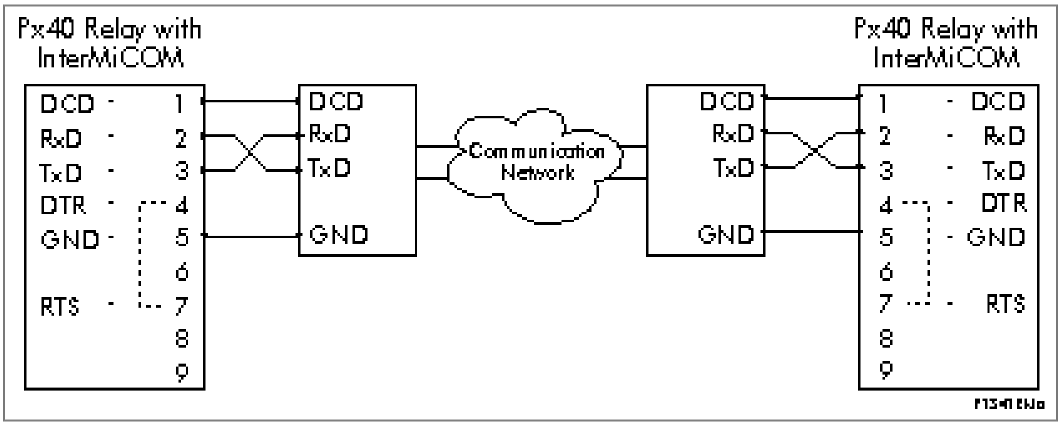


Figure 27: InterMiCOM teleprotection via a MODEM link

This type of connection should be used when connecting to multiplexers which provide an EIA(RS)232 channel with the ability to control the DCD line. With this type of connection the maximum distance between the Px40 relay and the modem should not exceed 15m, and that a baud rate suitable for the communications path used should be selected.

6.2.6 RS422 connection

An RS232 to RS422 converter such asan CK212 may be employed to enable MODEM InterMiCOM to be applied if 4-wire pilots are available for signaling as shown in the example below:

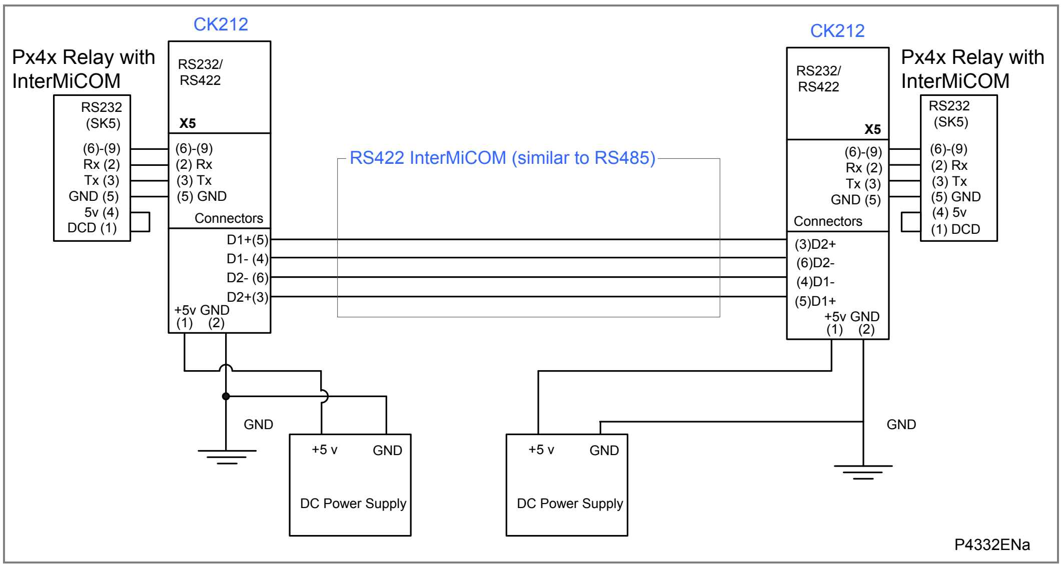


Figure 28: MODEM InterMiCOM teleprotection via a RS422 protocol

Using an appropriate converter, pilots of up to 1.2km in length can be used, depending on the converter performance.

In this case, the maximum distance between the Px40 relay and the converter should not exceed 15m.

6.2.7 Fiber optic connection

Although InterMiCOM^{64} is the recommended variant of InterMiCOM for use with optical fiber connections, MODEM InterMiCOM may also be applied over optical fibers using EIA(RS)232 to fiber optic converters. In this the case the following connections should be made:

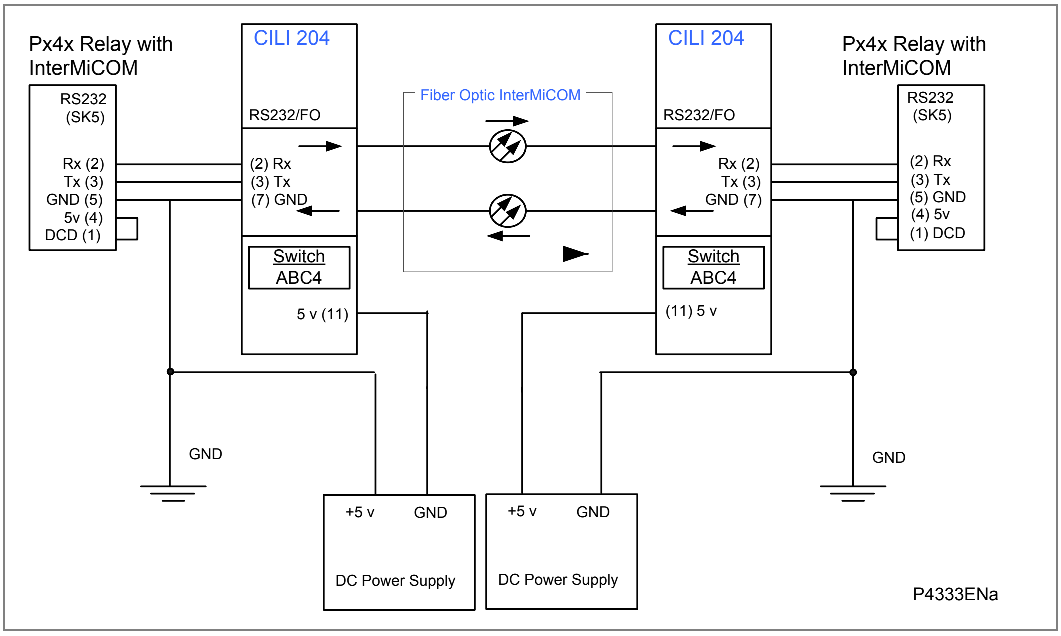


Figure 29: MODEM InterMiCOM teleprotection via fiber optic

The overall fiber length that can be achieved depends on the converter performance.

In this case, the maximum distance between the Px40 relay and the converter should not exceed 15m.

6.2.8 InterMiCOM functional assignment

The settings to control the mode of the intertrip signals are made using the relay's menu software. In addition to this, it is necessary to assign InterMiCOM input and output signals in the relay Programmable Scheme Logic (PSL) editor. Two icons are provided on the PSL editor of MiCOM S1 AGILE for **Integral tripping In** and **Integral tripping out** which can be used to assign the eight intertripping commands. The example shown in Figure 30 shows a **Control Input_1** connected to the **Intertrip O/P1** signal which would then be transmitted to the remote end. At the remote end, the **Intertrip I/P1** signal would then be assigned within the PSL. In this example, we can see that when intertrip signal 1 is received from the remote relay, the local end relay would operate an output contact, R1.

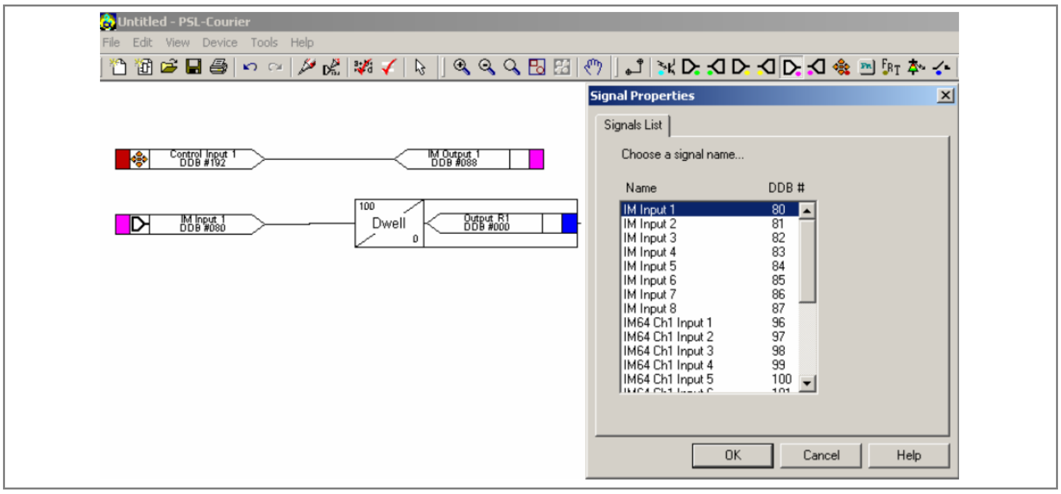


Figure 30: Example assignment of signals within the PSL

> **Note:** *when an InterMiCOM signal is sent from the local relay, only the remote end relay will react to this command. The local end relay will only react to InterMiCOM commands initiated at the remote end and received locally, and vice-versa. Therefore InterMiCOM can be described as a duplex teleprotection system.*

6.2.9 InterMiCOM statistics and diagnostics

MODEM InterMiCOM channel statistics and diagnostics are available via the menu software. These can be hidden by setting the **Ch Statistics** cell or **Ch Diagnostics** cell, or both, to **Invisible**. All channel statistics are reset when the relay is powered up, or by user selection using the **Reset Statistics** cell.

6.3 InterMiCOM^{64} (“fiber InterMiCOM”)

6.3.1 General features and implementation

InterMiCOM^{64} is an optional feature, offering very fast fault clearance in distance aided schemes with a typical end-end delay of 5 ms for Permissive/Blocking signals and around 6 ms for Intertripping (adding the channel time delay where multiplexers are used).

InterMiCOM^{64} provides a direct fiber output from the relay’s co-processor board that can be connected either directly to the protection at the remote end(s) or via appropriate interfaces and multiplexed communications channels, similar to MiCOM P54x line differential relays. InterMiCOM^{64} can use two channels for communication. The second channel is used in dual redundant two-terminal scheme or three-terminal scheme configurations. (Sometimes such schemes are termed “**hot standby**” and “**triangulated**” schemes, respectively).

InterMiCOM^{64} is designed, primarily, to work over fiber optic and multiplexed digital communications channels. A total of sixteen InterMiCOM^{64} commands (16 inputs and 16 outputs) are available in the MiCOM P44T. These are arranged as two groups of 8 bits each, and are referenced as Channel 1 and Channel 2.

> Note: *InterMiCOM^{64} Channel 1 and 2 references are not the same as references to communications Channels 1 and 2 and this can cause some confusion.*

InterMiCOM^{64} communications can run using two different user settable Baud rates: 56 and 64 kbits/s, for ease of interfacing with standard public and private telecommunication networks.

InterMiCOM^{64} also supports the IEEE C37.94 standard for direct optical fiber connection to appropriately equipped multiplexers. In this case the data rate is matched to one of the Nx64 channels supported by the multiplexer.

6.3.2 Configuring InterMiCOM^{64}

InterMiCOM^{64} provides two groups of eight InterMiCOM^{64} commands. These groups of InterMiCOM^{64} commands are referenced as Channel 1 and Channel 2. The mapping of the InterMiCOM^{64} command signals is performed using the programmable scheme logic (PSL) editor (which is part of the MiCOM S1 AGILE support tool) in a manner similar to that described in section 6.2.8.

In addition to mapping the commands with the PSL editor, it is also necessary to configure the InterMiCOM^{64} communications scheme. This configuration is made using the settings found in the **PROT COMMS/IM^{64}** column of the menu software. These settings are described in detail in the settings (ST) section of this manual, but to facilitate understanding of InterMiCOM^{64} operation, they are also presented in the following sections.

The MiCOM P44T can be equipped with either one or two fiber communications ports to support InterMiCOM^{64}. For the purposes of setting, labeling, etc., these communications ports are referenced as protection communications Channels 1 and 2. Although there is some association of the InterMiCOM^{64} signal groupings referenced Channels 1 and 2, with communications Channels 1 and 2, they have subtly different meanings and care needs to be taken to avoid confusion.

6.3.2.1 InterMiCOM64 scheme setup - application

Three InterMiCOM^{64} scheme arrangements are possible:

- Two-terminal with a single communications link
- Two-terminal with a dual redundant communications link (sometimes referred to as '**hot standby**'
- Three terminal (or triangulated) scheme

The selection is made using the Scheme Setup setting.

In the two-terminal configurations, the 8 InterMiCOM^{64} commands of both channel 1 and channel 2 (i.e. all 16 commands) can be freely assigned within the scheme logic of the two relays. So long as a communications link between the two terminals is functioning, all 16 commands are usable. The advantage of a dual redundant scheme is the fact that scheme integrity can be maintained in the event of a failure of one of the communications links.

The triangulated scheme is designed such that the InterMiCOM^{64} communications can self-heal in the event of a failure of a communication link between any two terminals. It achieves this by routing the 8 InterMiCOM^{64} commands on Channel 1 for use by the relay connected to communications channel 1 (remote 1), and the 8 InterMiCOM^{64} commands on Channel 2 for use by the relay connected to communications channel 2 (remote 2). In the event of a failure of communications between say the local relay and remote 1, remote 2 will pass on the 8 InterMiCOM^{64} commands intended from local to remote1 using the second communications channel.

The recommended InterMiCOM^{64} connection for a three ended application is shown in Figure 27.

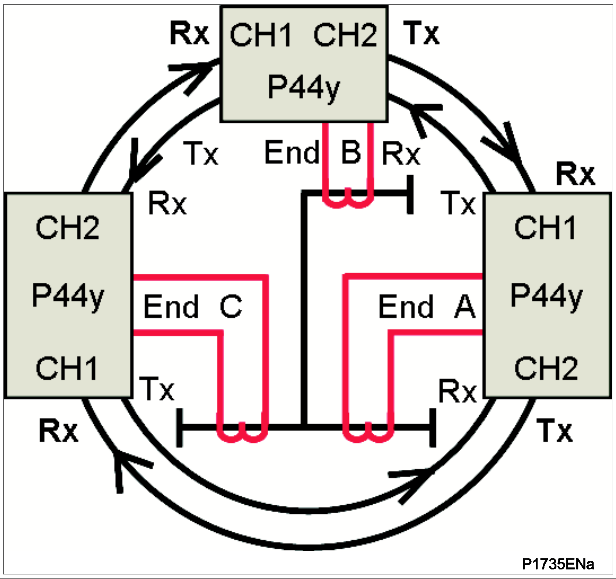


Figure 31: Triangulated InterMiCOM^{64} application

In the case when one leg of the communication triangle fails, for example, channel A-C becomes unavailable, the InterMiCOM^{64} will continue to provide the full teleprotection scheme between all three ends in a degraded chain topology because of the way the 8 Channel 2 InterMiCOM^{64} commands are passed on via the scheme logic. In this degraded '**Chain**' topology, relays A and C will receive and transmit teleprotection commands via relay B. The retransmitting done by relay B (A-B-C and C-B-A) provides the self-healing for the lost links A-C and C-A).

This Chain topology may be employed as a means to save cost in implementing a three-terminal scheme, since two legs may be cheaper to install than full triangulation, or if a suitable communication link is not available between two of the line ends. However, that the operating speed of teleprotection commands will increase by approximately 7 ms (plus communications channel signaling delay) when retransmitted in Chain topology, due to the extended path length.

6.3.2.2 InterMiCOM64 protection communications address

The InterMiCOM^{64} communication messages include an address field to ensure correct scheme connection. There are twenty one address group selections available. These addresses are provided to ensure that commands are communicated only between the particular relays in the scheme. The address patterns are carefully designed to provide maximum security for the application, and within the ranges given, they are freely assignable.

The Universal Address can be useful during testing, but in deployment it should be avoided to prevent the possibility of incorrect operation during inadvertent loopback connections. In addition, and any schemes sharing the same communications services should be set to have different address patterns to avoid any problems caused by inadvertent cross-channel connection.

The groups of addresses available when a two-terminal or dual redundant InterMiCOM^{64} scheme is selected are as follows:

	Relay A	Relay B
Universal Address	0-0	0-0
Address Group 1	1-A	1-B
Address Group 2	2-A	2-B
Address Group 3	3-A	3-B
Address Group 4	4-A	4-B
Address Group 5	5-A	5-B
Address Group 6	6-A	6-B
Address Group 7	7-A	7-B
Address Group 8	8-A	8-B
Address Group 9	9-A	9-B
Address Group 10	10-A	10-B
Address Group 11	11-A	11-B
Address Group 12	12-A	12-B
Address Group 13	13-A	13-B
Address Group 14	14-A	14-B
Address Group 15	15-A	15-B
Address Group 16	16-A	16-B
Address Group 17	17-A	17-B
Address Group 18	18-A	18-B
Address Group 19	19-A	19-B

	Relay A	Relay B
Address Group 20	20-A	20-B
Address Group 21	21-A	21-B
Address Group 22	22-A	22-B
Address Group 23	23-A	23-B
Address Group 24	24-A	24-B
Address Group 25	25-A	25-B
Address Group 26	26-A	26-B
Address Group 27	27-A	27-B
Address Group 28	28-A	28-B
Address Group 29	29-A	29-B
Address Group 30	30-A	30-B
Address Group 31	31-A	31-B
Address Group 32	32-A	32-B

Table 7: Groups of addresses available in 2 Terminal scheme

For two relays to communicate with one another, their addresses need to be in the same address group. One relay should be assigned with address A and the other with address B. For example, if the group 1 address is used, one relay should be given the address 1-A, and the other relay should be given the address 1-B. The relay with address 1-A will only accept messages with the 1-A address and will send out messages carrying address 1-B. The relay assigned with address 1-B will only accept messages with address 1-B and will send out messages carrying address 1-A.

The groups of addresses available when a three-terminal InterMiCOM^{64} scheme is selected are as follows:

	Relay A	Relay B	Relay C
Address Group 1	1-A	1-B	1-C
Address Group 2	2-A	2-B	2-C
Address Group 3	3-A	3-B	3-C
Address Group 4	4-A	4-B	4-C
Address Group 5	5-A	5-B	5-C
Address Group 6	6-A	6-B	6-C
Address Group 7	7-A	7-B	7-C
Address Group 8	8-A	8-B	8-C
Address Group 9	9-A	9-B	9-C
Address Group 10	10-A	10-B	10-C
Address Group 11	11-A	11-B	11-C
Address Group 12	12-A	12-B	12-C
Address Group 13	13-A	13-B	13-C
Address Group 14	14-A	14-B	14-C
Address Group 15	15-A	15-B	15-C
Address Group 16	16-A	16-B	16-C
Address Group 17	17-A	17-B	17-C
Address Group 18	18-A	18-B	18-C
Address Group 19	19-A	19-B	19-C

	Relay A	Relay B	Relay C
Address Group 20	20-A	20-B	20-C
Address Group 21	21-A	21-B	21-C
Address Group 22	22-A	22-B	22-C
Address Group 23	23-A	23-B	23-C
Address Group 24	24-A	24-B	24-C
Address Group 25	25-A	25-B	25-C
Address Group 26	26-A	26-B	26-C
Address Group 27	27-A	27-B	27-C
Address Group 28	28-A	28-B	28-C
Address Group 29	29-A	29-B	29-C
Address Group 30	30-A	30-B	30-C
Address Group 31	31-A	31-B	31-C
Address Group 32	32-A	32-B	32-C

Table 8: Groups of addresses available in 3 Terminal scheme

For three relays to work together as a protection system, their addresses must be in the same group and they should be assigned separately with addresses A, B and C. They must also have a fixed connection configuration, as shown in Figure 25, in which channel 1 of one relay is connected to channel 2 of another relay.

For example, if the group 1 address is used, addresses 1-A, 1-B and 1-C should be assigned to relays A, B and C respectively. Relay A will only accept messages with address 1-A and will send messages carrying addresses 1-B and 1-C to channel 1 and channel 2 respectively. Relay B will only accept messages with address 1-B and will send messages carrying addresses 1-C and 1-A to channel 1 and to channel 2 respectively. Similarly relay C will only accept messages with address 1-C and will send messages carrying addresses 1-A and 1-B to channel 1 and to channel 2 respectively.

6.3.2.3 InterMiCOM64 communications mode setup

The Communications Mode setup configures the optical fiber ports either as **Standard**, or **IEEE C37.94**. If connecting to a multiplexer that supports the IEEE C37.94 interface, select **IEEE C37.94**, otherwise select **standard**. This setting applies to both communications channels - they cannot be set independently. If this setting is changed, the relay must be power cycled before it takes effect.

6.3.2.4 InterMiCOM64 communications baud rate

The baud rate for communication over channel 1 (and channel 2 where fitted) can be selected (independently) between 56 kbits/s and 64 kbits/s. For direct fiber connection 64 kbits/s should be selected. If MiCOM P590 units are being used to interface to a telecommunications network, the setting will be dictated by the network. In general, 56 kbits/s is only required when using the P592 V.35 interface. This setting is hidden if the IEEE C37.94 mode has been selected.

6.3.2.5 InterMiCOM64 communications clock source

The clock source for communication channel 1 (and channel 2 where fitted) can be selected (independently) between “**internal**” and “**external**”. For direct fiber connection “**internal**” should be selected. If MiCOM P590 units are being used to interface to a telecommunications network, the setting will be dictated by the network. In general, the “**external**” setting will be used when connecting to a telecommunications network, since the network will normally provide a clock master.

This setting is hidden if the IEEE C37.94 mode has been selected.

6.3.2.6 InterMiCOM64 IEEE C37.94 channel selection

This setting is only visible if the IEEE C37.94 mode has been selected. It allows the channels to be assigned to a particular channel presented by the interface. Setting it to Auto enables the relay to configure itself to match the multiplexer.

6.3.2.7 InterMiCOM64 communications fail timer

The "**Comm Fail Timer**" sets how long after a communications failure the alarm will be issued. In this context, a communications failure is defined as no messages received during the channel timeout period, or the alarm level being exceeded.

6.3.2.8 InterMiCOM64 communications failure mode

The "**Comm Fail Mode**" setting applies only to relays configured for dual redundant or three-terminal configuration. It prescribes what combination of failures on the two communications channels is used to flag an alarm.

6.3.2.9 InterMiCOM64 channel timeout

If an InterMiCOM^{64} command has been set to revert to a default value after a communications failure, this timer sets how long will elapse before the defaults are applied.

6.3.2.10 InterMiCOM64 propagation delay statistics

The "**Prop Delay Stats**" setting can be either enabled or disabled. When enabled The "**Max Ch Prop Delay**" settings for communications channel 1 (and 2 if fitted) become visible. These are settings whereby, if InterMiCOM^{64} messages take longer to be received than the setting value, the message can be rejected.

6.3.2.11 InterMiCOM64 command type

Each of the InterMiCOM^{64} commands can be set via the "**IMn Cmd Type**" setting (n=1-8) to be conditioned for either direct transfer tripping (setting = "**Direct**") or for use in a blocking or permissive scheme (setting = "**Permissive**").

> *Note:* *There are 8 of these settings, one for each of eight InterMiCOM^{64} commands. The 8 settings are applied the same to the 8 InterMiCOM^{64} commands on Channel 1 as to the 8 InterMiCOM^{64} commands on Channel 2, so that if "**IM1 Cmd Type**" is set to "**Direct**", then IM1 channel 1 and IM1 channel2 with both be conditioned for direct transfer tripping.*

6.3.2.12 InterMiCOM64 fallback mode

Each of the InterMiCOM^{64} command can be set via the "**IMn FallBackMode**" setting (n=1-8) to define its behavior under communications failure conditions. They can be programmed to either latch the state of the last good command received, or they can revert to a default state (either 1 or 0) defined in the "**IMn DefaultValue**" setting (n=1-8).

> *Note:* *There are 8 of each of these settings, one for each of eight InterMiCOM^{64} commands. The 8 settings are applied the same to the 8 InterMiCOM^{64} commands on Channel 1 as to the 8 InterMiCOM^{64} commands on Channel 2.*

6.3.2.13 InterMiCOM64 communications alarm management

Due to the criticality of InterMiCOM^{64} communications for correct scheme performance, there is an extensive regime to monitor signal quality and integrity, generate and report alarms. For most applications, the alarming supplied as standard should satisfy the needs of the scheme. For some applications, however, it may be necessary to provide additional qualifications using the programmable scheme logic. To do this, it is necessary to understand the concepts behind the alarm signals and their implementation in the MiCOM P44T relay.

Fundamental to the implementation of scheme logic in the MiCOM Px4x series of relays is the concept of the DDB introduced earlier. The complete list of DDB signals applicable to InterMiCOM^{64} communications are described in section 6.3.2.14 below.

6.3.2.14 InterMiCOM64 DDB signal list

The DDB signals applicable to the optional InterMiCOM^{64} feature are shown below. (For a complete list of all DDB signals applicable to the IED please refer Appendix C.

DDB No.	English Text	Description
291	Test Loopback	Indicates that the local relay has been selected to Loopback mode (internal or external) in the “Commission Tests” options.
292	Test IM64	Indicates that the local relay has been selected to Test mode in the “Commission Tests” options.
311	Signaling Fail	Indicates when the local receive signal is totally lost, or exceeds the alarm threshold, on either channel 1 or channel 2.
337	Comms Changed	Indicates that the “Comms Mode” setting has been changed between Standard and IEEEC37.94 or vice versa. The relay must be power-cycled to remove this alarm and activate the new communication mode.
315	IEEE C37.94	Indicates that one or more IEEE C37.94 communication alarms are currently active. (IEEE C37.94 alarms are DDB # 1123 - 1126 and DDB # 1133 - 1136. This signal is only used when the “Comms Mode” is selected to IEEE C37.94.
314	IM64 Scheme Fail	Indicates when the communications between the relays has been compromised and therefore IM64 doesn’t work. For 2-ended schemes, this is functionally identical to the Signaling Fail DDB signal (DDB # 285). For 3-ended schemes, this is only active when it is no longer possible to provide communications even allowing for pass through mode i.e. more than one link has failed.
96	IM64 Ch1 Input 1	Input DDB signal used in the PSL which is the receive signal for Channel 1, bit 1.
97 - 103	IM64 Ch1 Input 2 … 8	Input DDB signal used in the PSL which is the receive signal for Channel 1, bit 2 to 8.
104	IM64 Ch2 Input 1	Input DDB signal used in the PSL which is the receive signal for Channel 2, bit 1.
105 - 111	IM64 Ch2 Input 2 … 8	Input DDB signal used in the PSL which is the receive signal for Channel 2, bit 2 to 8.
112	IM64 Ch1 Output1	Output DDB signal used in the PSL which is the transmit signal for Channel 1, bit 1.
113 - 119	IM64 Ch1 Output2 … 8	Output DDB signal used in the PSL which is the transmit signal for Channel 1, bit 2 to 8.
120	IM64 Ch2 Output1	Output DDB signal used in the PSL which is the transmit signal for Channel 2, bit 1.
121 - 127	IM64 Ch2 Output 2 … 8	Output DDB signal used in the PSL which is the transmit signal for Channel 2, bits 2 to 8.

DDB No.	English Text	Description
1123	Ch1 Mux Clk	Output DDB signal used to indicate that the frequency of the signal on Channel 1 is outside the frequency expected by the multiplexer. This signal is only used when the “Comms Mode” is selected to IEEE C37.94.
1124	Ch1 Signal Lost	Output DDB signal used to indicate that the multiplexer has lost the signal over channel 1. i.e. no receive information on Channel 1. This signal is only used when the “Comms Mode” is selected to IEEE C37.94.
1125	Ch1 Path Yellow	Output DDB signal used to indicate that the multiplexer has detected one way communication on Channel 1. i.e. the transmit information is not being received by the remote end on Channel 1. This signal is only used when the “Comms Mode” is selected to IEEE C37.94.
1126	Ch1 Mismatch RxN	Output DDB signal used to indicate that there is a mismatch between the communication settings on the InterMiCOM64 Channel 1 and the multiplexer. This signal is only used when the “Comms Mode” is selected to IEEE C37.94.
1127	Ch1 Timeout	Output DDB signal used in the PSL to indicate that no valid messages have been received on Channel 1 during the “Channel Timeout” period (settable).
1128	Ch1 Degraded	Output DDB signal used in the PSL to indicate poor channel quality on Channel 1. This is determined by the percentage of bad messages received on Channel 1 exceeding the “IM Msg Alarm Lvl” setting during the previous 100ms.
1129	Ch1 Passthrough	Output DDB signal used in the PSL to indicate when the Channel 1 signaling bits have been received through Channel 2 because of failure of channel 1. This signal is only relevant for 3 ended signaling schemes and is part of the “self-healing” capability.
1133	Ch2 Mux Clk	Output DDB signal used to indicate that the frequency of the signal on Channel 2 is outside the frequency expected by the multiplexer. This signal is only used when the “Comms Mode” is selected to IEEE C37.94.
1134	Ch2 Signal Lost	Output DDB signal used to indicate that the multiplexer has lost the signal over channel 2. i.e. no receive information on Channel 2. This signal is only used when the “Comms Mode” is selected to IEEE C37.94.
1135	Ch2 Path Yellow	Output DDB signal used to indicate that the multiplexer has detected one way communication on Channel 2. i.e. the transmit information is not being received by the remote end on Channel 2. This signal is only used when the “Comms Mode” is selected to IEEE C37.94.
1136	Ch2 Mismatch RxN	Output DDB signal used to indicate that there is a mismatch between the communication settings on the InterMiCOM^{64} Channel 2 and the multiplexer. This signal is only used when the “Comms Mode” is selected to IEEE C37.94.

DDB No.	English Text	Description
1137	Ch2 Timeout	Output DDB signal used in the PSL to indicate that no valid messages have been received on Channel 2 during the "Channel Timeout" period (settable).
1138	Ch2 Degraded	Output DDB signal used in the PSL to indicate poor channel quality on Channel 2. This is determined by the percentage of bad messages received on Channel 2 exceeding the "IM Msg Alarm Lvl" setting during the previous 100ms.
1139	Ch2 Passthrough	Output DDB signal used in the PSL to indicate when the Channel 2 signaling bits have been received through Channel 1 because of failure of channel 2. This signal is only relevant for 3 ended signaling schemes and is part of the "self-healing" capability.
338	Max Prop Alarm	Output DDB set if the communications propagation delay on either channel 1 or channel 2 exceeds its setting.
1386	Max Ch1 PropDelay	Output DDB set if the communications propagation delay on channel 1 exceeds its setting.
1387	Max Ch2 PropDelay	Output DDB set if the communications propagation delay on channel 2 exceeds its setting.

Table 9: DDB signal list

6.3.2.15 InterMiCOM64 communications alarm logic

The operation of the main alarm DDB signals associated with InterMiCOM^{64} are shown in the conceptual diagrams below. Some of the signals are setting/hardware dependent, for example Channel 2 alarms will not be available on a simple 2-terminal single communications link application.

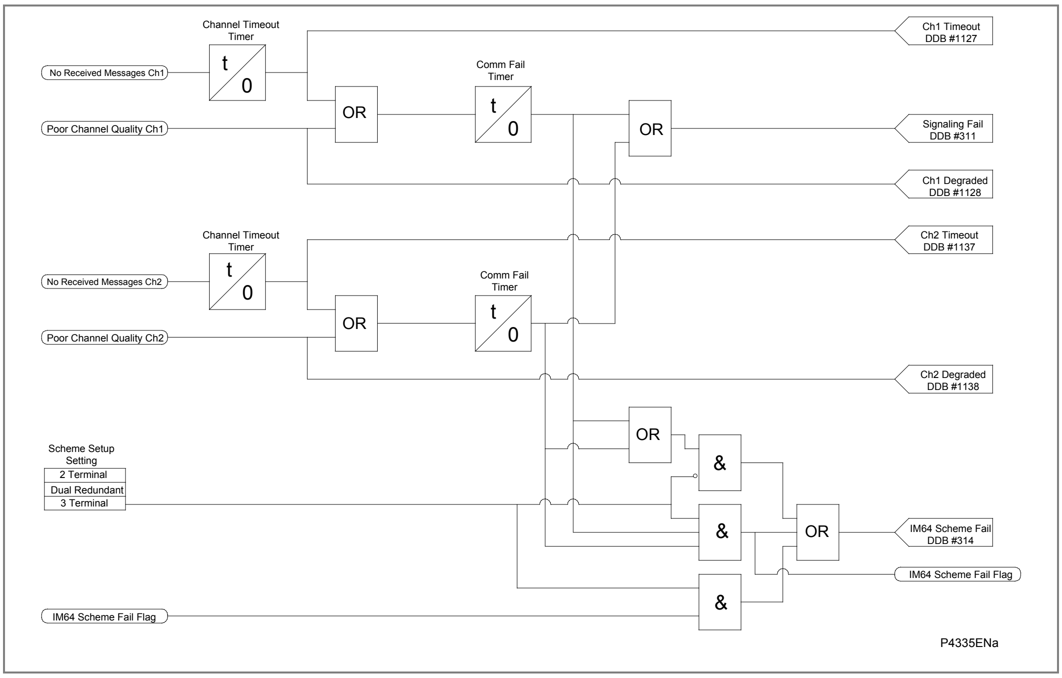


Figure 32: InterMiCOM^{64} channel fail and scheme fail conceptual logic

The messages received on each channel are individually assessed for quality to ensure that the InterMiCOM^{64} signaling scheme is available for use. In the event of no messages being received for a period equal to the "**Channel Timeout**" setting, or the signal quality falling below a defined value then DDB signals will be activated as shown in the figure.

Poor quality is indicated if the percentage of incomplete messages exceeds the "**IM Msg Alarm Lvl**" setting within a 100 ms period (rolling window), or if the communications propagation time of the InterMiCOM^{64} message exceeds the "**Ch Max PropDelay**" (if the "**Prop DelayStats**" setting is enabled), or if (in IEEE C37.94 configuration only, and not shown on the diagram) the "**Ch Mux Clk**" flag is set to indicate an incorrect baud rate.

If either the "**Ch Timeout**", or the "**Ch Degraded**" signal persists in the alarmed state for more than the duration of the "**Comm Fail Timer**" setting, then the "**Signaling Fail**" signal will be raised and indicated on the relay according to the conditions set in the "**Comm Fail Mode**" setting of the relay.

In the case of two-ended schemes (including dual redundant schemes), the "**IM64 Scheme Fail**" signal will be generated at the same time as the "**Signaling Fai**l" signal. However, for three-terminal applications, the "**IM64 Scheme Fail**" signal gives an indication of when the full set of signaling bits cannot be processed by the scheme. Due to the self-healing nature of the three-terminal application, this occurs when both channels at any one end are not receiving good signals. This will generate a flag within the InterMiCOM^{64} message structure which is passed to both remote ends, as well as generating the local "**IM64 Scheme Fail**" signal. By this method, in three-terminal applications the scheme fail indication will be raised at all three ends.

The scheme fail signaling is generated by the inability of the relays to receive messages through communication failure. That is to say that a transmitting relay will only know that its communication to a remote relay is in a failed state if it receives notification from the remote relay that that is the case. If a relay in the scheme is put into test mode, the communication failure information is not passed on to the remote ends. In this instance then it might be that the communications are in a failed state, but that there is no indication to the remote relays that this is the case. Should this cause operational issues then it may be necessary to include other signals to enable more precise indication of scheme failure, as described in the Application Examples chapter.

In addition to the main InterMiCOM^{64} channel fail and scheme fail conceptual logic in the figure above, there are number of additional alarm DDB signals associated with test modes, reconfiguration for 3-terminal schemes, and the communication mode (standard vs IEEE C37.94). These are outlined in the two figures below:

Figure 33: InterMiCOM^{64} general alarm signals (conceptual logic)

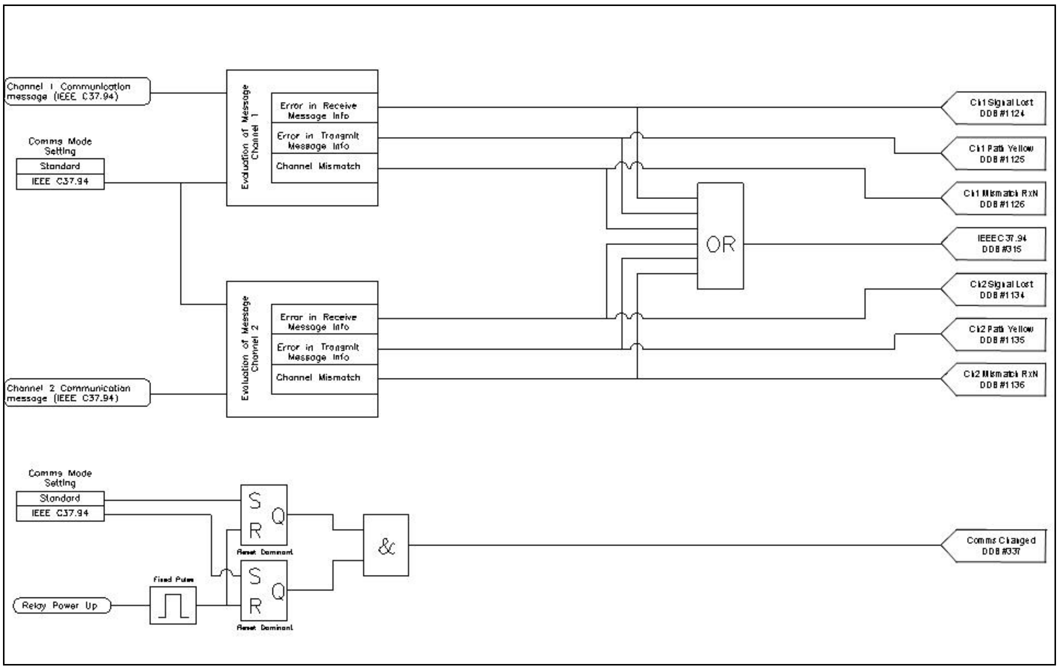


Figure 34: InterMiCOM^{64} communications mode and IEEE C37.94 alarm signals

The majority of signals described in Figure 35 are associated with the IEEE C37.94 communications mode and will not be activated if the standard communication mode is selected. As can be seen from the "**Comms Changed DDB**" logic, switching between the different communication modes requires a power-cycle to be performed.

6.3.2.16 InterMiCOM64 two ended scheme extended supervision

Referring to the logic in section 6.3.2.15, it may be seen that for two-ended applications, the "Signaling Fail" and "IM64 Scheme Fail" signals operate together. As such, the basic indications available on each relay should be considered as local-end indications only. If remote indication is needed to assure scheme functionality, it is necessary to use additional signals to communicate the status to the remote end. One method of performing this is shown below:

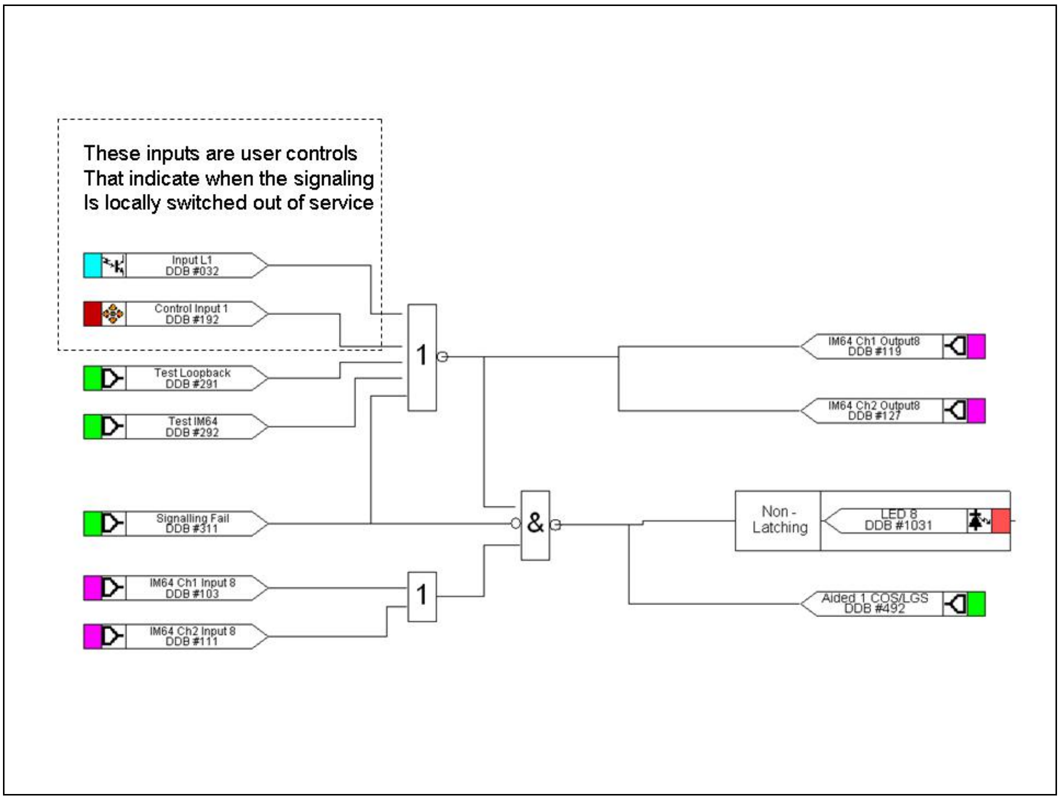


Figure 35: InterMiCOM64 two ended scheme extended supervision

In this example scheme, a number of signals are used to permanently pass an InterMiCOM64 signal to the remote end. These signals take account of the local ability to receive InterMiCOM64 messages, local test/loopback modes and any other external methods of switching the signaling scheme out of service. If any of these driving signals are energized, then the InterMiCOM64 message is reset (a "**0**" sent on InterMiCOM64 bit 8), causing both ends to raise an alarm (LED 8) and/or switch the aided scheme out of service due to loss of channel.

The logic presented above is intended only as an example. It is likely that some customization would be required to suit actual application requirements.

6.3.2.17 InterMiCOM64 three ended scheme extended supervision

The example scheme shown in sub-clause 6.3.2.16 can be extended to cover 3-terminal applications. In this case the "**IM64 Scheme Fail**" signal that is automatically communicated to all ends of the scheme is incorporated rather than the "**Signaling Fail**" of the previous example.

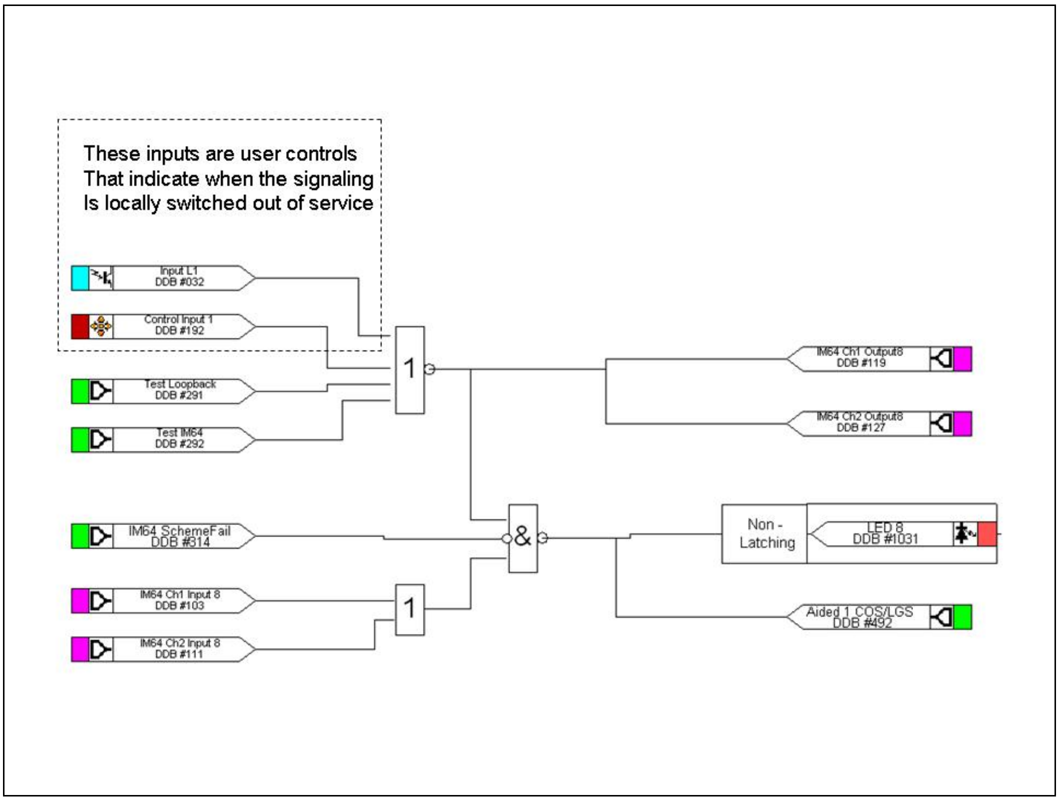


Figure 36: Triangulated InterMiCOM^{64} application

In this example if both channels at any one end fail to receive information, then this will be communicated to the other ends with an alarm raised and aided scheme switched out of service. The example above takes into account the test modes and local switching, such that the scheme will be signaled out of service at all ends if one end is locally disabled.

The logic presented above is an example. It is likely that some customization would be required to suit actual application requirements.

6.3.3 InterMiCOM^{64} communications link options

A number of communications options are available, for the communication channels between MiCOM P44T system ends. The various connection options are shown below. Choosing between each of these options will depend on the type of communications equipment that is available.

- Where existing suitable multiplexer communication equipment is installed for other communication between substations, the 850 nm option together with an appropriate ITU-T compatible electrical interface (P590 series unit) should be selected to match the existing multiplexer equipment. Where an IEEE C37.94 compatible multiplexer is installed the 850 nm option should be configured to interface directly to the multiplexer.
- Where no multiplexer is installed, a direct 1300 nm optical fiber connection can be used. The type of fiber used (multi-mode or single-mode) will be determined by the distance between the ends of the MiCOM P44T relay scheme.

In any configuration, except the IEEE C37.94, the data rate may be selected as either 64 kbit/sec or 56 kbit/sec.

6.3.3.1 InterMiCOM64 optical fiber communications link options

The list of all available fiber channel options is:

- 850 nm multi-mode - always two channels supplied as standard
- 1300 nm multi-mode - one channel only
- 1300 nm multi-mode - both channels (CH1 and CH2)
- 1300 nm single-mode - one channel only
- 1300 nm single-mode - both channels (CH1 and CH2)

6.3.3.1.1 Direct optical fiber link, 850 nm multi-mode fiber

It is possible to connect two MiCOM P44T relays using 850 nm multi-mode fiber but since the above configuration is typically suitable for connection only up to 1km, it is unlikely that this application will ever be applied in practical applications. This interface is, however, the most commonly supplied, since it is suitable for connection using the P590 series of interface units and/or an interface compliant with the IEEE C37.94 standard described later.

6.3.3.1.2 Direct optical fiber link, 1300 nm multi-mode fiber

The relays are connected directly using two 1300 nm multi-mode fibers for each signaling channel. Multi-mode fiber type 50/125 μm or 62.5/125 μm is suitable. BFOC/2.5 type fiber optic connectors are used.

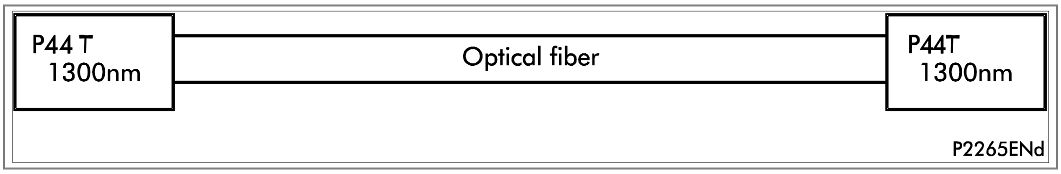


Figure 37: Direct optical fibre link for up to approximately 50km

This is typically suitable for connection up to approximately 50 km.

6.3.3.1.3 Direct optical fibre link, 1300 nm single-mode fiber

The relays are connected directly using two 1300 nm single-mode fibers, type 9/125 μm for each signaling channel. BFOC/2.5 type fiber optic connectors are used.

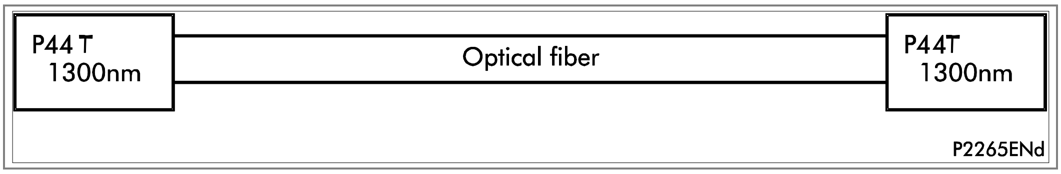


Figure 38: Direct optical fibre link for up to approximately 100km

This is typically suitable for connection up to approximately 100km.

6.3.3.1.4 IEEE C37.94 interface to multiplexer

A relay with 850 nm short haul optical interface is connected directly to the multiplexer by 850 nm multi-mode optical fiber. Multi-mode fiber type 50/125 μm or 62.5/125 μm is suitable. BFOC/2.5 type fiber optic connectors are used.

The setting Comms Mode should be set to IEEE C37.94.

> *Note:* *The relay must be powered off and on before this setting change becomes effective. The IEEE C37.94 standard defines an N*64kbits/s standard where N can be 1 - 12. N can be selected on the relay or alternatively set to Auto in which case the relay will configure itself to match the multiplexer.*

6.3.3.2 InterMiCOM^{64} connection via P590 series optical fiber to electrical interface units

To connect the relays via a pulse code modulation (PCM) multiplexer network or digital communication channel, Type P590 type interface units are required. The following interface units are available:

- P591 interface to multiplexing equipment supporting ITU-T (formerly CCITT) Recommendation G.703 co-directional electrical interface
- P592 interface to multiplexing equipment supporting ITU-T Recommendation V.35 electrical interface
- P593 interface to multiplexing or ISDN equipment supporting ITU-T Recommendation X.21 electrical interface

The data rate for each unit can be 56 kbits/s or 64 kbits/s as required for the data communications link.

One P590 unit is required per relay per data channel (i.e. for each transmit and receive signal pair). It provides optical to electrical and electrical to optical signal conversion between the MiCOM P44T relay and the multiplexer. The interface unit should be located as close to the PCM multiplexer as possible, to minimize any effects on the data of electromagnetic noise or interference. The units are housed in a 20TE MiCOM case.

Fiber optic connections to the unit are made through BFOC/2.5 type connectors, more commonly known as '**ST**' connectors. The optical characteristics are similar to the MiCOM P44T 850 nm multi-mode fiber optic interface.

6.3.3.2.1 Multiplexer link with G.703 using type P591 interface

A relay with 850 nm short haul optical interface is connected to a P591 unit by two cores of 850 nm multi-mode optical fiber. Multi-mode fiber type 50/125 μm or 62.5/125 μm is suitable. BFOC/2.5 type fiber optic connectors are used. The P591 unit converts the data between optical fiber and ITU-T compatible G.703 co-directional electrical interface. The G.703 output must be connected to an ITU-T compatible G.703 co-directional channel on the multiplexer.

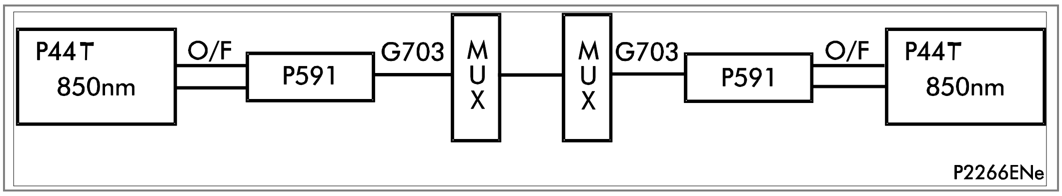


Figure 39: P591 G.703 interface

The G.703 signals are isolated by pulse transformers to 1 kV.

Since the G.703 signals are only of ±1 V magnitude, the cable connecting the P591 unit and the multiplexer must be properly screened against electromagnetic noise and interference. The interface cable should consist of twisted pairs of 24 AWG, overall shielded, and have a characteristic impedance of about 120 Ω. It is generally recommended that the interface cable shield should be connected to the multiplexer frame ground only. The choice of grounding depends however on local codes and practices.

Electrical connections to the P591 unit are made via a standard 28-way Midos connector. The MiCOM P44T must be set with Clock Source as '**External**'.

6.3.3.2.2 Multiplexer link with V.35 using type P592 interface

A relay with 850 nm short haul optical interface is connected to a P592 unit by two cores of 850 nm multi-mode optical fiber. Multi-mode fiber type 50/125 μm or 62.5/125 μm is suitable. BFOC/2.5 type fiber optic connectors are used. The P592 unit converts the data between optical fiber and ITU-T compatible V.35 electrical interface. The V.35 output must be connected to an ITU-T compatible V.35 channel on the multiplexer.

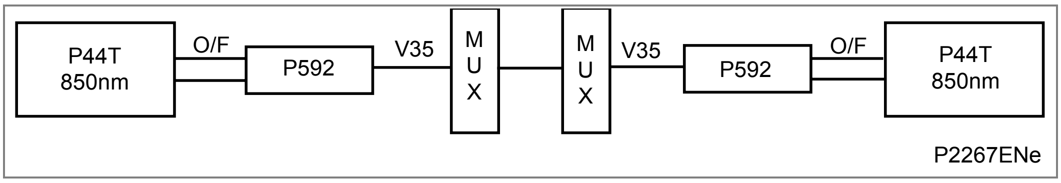


Figure 40: P592 V.35 interface

Connections of V.35 signals to the P592 unit are made via a standard female 34 pin ‘**M**’ block connector. Since the V.35 signals are either of ±0.55 V or ±12 V magnitude, the cable connecting the unit to the multiplexer must be properly screened against electromagnetic noise and interference. The interface cable should consist of twisted pairs of wires which are shielded, and have a characteristic impedance of about 100 Ω. It is generally recommended that the interface cable shield is connected to the multiplexer frame ground. The choice of grounding depends however on local codes and practices.

The P592 front panel consists of five indicating LEDs and six DIL (dual in line) switches. The switch labeled ‘**Clockswitch**’ is provided to invert the V.35 transmit timing clock signal if required.

The switch labeled ‘**Fiber-optic Loopback**’ is provided to allow a test loopback of the communication signal across the fiber optic terminals. When switched on, the red LED labeled **'Fiber-optic Loopback'** is illuminated.

The switch labeled ‘**V.35 Loopback**’ is provided to allow a test loopback of the communication signal across the V.35 terminals. It loops the incoming V.35 ‘**Rx**’ data lines internally back to the outgoing V.35 ‘**Tx**’ data lines. When switched on, the red LED labeled ‘**V.35 Loopback**’ is illuminated.

The switch labeled ‘**DSR**’ is provided to select/ignore the DSR (Data Set Ready) handshaking control signal. The red LED labeled DSR Off is extinguished either when DSR is asserted or when overridden by setting the DSR switch On.

The switch labeled ‘**CTS**’ is provided to select/ignore the CTS (Clear To Send) handshaking control signal. The red LED labeled CTS Off is extinguished either when CTS is asserted or when overridden by setting the CTS switch On.

The switch labeled ‘**Data Rate**’ is provided to allow the selection of 56 or 64k bits/s data rate, as required by the PCM multiplexing equipment.

The LED labeled ‘**Supply Healthy**’ is green and provides indication that the unit is correctly powered.

The timing for the InterMiCOM^{64} communication channel may be set either with Clock Source as ‘**External**’ for a multiplexer network which is supplying a master clock signal, or with Clock Source as ‘**Internal**’ for a multiplexer network recovering signal timing from the equipment.

6.3.3.2.3 Multiplexer link with X.21 using type P593 interface

The P593 unit supports the ITU-T Recommendation X.21 interface. It is approved as line interface equipment by the British Approvals Board for Telecommunications (BABT) for connection to the services described in this section; License Certificate Number NS/1423/1/T/605362.

A relay with 850 nm short haul optical interface is connected to a P593 unit by two cores of 850 nm multi-mode optical fiber. Multi-mode fiber type 50/125 μm or 62.5/125 μm is suitable. BFOC/2.5 type fiber optic connectors are used. The P593 unit converts the data between optical fiber and ITU-T compatible X.21 electrical interface. The X.21 output must be connected to an ITU-T compatible X.21 channel on the multiplexer or ISDN digital data transmission link.

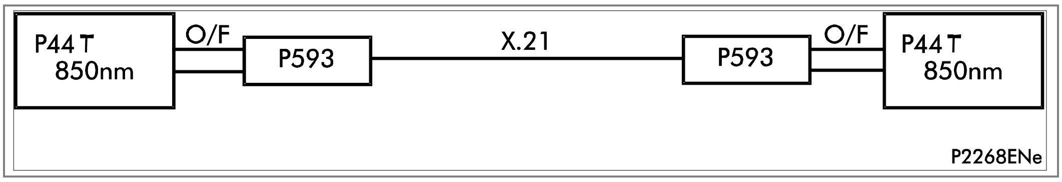


Figure 41: P593 x.21 interface

The relays require a permanently open communications channel. Consequently, no communications handshaking is required, and it is not supported in the P593 unit. The signals supported are shown in the table below.

ITU-T Recommendation X.21 is closely associated with EIA specifications RS422 and RS449. The P593 can be used with RS422 or RS449 communications channels which require only the signals shown below.

ITU-T Designation	Description	Connector Pin	Direction
-	Case earth	1	-
G	Common return	8	-
T	Transmit data A	2	From P593
T	Transmit data B	9	From P593
R	Receive data A	4	To P593
R	Receive data B	11	To P593
S	Signal element timing A	6	To P593
S	Signal element timing B	13	To P593

Table 10: X.21 circuits supported by P593 unit

Connections of X.21 signals to the P593 unit are made via a standard male 15 way D-type connector, wired as a DTE device. The interface cable should consist of twisted pairs of 24AWG, overall shielded, and have a characteristic impedance of about 100 Ω. It is generally recommended that the interface cable shield is connected to the multiplexer frame ground. The choice of grounding depends however on local codes and practices.

See the Wiring Diagrams chapter for the External Connection Diagrams.

The timing for the InterMiCOM^{64} communication channel must be set with Clock Source as '**External**'.

The P593 front panel consists of four indicating LEDs and two switches.

The LED labeled '**Supply healthy**' is green and provides indication that the unit is correctly powered.

The LED labeled '**Clock**' is green and provides indication that an appropriate X.21 signal element timing signal is presented to the unit.

One of the switches is labeled '**Fiber Optic Loopback**'. This is provided to allow a test loopback of the communication signal across the fiber optic terminals. When switched on, the red LED labeled '**Fiber Optic Loopback**' is illuminated.

The second switch is labeled '**X.21 Loopback**'. This is provided to allow a test loopback of the communication signal across the X.21 terminals. It loops the incoming X.21 '**Rx**' data lines internally back to the outgoing X.21 '**Tx**' data lines, and also loops the incoming fiber optic '**Rx**' data line (via the X.21 signal conversion circuitry) back to the outgoing fiber optic 'Tx' data line. When switched on, the red LED labeled 'X.21 Loopback' is illuminated.

6.3.3.3 InterMiCOM64 connection over unconditioned pilot wires

It is possible to deploy InterMiCOM^{64} on certain circuits where unconditioned 2-wire or 4-wire pilots are available for communication. To achieve this requires a combination of P590 series optical fiber to electrical interface units together with third-party baseband modems. The application will be restricted by the length and quality of the pilots, with maximum pilot lengths restricted to less than 20km.

When considering applying a scheme based on InterMiCOM^{64}, P590, and baseband modems, the impact of the modem retrain time on the application needs to be understood before making the decision. Unconditioned 2-wire and 4-wire pilots are generally routed in proximity to the electrical power transmission and distribution feeders that they are helping to protect. As such, they are partial to electro-magnetic interference during switching or fault conditions on the power system. The induced interference on the pilots can cause disruption of the communications signals, and if this is sufficient to cause the synchronization of the communications to be lost, then the modems will have to re-synchronize, or retrain.

> *Note:* *If the possibility of communications breaks of up to 10 seconds during switching or fault conditions on the power system cannot be tolerated by the InterMiCOM^{64} application, then the decision to implement a scheme using pilot wire circuits should be reviewed.*

6.3.3.3.1 Pilot isolation

During primary earth faults, the strong magnetic field generated can induce a significant voltage between the pilots and ground (longitudinal voltage). To prevent damage to any equipment connected to the pilot circuit, it must be ensured that the modem can provide an adequate isolation barrier between the pilot itself and all other electrically isolated circuits. Although it may be difficult to accurately predict the induced pilot voltage during an earth fault, the following equations can be used to give an approximation:

Induced voltage for un-screened pilots $\approx 0.3 \times I_F \times L$

Induced voltage for screened pilots $\approx 0.1 \times I_F \times L$

Where:

I_F = Maximum prospective earth fault current in amperes

L = Length of pilot circuit in miles

In cases where the calculated voltage exceeds, typically 60% of the relay/modem isolation level, additional isolation must be added. GE offers the PCM-FLÜ 10 kV or 20 kV isolating transformers for use in conjunction with such baseband modems. The choice of 10 kV or 20 kV will depend on the predicted magnitude of the induced voltage.

> *Note:* *The PCM-FLÜ isolating transformer has "**a**", "**m**" and "**b**" taps on both primary and secondary windings. For all InterMiCOM^{64} applications, connection must be made between taps '**a**' and '**m**', since the frequency range of this winding extends to 2MHz. Connection between '**a**' and '**b**' may result in unreliable communications as the maximum frequency for this tap configuration is 6kHz. Connection to '**a**' and '**m**' taps must be adhered to on both primary and secondary so as to maintain a 1:1 ratio.*

6.3.3.3.2 Baseband modem and P590 specification

Deployment of the Patton "**Campus**" 1092A baseband modem has been demonstrated with the MiCOM relays and a scheme based on this is presented below.

The Patton "**Campus**" 1092A baseband modem offers a relatively short retrain time (by baseband modem standards), but this can be as long as ten seconds and the effect of this should be recognized as per the note in section 6.3.3.3.

On a 2-wire pilot connection a maximum link length of approximately 17km can be achieved. On a 4-wire pilot, approximately 18km is possible. These figures are, however, dependent on the diameter and quality of the pilot wires. The effect of cable diameter on distance is shown in the following table.

Wire Gauge	Wire Diameter	Maximum Distance (2-wire connection)	Maximum Distance (4-wire connection)
19 AWG	0.9 mm	17.2km	18.2km
22 AWG	0.64 mm	11.5km	12.1km
24 AWG	0.5 mm	8km	8.5km
26 AWG	0.4 mm	5.5km	5.7km

Table 11: Pilot wire and distances

For maximum security and performance it is strongly recommended that the pilots use screened twisted pairs of conductors.

The Campus modem should be specified with a G.703 interface and should be used in conjunction with a MiCOM P591.

6.3.3.3.3 Baseband modem propagation delay

The use of a baseband modem will bring an additional propagation delay time that needs to be taken into account. For a 2-wire connection to the Campus modem the additional delay will be 1.02 ms. For a 4-wire connection to the Campus modem the additional delay will be 1.08 ms.

6.3.3.3.4 Baseband modem and relay configuration

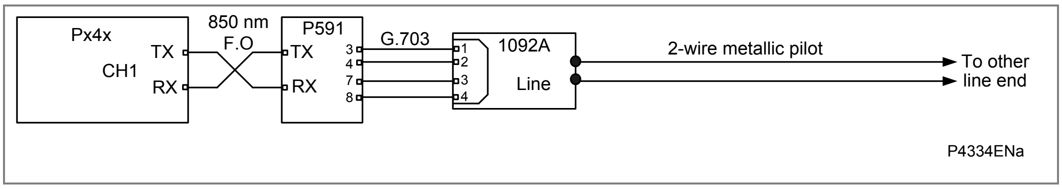


Figure 42: Configuration using 2-wire connection without additional isolation

The MiCOM P44T relays should have their "**IM64 Comms Mode**" set to "**standard**", their data rates set to 64 kbits/s, and their clock sources set to external.

One of the Campus modems on the pilot wire should be assigned as a "**master**" and the other assigned as "**slave**". The "**master**" should be set to generate an internal clock, and the "**slave**" should be set for "**receive recovery**". This is achieved by means of setting dual in-line (DIL) switches inside the modem. To implement these settings, the switches should be set as per the following tables:

MASTER

S1 (on the bottom side of the modem)								
Pin no.	1	2	3	4	5	6	7	8
Setting	1	0	1	0	0	1	1	1
S2 (on the bottom side of the modem)								
Pin no.	1	2	3	4	5	6	7	8
Setting	0	0	0	0	0	1	0	0
S? (inside the interface card)								
Pin no.	1	2	3	4				
Setting	1	0	1	1				

SLAVE

S1 (on the bottom side of the modem)								
Pin no.	1	2	3	4	5	6	7	8
Setting	1	0	1	0	0	1	0	1
S2 (on the bottom side of the modem)								
Pin no.	1	2	3	4	5	6	7	8
Setting	0	0	0	0	0	1	0	0
S? (inside the interface card)								
Pin no.	1	2	3	4				
Setting	1	0	1	1				

The MiCOM P591 communications interface units do not require any special setting up and the scheme should be now operational.

7 SCHEME LOGIC (BASIC AND AIDED SCHEME LOGIC)

7.1 Switch on to fault (SOTF) and trip on reclose (TOR)

The settings for SOTF and TOR are in the menu TRIP ON CLOSE (TOC). The settings are designed to deal with two different situations.

- SOTF provides instantaneous operation of selected elements for a fault present on manual closure of the circuit breaker.
- TOR provides instantaneous operation of selected elements for a persistent fault present on auto-reclosing of the circuit breaker.

The SOTF and TOR functions are known as Trip on Close logic. Figure 43: shows the Trip On Close function in relation to the Distance zones. Figure 44 shows the Trip On Close driven by Current No Volt level detectors. Both methods operate in parallel if mapped to the SOTF and TOR Tripping matrix in the setting file.

The Current No Volt (CNV) level detectors can be set in the menu GROUP X CB FAIL & P.DEAD. The same settings are used for pole dead logic detection. The 20 ms time delay in Figure 44 avoids a possible race between very fast overvoltage and undercurrent level detectors.

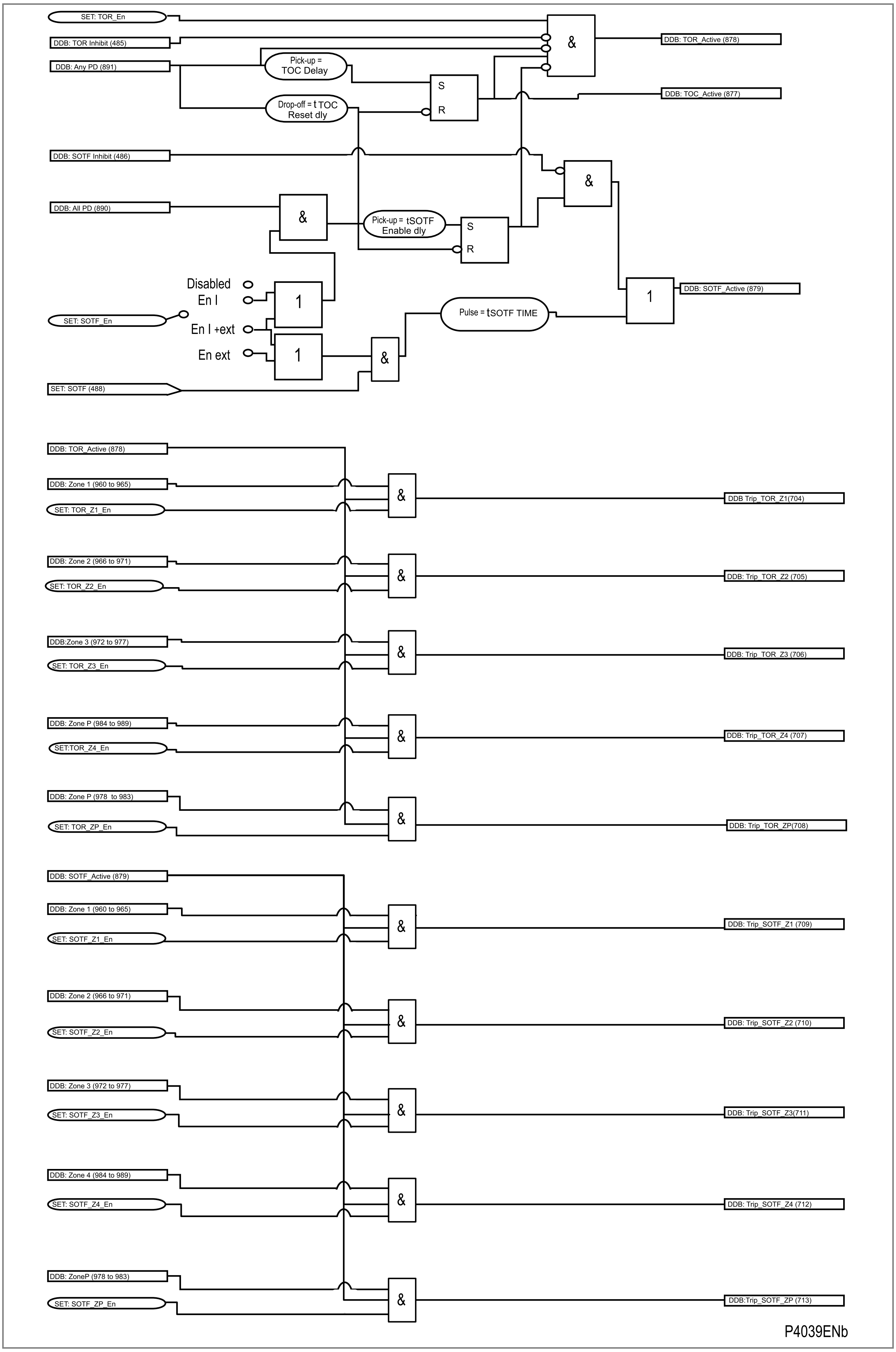


Figure 43: Trip on close based on Distance Zones for P44T Relay

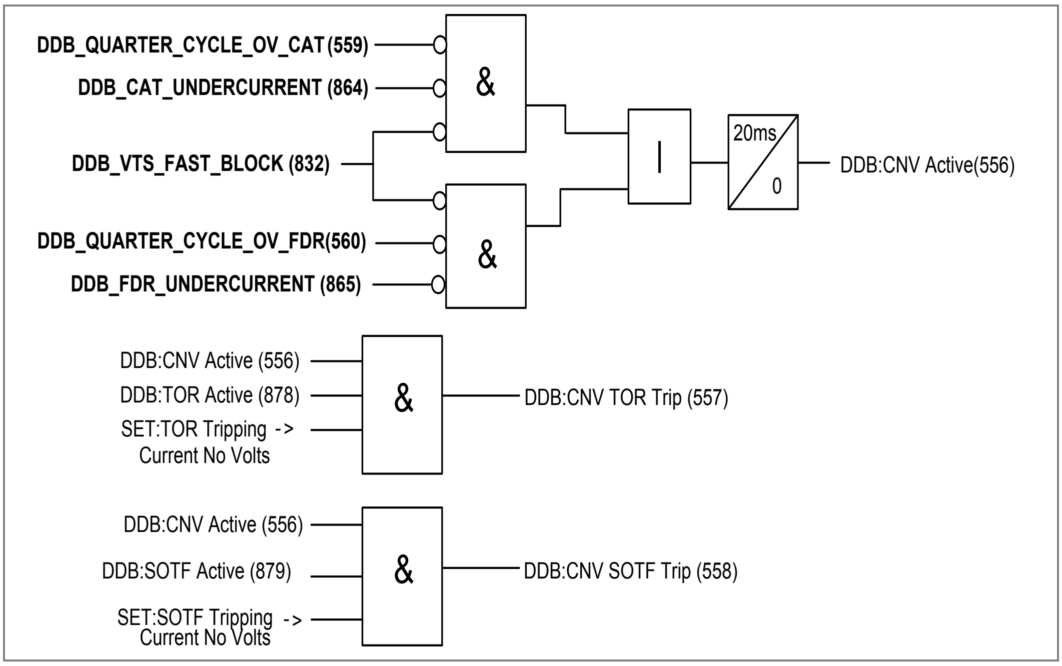


Figure 44: Trip on close based on CNV level detectors for P44T Relay

7.1.1 Switch On To Fault (SOTF) mode

SOTF Status. SOTF can be activated in three different ways.

- Enabled using pole dead detection logic. If an All Pole Dead condition is detected, the SOTF Delay timer starts. Once this timer expires, SOTF is enabled and stays active for the period set in the TOC Reset Delay setting.
- Enabled by an external pulse. SOTF is enabled after an external pulse linked to DDB Set SOTF (DDB 488) is ON. The external pulse could be a circuit breaker close command, for example. The function stays active for the duration of the SOTF Pulse setting.
- Enabled using both pole dead detection logic and an external pulse.

One or all poles (classic or autotransformer) instantaneous tripping (and auto-reclose blocking) occurs for any fault detected by the selected zones or Current No Volt level detectors when in SOTF mode. Whether this feature is enabled or disabled, the normal time delayed elements or aided channel scheme continues to function and can trip the circuit.

SOTF Delay. The SOTF Delay is a pick up time delay that starts after opening one or two poles (classic or autotransformer) of a CB. If the CB is then closed after the set time delay has expired, SOTF protection is active. SOTF provides enhanced protection for manual closure of the breaker (not for auto-reclosure).

This setting is visible only if **Pole Dead** or **Pdead + Pulse** are selected to enable SOTF.

SOTF Tripping. While the Switch on to Fault Mode is active, the IED trips instantaneously for pick up of any zone selected in these links. To operate for faults on the entire circuit length, at least Zone 1 and Zone 2 should be selected. If no elements are selected, the normal time delayed elements and aided scheme provide the protection.

SOTF Pulse. A user settable time window during which the SOTF protection is available. This setting is visible only if **ExtPulse** or **Pdead + Pulse** are selected to enable SOTF.

7.1.2 Trip On Reclose (TOR) mode

TOR Status. Enables or disables special protection following auto-reclosure. When enabled, TOR is activated after the **TOC Delay** expires, ready for application when an auto-reclose shot occurs.

With this feature Enabled, for a period following circuit breaker closure, the IED operates in **Trip on Reclose** mode. One or all poles (classic or autotransformer) instantaneous tripping occurs for any fault detected by the selected zones or Current No Volt level detectors. Whether this feature is enabled or disabled, the normal time delayed elements or aided channel scheme continue to function and can trip the circuit.

TOC Reset Delay. The SOTF and TOR features stay in service for the duration of the TOC Reset Delay once the circuit is energized. The delay timer starts on CB closure and is common for SOTF and TOR protection. Once this timer expires after successful closure, all protection reverts to normal.

TOC Delay. A user settable time delay that starts when the CB opens, after which TOR is enabled. The time delay must not exceed the minimum Dead Time setting of the auto-reclose because both times start simultaneously and TOR protection must be ready by the the CB closes on potentially persistent faults.

TOR Tripping. While the Trip on Reclose Mode is active, the IED trips instantaneously for pick up of any selected Distance zone. For example, Zone 2 could operate without waiting for the usual time delay if a fault is in Zone 2 on CB closure. Also Current No Volts can be mapped for fast fault clearance on line reclosure on a permanent fault. To operate for faults on the entire circuit length, at least Zone 1 and Zone 2 should be selected. If no elements are selected, the normal time delayed elements and aided scheme provide the protection. TOR tripping is one or all phase (classic or autotransformer) and auto-reclose is blocked.

7.1.3 Polarization during circuit energization

While the Switch on to Fault and Trip on Reclose modes are active, the directionalized distance elements are partially cross polarized from other phases. The same proportion of healthy phase to faulted phase voltage, as given by the **Distance Polarizing** setting in the **DISTANCE SETUP** menu, is used.

Partial cross polarization is therefore substituted for the normal memory polarizing, for the duration of the TOC window. If insufficient polarizing voltage is available, a slight reverse offset (25% of the forward reach) is included in the zone 1 characteristic to enable fast clearance of close up one or two phase faults (classic or autotransformer). Therefore, the mapping of the CNV function to the SOTF tripping matrix is not essential.

7.2 Channel aided schemes

The IED has two sets of aided channel (pilot) schemes which can be operated in parallel.

Aided Scheme 1 - May be keyed by distance

Aided Scheme 2 - May be keyed by distance

The provision of two discrete channel selections would allow the following to be implemented, as an example:

- Distance POR scheme operating over a common shared channel… Select both in AIDED SCHEME 1 only, with AIDED SCHEME 2 Disabled.
- Distance PUR operating over separate channels due to the dissimilar scheme types. Assign Distance to AIDED SCHEME 1.

> *Note: Where schemes share a common channel, the signal send and signal receive logic operates in a logical “OR” mode.*

Aided Scheme 1 and Aided Scheme 2 are two instances of the same logic. Each of these schemes provides the same options and can be independently applied. The scheme logic is split into three sections defined in the following diagram: send logic, receive logic, and aided tripping logic, as shown in Figure 45. Detailed scheme descriptions follow later. As there are two instances of the aided scheme, any internal logic signals which are specific to the instance of the scheme are shown in the diagrams with two DDB numbers relating to the first and second instance, respectively.

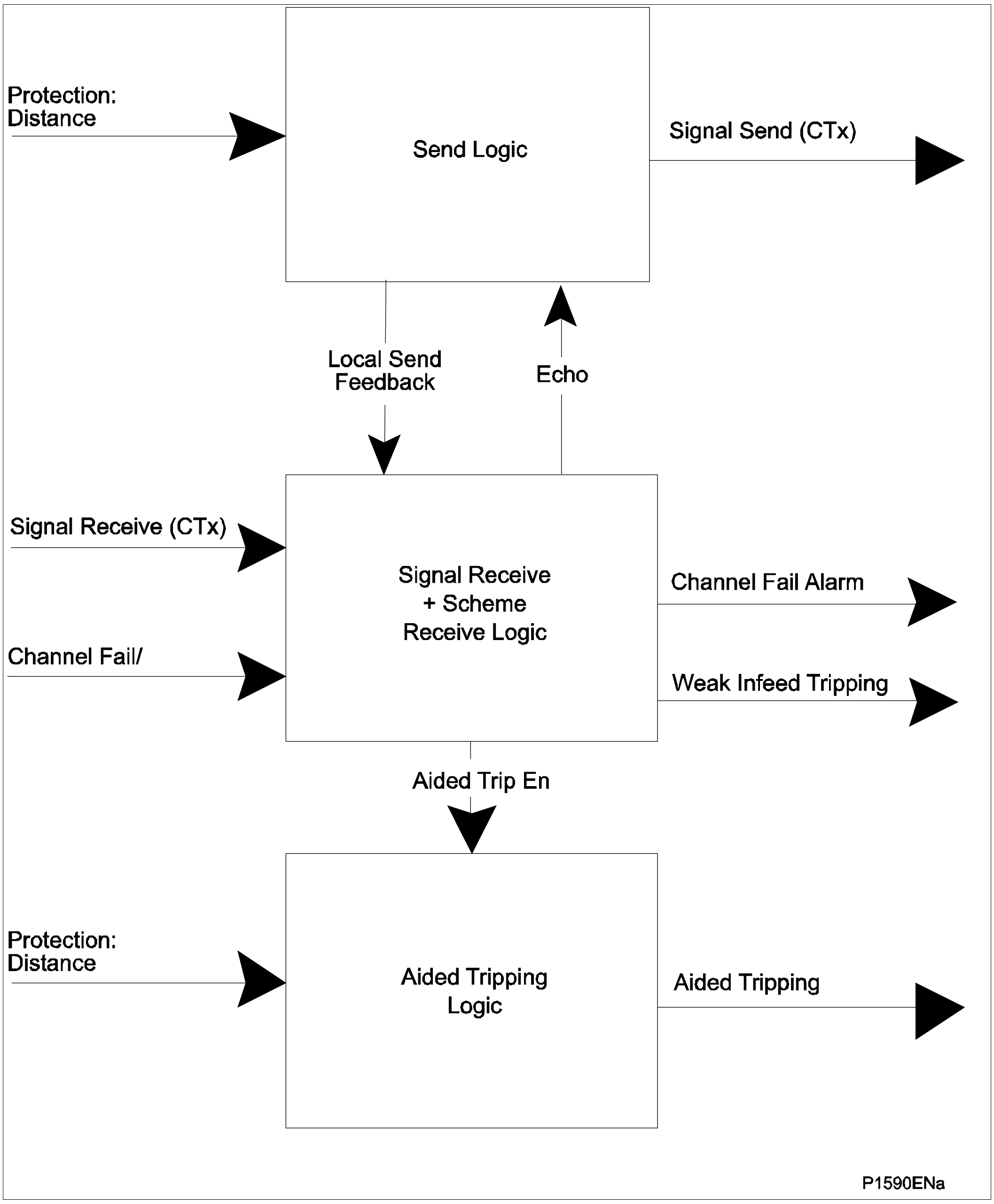


Figure 45: Aided scheme logic overview

The full logic of Send, Receive and Aided Trip are shown in the following diagrams:

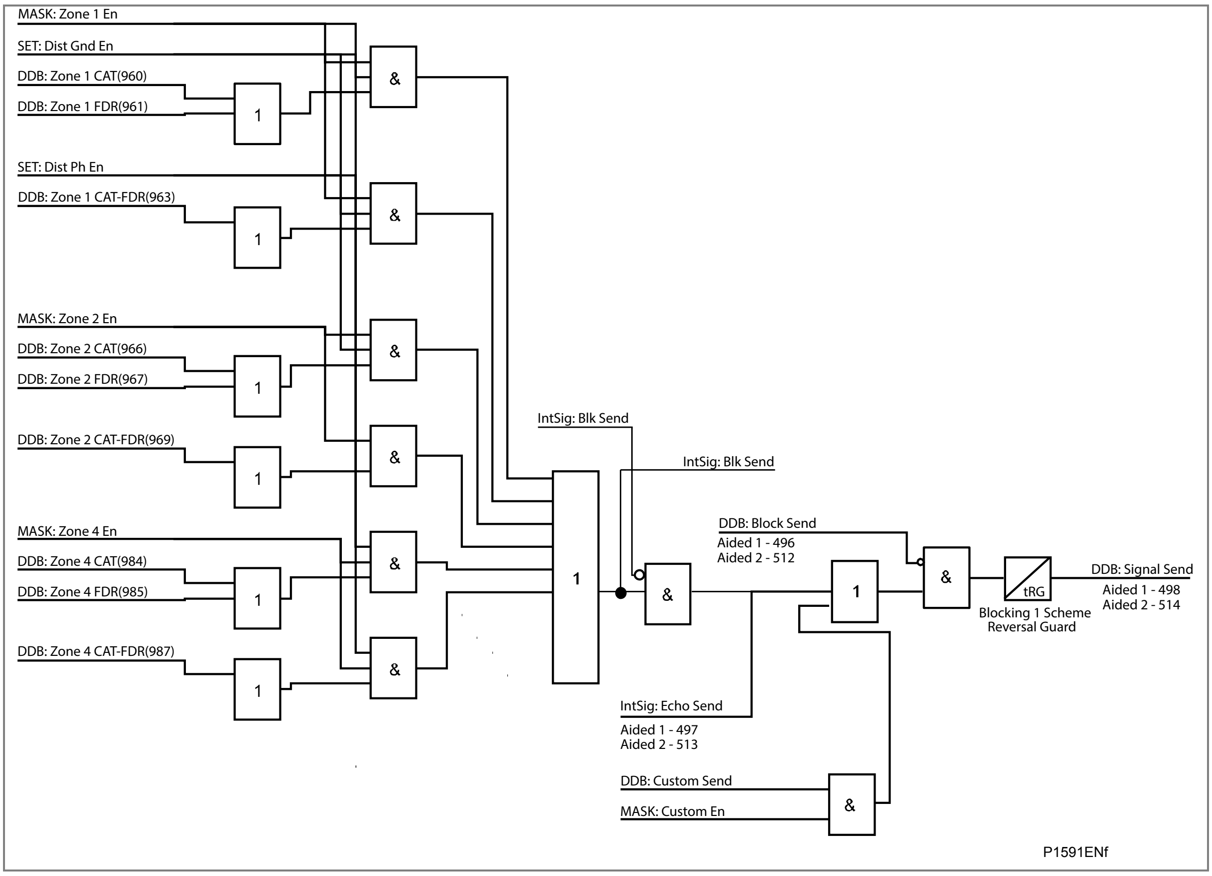


Figure 46: Send logic

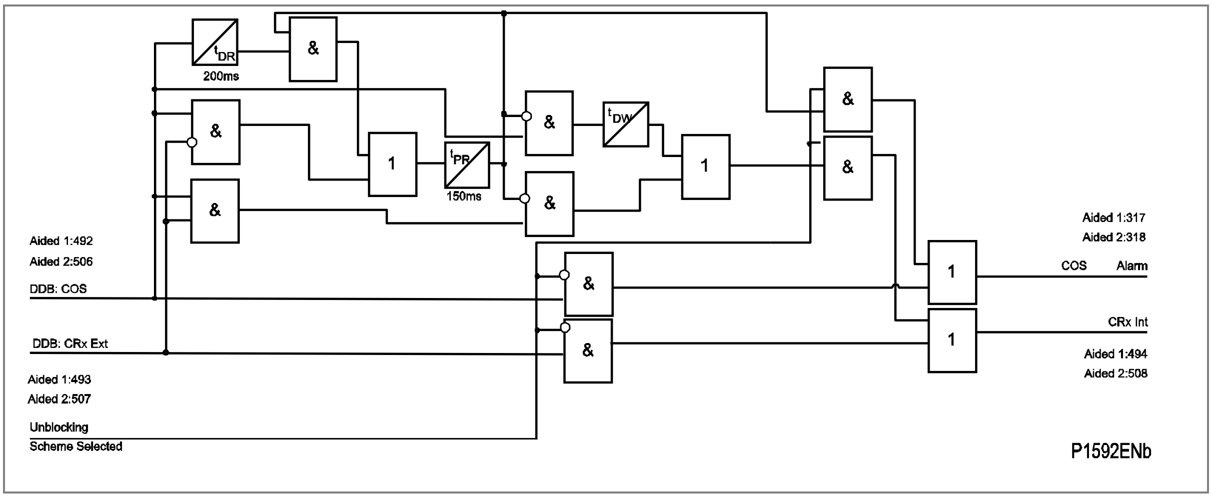


Figure 47: Receive logic

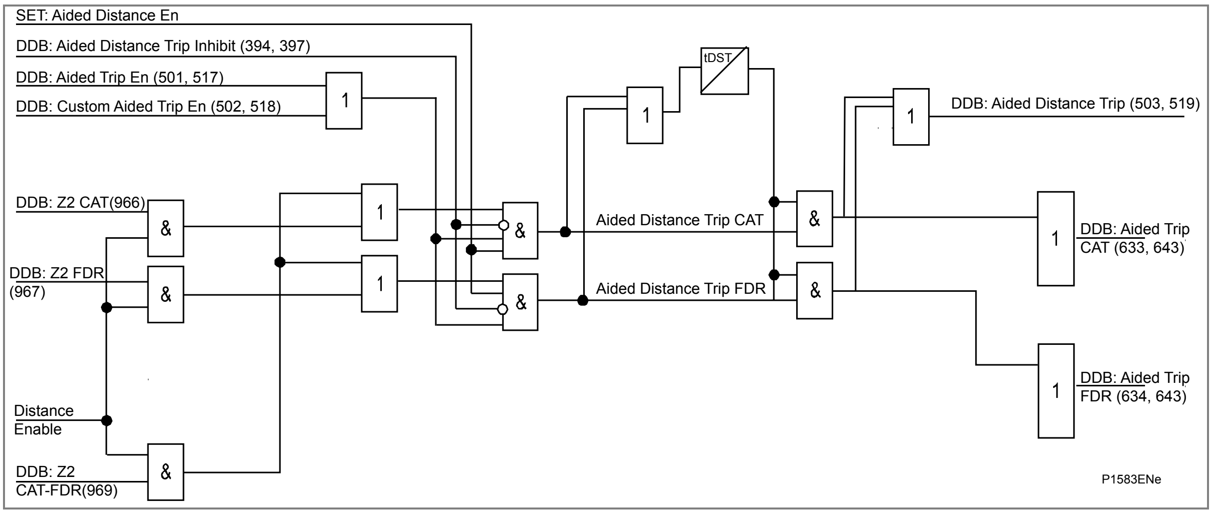


Figure 48: Aided tripping logic

7.2.1 Distance scheme PUR - permissive underreach transfer trip

To provide fast fault clearance for all faults, both transient and permanent, along the length of the protected circuit, it is necessary to use a signal aided tripping scheme. The simplest of these is the permissive underreach protection scheme (PUR). The channel for a PUR scheme is keyed by operation of the underreaching zone 1 elements of the IED. If the remote IED detects a forward fault on receipt of this signal, the IED operates with no additional delay. Faults in the last 20% (Note 1) of the protected line are therefore cleared with no intentional time delay.

> *Note: Assuming a 20% typical “end-zone” when Zone 1 is set to 80% of the protected line.*

The following are some of the main features and requirements for a permissive underreaching scheme.

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

Figure 49 shows the simplified scheme logic.

Send logic: Zone 1

Permissive trip logic: Zone 2 plus Channel Received

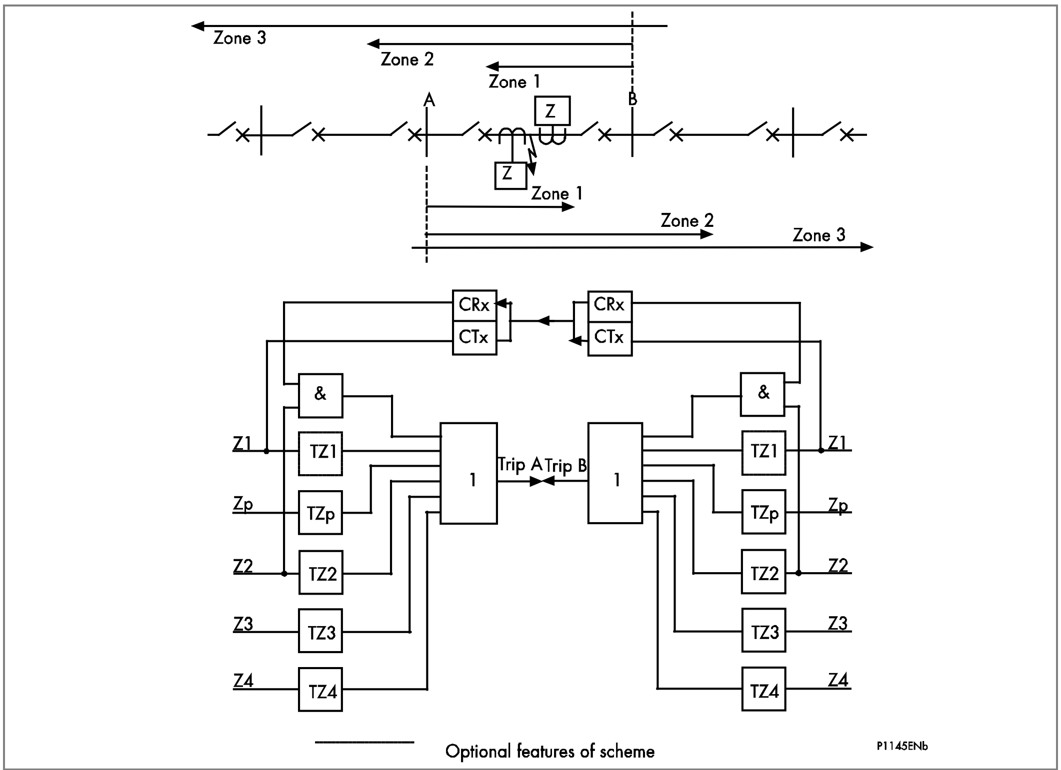


Figure 49: Permissive underreach transfer trip scheme (PUR)

Detailed logic is shown in Figure 50, as follows:

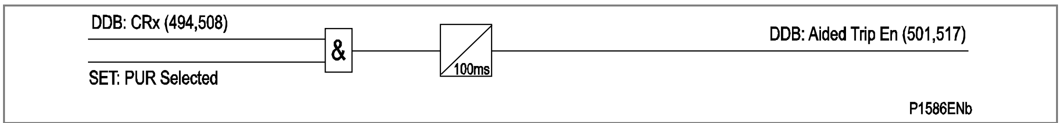


Figure 50: PUR

7.2.2 Distance scheme POR - permissive overreach transfer trip

The channel for a POR scheme is keyed by operation of the overreaching zone 2 elements of the IED. If the remote IED detects a forward fault when it receives this signal, the IED operates with no additional delay. Faults in the last 20% (Note 1) of the protected line are therefore cleared with no intentional time delay.

Note: Assuming a 20% typical "end-zone" when Zone 1 is set to 80% of the protected line.

The following are some of the main features and requirements for a permissive overreaching scheme:

- The scheme requires a duplex signaling channel to prevent possible IED maloperation due to spurious keying of the signaling equipment. This is necessary because the signaling channel is keyed for faults external to the protected line.
- The POR scheme may be more advantageous than permissive underreach schemes for the protection of short transmission lines, since the resistive coverage of the Zone 2 elements may be greater than that of the Zone 1 elements.
- Current reversal guard logic is used to prevent healthy line protection maloperation for the high speed current reversals experienced in double circuit lines, caused by sequential opening of circuit breakers.
- If the signaling channel fails, Basic distance scheme tripping is available.

> *Note:* *The POR scheme also uses the reverse looking zone 4 of the IED as a reverse fault detector. This is used in the current reversal logic and in the optional weak infeed echo feature, shown dotted in Figure 51.*

Send logic: Zone 2

Permissive trip logic: Zone 2 plus Channel Received

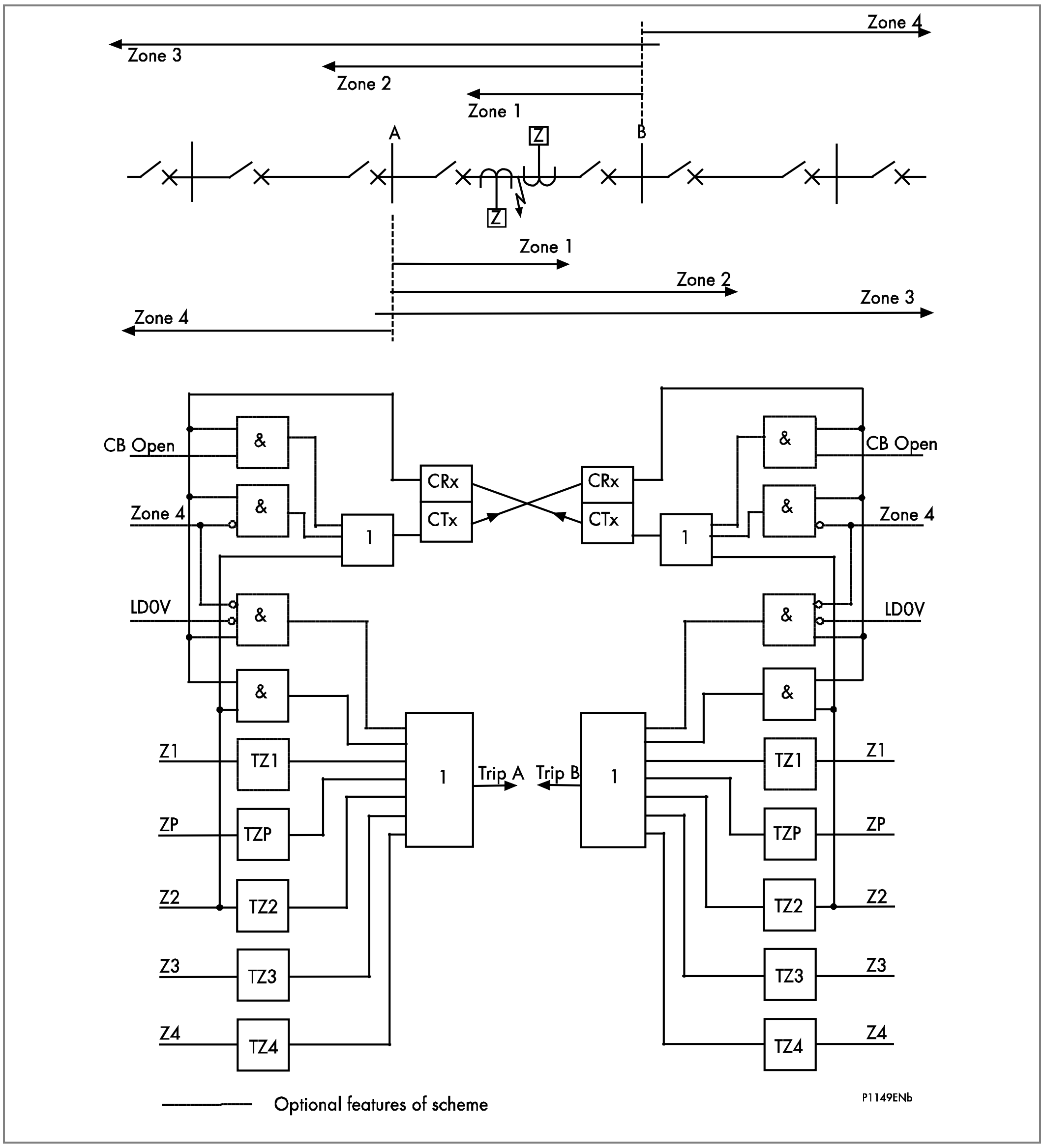


Figure 51: Permissive overreach transfer trip scheme (POR)

Detailed logic is shown in Figure 52, as follows:

> *Note:* *The DDB Any Trip (522) feeds into a 100 ms delay on drop-off timer, which in turn leads to signal sending. This is a principle similar to the logic which results in a signal send for weak infeed and breaker open echoing.*

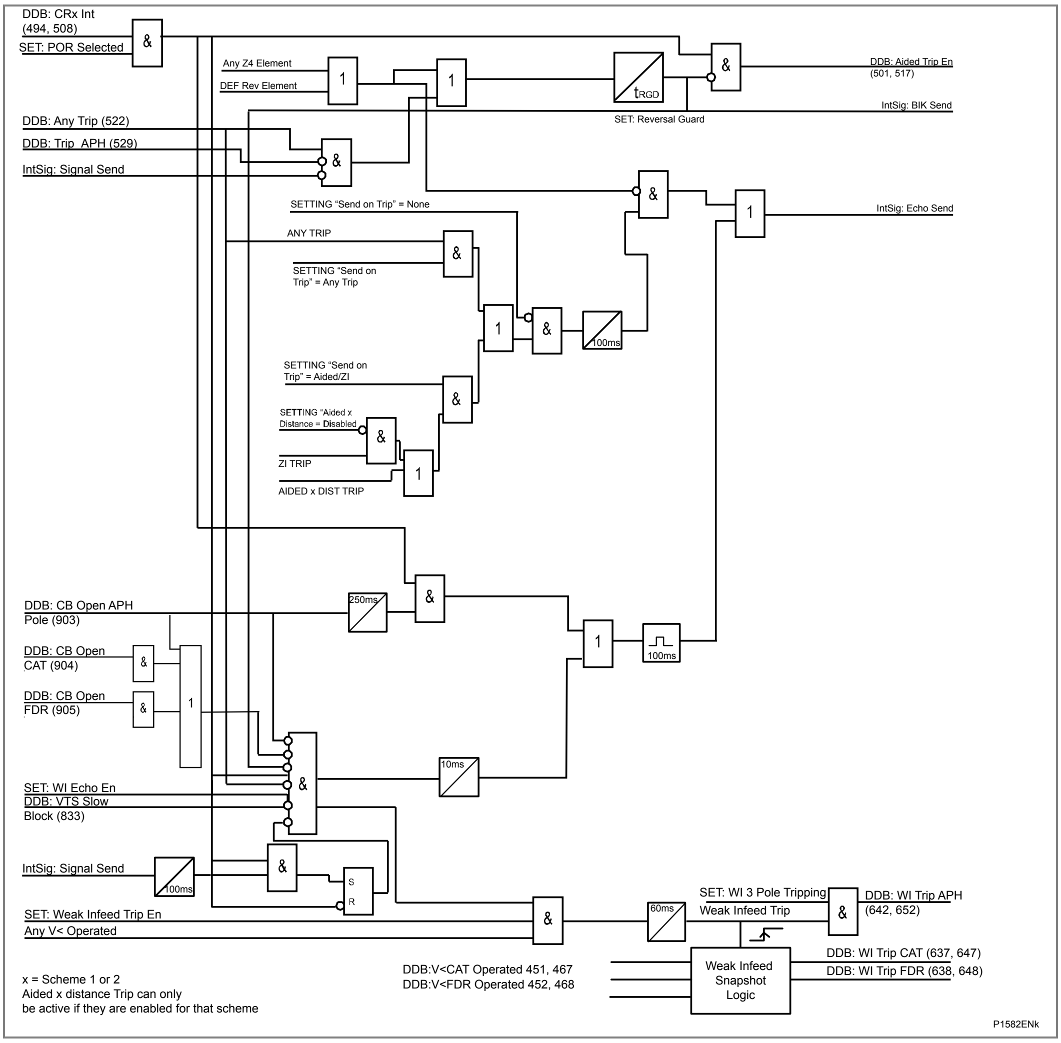


Figure 52: POR

7.2.3 Permissive overreach trip reinforcement

The send logic in the POR scheme is arranged so that for any trip command at the local end, the IED sends a channel signal to the remote end(s). This maximizes the chances for the fault to be isolated at all ends. The send signal generated by the **Any trip** command is sent on both Ch1 and Ch2, if more then one channel is in use. This feature is called permissive trip reinforcement and is a deliberate attempt to ensure that synchronous tripping occurs at all line ends.

7.2.4 Permissive overreach scheme weak infeed features

Weak infeed logic can be enabled to run in parallel with the POR schemes. Two options are available: WI Echo, and WI Tripping.

Note:	*Special stub-end transformer Weak Infeed is covered in section 1*

Weak Infeed Echo

For permissive schemes, a signal would only be sent if the required signal send zone detects a fault. However, the fault current infeed at one line end may be so low that it is insufficient to operate any distance zones, and risks a failure to send the signal. Also, if one circuit breaker is left open, the current infeed is zero. These are termed weak infeed conditions, and may result in slow fault clearance at the strong infeed line end (tripping after time tZ2). To avoid this slow tripping, the weak infeed IED can be set to “echo” back any channel received to the strong infeed IED, to immediately send a signal once a signal has been received. This allows the strong infeed IED to trip instantaneously in its permissive trip zone.

The additional signal send logic is as follows.

Echo Send
No Distance Zone Operation, plus Channel Received.

Weak Infeed Tripping

Weak infeed echo logic ensures an aided trip at the strong infeed terminal but not at the weak infeed. The IED also has a setting option to allow tripping of the weak infeed circuit breaker of a faulted line. Two undervoltage elements, Vcat< and Vfdr are used to detect the line fault at the weak infeed terminal. This voltage check prevents tripping during spurious operations of the channel or during channel testing.

The additional weak infeed trip logic is as follows.

Weak Infeed Trip
No Distance Zone Operation, plus V<, plus Channel Received.

Weak infeed tripping is time delayed according to the **WI Trip Delay** value. Due to the use of phase segregated undervoltage elements, single pole tripping can be enabled for WI trips if required. If single pole tripping is disabled, there is a three pole trip after the time delay.

7.2.5 Permissive scheme unblocking logic - loss of guard

This mode is designed for use with frequency shift keyed (FSK) power line carrier communications. When the protected line is healthy, a guard frequency is sent between line ends to verify the channel is in service. However, when a line fault occurs and a permissive trip signal must be sent over the line, the power line carrier frequency is shifted to a new (trip) frequency. Therefore the distance function should receive either the guard or trip frequency but not both together. With any permissive scheme the PLC communications are transmitted over the power line which may contain a fault. For certain fault types, the line fault can attenuate the PLC signals so the permissive signal is lost and not received at the other line end. To overcome this problem, when the guard is lost and no trip frequency is received, the IED opens a window of time during which the permissive scheme logic acts as though a trip signal had been received. Two opto inputs to the IED need to be assigned, one is the Channel Receive opto, the second is designated Loss of Guard (the inverse function to guard received).

System condition	Permissive channel received	Loss of guard	Permissive trip allowed	Alarm generated
Healthy Line	No	No	No	No
Internal Line Fault	Yes	Yes	Yes	No
Unblock	No	Yes	Yes, during a 150 ms window	Yes, delayed on pickup by 150 ms
Signaling Anomaly	Yes	No	No	Yes, delayed on pickup by 150 ms

Table 12: Loss of Guard function logic

The window of time during which the unblocking logic is enabled starts 10 ms after the guard signal is lost, and continues for 150 ms. The 10 ms delay gives time for the signaling equipment to change frequency, as in normal operation. For the duration of any alarm condition, zone 1 extension logic is invoked if **Z1 Ext on Chan. Fail** is **Enabled**.

7.2.6 Distance scheme BLOCKING

The signaling channel is keyed from operation of the reverse zone 4 elements of the IED. If the remote IED picks up in zone 2, it operates after the trip delay if no block is received. Listed below are some of the main features and requirements for a BLOCKING scheme:

- BLOCKING schemes require only a simplex signaling channel
- Reverse looking Zone 4 is used to send a blocking signal to the remote end to prevent unwanted tripping
- When a simplex channel is used, a BLOCKING scheme can easily be applied to a
- Multi-terminal line provided that outfeed does not occur for any internal faults
- The blocking signal is transmitted over a healthy line, and so there are no problems associated with power line carrier signaling equipment
- BLOCKING schemes provides similar resistive coverage to the permissive overreach schemes
- Fast tripping occurs at a strong source line end, for faults along the protected line section, even if there is weak or zero infeed at the other end of the protected line
- If a line terminal is open, fast tripping still occurs for faults along the whole of the protected line length
- If the signaling channel fails to send a blocking signal during a fault, fast tripping occurs for faults along the whole of the protected line, but also for some faults in the next line section
- If the signaling channel is taken out of service, the IED operates in the conventional basic mode
- A current reversal guard timer is included in the signal send logic to prevent unwanted trips of the IED on the healthy circuit, during current reversal situations on a parallel circuit

Figure 53 shows the simplified scheme logic.

Send logic:Reverse Zone 4

Trip logic: Zone 2, plus Channel NOT Received, delayed by Tp

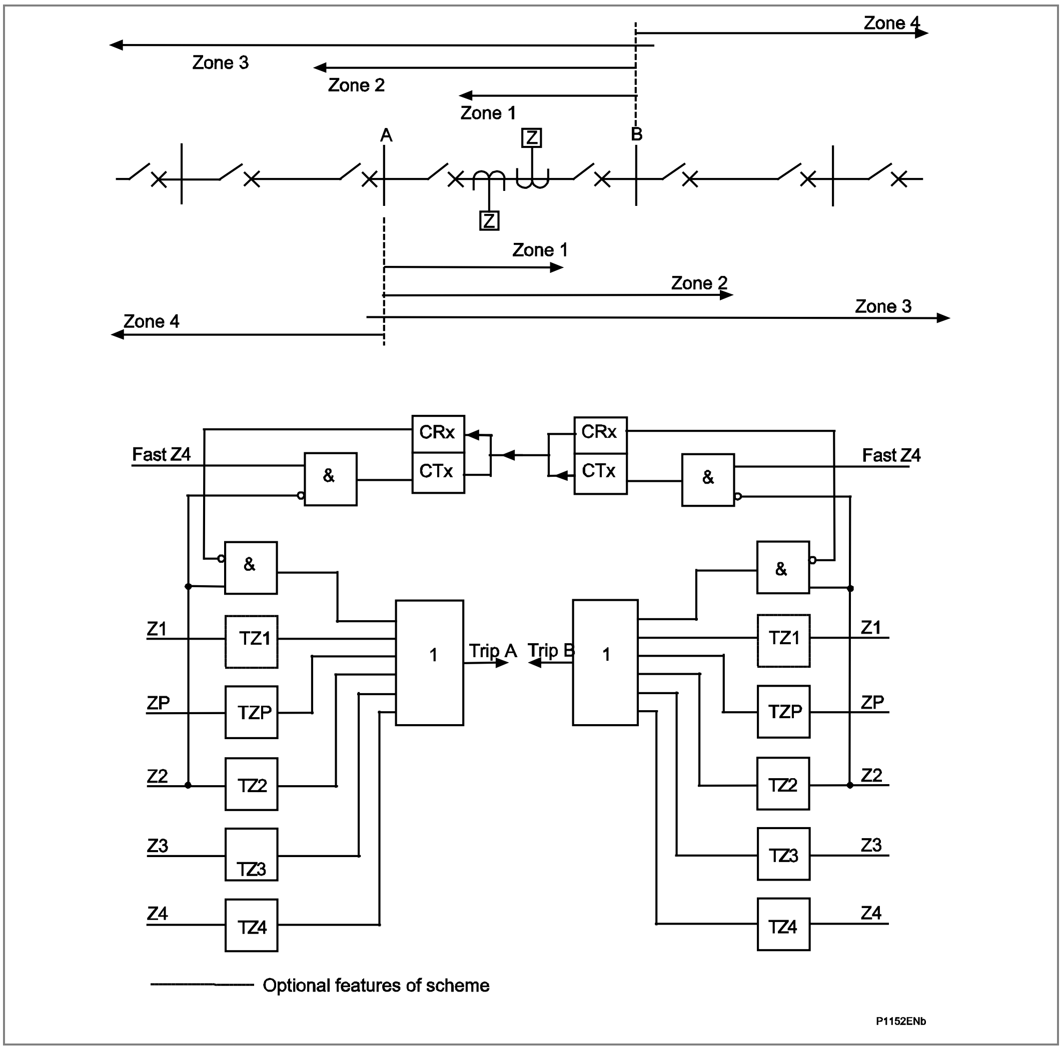


Figure 53: Distance blocking scheme (BOP)

7.2.7 Distance schemes current reversal guard logic

For double circuit lines, the fault current direction can change in one circuit when circuit breakers open sequentially to clear the fault on the parallel circuit. The change in current direction causes the overreaching distance elements to see the fault in the opposite direction to the direction in which the fault was initially detected (settings of these elements exceed 150% of the line impedance at each terminal). The race between operation and resetting of the overreaching distance elements at each line terminal can cause the Permissive Overreach, and Blocking schemes to trip the healthy line. A system configuration that could result in current reversals is shown in Figure 54. For a fault on line L1 close to circuit breaker B, as circuit breaker B trips it causes the direction of current flow in line L2 to reverse.

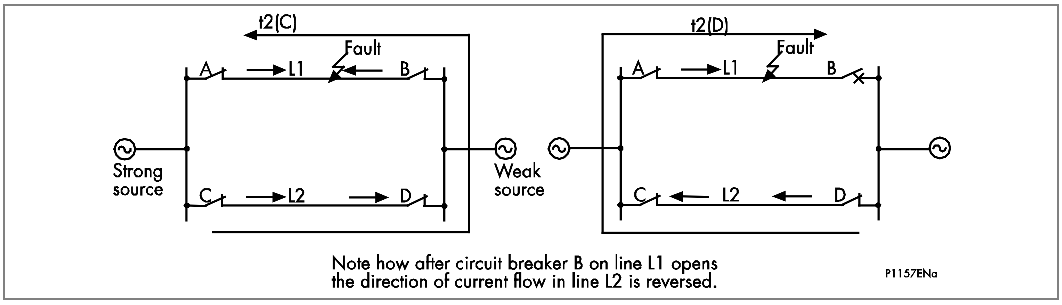


Figure 54: Example of fault current reverse of direction

7.2.8 Permissive overreach schemes current reversal guard

The current reversal guard incorporated in the POR scheme logic is initiated when the reverse looking Zone 4 elements operate on a healthy line. Once the reverse looking Zone 4 elements have operated, the IED's permissive trip logic and signal send logic are inhibited at substation D. The reset of the current reversal guard timer is initiated when the reverse looking Zone 4 resets. A time delay tREVERSAL GUARD is required in case the overreaching trip element at end D operates before the signal send from the IED at end C has reset. Otherwise this would cause the IED at D to over trip. Permissive tripping for the IEDs at D and C substations is enabled again, once the faulted line is isolated and the current reversal guard time has expired.

7.2.9 Blocking scheme 1 and 2 current reversal guard

The current reversal guard incorporated in the BLOCKING scheme logic is initiated when a blocking element picks-up to inhibit the channel-aided trip. When the current reverses and the reverse looking Zone 4 elements reset, the blocking signal is maintained by the timer tREVERSAL GUARD. Therefore, the IEDs in the healthy line are prevented from over tripping due to the sequential opening of the circuit breakers in the faulted line. After the faulted line is isolated, the reverse-looking Zone 4 elements at substation C and the forward looking elements at substation D resets.

Two variants of Blocking scheme exist, BLOCKING 1, and BLOCKING 2. The only difference in functionality is:

- BLOCKING 1 - The Reversal Guard is applied to the Signal Send
- BLOCKING 2 - The Reversal Guard is applied to the Signal Receive

The difference in the receive logic is shown in Logic Diagrams, Figure 55 and Figure 56 below:

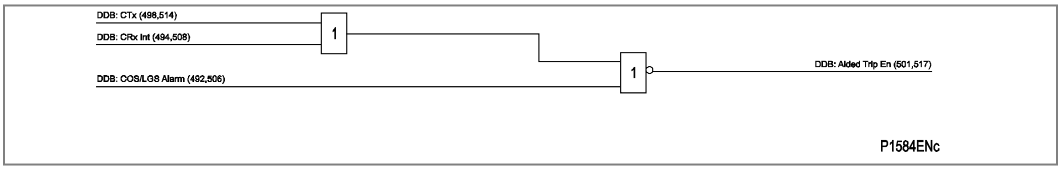


Figure 55: Blocking 1

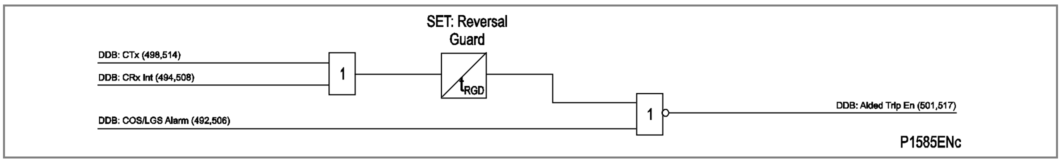


Figure 56: Blocking 2

The relative merits of Blocking 1 and Blocking 2 are discussed in Application Examples.

7.3 Zone 1 extension scheme

MiCOM P44T offers additional non-channel distance scheme, notably Zone 1 extension.

7.3.1 Zone 1 extension scheme

Auto-reclosure is widely used on radial overhead line circuits to re-establish supply following a transient fault. A Zone 1 extension scheme may therefore be applied to a radial overhead feeder to provide high speed protection for transient faults along the whole of the protected line. Figure 57 shows the alternative reach selections for zone 1: Z1 or the extended reach Z1X.

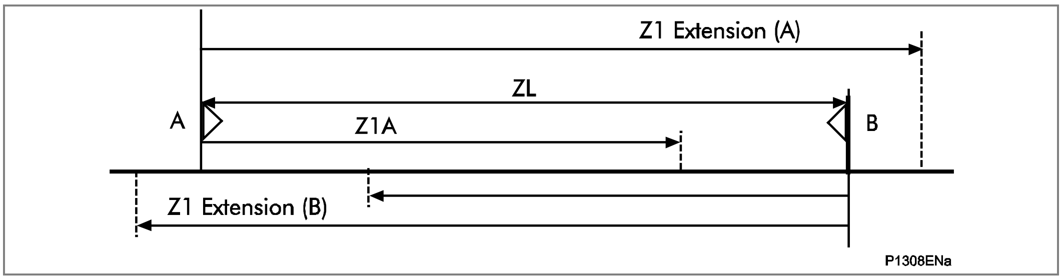


Figure 57: Zone 1 extension scheme

In this scheme Zone 1X is enabled and set to overreach the protected line. A fault on the line, including one in the end 20% not covered by zone 1, results in instantaneous tripping followed by auto-reclosure. Zone 1X has resistive reaches similar to Zone 1. The auto-recloser in the IED is used to inhibit tripping from zone 1X so that on reclosure the IED operates with Basic scheme logic only, to co-ordinate with downstream protection for permanent faults. Therefore transient faults on the line are cleared instantaneously, which reduces the probability of a transient fault becoming permanent. However, the scheme can operate for some faults on an adjacent line, although this is followed by auto-reclosure with correct protection discrimination. Increased circuit breaker operations would occur, together with transient loss of supply to a substation.

Fault trip	Z1X time delay
First fault trip	= tZ1
Fault trip for persistent fault on auto-reclose	= tZ2

Table 13: Time delays associated with extended zone Z1X

The Zone 1X reach is set as a percentage of the Zone 1 reach, as a reach multiplier and can be Disabled, permanently Enabled or just brought into service when the communication channel fails and the aided scheme is inoperative. It can be set to be enabled when Ch 1 or Ch 2 fails, or when all channels fail, or when any channel fails. See Figure 58.

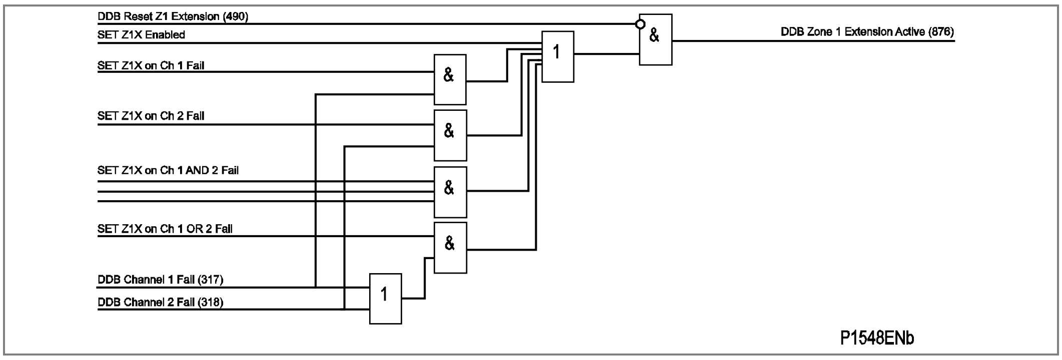


Figure 58: Zone 1 extension

8 DEFROST PROTECTION

In the cold conditions, ice build-up on the catenary may be an issue if the interval between trains is long.

In such cases, the control operator may switch the feeding arrangement temporarily to apply a distant, deliberate short circuit – to warm the contact wire and melt any ice build up, which could otherwise foul pantographs.

The P44T provides a defrost protection function to handle conditions where catenaries have iced over. The defrost protection measures the feed and return current and processes these current values in a differential protection function for sensitive short-circuit protection.

Defrost protection can be disabled or enabled from the local control panel. In addition, the defrost protection may be disabled internally or externally by DDB signals associated with it.

8.1 Defrost Protection Principle

8.1.1 Current Transformer matching factor

The current transformer for the acquisition of the catenary and defrost current can be dimensioned with a certain range. From the CT transformation ratio data, the P44T calculates a matching factor (MF) before actually performing defrost protection. Since the differential current calculation is based on the catenary side current, so the MF can be calculated as below

$$MF = I_{X,prim}/I_{cat,prim}$$

Where I_{x_prim} = Defrost CT ratio

I_{cat_prim} = Catenary CT ratio

The matching factor is limited to a range of 1 at the minimum and 8 at the maximum. If it is outside these limits, the P44T will generate an alarm (DDB294), the DDB signal is then used to inhibit the defrost protection.

8.1.2 Differential protection characteristics

The P44T forms a differential current (I_{DIFF}) and a restraining current (I_{BIAS}) from the catenary current and the defrost current.

$$I_{DIFF} = |I_{cat} + I_{def}|$$

$$I_{BIAS} = 0.5^* (|I_{cat}| + |I_{def}|)$$

Where I_{cat} and I_{def} are the current vectors of catenary and defrost respectively.

Current monitoring is based on a single differential protection characteristic with two slopes K_1 and K_2. The two parts of the characteristic are given below.

Characteristic equation for the range $0 \le I_{BIAS} \le I_{s2}$

$$I_{DIFF} = I_{s1} + (K_1 * I_{BIAS})$$

Characteristic equation for the range $I_{BIAS} > I_{s2}$

$$I_{DIFF} = K_2 * I_{BIAS} - I_{s2} * (K_2 - K_1) + I_{s1}$$

Where I_{s1}, I_{s2}, K_1 and K_2 are the settings for the defrost protection function.

8.1.3 Differential protection tripping characteristics diagram

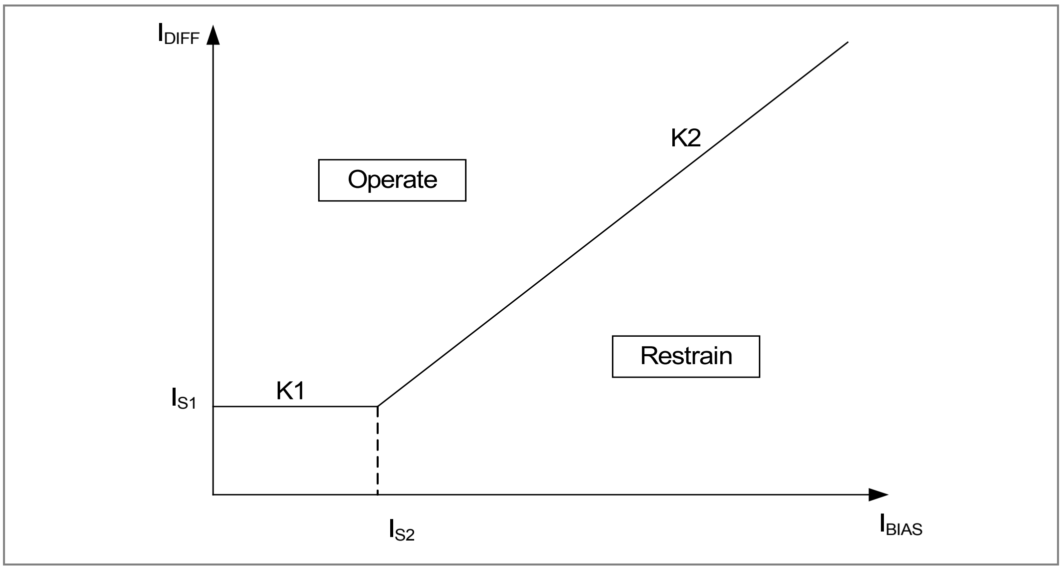


Figure 59: Defrost Protection Operation characteristic

8.1.4 Internal Operating Mode

Following defrost protection logic diagram can be used for both classic and autotransformer operation modes.

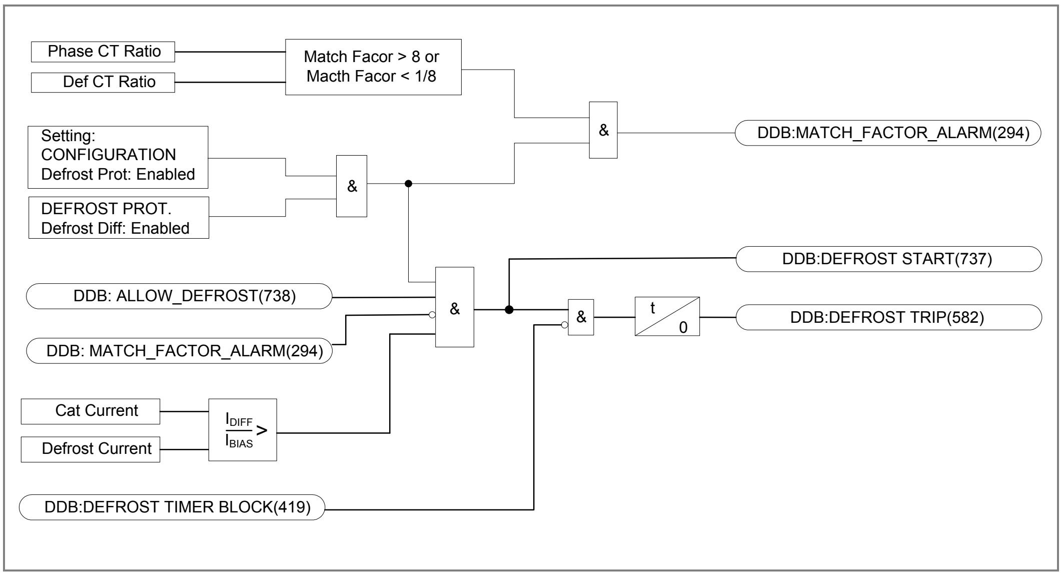


Figure 60: Defrost Protection Logic for P44T both in Classic and AT Feed Mode

9 PHASE FAULT OVERCURRRENT PROTECTION

Phase fault overcurrent protection is provided as a form of back-up protection that could be:

- Permanently disabled
- Permanently enabled
- Enabled only in case of VT fuse/MCB failure

In addition, each stage may be disabled by a DDB (463, 464, 465 or 466) Inhibit I > x (x = 1, 2, 3 or 4).

Phase overcurrent protection is phase segregated, but the operation of any phase is mapped to All phase tripping in the default PSL.

The VTS element of the IED can be selected to either block the directional element or simply remove the directional control.

9.1 Pick-up characteristics

The first two stages can be set either inverse time or definite time only. The third and fourth stages have a DT characteristic only. Each stage can be configured to be directional forward, directional reverse or non-directional.

The IEC/UK IDMT curves conform to the following formula:

$$t = T \times \left(\frac{\beta}{(I/Is)^{\alpha} - 1} + L \right)$$

The IEEE/US IDMT curves conform to the following formula:

$$t = TD \times \left(\frac{\beta}{(I/Is)^{\alpha} - 1} + L \right)$$

t = Operation time

β = Constant

I = Measured current

Is = Current threshold setting

α = Constant

L = ANSI/IEEE constant (zero for IEC curves)

T = Time multiplier setting for IEC/UK curves

TD = Time multiplier setting for IEEE/US curves

IDMT curve description	Standard	β Constant	α Constant	L Constant
Standard Inverse	IEC	0.14	0.02	0
Very Inverse	IEC	13.5	1	0
Extremely Inverse	IEC	80	2	0
Long Time Inverse	UK	120	1	0
Rectifier	UK	45900	5.6	0
Moderately Inverse	IEEE	0.0515	0.02	0.114
Very Inverse	IEEE	19.61	2	0.491
Extremely Inverse	IEEE	28.2	2	0.1217
Inverse	US-C08	5.95	2	0.18
Short Time Inverse	US	0.16758	0.02	0.11858

Table 14: IDMT curve characteristics

> *Note: The IEEE and US curves are set differently to the IEC/UK curves, with regard to the time setting. A time multiplier setting (TMS) is used to adjust the operating time of the IEC curves, whereas a time dial setting is used for the IEEE/US curves. The menu is arranged so that if an IEC/UK curve is selected, the* ***I> Time Dial*** *cell is not visible and vice versa for the TMS setting.*

9.2 Reset characteristics

The IEC/UK inverse characteristics can be used with a definite time reset characteristic, however, the IEEE/US curves may have an inverse or definite time reset characteristic. The following equation can used to calculate the inverse reset time for IEEE/US curves:

$$tRESET = \frac{TD \times S}{(1 - M^2)} \text{ in seconds}$$

Where:

TD = Time dial setting for IEEE curves

S = Constant

M = I/Is

Curve description	Standard	S constant
Moderately Inverse	IEEE	4.85
Very Inverse	IEEE	21.6
Extremely Inverse	IEEE	29.1
Inverse	US	5.95
Short Time Inverse	US	2.261

Table 15: Reset characteristics

9.3 Directional overcurrent protection

The phase fault elements of the IEDs are internally polarized, as shown in the table below:

	Phase of protection	Operate current	Polarizing voltage
Single Phase	Catenary Phase	Icat	Vcat
Autotransformer	Catenary Phase	Icat	Vcat-Vfdr
	Feeder Phase	Ifdr	Vfdr-Vcat

Table 16: Parallel voltage polarisation

Under system fault conditions, the fault current vector lags its nominal phase voltage by an angle depending on the system X/R ratio. The IED must therefore operate with maximum sensitivity for currents lying in this region. This is done using the IED characteristic angle (RCA) setting. The RCA is the angle by which the current applied to the IED must be displaced from the voltage applied to the IED to obtain maximum sensitivity. This is set in cell **I>Char Angle** in the **overcurrent** menu. It is possible to set characteristic angles anywhere in the range –95° to +95°.

Figure 61 shows the functional logic block diagram for directional overcurrent.

The overcurrent block is a level detector that detects if the current magnitude is above the threshold, and together with the respective polarizing voltage, a directional check is performed based on the following criteria:

Directional forward

-90° < (angle(I) - angle(V) - RCA) < 90°

Directional reverse

-90° > (angle(I) - angle(V) - RCA) > 90°

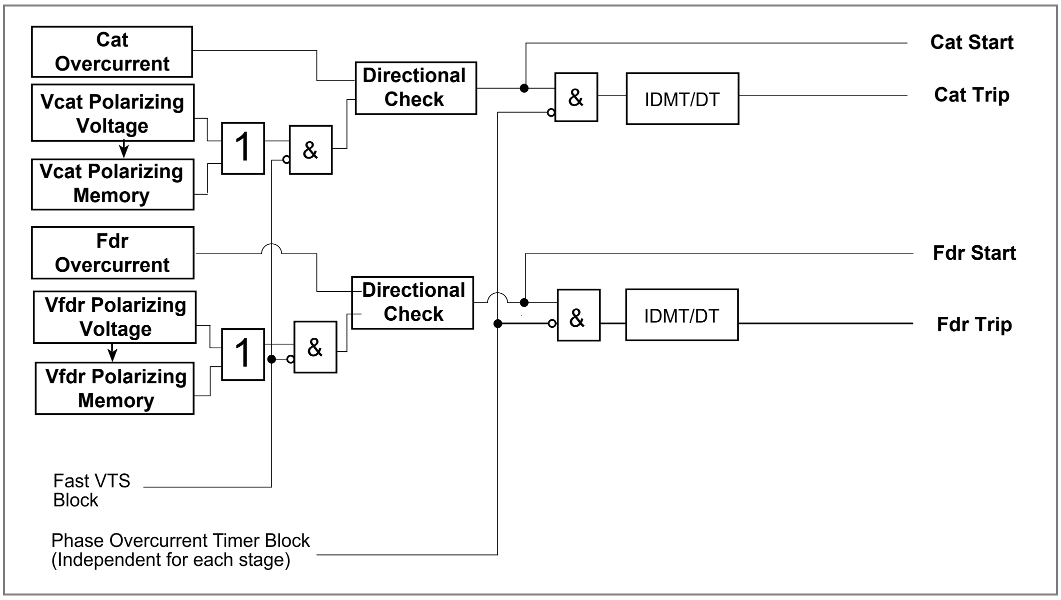


Figure 61: Directional overcurrent logic for P44T Relay

Any of the four overcurrent stages may be configured to be directional noting that IDMT characteristics are only selectable on the first two stages. When the element is selected as directional, a VTS Block option is available. When the relevant bit is set to 1, operation of the Voltage Transformer Supervision (VTS), blocks the stage if directionalized. When set to 0, the stage reverts to non-directional when the VTS operates.

9.4 Synchronous polarization

For a close up all-phase fault, all voltages collapse to zero and no healthy phase voltages is present. For this reason, the IED includes a synchronous polarization feature that stores the prefault voltage information and continues to apply it to the directional overcurrent elements for 3.2 seconds. This ensures that either instantaneous or time delayed directional overcurrent elements are allowed to operate, even with a phases voltage collapse.

10 PANTO FLASH OVER

One side of the insulated overlap may become dead while the other section is live due to the tripping of respective feeder CB on fault or manual tripping. This condition can take place during normal operation or a feed extended condition. During a dead condition, the secondary voltage in the dead section is very low.

If voltage is present on the secondary and the respective feeder CB is in the open condition, this voltage is due to a train entering from a live section, in this case, there may be a heavy flashover when the Pantograph leaves the insulating overlap. This will lead to damage to the Pantograph(s).

This relay's function must identify such a situation and trip the feeder circuit breaker connected to the live side of the overlap. The relay continuously monitors the voltage status and the CB at the respective section depending on appropriate logic to give a trip command to the associated CB.

The relay has a separate undervoltage setting, if voltage is less than the set undervoltage, the relay will close the respective NO contact, which can be used to operate an indicator light to give advance warning to train driver to take necessary action.

10.1 Panto Flash Over principle

Panto Flash Over protection that could be:

- Permanently disabled
- Permanently enabled

Is provided as a form of back-up protection and can be set in the menu column **GROUP x PANTO FLASH OVER** (where x is the setting group).

Both the under and overvoltage protection functions are used in the Panto flash Over Protection menu. The measuring mode is always Cat-N for both classic or autotransformer mode.

One undervoltage stage are included to provide alarm, **Panto V< Set**, and a overvoltage stage to provide the trip, **Panto V> Set**, where required. Different time settings may be required for both stages, so you can set differents time delays for alarm and trip, **Panto AlarmDelay** and **Panto Trip Delay**.

In addition, each stage may be inhibit by DDB 398 or DDB 399, Inhibit Alarm and Inhibit Trip respectively.

This feature is continuous monitoring the voltage of catenary and its CB position.

1. It should indicate an alarm when meet all of the following conditions,
   - Panto flash over is enabled
   - No block signal
   - Circuit breaker is open
   - Monitor voltage is smaller than Panto V< Set
   - Alarm Delay is expired
2. It should issue a trip when meet all of the following conditions
   - Panto flash over is enabled
   - No block signal
   - Circuit breaker is in open status
   - Monitor voltage is bigger than Panto V> set

- Trip Delay is expired

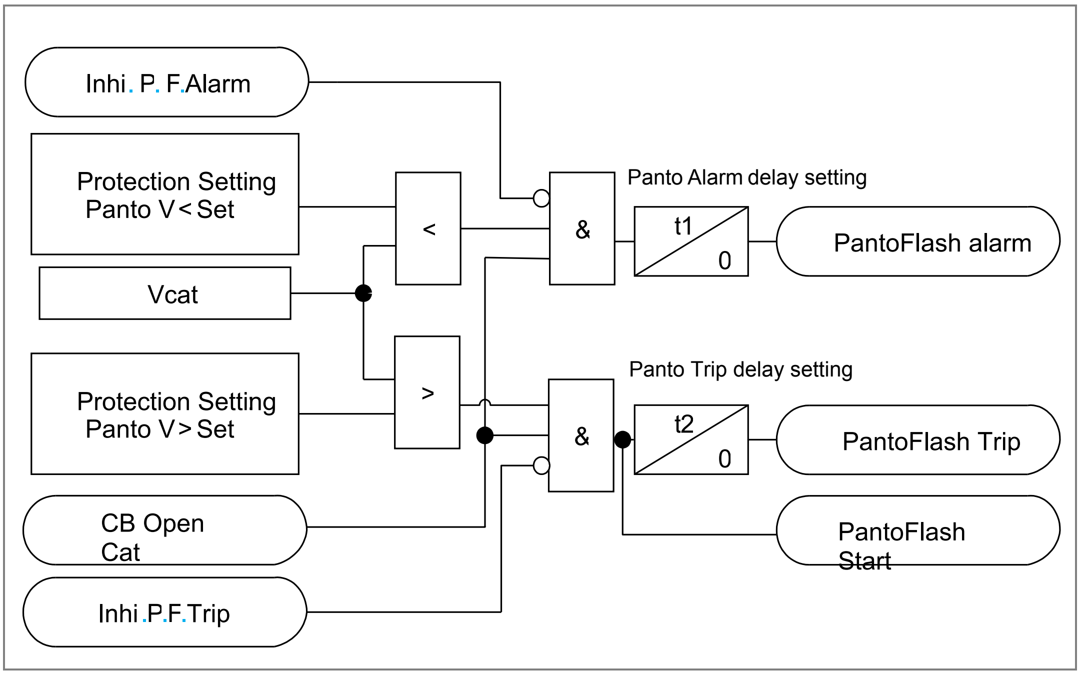


Figure 62: Panto Flash Over logic

11 THERMAL PROTECTION

It is important that the catenary is not allowed to overheat, as this will lead to loss of the correct contact wire mechanical position above track, or conductor sagging.

The P44T relay inclorporates a current based thermal replica using load current to model heating and cooling of the protected plant. The element can be set with both alarm and trip stages.

The heat generated in an item of plant, such as a cable or a transformer, is the resistive loss (I2R x t). Therefore, heating is directly proportional to current squared. The thermal time characteristic used in the IED is therefore based on current squared, integrated over time. The IED automatically uses the largest phase current for input to the thermal model.

Equipment is designed to operate continuously at a temperature corresponding to its full load rating, where heat generated is balanced with heat dissipated by radiation etc. Over-temperature conditions therefore occur when currents in excess of rating are allowed to flow for a period of time. It can be shown that temperatures during heating follow exponential time constants and a similar exponential decrease of temperature occurs during cooling.

The IED provides two characteristics that may be selected according to the application.

11.1.1 Single time constant characteristic

This characteristic is used to protect cables, dry type transformers such as AN (Air Natural) type, and capacitor banks.

The thermal time characteristic is given by:

$$t = -\tau \log_e \left(\frac{I^2 - (K.I_{FLC})^2}{(I^2 - Ip^2)} \right)$$

Where:

t = Time to trip, following application of the overload current, I;

τ = Heating and cooling time constant of the protected plant;

I = Largest phase current;

IFLC = Full load current rating (IED setting 'Thermal Trip');

k = 1.05 constant, allows continuous operation up to <1.05 I_{FLC};

IP = Steady state preloading before application of the overload.

The time to trip varies depending on the load current carried before application of the overload, therefore whether the overload was applied from 'hot" or "cold".

The thermal time constant characteristic may be rewritten as:

$$e^{(-t/\tau)} = \left(\frac{\theta - \theta p}{\theta - 1} \right)$$

Where:

θ = $I^2/k^2\ I_{FLC}^2$

and

θp = $Ip^2/k^2\ I_{FLC}^2$

Where θ is the thermal state and is θp the prefault thermal state.

> *Note: A current of 105%Is (kIFLC) has to be applied for several time constants to cause a thermal state measurement of 100%.*

11.1.2 Dual time constant characteristic

This characteristic is used to protect oil-filled transformers with natural air cooling, such as the ONAN (Oil Natural Air Natural) type. The thermal model is similar to that of the single time constant, except that two time constants must be set.

When there is marginal overloading, heat flows from the windings into the bulk of the insulating oil. Therefore at low current the replica curve is dominated by the long time constant for the oil. This protects against a general rise in oil temperature.

When there is severe overloading, heat accumulates in the transformer windings with little opportunity for dissipation into the surrounding insulating oil. Therefore at high current the replica curve is dominated by the short time constant for the windings. This protects against hot spots developing in the transformer windings.

Overall, the dual time constant characteristic provided in the IED protects the winding insulation from ageing, and to minimize gas production by overheated oil.

> *Note: The thermal model does not compensate for the effects of ambient temperature change.*

The thermal curve is defined as:

$$0.4e^{(-t/\tau)} + 0.6e^{(-t/\tau)} = \frac{I^2 - (k.IFLC)^2}{I^2 - Ip^2}$$

Where:

$\tau 1$ = Heating and cooling time constant of the transformer windings;

$\tau 2$ = Heating and cooling time constant for the insulating oil.

A graphical solution using a spreadsheet is recommended to solve this equation to give the operating time (t). The spreadsheet can be set to calculate the current to give a chosen operating time. The equation to calculate the current is:

$$I = \sqrt{\frac{0.4Ip^2.e^{(-t/\tau 1)} + 0.6Ip^2.e^{(-t/\tau 2)} - k^2.I_{FLC}^2}{0.4\,e^{(-t/\tau 1)} + 0.6\,e^{(-t/\tau 2)} - 1}} \quad \text{…….. Equation 1}$$

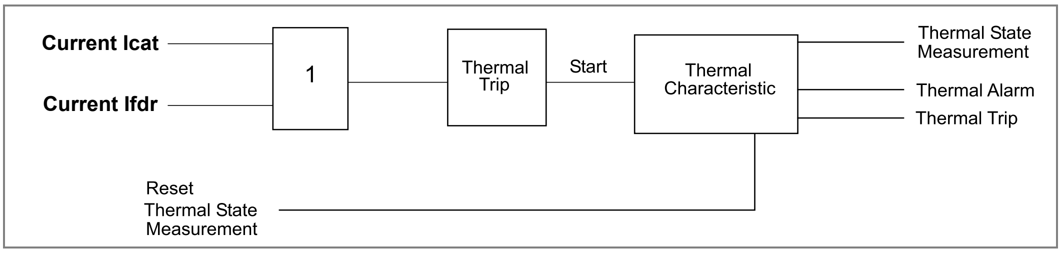


Figure 63: Thermal overload protection logic diagram for P44T Relay

Figure 63 shows how the magnitudes of the two phase input currents are compared and the largest magnitude taken as the input to the thermal overload function. If this current exceeds the thermal trip threshold setting, a start condition is asserted.

12 VOLTAGE PROTECTION

12.1 Undervoltage protection

Both the under and overvoltage protection functions are in the IED Volt Protection menu. By default in classic mode the measuring mode is always ph-N and sinle phase trip mode. In autotransformer mode the measuring mode (ph-N or ph-ph) and operating mode (single phase or all phases) for both stages can be set independently using **V<Operate Mode** cell.

From the **V<1** function cell, stage 1 can be set as either IDMT, DT or Disabled.

From the **V<2** status cell, stage 2 can be set as DT only which can be enabled or disabled.

Two stages are included to provide both alarm and trip stages, where required. Alternatively, different time settings may be required depending on the severity of the voltage dip.

If the protected feeder is de-energized, or the circuit breaker is opened, an undervoltage condition is detected. **V<Polehead Inh** is used for each of the two stages, to block the undervoltage protection from operating for this condition. If **V<Polehead Inh** is enabled, the relevant stage is inhibited by the inbuilt pole dead logic in the IED. This logic produces an output when it detects either an open circuit breaker through auxiliary contacts feeding the IED opto inputs or it detects a combination of both undercurrent and undervoltage on any one phase.

The IDMT characteristic of the first stage is defined by the following formula:

$t = K/(1 - M)$

Where:

K = Time multiplier setting

t = Operating time in seconds

M = Measured voltage / IED setting voltage (V< Voltage Set)

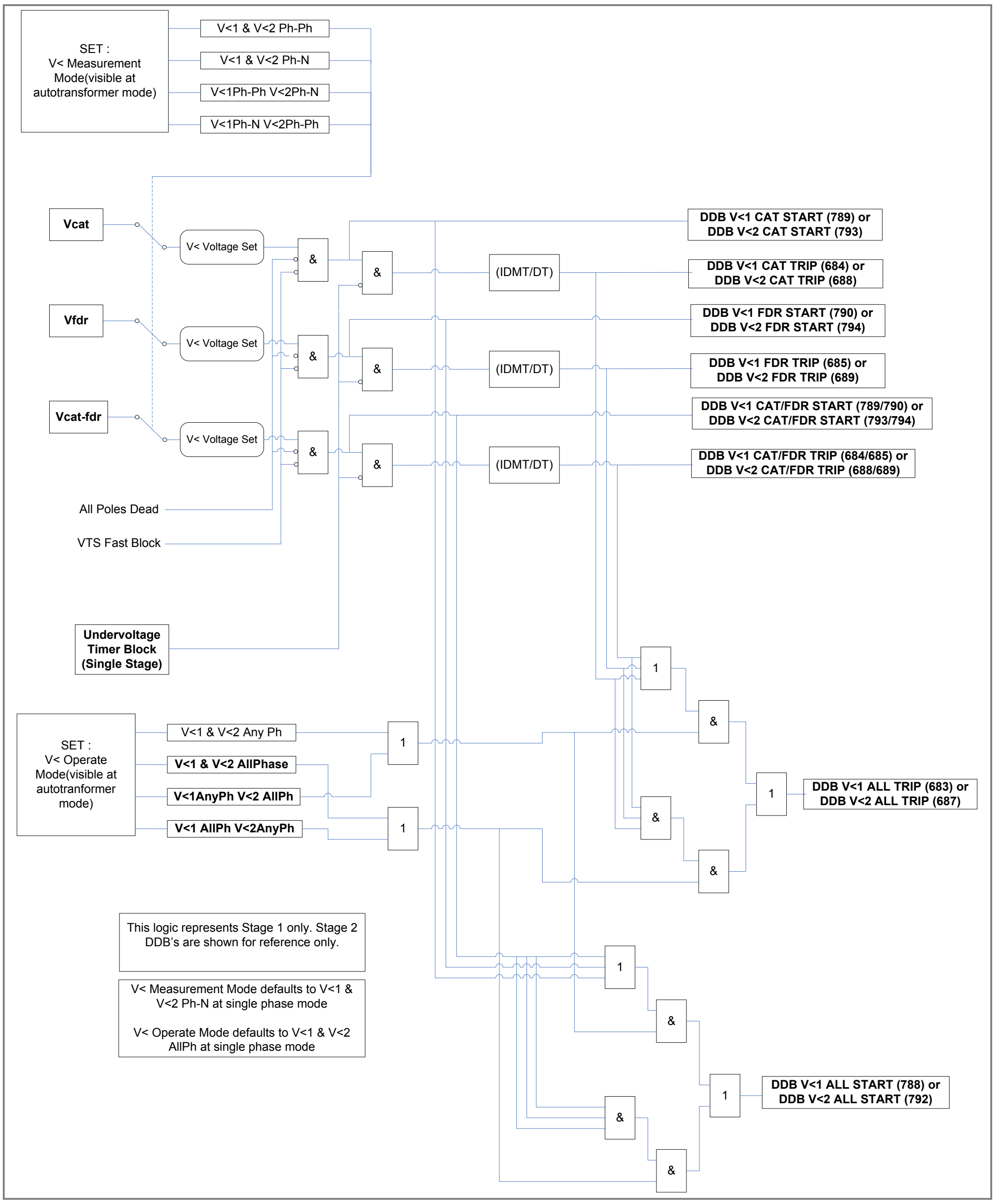


Figure 64: First stage undervoltage function - single and 2 phases tripping mode for P44T Relay

> *Note: Undervoltage protection is phase segregated but the operation of any phase is mapped to all phases tripping in the default PSL.*

Each stage of Undervoltage protection can be disabled by a DDB (471 or 472) Inhibit Vx<.

12.2 Overvoltage protection

Both the under and overvoltage protection functions are in the IED Volt Protection menu. By default in classic mode the measuring mode is always ph-N and sinle phase trip mode. In autotransformer mode the measuring mode (ph-N or ph-ph) and operating mode (single phase or all phases) for both stages can be set independently using **V>Operate Mode** cell.

The IDMT characteristic on the first stage is defined by the following formula:

t = K/(M - 1)

Where:

K = Time multiplier setting

t = Operating time in seconds

M = Measured voltage/IED setting voltage (V> Voltage Set)

The logic diagram for the first stage overvoltage function is shown in Figure 65.

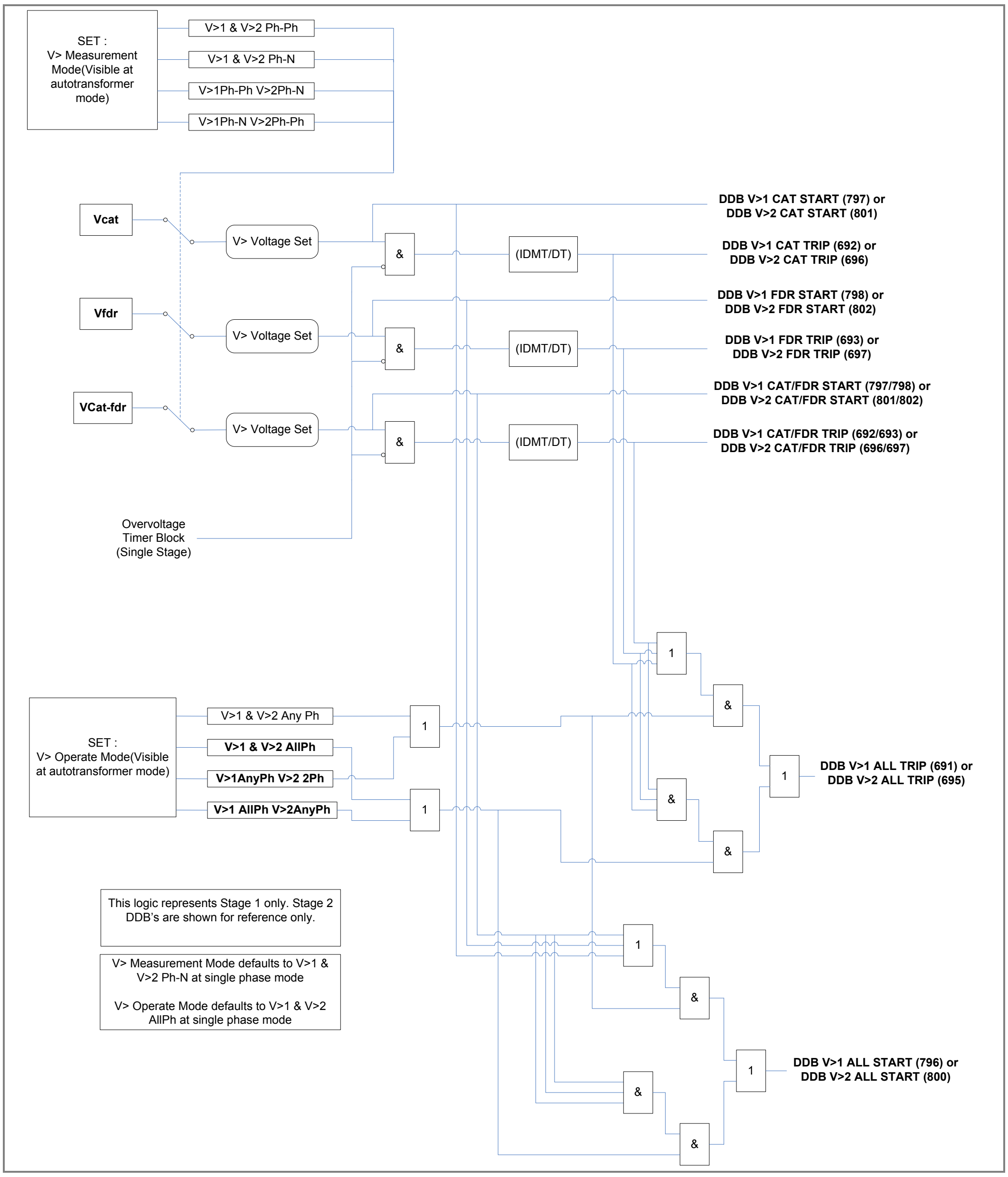


Figure 65: Overvoltage - single and 2 phases tripping mode (single stage) for P44T relay

> *Note:* *Phase overvoltage protection is phase segregated, but the operation of any phase is mapped to all phase tripping in the default PSL.*

Each stage of Overvoltage protection may be disabled by a DDB (473 or 474) Inhibit Vx> (x = 1, 2).

13 HIGH IMPENDANCE DELTA I FUNCTION

Loads in rail power systems constantly vary between light and heavy loaded conditions. Fault currents, in cases of high fault impedance, can be comparable and even smaller than load currents. One way to distinguish between a fault and sudden load change, such as the start of a train, is the current's rate of change, which is higher for a fault condition. Another distinctive characteristic between the fault and load current, due to the use of static converters in locomotives, is that current during normal load conditions is rich in 3rd and some 5th harmonics, while fault currents have a very small amount of harmonics.

In order to detect high impedance faults, a Delta I technique is provided, to detect sudden current change and is supervised by the presence of 3rd harmonics. If a 3rd harmonic is present, the protection should be blocked or restrained.

In addition to 3rd harmonics, there are other settable supervision elements, as follows:

- 5th harmonic
- Delta I angle
- Reactance line
- Current sensitivity
- Voltage sensitivity

13.1 Delta Function configuration

The *High Z Delta I* setting in the CONFIGURATION column is used to enable and disable High impedance delta I protection. The setting is also available in each group to enable/disable the High impedance delta I protection. If disabled, the function shall not de active and none of the features related to this functions will be visible.

There is a DDB signal HZDeltIBlock used to block the function from issuing a trip signal.

13.2 High impedance Delta I function

13.2.1 High Z Delta I

Delta looks at the relative magnitude and phase angle of the superimposed current Delta I at the instant of fault inception.

When a fault occurs on the system, the delta I changes measured are:

DeltaI = fault current (time "t") - prefault load current (t-2 cycles)

The delta measurements are a vector difference, resulting in a delta magnitude and angle. Under healthy system conditions the prefault values are those measured 2 cycles earlier. When a fault is detected the prefault values are retained for the duration of the fault.

> *Note: The feeder current will only be available when the operation mode is set to Autotransformer*

Delta current magnitude and phase angle are measured separately and users can set the desired delta threshold in the settings as given below:

The HZ Delta I mag threshold is used to set the magnitude change in current to identify a high impedance fault on catenary or feeder. This setting is visible if *High Z Delta I* is set to Enabled.

HZDeltI CatMag and *HZDeltI FdrMag* DDB signals indicate the threshold *HZ Delta I mag* has been exceeded.

The HZ Delta I angle threshold is used to set the minimum angle change required in the current for a fault condition to be identified. If the measured *Delta I Angle* (catenary OR feeder– if autotransformer is enabled) is greater than the *HZ Delta I Angle* setting, Block *High Z Delta I* will not be set. However, if the measured Delta I angle (catenary OR feeder– if autotransformer is enabled) is smaller than the setting *HZ Delta I Angle,* blocking of *High Z Delta I* is set.

HZDeltI CatAng and *HZDeltI FdrAng* DDB signals indicate the threshold *HZ Delta I angle* has been exceeded.

Note:	*For angles less than 10° the minimum I sensitivity HZ Delta I Sens. should be greater than 0.1IN.*

The detection of catenary magnitude change and phase angle change produce a Delta I high impedance start *HZDeltI StartCat* DDB signal to indicate that there has been a potential high impedance fault detected on catenary phase. Both magnitude and angle must exceed the set respective thresholds for the HZ Delta I fault to be deemed as detected.

When both magnitude and angle are detected, the start signal is activated and at this stage the continuous delta calculation of magnitude and angle will be halted to ensure that delta calculation is always performed with respect to pre-fault conditions. The process/logic for setting the Delta Buffer is shown below:

There is a minimum value of current to allow operation of the High Z Delta I function. This is a settable value *HZ Delta I Sens.*

HZ Delta I Angle works only if the current is above the setting *HZ Delta I Sens.* (Catenary and feeder respectively).

There is a time delay for the operation of the High Z Delta I function and is set using the *HZ Delta I Delay* setting.

The following DDB signals are produced:

- HZDeltI StartCat
- HZDeltI StartFdr
- HZDeltI TripCat
- HZDeltI TripFdr

Delta latch reset occurs after *HZ Delta I Delay* plus 100 ms

Note:	The *HZ Delta I mag* works independently to *HZ Delta I angle* i.e. is not a vectorial difference but an absolute difference. *HZ Delta I mag* = | Imag actual - Imag 2cycles earlier | *HZ Delta I angle* = | Iangle actual - Iangle 2cycles earlier |

13.2.2 High Z Delta I reactance line supervision

Forward and reverse reactance lines are used to limit the operation of the *High Z Delta I* function. For some applications, it may be desirable to limit the *High Z Delta I* function operation to faults on the immediate line section by setting a forward reach *HZD ZGND Forw* between 80 – 100 % of the line Impedance. This ensures the *High Z Delta I* function will only operate for faults on its line section and not require time grading with *High Z Delta I* relays at other points in the system. A reverse reach setting, *HZD ZGND Rev* may be used to provide fast backup fault clearance for faults behind the relaying point. To ensure accuracy of the reactance calculated, a valid VT measurement has to be available.

This optional supervision for the *High Z Delta I* function is operated by setting *HZ Delta Ireact.* to Enable/Disable. If Disabled, the function does not block *High Z Delta I*. If enabled, the function blocks *High Z Delta I* if the Impedance locus for the faulted loop (Delta I current) is outside the forward and reverse reactance lines as follows:

- *High Z Delta I* for the Catenary, is supervised by the reactance lines of the Catenary-rail. The reactance line uses catenary voltage and catenary current.
- *High Z Delta I* for the Feeder, is supervised by the reactance lines of the Feeder-rail . The reactance line uses the feeder voltage and feeder current.

Impedance settings for this reactance function are shown below:

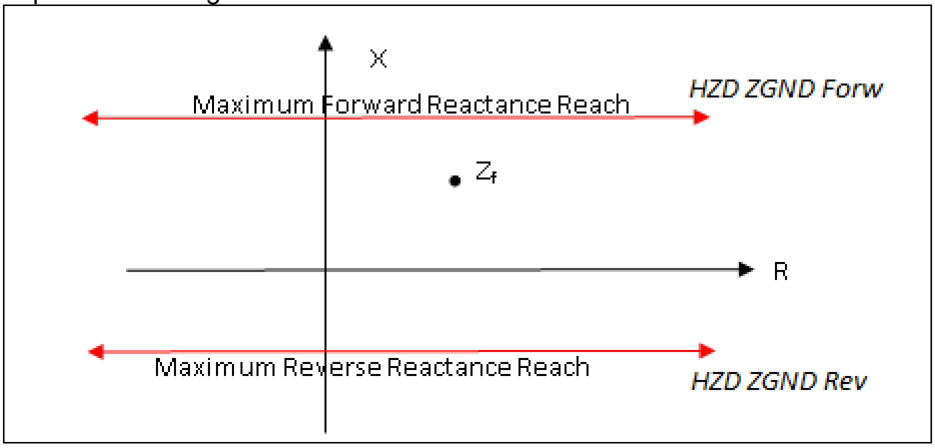


Figure 66: Forward and reverse reactance lines

Note:	*This function is completely separate to the Distance function.*

This feature is supervised as follows:

- *HZ Delta Ireact.* operates only if the current is above the setting *HZ Delta Imin*
- *HZ Delta Ireact.* does not operate in case VTS, MCB
- *HZ Delta Ireact.* will only operate if the voltage has exceeded the *HZ Delta V Sens.setting*

HZ Delta Ireact. settings *HZD ZGND Forw* and *HZD ZGND Rev* are in ohms and follows same distance setting rules:

- if *Setting Values* is set to *Primary*, the reactive impedance must be the value in primary
- if *Setting Values* is set to *Secondary*, the reactive impedance must be the value in secondary.

For Catenary-rail and Feeder-rail loops *HZD ZGND Forw* and *HZD ZGND Rev* settings are only available when *HZ Delta Ireact.* is set to *Enabled.*

Two DDB signals, *HZD ZGND Fw Cat* and *HZD ZGND Fw Fdr* indicate the impedance locus is below the *HZD ZGND Forw* setting.

Two DDB signals, *HZD ZGND Rv Cat* and *HZD ZGND Rv Fdr,* which indicate the impedance locus is below the *HZD ZGnd Rev* setting (in this case is below in the negative direction and therefore effectively the reactance of the impedance locus is higher than the *HZD ZGnd Rev).*

13.2.3 High Z Delta I where voltage is not available or suitable

Reactance line supervision calculation requires both voltage and current.

For *HZ Delta Ireact.,* where voltage is required, the *High Z Delta I* function can be allowed to operate if there is not enough voltage or a VTS is present. This can be achieved by a setting: *HZ DeltaI V Mode* to Enabled VTS/Vmin or Disabled VTS/Vmin:

- If *HZ DeltaI V Mode* is set to *Enabled, the High Z Delta I* function is still operative where there is not enough voltage or a VTS condition is declared and the function *HZ Delta Ireact.* is overridden.
- If *HZ DeltaI V Mode* is set to *Disabled, High Z Delta I* function is blocked if there is not enough voltage or a VTS condition is declared.

13.2.4 Sensitivity

DDB signals, *HZDIVSensitCat*, *HZDIVSensitFdr*, *HZDIISensitCat* and *HZDIISensitFdr* indicate when catenary and feeder voltage and current levels are below the minimum set threshold.

13.2.5 High Z Delta I harmonic supervision

Harmonics are measured to distinguish between current changes due to load alterations and high impedance faults. The levels of 3rd and 5th harmonic are compared to the level of the fundamental current. Current changes due to high impedance faults do not show uneven harmonics. Adjustable thresholds are therefore provided to allow blocking or restraint of the *High Z Delta I* function if the level of 3rd and 5th harmonics are exceeded. The restraint can be achieved by increasing the *HZ Delta I mag*. setting. For this purpose, the *HZ DeltaI HarmRe* setting is available. Once one of the relevant uneven (3rd or 5th) harmonics is above its threshold, the High Z Delta I function uses this threshold instead of *HZ Delta I mag.*

13.2.5.1 Third harmonic

The *HZ DeltI 3rdHarm* setting under the *HIGH Z DELTA I* column has *Disabled/Blocking/Restraint* options. If set to Disabled, the *High Z Delta I* function is not used.

If the *HZ DeltI 3rdHarm setting* is set to *Blocking* or *Restraint* it uses the *I>3rd Harmonic* setting in the SUPERVISION column.

I>3rd Harmonic measures the third harmonic in the current (not Delta I). The setting is a percentage of the 3rd harmonic to the fundamental value.

If the *HZ DeltI 3rdHarm* setting *is set* to *Blocking*, the *High Z Delta I* function is blocked when the respective current has a percentage of harmonics higher than the threshold *I>3rd Harmonic*.

If setting *HZ DeltI 3rdHarm is set* to *Restraint*, the *High Z Delta I* works with the *HZ DeltaI HarmRe* setting when the respective current has a percentage of harmonics higher than the threshold *I>3rd Harmonic*.

Ih(3) Blk Cat and Ih(3) Blk Fdr DDB signals indicate the 3rd harmonic current ratio exceeds threshold on I catenary and I feeder respectively. They do not indicate the *High Z Delta I* function has been blocked by a 3rd harmonic.

13.2.5.2 Fifth harmonic

The *HZ DeltI 5thHarm* setting, under the *HIGH Z DELTA I* column, has *Disabled/Blocking/Restraint options*. If set to Disabled High Z Delta I function is not used.

If *HZ DeltI 5thHarm* is set to *Blocking* or *Restraint* it uses the *I>5th Harmonic* setting in the SUPERVISION column.

I>5th Harmonic will measure the fifth harmonic in the current (not Delta I). The setting is a percentage of the 5th harmonic to the fundamental value.

If the *HZ DeltI 5thHarm* setting is set to *Blocking*, the *High Z Delta I* function is blocked when the respective current has a percentage of harmonics higher than the *I>5th Harmonic* threshold.

If the *HZ DeltI 5thHarm* setting is set to *Restraint*, the *High Z Delta I* shall work with the setting *HZ DeltaI HarmRe* if the respective current has a percentage of harmonics higher than the threshold *I>5th Harmonic*.

Ih(5) Blk Cat and Ih(5) Blk Fdr DDB signals indicate the 5th harmonic current ratio exceeds threshold on I catenary and I feeder respectively. They do not indicate the *High Z Delta I* function has been blocked by a 5th harmonic.

13.3 HZ Delta I Logic

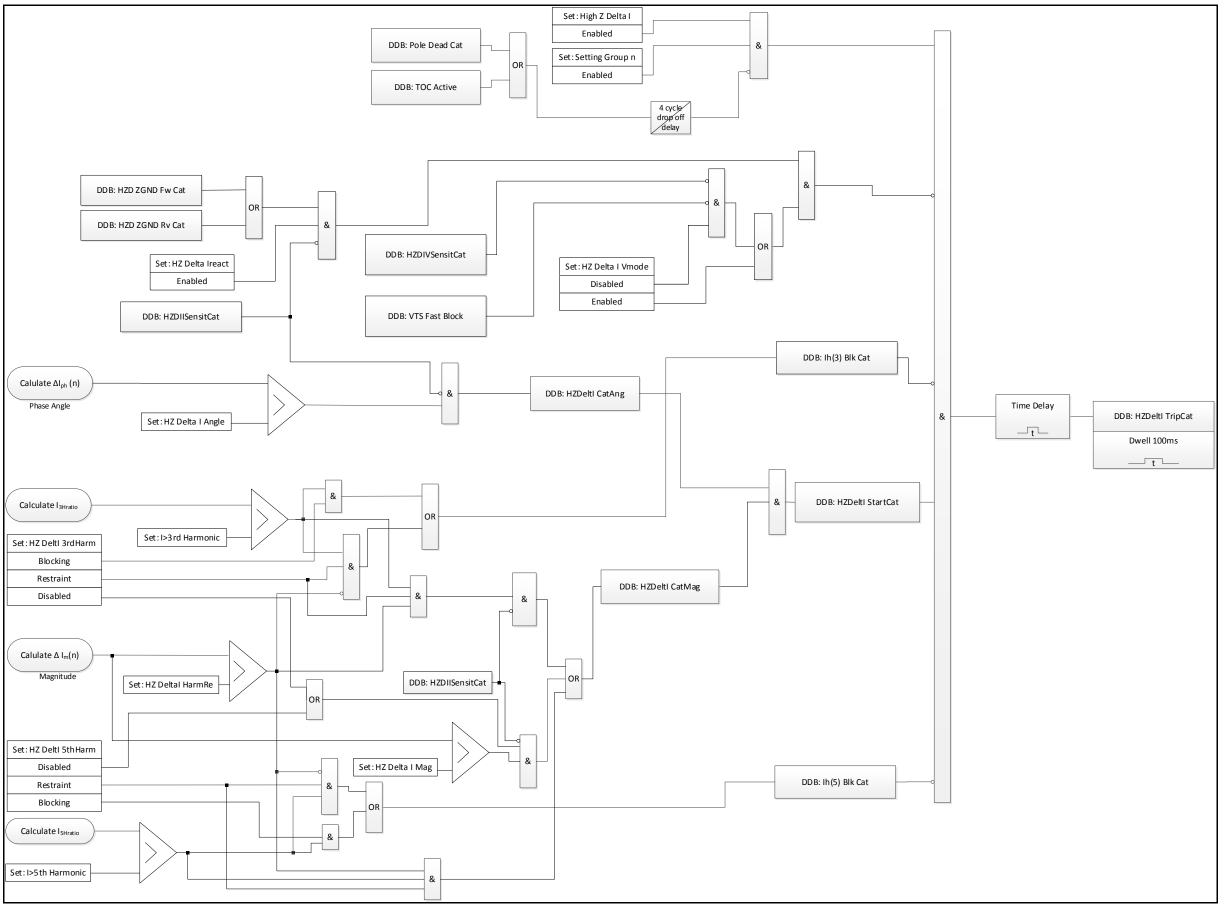


Figure 67: HZ Delta Trip Logic

Notes: *For clarity, only catenary HZ Delta I trip logic is shown. Feeder HZ Delta I trip logic is the same.*

DDB signals, HZDIVSensitCat, HZDIVSensitFdr, HZDIISensitCat and HZDIISensitFdr indicate when catenary and feeder voltage and current levels are <u>below</u> the minimum set threshold.

DDB signals to inhibit 3rd or 5th harmonics, (Ih(3) Blk Cat, Ih(5) Blk Cat, Ih(3) Blk Fdr and Ih(5) Blk Fdr) are only active when HZ DeltI 3rdHarm and HZ DeltI 5thHarm settings are not Disabled.

14 TRAIN STARTUP

In heavy line load conditions, (e.g. high train startup loads or long lines), P44T zones 2 and or 3 may pickup and incorrectly trip the line. To avoid this problem, the train startup feature is used to detect these conditions and change the zone 2 and/or zone 3 timers to a longer interval. On the other hand, when a fault occurs, the relay should switch the zone 2 and/or zone 3 timers to a lesser value to issue a fast trip.

14.1 Train Startup principle

The algorithm used on Train Startup function is similar to the Delta Direction function, as follows:

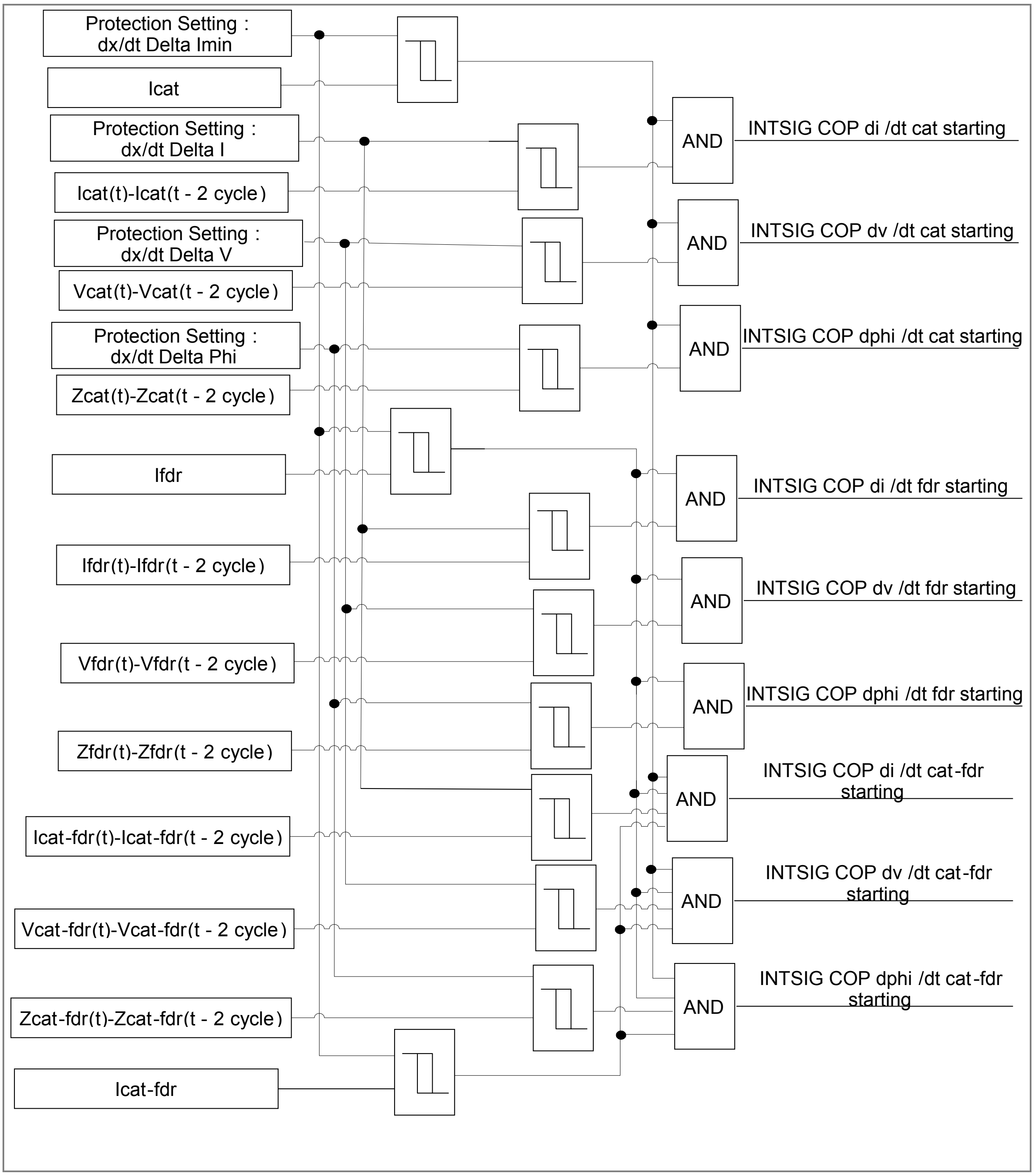


Figure 68: P44T Delta dx/dt algorithm logic

This function was implemented using a combination of rate of change of current, voltage and phase angles (**X** can be Icat, Ifdr/Icat-fdr/Vcat/Vfdr/Vcat-fdr and angle of Vcat/Icat, Vfdr/Ifdr, Vcat-fdr/Icat-fdr).

- dx/dt

The rate of change was fixed at 2 cycles period when no fault is present, but it will keep the pre-fault value after fault occurs including when TOC is active.

The three train start-up detection stages (di/dt, dv/dt and dphi/dt) can be enabled separately and in addition, these conditions can be individually set for Zone 2 and 3.

The train start-up detection stages are ready if the following conditions are met:

- Distance protection is enabled
- The Zone 2 and/or zone 3 are set to operate with Train Startup detection stages
- The operate value of the respective Train Startup detection stages (di/dt, dv/dt or dphi/dt) is not set to block

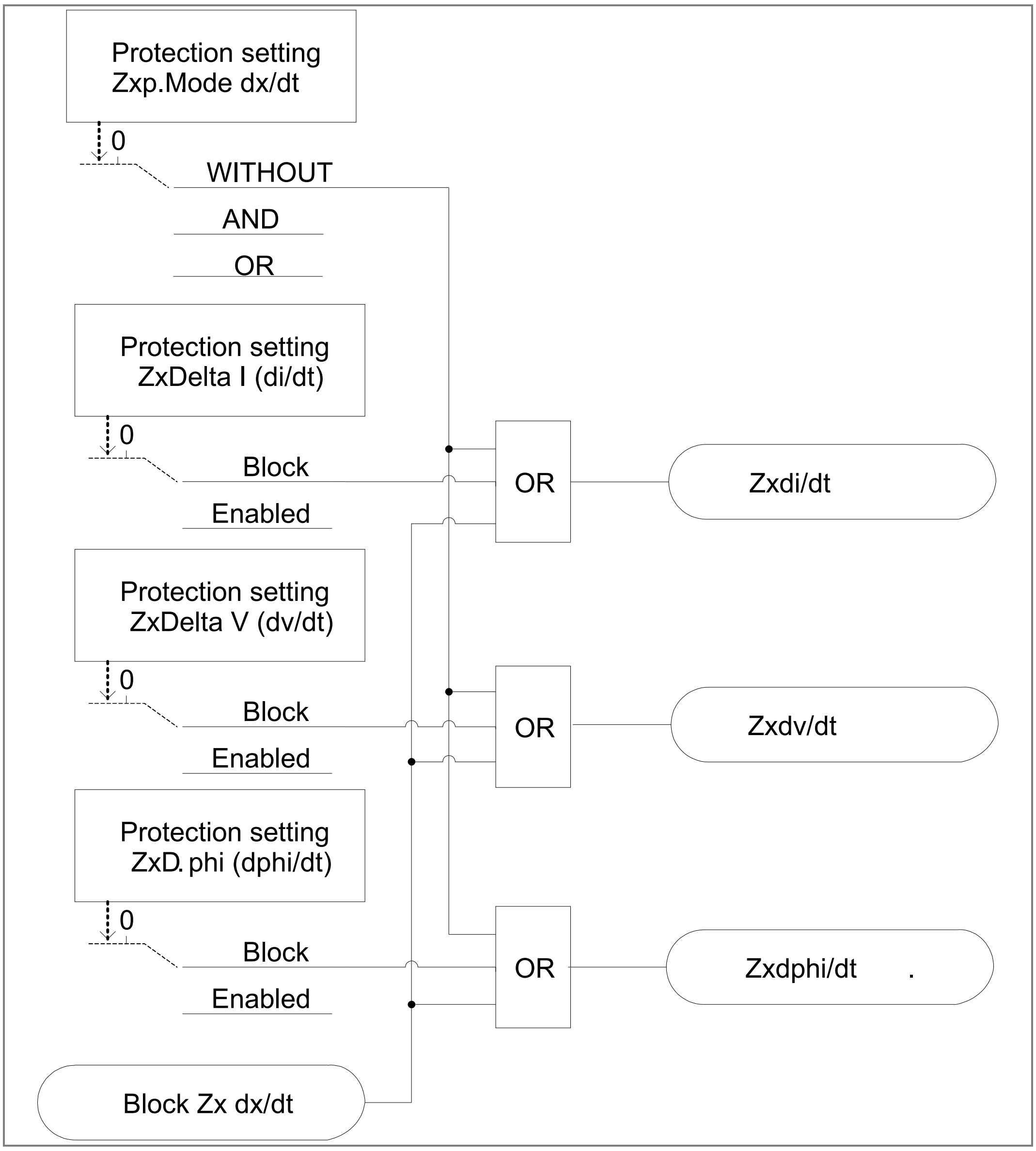


Figure 69: P44T condition for Z2 or z3 Train startup detection stages

Note: Zx means Z2 or Z3.

P44T can select by setting whether all three criteria (AND operation) or just one criteria (OR operation) must be met for a short-circuit detection.

If not all the criteria are used, the P44T will set outputs of the blocked stages according to the operation selected such that a switch between overload and short-circuit mode can be effected by the remaining stages, as required,

- If all three delta criteria are set to Blocked, short time-delays **tZ2S, tZ3S** are always used regardless of the operation criteria (**WITHOUT, OR and AND**)
- If a short-circuit is detected, short time-delays **tZ2S, tZ3S** are used
- If an overload is detected, long time-delays **tZ2L, tZ3L** are used, and the timer start again from zero
- If no dx/dt stage is enabled, time delays **tZ2S,tZ3S** are always used
- The dx/dt decisions remain stored for the duration of the relative distance protection start, the **Cat** will start work only with **single Cat fault**; and the **Feeder** will start work with **single Feeder fault** and both the **Cat** and **Feeder** will start work only with **phase Cat-Fdr fault**

A short circuit is detected if the following conditions are met during a sampling interval:

- The current rises by more than the set Delta I
  AND/OR
- The voltage falls by more than the set Delta V
  AND/OR
- The angle changes by more than the set Delta phi
- The current has exceeded the Inom threshold.

For more details see the following three figures:

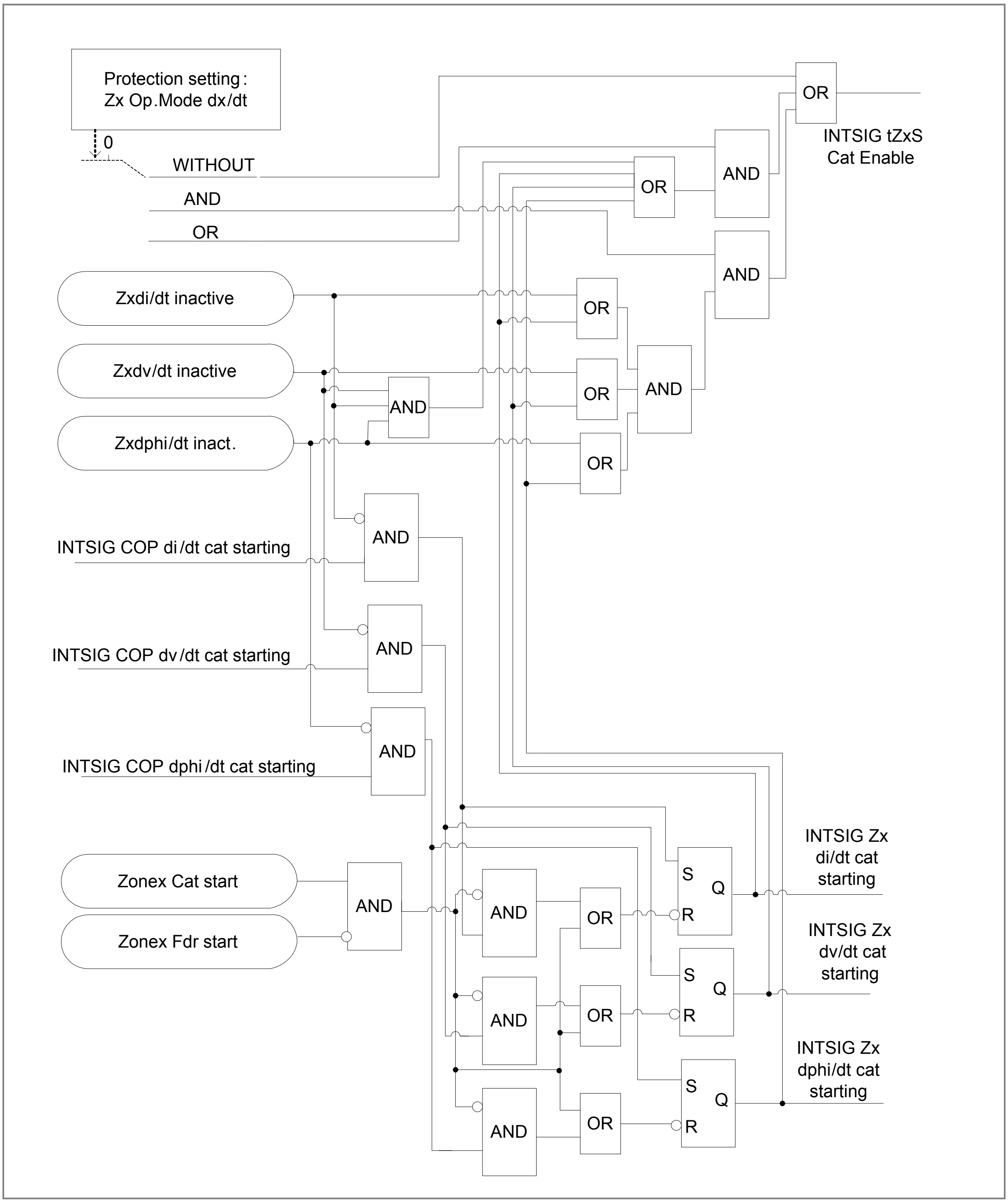


Figure 70: P44T Delta dx/dt algorithm logic for Cat

Note:	*Zx means Z2 or Z3.*

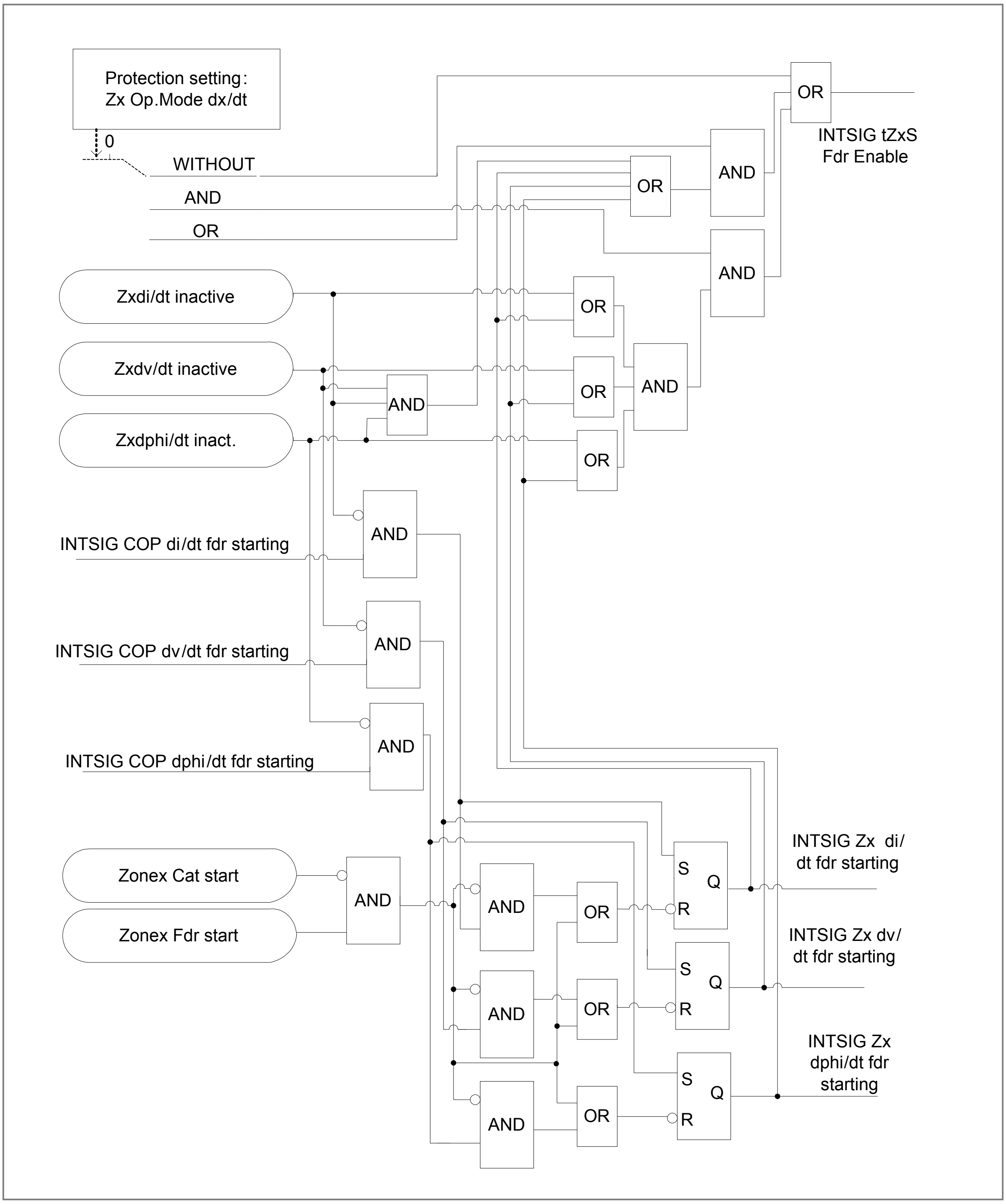


Figure 71: P44T Delta dx/dt algorithm logic for Fdr

Note:	*Zx means Z2 or Z3.*

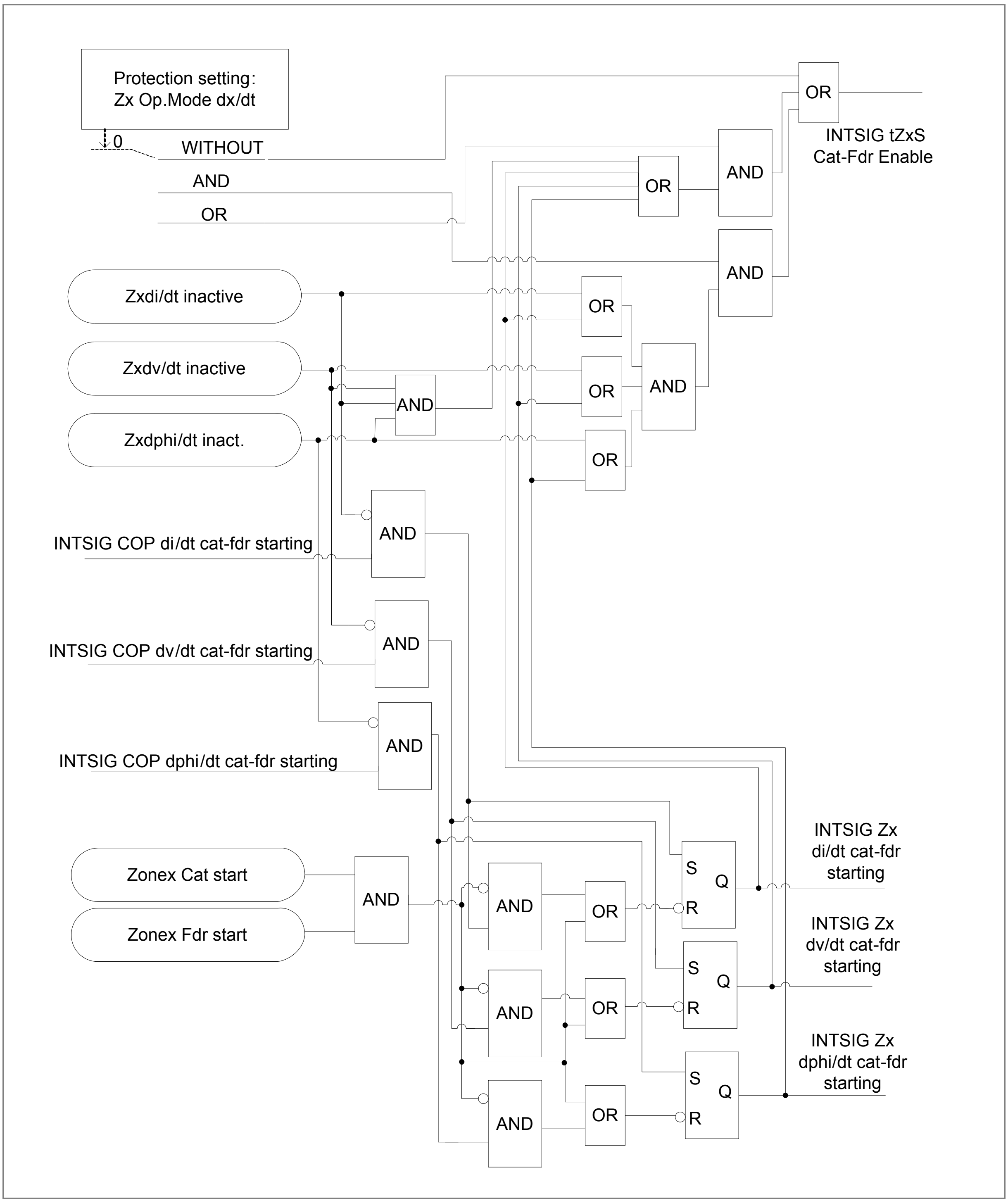


Figure 72: P44T Delta dx/dt algorithm logic for Cat-Fdr

Note:	*Zx means Z2 or Z3.*

Always one of the timers (shorter or longer) in use for Zone 2 or 3, when switch, the existing timer will reset and other timer will start from Zero. The DDB's created and associate with the result for Zone 2 and Zone 3, to switch long or short timer, is shown in figures below:

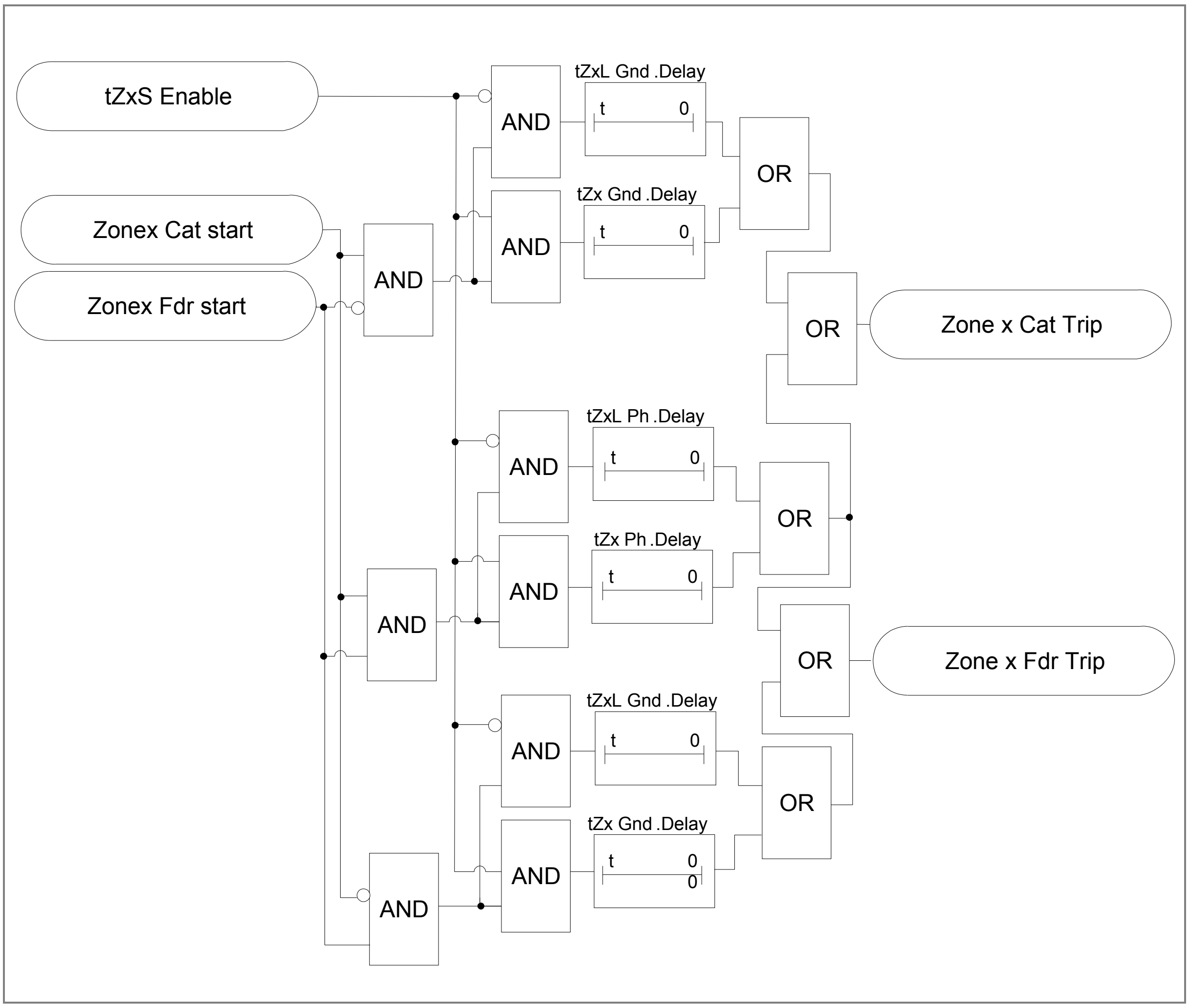


Figure 73: P44T delay timers switch between longer and shorter timer

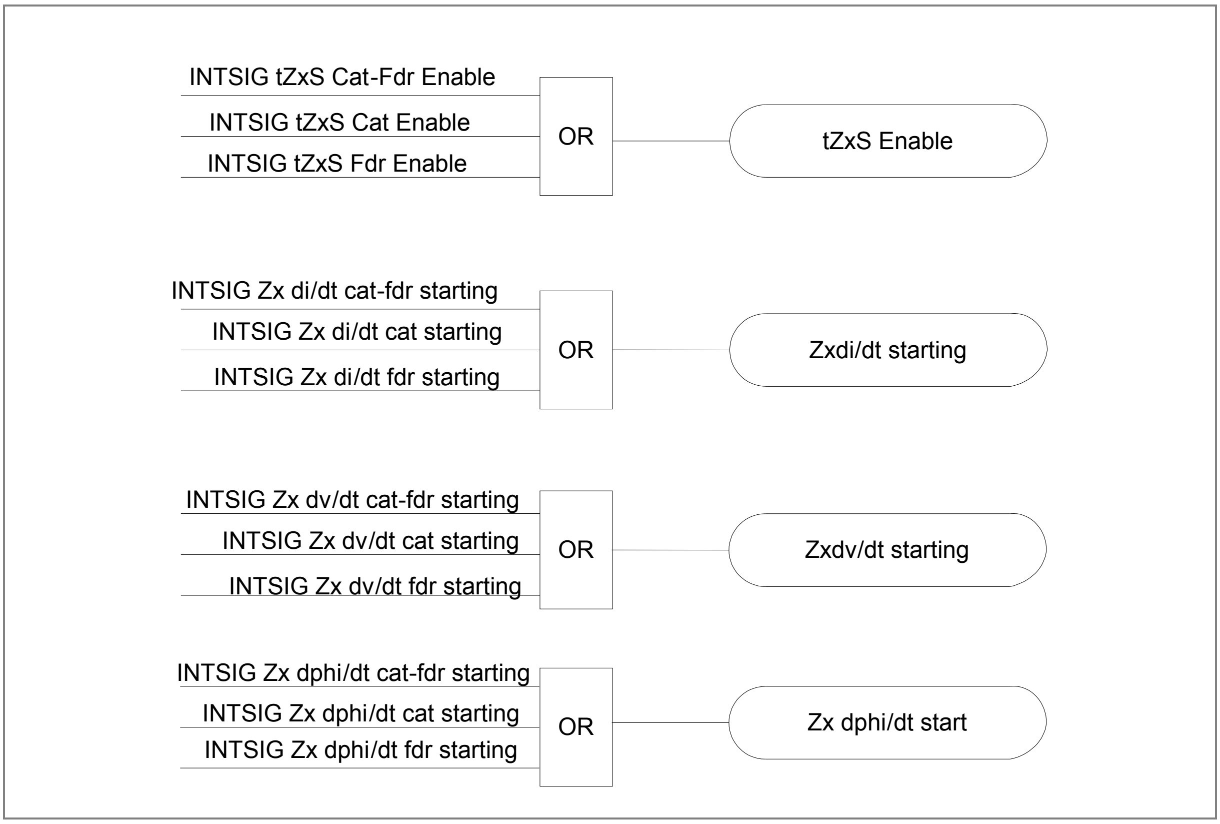


Figure 74: P44T Delta dx/dt release DDB's

Note: *Zx means Z2 or Z3.*

15 CIRCUIT BREAKER FAIL AND POLE DEAD DETECTION FUNCTION

15.1 Circuit breaker fail protection (CBF)

The circuit breaker failure protection incorporates two timers, **CB Fail 1 Timer** and **CB Fail 2 Timer**, allowing configuration for the following situations:

- Simple CBF, where only **CB Fail 1 Timer** is enabled. For any protection trip, the CB Fail 1 Timer is started, and normally reset when the circuit breaker opens to isolate the fault. If breaker opening is not detected, CB Fail 1 Timer times out and closes an output contact assigned to breaker fail (using the programmable scheme logic). This contact is used to backtrip upstream switchgear, generally tripping all infeeds connected to the same busbar section.
- A retripping scheme, plus delayed backtripping. **CB Fail 1 Timer** is used to route a trip to a second trip circuit of the same circuit breaker. This requires duplicated circuit breaker trip coils and is known as retripping. If retripping fails to open the circuit breaker, a backtrip may be issued following an additional time delay. The backtrip uses **CB Fail 2 Timer**, which is also started at the instant of the initial protection element trip.

CBF elements **CB Fail 1 Timer** and **CB Fail 2 Timer** can be configured to operate for trips triggered by protection elements in the IED or using an external protection trip. The latter is done by allocating one of the IED opto-isolated inputs to **External Trip** using the programmable scheme logic.

All-phase and phase-segregated outputs of CB Fail 1 Timer and CB Fail 2 Timer are in PSL.

15.1.1 Initiation of circuit breaker failure protection

If ‘ExtTrip Only Ini’ setting is ‘Disabled’, CBF protection can be initiated when any internal protection function issues a trip or if an external protection trip occurs. If ‘ExtTrip Only Ini’ setting is ‘Enabled’, then only external protection is allowed to initiate CBF function.

An external protection and internal current-based protections initiate CB Fail function on per-phase basis, while non-current-based protections initiate CB Fail for all phases simultaneously.

15.1.2 Reset mechanisms for breaker fail timers

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

- Where circuit breaker auxiliary contacts are defective, or cannot be relied on to definitely indicate that the breaker has tripped.
- Where a circuit breaker has started to open but has become jammed. This may result in continued arcing at the primary contacts, with an additional arcing resistance in the fault current path. Should this resistance severely limit fault current, the initiating protection element may reset. Therefore resetting the element may not give a reliable indication that the circuit breaker has opened fully.

For any protection function that needs current to operate, the IED uses operation of undercurrent elements (I<) to detect that the necessary circuit breaker poles have tripped and reset the CB fail timers. However, the undercurrent elements may not be reliable methods of resetting circuit breaker fail in some applications. For example:

- Where non-current operated protection, such as under/overvoltage derives measurements from a line connected voltage transformer. Here, I< only gives a reliable reset method if the protected circuit would always have load current flowing. Detecting drop-off of the initiating protection element might be a more reliable method.
- Similarly, where the distance scheme includes Weak Infeed ("WI") trip logic, the reset of the WI trip condition should be used in addition to the undercurrent check. Set: 'WI Prot Reset' = Enabled.
- Where non-current operated protection, such as under/overvoltage derives measurements from a busbar connected voltage transformer. Again using I< would rely on the feeder normally being loaded. Also, tripping the circuit breaker may not remove the initiating condition from the busbar, and so drop-off of the protection element may not occur. In such cases, the position of the circuit breaker auxiliary contacts may give the best reset method.

Resetting of the CBF is possible from a breaker open indication (from the IED's pole dead logic) or from a protection reset. In these cases resetting is only allowed provided the undercurrent elements have also reset.

If the CBF protection is initiated by an external protection trip, then two resetting options are provided which doesn't necessarily require undercurrent elements (I<) operation: **Prot Reset OR I<** and **ProtRstOrCBOp&I<** (see the table below). These options can be especially useful if re-tripping is not implemented, since they allow avoiding back-tripping due to spurious short-time energization of **External Trip** opto-inputs.

Important Note:

*If **Prot Reset OR I<** or **ProtRstOrCBOp&I<** options is used, **External Trip** inputs MUST NOT be connected to Trip Conversion logic inputs in PSL.*

Initiation	Setting	Value	Resetting mechanism
Current based protection (e.g. 50/51/46/21/67)	-	-	The resetting mechanism is fixed: ['ICat(Fdr) < Fast Undercurrent' elements operate] for all initiated phases
Non-current based protection (e.g. 27/59)	Non I Prot Reset	I< Only	[All 'ICat(Fdr) < Fast Undercurrent' elements operate]
		CB Open & I<	['All Poles Dead' state detected] AND [All 'ICat(Fdr) < Fast Undercurrent' elements operate]
		Prot Reset & I<	[Protection element reset] AND [All 'ICat(Fdr) < Fast Undercurrent' elements operate]

Initiation	Setting	Value	Resetting mechanism
External protection	Ext Prot Reset	I< Only	[‘ICat(Fdr) < Fast Undercurrent’ elements operate] for all initiated phases
		CB Open & I<	[[‘Pole Dead Cat(Fdr)’ is detected] AND [‘ICat(Fdr) < Fast Undercurrent’ elements operate]] for all initiated phases
		Prot Reset & I<	[External protection reset] AND [‘ICat(Fdr) < Fast Undercurrent’ elements operate for all initiated phases]
		Prot Reset OR I<	[External protection reset] OR [‘ICat(Fdr) < Fast Undercurrent’ elements operate for all initiated phases]
		ProtRstOrCBOp&I<	[External protection reset] OR [[[‘Pole Dead Cat(Fdr)’ is detected] AND [‘ICat(Fdr) < Fast Undercurrent’ elements operate]] for all initiated phases]

Table 17: CB Fail resetting mechanisms

The complete breaker fail logic is shown in the following figures:

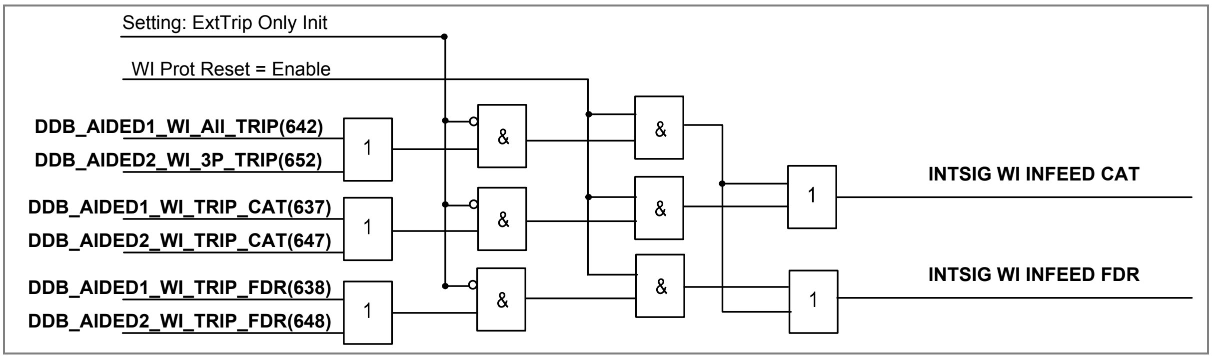


Figure 75: CB failure part 1

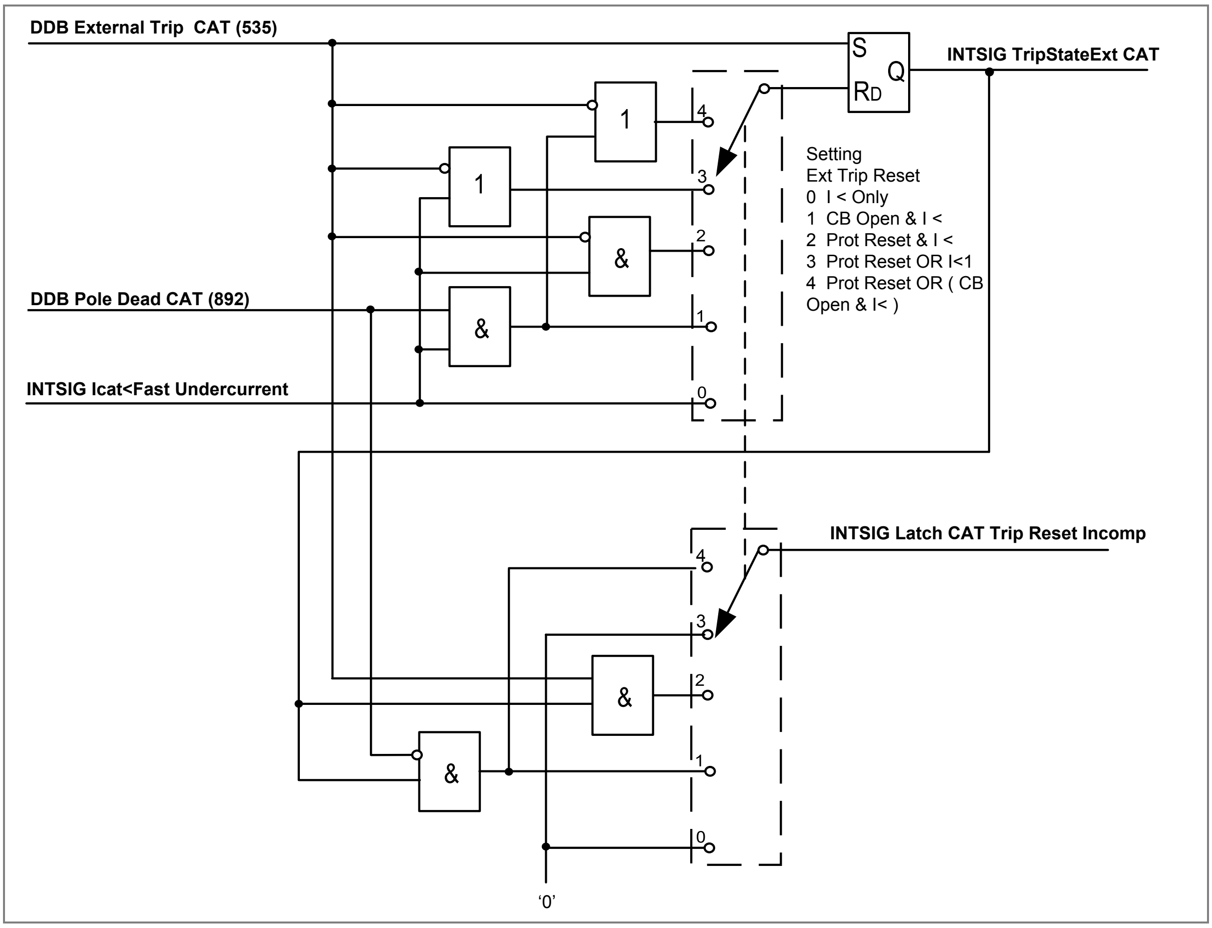


Figure 76: CB failure part 2

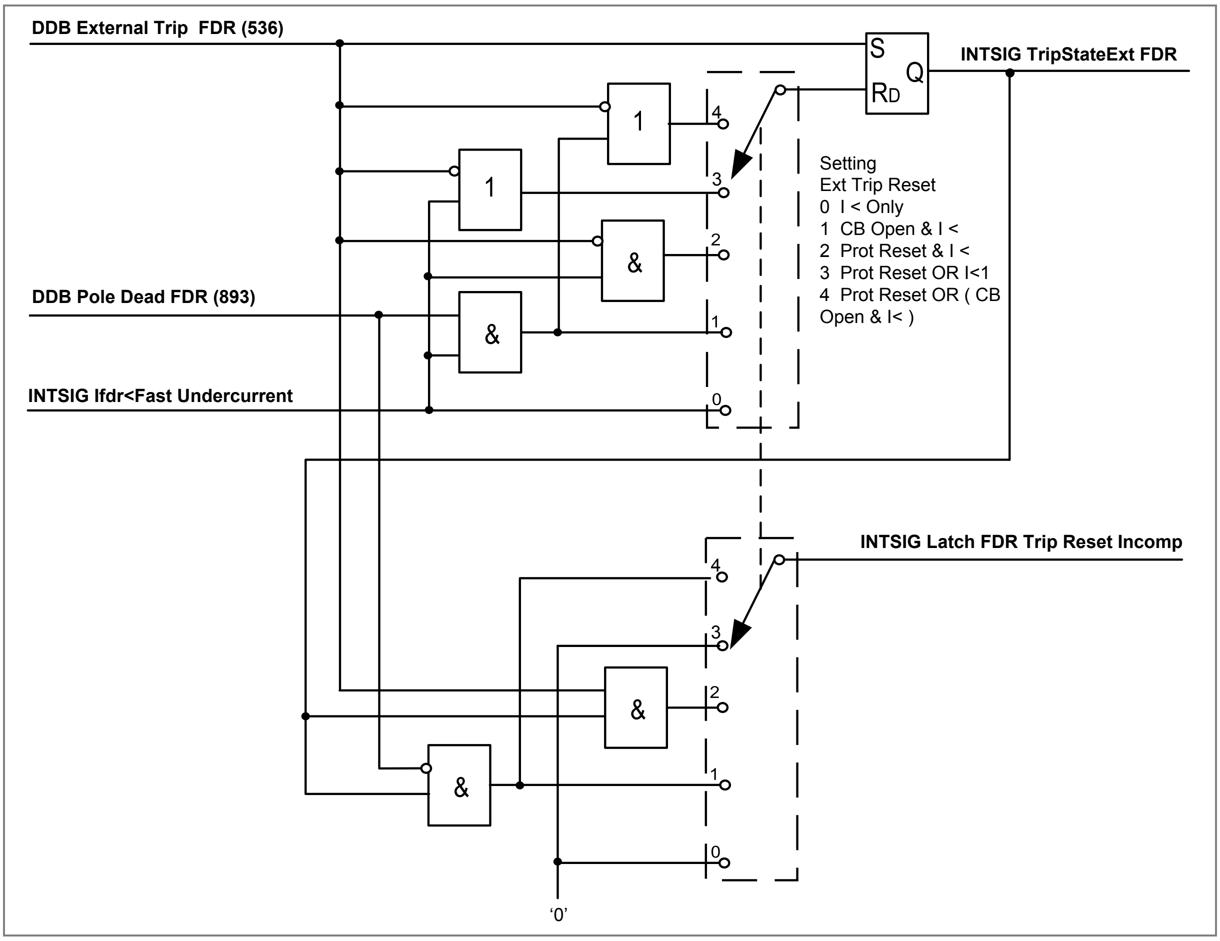


Figure 77: CB failure part 3

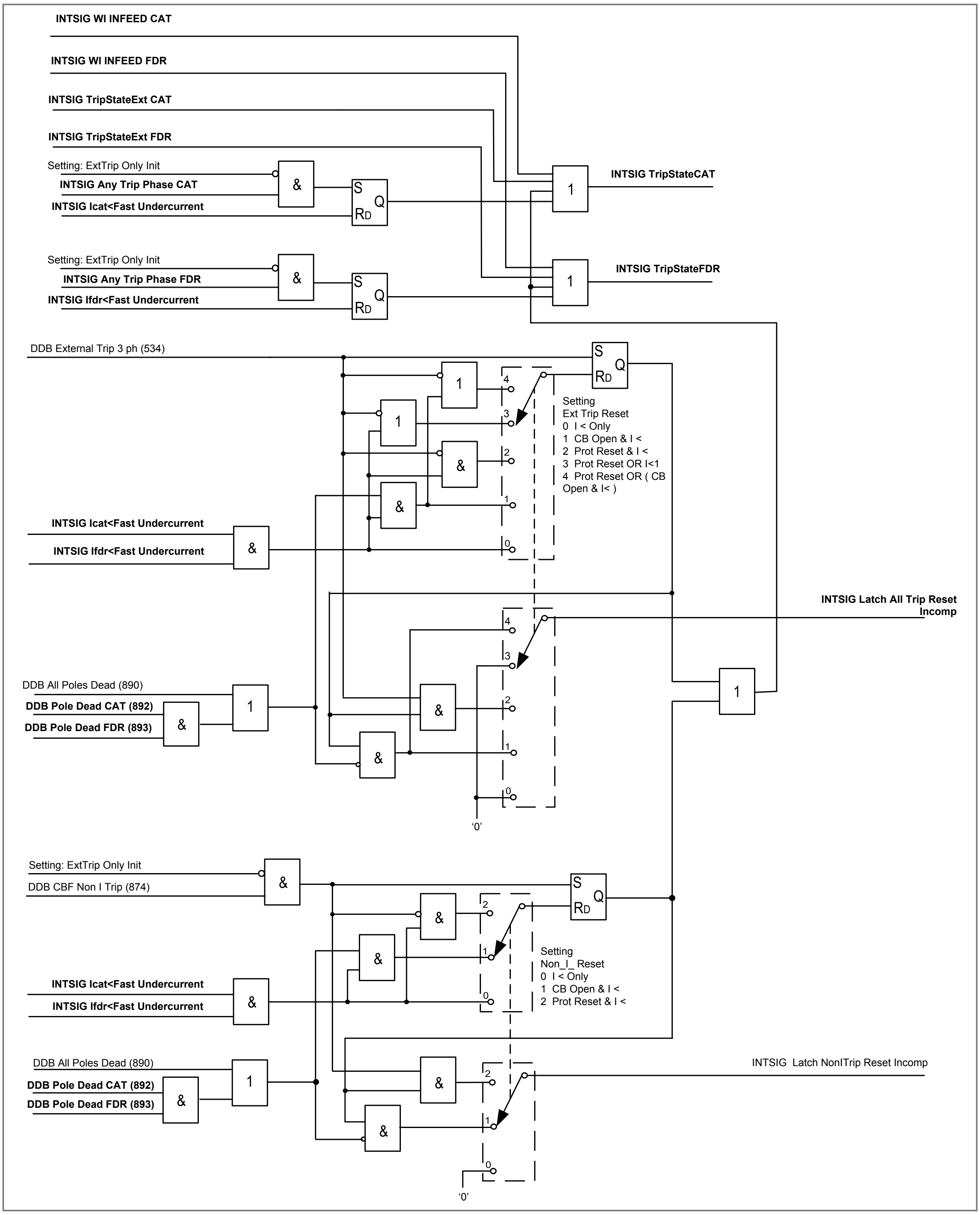


Figure 78: CB failure part 4

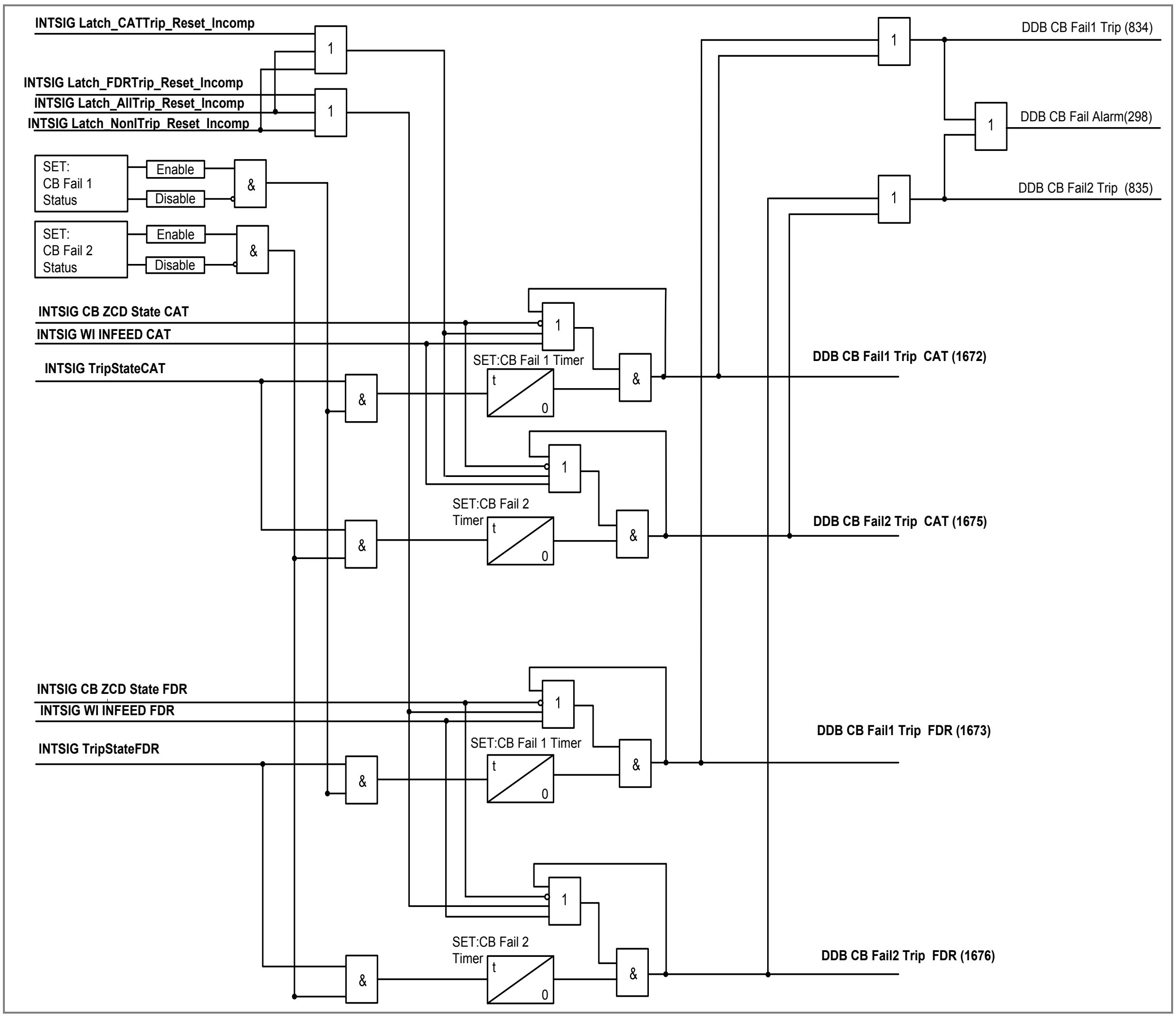


Figure 79: CB failure part 5

15.2 Pole dead logic

The IED uses pole dead logic to determine when the circuit breaker poles are open (pole dead). This logic produces an output when it detects either an open circuit breaker through auxiliary contacts feeding the IED opto inputs or it detects a combination of both undercurrent and undervoltage on any one phase.

This indication can be forced by a status indication from CB auxiliary contacts (52a or 52b), or internally determined by the IED.

The undercurrent detector uses setting (**CB FAIL & I< / UNDER CURRENT / I< Current Set**) and the undervoltage level detector uses setting (**CB FAIL & I< / PoleDead Voltage / V<**). The undervoltage level detector **V<** is set using the pick-up setting, default value 38.1 V. The drop-off is calculated at (43.8 / 38.1) x pick-up setting.

Note:	*If the VT is connected at the busbar side, auxiliary contacts (52a or 52b) must be connected to the IED for a correct pole dead indication.*

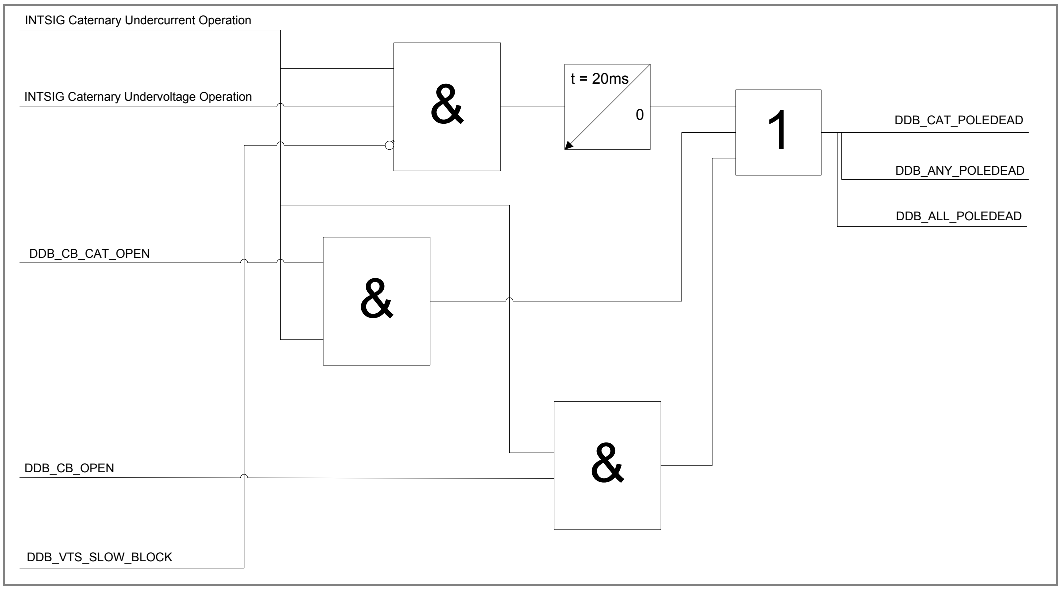


Figure 80: Pole dead logic in Classic Feed Mode

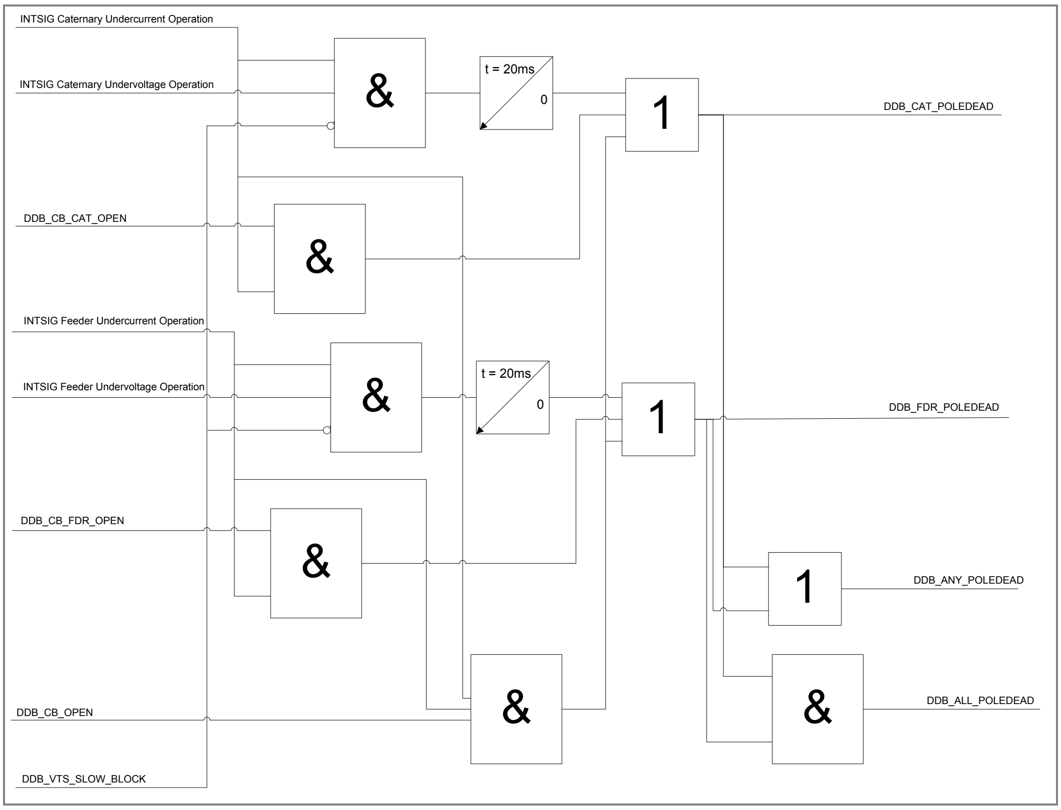


Figure 81: Pole dead logic in Autotransformer Feed Mode

16 SUPERVISION (VTS AND INRUSH DETECTION)

16.1 Voltage transformer supervision - fuse fail

The voltage transformer supervision (VTS) feature is used to detect failure of the ac voltage inputs to the IED. This may be caused by internal voltage transformer faults, overloading, or faults on the interconnecting wiring to IEDs. This usually results in one or more VT fuses blowing. Following a failure of the ac voltage input there would be a misrepresentation of the phase voltages on the power system, as measured by the IED, which may result in maloperation.

The VTS logic in the IED is designed to detect the voltage failure, and automatically adjust the configuration of protection elements whose stability would otherwise be compromised. A time-delayed alarm output is also available.

VTS can be declared by a mini circuit breaker (MCB) status input, by internal logic using IED measurement, or both. The setting **VTS Mode (Measured + MCB /Measured Only/MCB Only)** is used to select the method of declaring VT failure.

For the measured method, there are three main aspects to consider regarding the failure of the VT supply:

- Loss of one phase voltages (for Autotransformer Mode)
- Loss of all phases voltages under load conditions
- Absence of all phases voltages on line energization

16.1.1 Loss of one phase voltages (for Autotransformer Mode)

The VTS feature of the IED operates on detection of one phase voltage lost and another is normal. This gives operation for the loss of one phase voltage.

The VTS Element is blocked by **Any Pole Dead** signal during 1P AR dead time. The resetting of the blocking signal is delayed by 240 ms after Any Pole Dead condition disappears.

The phase voltage level detectors are fixed and drop off at 10 V and pickup at 30 V.

16.1.2 Loss of all phase voltages under load conditions

If all phases voltages to the IED are lost, the logic of one phase lost shall not operate the VTS function. However, under such circumstances, a collapse of the all phases voltages occurs. If this is detected without a corresponding change in any of the phase current signals (which would indicate a fault), a VTS condition is raised. The IED detects the presence of superimposed current signals, which are changes in the current applied to the IED. These signals are generated by comparing the present value of the current with the value from one cycle previously. Under normal load conditions, the value of superimposed current should therefore be zero. Under a fault condition a superimposed current signal is generated which prevents operation of the VTS.

To avoid blocking VTS due to changing load condition, the superimposed current signal can only prevent operation of the VTS during the time window of 40 ms following the voltage collapse.

The phase voltage level detectors are fixed and drop off at 10 V and pickup at 30 V.

The sensitivity of the superimposed current elements is fixed at 0.1 In.

16.1.3 VTS logic

The IED may respond as follows, on operation of any VTS element:

- VTS set to provide alarm indication only;
- Optional blocking of voltage dependent protection elements;
- Optional conversion of directional overcurrent elements to non-directional protection (available when set to Blocking mode only). These settings are in the Function Links cell of the relevant protection element columns in the menu.

The **VTS I> Inhibit** elements are used to override a VTS block if a fault occurs on the system which could trigger the VTS logic. However, once the VTS block is set, subsequent system faults must not override the block. Therefore the VTS block is latched after a user settable time delay **VTS Time Delay**. Once the signal has latched there are two methods of resetting. The first is manually using the front panel interface or remote communications, if the VTS condition has been removed. The second is in Auto mode, by restoring the phases voltages above the phase level detector settings mentioned previously.

VTS Status can be set to **Disabled**, **Blocking** or **Indication**.

A VTS indication is given after the VTS Time Delay has expired. If the VTS is set to indicate only, the IED may maloperate, depending on which protection elements are enabled. In this case the VTS indication is given before the VTS time delay expires, if a trip signal is given.

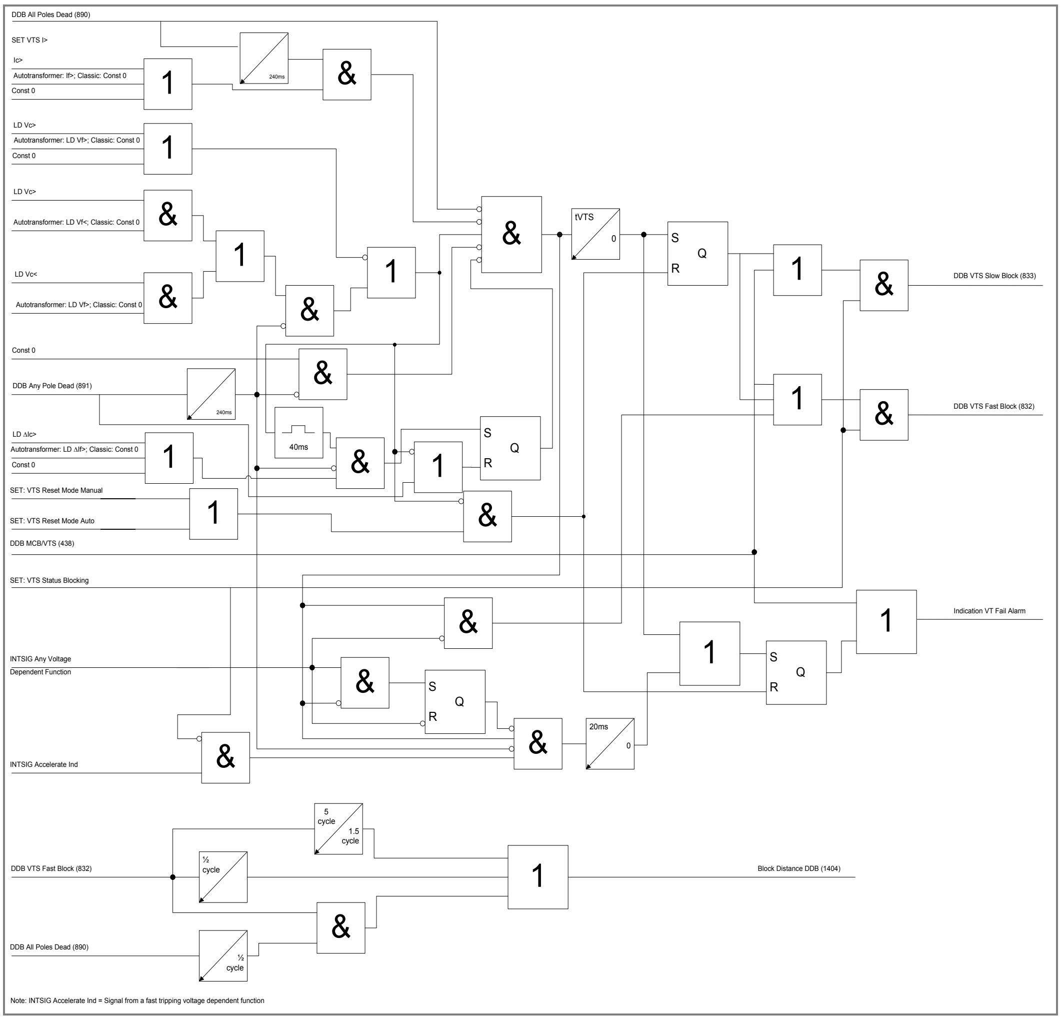


Figure 82: VTS logic

This scheme can also correctly operate under very low load or even no load conditions, by the combination of time delayed signals derived from the DDB signals VTS Fast block and all Poles Dead, to generate the Block Distance DDB.

> *Note: All non-distance voltage-dependent elements are blocked by the "VTS Fast Block" DDB.*

If a miniature circuit breaker (MCB) is used to protect the voltage transformer ac output circuits, MCB auxiliary contacts can be used to indicate a three phase output disconnection. As previously described, it is possible for the VTS logic to operate correctly without this input. However, this facility has been provided for compatibility with the current practices of various utilities. Energizing an opto-isolated input assigned to DDB: MCB/VTS on the IED therefore providess the necessary block.

16.2 Transformer magnetizing inrush detector

P44T has been designed as a fast distance protection IED. Distance zones should therefore not be slowed by forcing them to wait for detection or no detection of transformer inrush current (in general applications). For this reason, the IED has no second harmonic blocking of the distance elements in the standard protection algorithms.

However, if using a long Zone 1 reach through a transformer, harmonic blocking for magnetizing inrush current can be implemented. If Inrush Detection is Enabled, the output of the I(2)/I(1) detectors can be picked up in the Programmable Scheme Logic. Blocking functions can then be assigned in the PSL as necessary because this detector does not route directly into the IED's fixed logic.

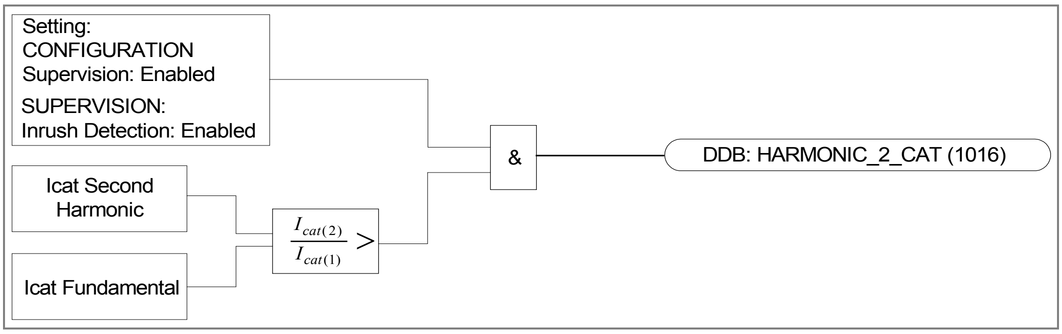


Figure 83: Inrush Detection Logic for P44T in Classic Operation Mode

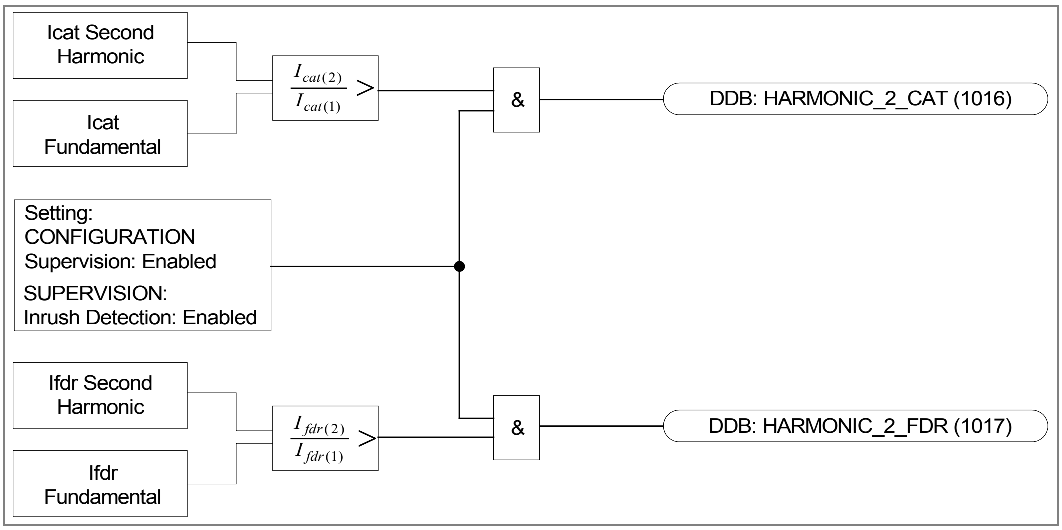


Figure 84: Inrush Detection Logic for P44T in Autotransformer Operation Mode

When using Inrush blocking, we recommend including a delay in the blocking of the time delayed zones, shown in Figure 85 below. This delay will avoid continuous resetting of distance zones (programmed to be blocked in the PSL), due to changing conditions such as evolving faults, which can generate second harmonics. The figure below shows blocking of zones 1, 2 and 3 based on the assumption that zone 1 is set to be instantaneous. Typically, if a zone reaches less than 50% of the transformer impedance, second harmonic blocking is not necessary. The figure below shows blocking for ground distance elements as used in a single phase system. For autotransformer fed systems, both phase and ground distance elements should be block accordingly.

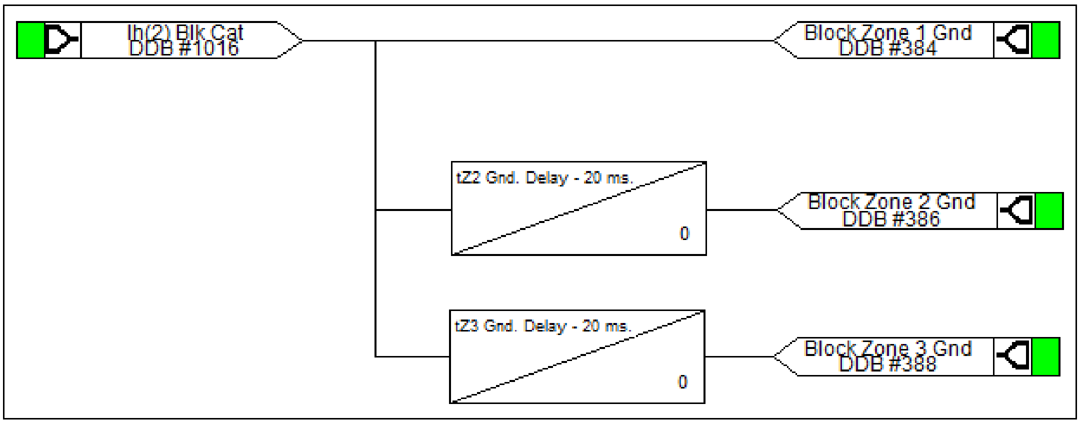


Figure 85: Time delay in Inrush block for ground distance protection

17 SYSTEM CHECKS

17.1 System voltage checks

17.1.1 System checks overview

In some situations it is possible for both “bus” and “line” sides of a circuit breaker to be live when the circuit breaker is open, for example at the ends of a feeder which has a power source at each end. Therefore, when closing the circuit breaker, it is normally necessary to check that the network conditions on both sides are suitable, before giving a “CB Close” command. This applies to both manual circuit breaker closing and auto-reclosure. If a circuit breaker is closed when the line and bus voltages are both live, with a large phase angle, frequency or magnitude difference between them, the system could be subjected to an unacceptable shock, resulting in loss of stability, and possible damage to connected machines.

System checks involve monitoring the voltages on both sides of a circuit breaker, and, if both sides are live, performing a synchronism check to determine whether the phase angle, frequency and voltage magnitude differences between the voltage vectors, are within permitted limits.

The pre-closing system conditions for a given circuit breaker depend on the system configuration and, for auto-reclosing, on the selected auto-reclose program. For example, on a feeder with delayed auto-reclosing, the circuit breakers at the two line ends are normally arranged to close at different times. The first line end to close usually has a live bus and a dead line immediately before reclosing, and charges the line (dead line charge) when the circuit breaker closes. The second line end circuit breaker sees live bus and live line after the first circuit breaker has re-closed. If there is a parallel connection between the ends of the tripped feeder, they are unlikely to go out of synchronism, i.e. the frequencies will be the same, but the increased impedance could cause the phase angle between the two voltages to increase. Therefore the second circuit breaker to close might need a synchronism check, to ensure that the phase angle has not increased to a level that would cause unacceptable shock to the system when the circuit breaker closes.

If there are no parallel interconnections between the ends of the tripped feeder, the two systems could lose synchronism, and the frequency at one end could “slip” relative to the other end. In this situation, the second line end would require a synchronism check comprising both phase angle and slip frequency checks.

If the second line end busbar has no power source other than the feeder that has tripped; the circuit breaker will see a live line and dead bus assuming the first circuit breaker has

re-closed. When the second line end circuit breaker closes the bus will charge from the live line (dead bus charge).

17.1.2 System voltage checks logic diagrams

The system voltage checks logic are shown in AR Figure 59 and AR Figure 60 (logic diagram supplement).

17.1.3 System voltage checks VT selection

The system voltage checks function performs a comparison of the line voltage and the bus voltage.

For a single circuit breaker application, there will be two voltage inputs to compare – one from the voltage transformer (VT) input from the line side of the circuit breaker, and one from the VT on the bus side of the circuit breaker.

In Classic Mode the line VT input will be only one phase but in auto-transformer the line VT input will be 2 phases, whereas the bus VTs will be single phase.

Since the bus VT inputs are normally single phase, the system voltage checks are made on single phases, and since the VT may be connected to either a phase to phase or phase to neutral voltage, then for correct synchronism check operation, the MiCOM P44T has to be programmed with the appropriate connection. The “CS Input” setting in the “CT AND VT RATIOS” can be set to “Cat-N”, “Fdr-N”, “Cat-Fdr”, according to the application.

The system checks logic comprises two modules, one to monitor the voltages, and one to check for synchronism.

The voltage monitor determines the voltage magnitudes, frequencies and relative phase angles of the VT inputs using the same VT inputs as the check sync reference phase voltage setting “CS Input”, The “Live Line”, “Dead Line”, etc., outputs from the voltage monitor are qualified by blocking inputs from the MiCOM P44T, external VT supervision, VT secondary MCB auxiliary switch contacts, and by external inputs mapped in the PSL to DDBs (1522, etc.) to individually inhibit the output DDBs (888, etc.) for each function.

17.1.4 System voltage synchronism checks

Two synchronism check stages are provided to compare the line and bus voltages when closing a circuit breaker.

Synchronism check logic is enabled or disabled per circuit breaker, by settings “System Checks” to “Enable” or “Disable”.

If “System Checks” is set to “Disable”, all other menu settings associated with system checks and synchronism checks for the circuit breaker become invisible, and a DDB (880) signal “SysChks Inactive” is set.

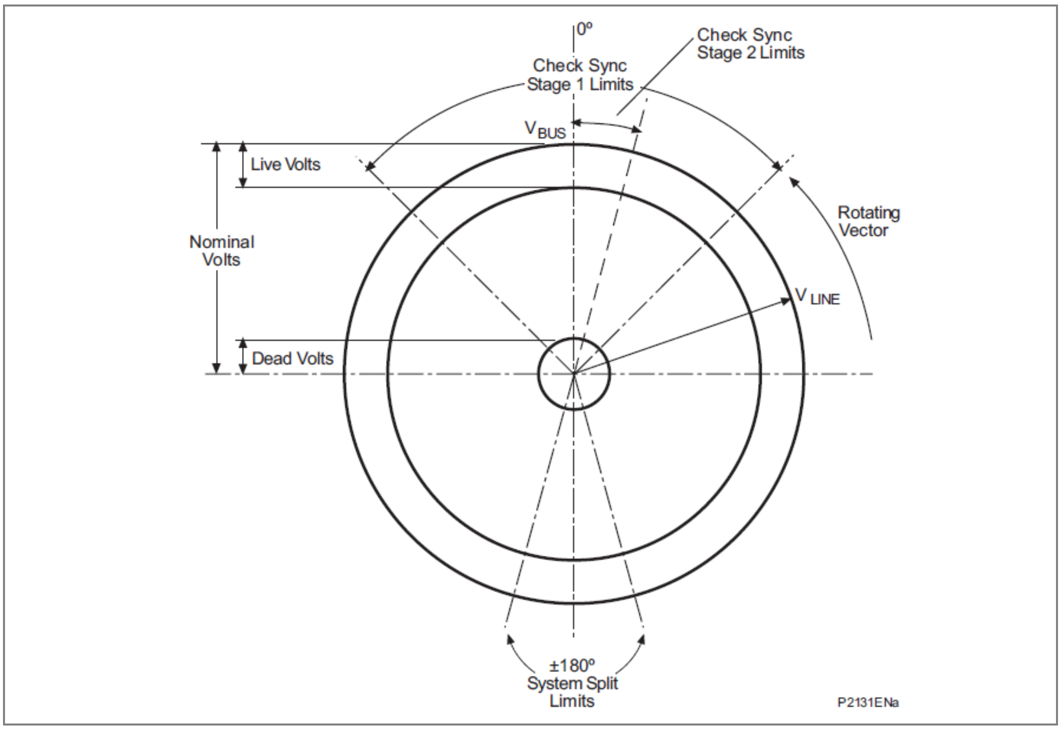


Figure 86: Synchro check functionality

Two stages of system synchronism check supervision are provided. When required, they control the manual closing and/or auto-reclosing of the associated circuit breaker.

The functionality of the second stage is similar to the first stage, but the second stage has an additional “adaptive” setting.

The synchronism check function in MiCOM P44T relays can be set to provide appropriate synchronism check supervision of circuit breaker closing for either synchronous or asynchronous systems.

The overall **Check Sync.** functionality is shown in Figure 85.

Two independently settable synchronism check functions are provided in the MiCOM P44T.

The first check sync element (CS1) is designed to be applied for synchronism check on synchronous systems, whilst the second one (CS2) provides additional features which may be required for synchronism check on asynchronous systems. In situations where it is possible for the voltages on either side of a circuit breaker to be either synchronous or asynchronous depending on plant connections elsewhere on the system, both CS1 and CS2 can be enabled, to provide a permissive close signal if either set of permitted closing conditions is satisfied.

Each synchronism check function, as well as having the basic maximum phase angle difference and slip frequency settings, can also be set to inhibit circuit breaker closing if selected “blocking” conditions such as overvoltage, undervoltage or excessive voltage magnitude difference are detected. In addition, CS2 requires the phase angle difference to be decreasing in magnitude to permit circuit breaker closing, and each has an optional “Adaptive” closing feature to issue the permissive close signal when the predicted phase angle difference immediately prior to the instant of circuit breaker main contacts closing (i.e. after CB Close time) is as close as practicable to zero.

Slip frequency can be defined as the difference between the voltage signals on either side of the circuit breaker, and represents a measure of the rate of change of phase between the two signals.

Having two system synchronism check stages available allows the circuit breaker closing to be enabled under different system conditions (for example, low slip / moderate phase angle, or moderate slip / small phase angle).

When the check synchronism criteria is satisfied, a DDB signal “Check Sync x OK” is set (x = 1 or 2).

For “Check Sync 1 OK” DDB (883) to be set, the following conditions are necessary:

- Settings “System Checks” and “CS1 Status” must **both** be Enabled;
  AND
- “Live Line” and “Live Bus” signals are both set;
  AND
- None of the selected “CS Voltage Block” conditions (V<, V>, VDiff) are true;
  AND
- The measured phase angle magnitude is less than the “CS1 Angle” setting;
  AND
- If “CS1 Slip Ctrl” setting is Enabled, the measured slip frequency between the line VT and Bus1 VT is less than the “CS1 SlipFreq” setting.
- For signal “Check Sync 2 OK” DDB (884) to be set, the following conditions are necessary:
- Settings “System Checks” and “CS2 Status” must both be Enabled;
  AND
- “Live Line” and “Live Bus” signals are both set;
  AND
- None of the selected “CS Voltage Block”” conditions (V<, V>, VDiff) are true;
  AND

- If “CS2 Slip Ctrl” setting is Enabled, the measured slip frequency between the line VT and Bus1 VTs is less than the “CS2 SlipFreq” setting;
AND
- The measured phase angle magnitude is decreasing;
AND
- If the “CS2 Adaptive” setting is Disabled, the measured phase angle magnitude is less than the “CS2 Angle” setting;
OR
If the “CS2 Adaptive” setting is Enabled, AND if the predicted phase angle when CB1 closes (after “CB Cl Time” setting) is less than the “CS2 Angle” setting AND as close as possible to zero AND still decreasing in magnitude.

In most situations where synchronism check is required, the Check Sync. 1 function alone provides the necessary functionality and the Check Sync. 2 signals can be ignored.

17.1.4.1 Slip control by timer

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

$$\frac{2 \times A}{T \times 360} \text{ Hz. for Check Sync. 1, or}$$

$$\frac{A}{T \times 360} \text{ Hz. for Check Sync. 2}$$

A = Phase Angle setting (°)
T = Slip Timer setting (seconds)

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

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

Slip control by Timer is not practical for “**large slip/small phase angle**” applications, because the timer settings required are very small, sometimes < 0.1 s. For these situations, slip control by frequency is recommended.

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

17.1.4.2 Check sync. 2

Check sync. 2 functions are included for situations where the maximum permitted slip frequency and phase angle for synchro check can change according to actual system conditions. A typical application is on a closely interconnected system, where synchronism is normally retained when a given feeder is tripped, but under some circumstances, with parallel interconnections out of service, the feeder ends can drift out of synchronism when the feeder is tripped. Depending on the system and machine characteristics, the conditions for safe circuit breaker closing could be, for example:

Condition 1: For synchronized systems, with zero or very small slip:

Slip ≦50 mHz; phase angle <30°

Condition 2: For unsynchronized systems, with significant slip:

Slip ≦250 mHz; phase angle <10° and decreasing

By enabling both Check Sync. 1, set for condition 1, and Check Sync. 2, set for condition 2, the MiCOM P44T can be configured to allow CB closure if either of the two conditions is detected.

For manual circuit breaker closing with synchro check, some utilities might prefer to arrange the logic to check initially for condition 1 only.

17.1.4.3 Predictive closure of circuit breaker

The “**Freq.+Comp.**” (Frequency + CB Time Compensation) setting modifies the Check Sync. 2 function to take account of the circuit breaker closing time. When set to provide CB Close Time compensation, a predictive approach is used to close the circuit breaker ensuring that closing occurs at close to 0º therefore minimising the impact to the power system. The actual closing angle is subject to the constraints of the existing product architecture, i.e. the protection task runs twice per power system cycle, based on frequency tracking over the frequency range of 40 Hz to 70 Hz.

18 CIRCUIT-BREAKER CONTROL: OPERATIONAL DESCRIPTION

18.1 Introduction

The circuit breaker control and monitoring in the MiCOM P44T provides single phase or all phases switching of a feeder controlled by a single circuit breaker.

This section introduces the operation of the circuit breaker scheme, describes the circuit breaker state monitoring, condition monitoring, and circuit breaker control, and then the circuit breaker auto-reclose operation.

The control of circuit breaker switching sequences represents a complex logic arrangement. The operation is best understood by reference to the design logic diagrams that have been used to implement the functionality. For ease of reference, all these logic diagrams have been put together in a supplementary section "Circuit Breaker Control and
Auto-Reclose Figures (AR figures)" in section 23 of this chapter. Any figures that are not explicitly presented in this chapter will be found in the AR figures section and will be clearly indicated.

> ***Note:*** *In the MiCOM P44T, the breaker is referred to as "CB1" in some figures and internal signal listings.* ***Equivalent settings, etc., featured in the*** *MiCOM P44T* ***are generally referred to as "CB".*** *In any figures that show CB2 functionality as well as CB1, the CB2 functionality can be ignored.*

The inputs and outputs of the logic described are, in many cases, DDB signals that are available to the programmable scheme logic (PSL). A description of these signals can be found in the Programmable Logic chapter of this manual. Other signals are also used to define the operation but are internal to the logic of the circuit breaker control. Unlike the DDB signals, these internal signals cannot be accessed using the programmable scheme logic. They are hard-coded into the application software. A second supplementary section lists these signals and provides a brief description to aid understanding.

18.2 Circuit breaker status

The MiCOM P44T incorporates circuit breaker state monitoring giving an indication of the position of the circuit breaker or, if the state is unknown, an alarm is raised.

The MiCOM P44T can be set to monitor normally open (52A) and normally closed (52B) auxiliary contacts of the circuit breaker. Under healthy conditions, the 52A and 52B contacts should be in opposite states. Should both sets of contacts be open, this would indicate one of the following conditions:

- Auxiliary contacts/wiring defective
- Circuit breaker is defective
- Circuit breaker is in an isolated position

Should both sets of contacts be closed, only one of the following two conditions would apply:

- Auxiliary contacts/wiring defective
- Circuit Breaker is defective

If any of the above conditions exist, an alarm will be issued after time delay as set in “CB Status time” in the CB CONTROL settings column of the menu. A normally open / normally closed output contact can be assigned to this function via the programmable scheme logic (PSL). The time delay is set to avoid unwanted operation during normal switching duties where fleeting abnormal circuit breaker status conditions may exist as the contacts change state.

In the CB CONTROL column of the relay menu there is a setting: “CB Status Input” which can be set at one of the following seven options to control the circuit breaker:

None	
52A	all poles
52B	all poles
52A & 52B	all poles
52A	single pole
52B	single pole
52A & 52B	single pole

If **None** is selected, no circuit breaker status will be available. This will directly affect any function within the relay that requires this signal, for example circuit breaker control, auto-reclose, etc.

Where only **52A** (open when the circuit breaker is open, closed when the circuit breaker is closed) is used then the relay will assume a **52B** signal from the absence of the **52A** signal. Circuit breaker status information will be available in this case but no discrepancy alarm will be available. The above is also true where only a **52B** (closed when the circuit breaker is open, open when the circuit breaker is closed) is used.

If both **52A** and **52B** are used, status information is available and a discrepancy alarm “CB Status Alarm” is issued according to the following table. **52A** and **52B** inputs are assigned to relay opto-isolated inputs using the PSL.

Auxiliary contact position		CB State Detected	Action
52A	52B		
Open	Closed	Breaker Open	Circuit breaker healthy
Closed	Open	Breaker Closed	Circuit breaker healthy
Closed	Closed	CB Failure	Alarm raised if the condition persists for greater than “CB Status time”
Open	Open	State Unknown	Alarm raised if the condition persists for greater than “CB Status time”

Table 18: CB Auxiliary contacts

In the internal logic of the MiCOM P44T, the breaker position used in the algorithm is considered to be open when the **CB State Detected** is **Breaker Open**. In all others cases, the breaker position is considered to be closed. Therefore, during operation of the circuit breaker, if the condition ‘52A=52B=0’ or ‘52A=52B=1’ is encountered, the circuit breaker is considered to be closed.

Where single pole tripping is used, then an open breaker condition will only be given if all phases indicate an open condition. Similarly for a closed breaker condition, indication that all phases are closed must be given. For single pole tripping applications 52A-cat and 52A-fdr and/or 52B-cat and 52B-fdr inputs should be used. The circuit breaker state monitoring logic diagram is shown in AR Figure 1 (logic diagram supplement).

18.3 Circuit breaker condition monitoring

Periodic maintenance of circuit breakers is necessary to ensure that the trip circuit and mechanism operate correctly and also that the interrupting capability has not been compromised due to previous fault interruptions. Generally, such maintenance is based on a fixed time interval or a fixed number of fault current interruptions. These methods of monitoring circuit breaker condition give a rough guide only and can lead to excessive maintenance. The circuit breaker monitoring features of the MiCOM P44T can help with more efficient maintenance regimes.

18.3.1 Circuit breaker condition monitoring features

For each trip operation of the circuit breaker, the relay records statistics as shown in the following table taken from the relay menu. The menu cells shown are counter values only. The Min./Max. values in this case show the range of the counter values. These cells can not be set.

Menu text	Default	Setting		Step size
		Min.	**Max.**	
CB Cat Operations	0	0	10000	1
Displays the total number of A phase trips issued by the IED for the circuit breaker.				
CB Fdr Operations	0	0	10000	1
Displays the total number of B phase trips issued by the IED for the circuit breaker.				
Total ICat Broken	0	0	25000 In^	1
Displays the total fault current interrupted by the IED for the A phase for the circuit breaker.				
Total IFdr Broken	0	0	25000 In^	1
Displays the total fault current interrupted by the IED for the A phase for the circuit breaker.				
CB Operate Time	0	0	0.5 s	0.001
Displays the calculated circuit breaker operating time.				
Reset CB Data	No		Yes, No	
Reset the circuit breaker condition counters.				

Table 19: Relay records statistics

The counters above may be reset to zero for example, following a maintenance inspection and overhaul. The circuit breaker condition monitoring counters will be updated every time the relay issues a trip command. In cases where the breaker is tripped by an external protection device it is also possible to update the circuit breaker condition monitoring data. This is achieved by allocating one of the MiCOM P44T opto-isolated inputs (via the Programmable Scheme Logic) to accept a trigger from an external device. The signal that is mapped to the opto is called ‘External Trip’.

Note: *When in ‘commissioning test mode’ the circuit breaker condition monitoring counters will not be updated.*

The measurement of circuit breaker broken current, operating time and the overall circuit breaker monitoring logic diagram, are shown in Figure 86, Figure 87 and Figure 88.

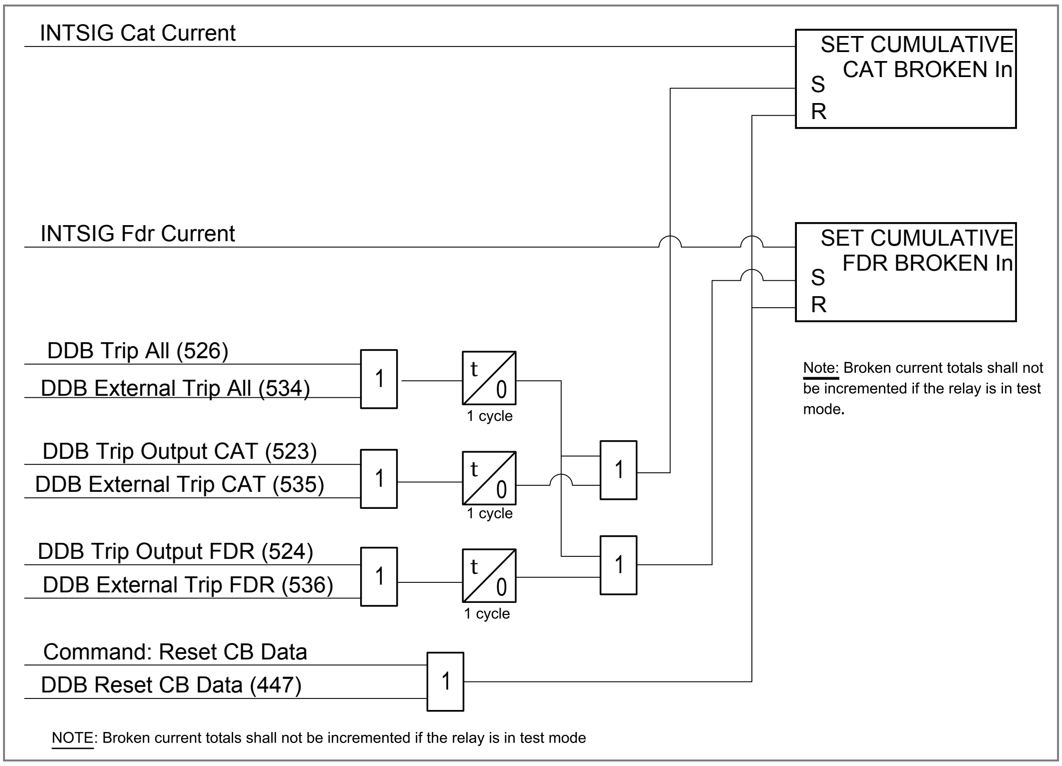


Figure 87: Circuit breaker condition monitoring - broken current

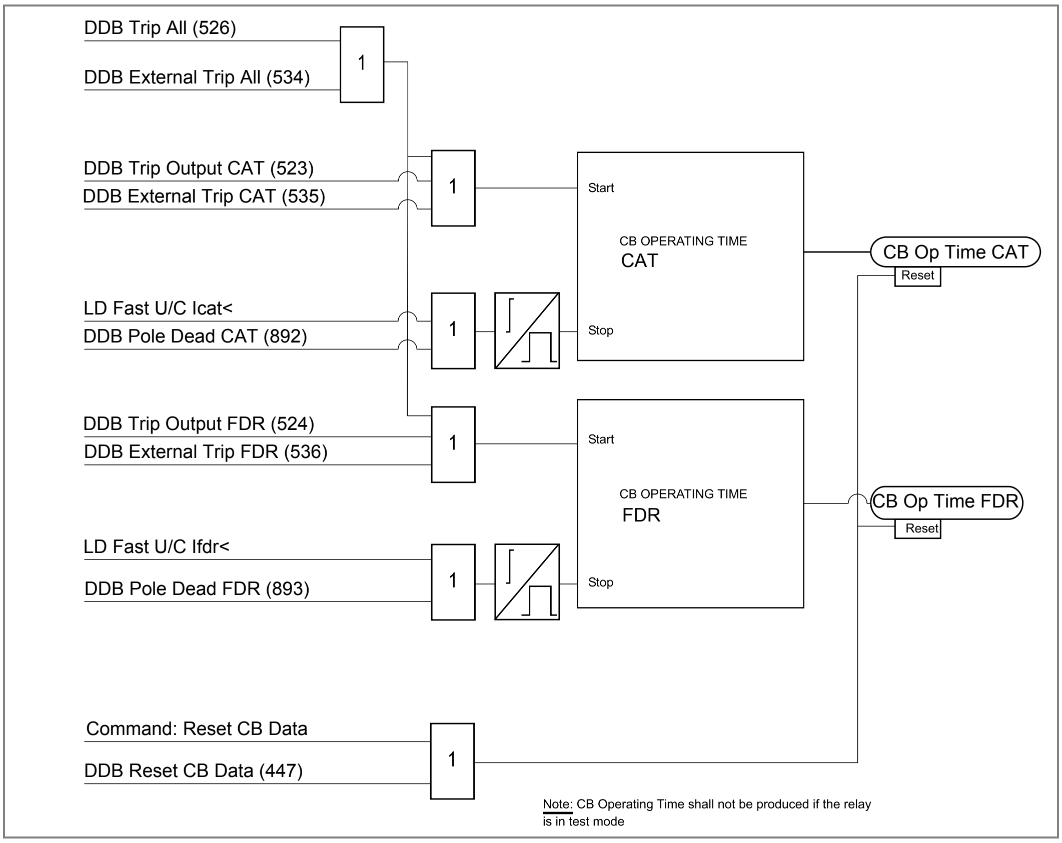


Figure 88: Circuit breaker condition monitoring - operation time

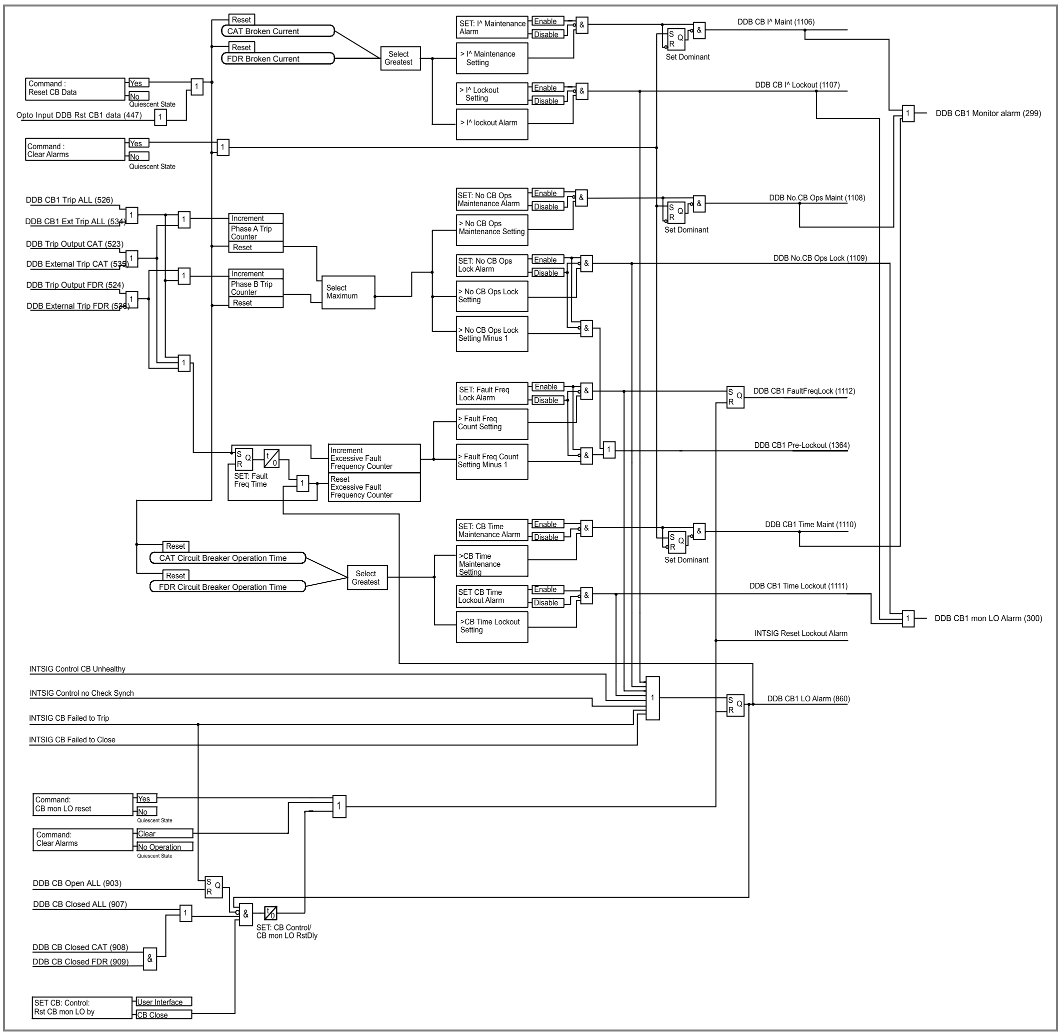


Figure 89: Circuit breaker monitoring

18.4 Circuit breaker control

This functionality shows how a circuit breaker close signal from the auto-reclose logic “AutoClose” is applied alongside operator controlled circuit breaker close and trip control

See AR Figure 43 (logic diagram supplement) for the circuit breaker control functionality.

The MiCOM P44T includes the following options for the control of the circuit breaker:

- Local tripping and closing, via the relay menu or *Hotkeys*
- Local tripping and closing, via relay opto-isolated inputs
- Remote tripping and closing, using the relay communications
- Auto-reclosing via the “Auto Close CB” signal in the Auto Close logic.

It is recommended that separate relay output contacts are allocated for remote circuit breaker control and protection tripping. This enables the control outputs to be selected via a local/remote selector switch as shown in Figure 89. Where this feature is not required the same output contact(s) can be used for both protection and remote tripping.

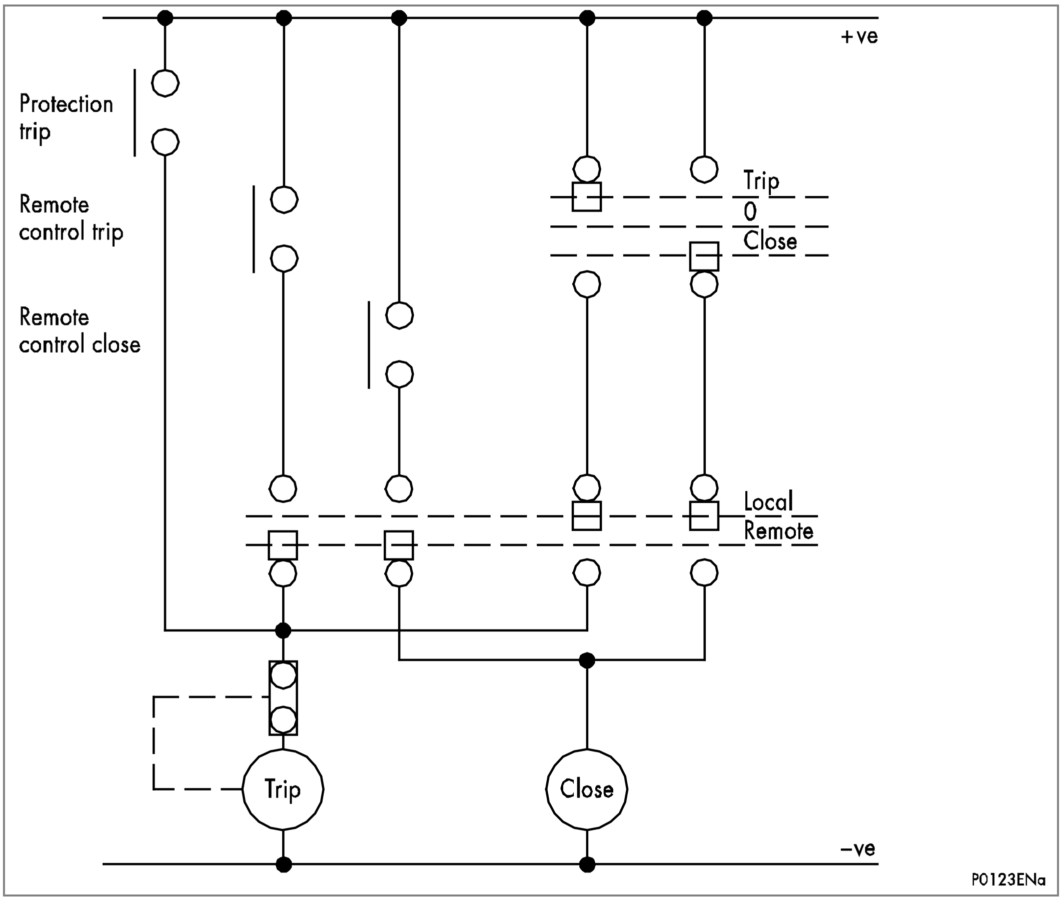


Figure 90: Remote control of circuit breaker

A manual trip will be permitted provided that the circuit breaker is initially closed. Likewise, a close command can only be issued if the circuit breaker is initially open. To confirm these states it will be necessary to use the circuit breaker 52A and/or 52B contacts (the different selection options are given from the “CB Status Input” cell above). If no circuit breaker auxiliary contacts are available then this cell should be set to “None”. Under these circumstances no circuit breaker control (manual or auto) will be possible.

A circuit breaker close command “CB Close” will initiate closing of the circuit breaker. The output contact, however, can be set to operate following a user defined time delay (‘Man Close Delay’). This is designed to give personnel time to retreat from the circuit breaker following the close command. This time delay applies to all manual circuit breaker close commands.

The control close cycle can be cancelled at any time before the output contact operates by any appropriate trip signal, or by activating DDB (443): “Reset Close Delay”.

An “Auto Close CB” signal from the “Auto close” logic bypasses the “Man Close Delay” time, and the “CB Close” output operate immediately to close the circuit breaker.

The length of the trip or close control pulse is set via the “Trip Pulse Time” and “Close Pulse Time” settings respectively. These should be set long enough to ensure the breaker has completed its open or close cycle before the pulse has elapsed.

Note: *The manual trip and close commands are found in the SYSTEM DATA column and the hotkey menu.*

If an attempt to close the circuit breaker is being made and a protection trip signal is generated, the protection trip command overrides the close command.

If the system check synchronism function is set, this can be enabled to supervise manual circuit breaker close commands. A circuit breaker close output will only be issued if the check synchronism criteria are satisfied. A user settable time delay (“Check Sync Time”) is included to supervise manual closure with check synchronizing criteria. If the check synchronism criteria are not satisfied in this time period following a close command the relay will lockout and alarm.

Before manual reclosure, in addition to a synchronism check there is also a circuit breaker healthy check, “CB Healthy”, which requires the circuit breaker to be capable of closing safely (for example, having its closing spring fully charged and/or gas pressure sufficient for a close and immediate fault trip), as indicated by DDB input “CB Healthy”. A user settable time delay “CB Healthy Time” is included for manual closure with this check. If the circuit breaker does not indicate a healthy condition in this time period following a close command (DDB input is still low when the set time has elapsed) then the relay will lockout the relevant circuit breaker and set an alarm. This check can be disabled by not allocating an opto input for DDB “CB Healthy". The signal defaults to high if no logic is mapped to a DDB in the PSL in the IED.

If auto-reclose is used it may be desirable to block its operation when performing a manual close. In general, the majority of faults following a manual closure will be permanent faults and it will be undesirable to allow auto-reclose.

To ensure that auto-reclosing is not initiated for a manual circuit breaker closure on to a pre-existing fault (switch on to fault), the AUTORECLOSE menu setting “CB IS Time” (circuit breaker in service time) should be set for the desired time window. This setting ensures that auto-reclose initiation is inhibited for a period equal to setting “CB IS Time” following a manual circuit breaker closure. If a protection operation occurs during the inhibit period, auto-reclosing is not initiated.

Following manual circuit breaker closure, if either a single phase or a all phase fault occurs during the inhibit period, the circuit breaker is tripped all phase, but auto-reclose is not locked out for this condition.

If the circuit breaker fails to respond to the control command (indicated by no change in the state of the circuit breaker status inputs) a “CB Trip Fail” or “CB Close Fail” alarm will be generated after the relevant “Trip pulse Time” or “Close Pulse Time” has expired. These alarms can be viewed on the relay LCD display, remotely via the relay communications, or can be assigned to operate output contacts for annunciation using the relays programmable scheme logic (PSL).

The “CB Healthy Time” timer and “Check Sync Time” timer described in this menu section are applicable to manual circuit breaker operations only. These settings are duplicated in the auto-reclose menu for auto-reclose applications.

For the description of settings and commands related to the various methods for resetting circuit breaker lockouts, refer to section 18.5.2.4 - Reset CB Lockout.

18.4.1 Circuit breaker control using hotkeys

The hotkeys allow direct access to the manual trip and close commands without the need to use the SYSTEM DATA column of the menu. Red or green color coding can be applied when used in circuit breaker control applications.

If <<TRIP>> or <<CLOSE>> is selected the user is prompted to confirm the execution of the relevant command. If a “trip” is executed, a screen displaying the circuit breaker status will be displayed once the command has been completed. If a “close” is executed a screen with a timing bar will appear while the command is being executed. This screen has the option to cancel or restart the close procedure. The timer used is taken from the manual close delay timer setting in the CB CONTROL menu. If the command has been executed, a screen confirming the present status of the circuit breaker will be displayed. The user is then prompted to select the next appropriate command or to exit - this will return to the default relay screen.

If no keys are pressed for a period of 25 seconds while the MiCOM P44T is waiting for the command confirmation, the MiCOM P44T will revert to showing the circuit breaker status. If no key presses are made for a period of 25 seconds whilst the MiCOM P44T is displaying the circuit breaker status screen, the MiCOM P44T will revert to the default relay screen. Figure 90 shows the hotkey menu associated with circuit breaker control functionality.

To avoid accidental operation of the trip and close functionality, the hotkey circuit breaker control commands are disabled for 10 seconds after exiting the hotkey menu.

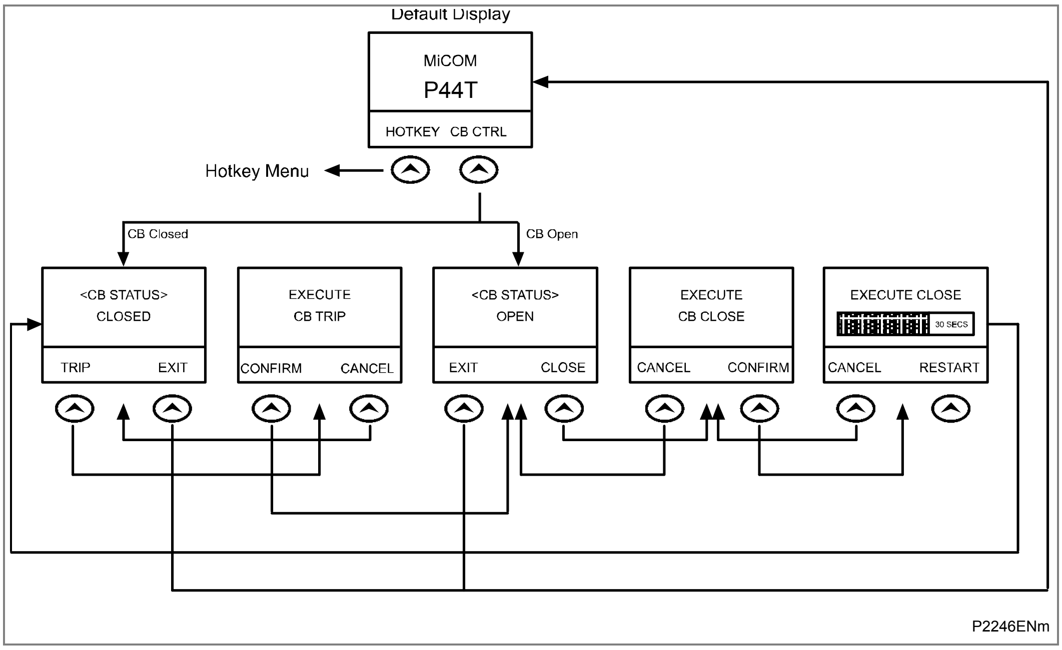


Figure 91: Circuit breaker control hotkey menu

18.4.2 Circuit breaker control using function keys

The function keys allow direct control of the circuit breaker if programmed to do this in the PSL. Local tripping and closing must be set in the CB CONTROL menu “CB control by” cell to one of the via “opto” settings to enable this functionality. All circuit breaker manual control settings and conditions will apply for manual tripping and closing via function keys.

The following default logic can be programmed to activate this feature:

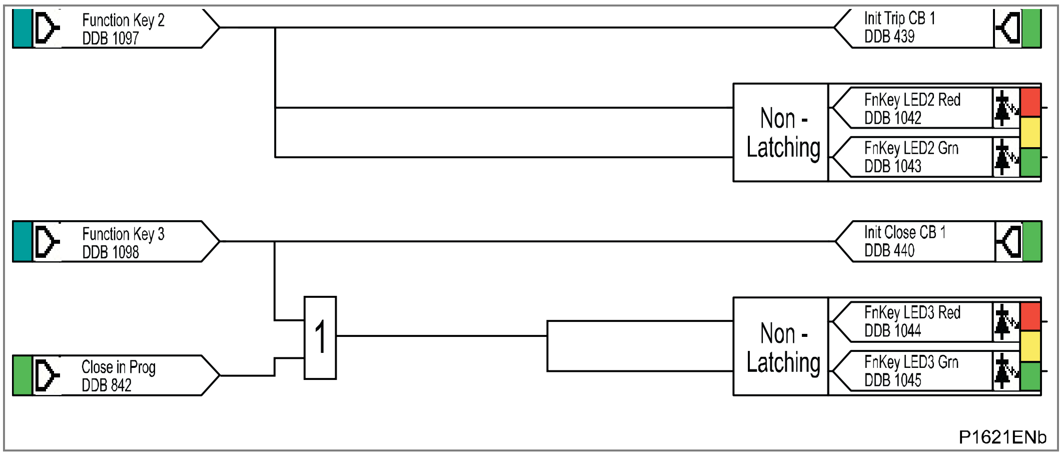


Figure 92: Circuit breaker control using function keys default PSL

Function key 2 and function key 3 are both enabled and set to ‘Normal’ Mode and the associated DDB signals (1097) and (1098) will be active high ‘1’ on a key press.

The following DDB signals must be mapped to the relevant function key:

Init Trip CB (DDB 439) - Initiate manual circuit breaker trip

Init Close CB (DDB 440) - Initiate manual circuit breaker close

The programmable function key LED's have been mapped such that the LED's will indicate yellow whilst the keys are activated.

18.5 Single and All phases auto-reclosing

The auto-reclose scheme in the MiCOM P44T provides single phase or All phases auto-reclosing of a single circuit breaker.

In Classic Mode the AR is ready if other condition are met but in auto-transformer Mode the scheme can be configured by menu settings, by control commands, or by opto inputs to operate in any of the following modes for the first shot (first auto-reclose attempt) by setting the "AR Mode":

- Single phase: "AR 1P"
- All phases: "AR AP"
- Single or All phases: "AR 1/AP"
- Controlled by DDBs signals from opto inputs or commands: "AR Opto"

Single phase reclosing is permitted only for the first shot of an auto-reclose cycle. If two shots are enabled, then in a multi-shot auto-reclose cycle the second and subsequent trips and reclosures will be all phases.

18.5.1 Time delayed and high speed auto-reclosing

MiCOM P44T can be set to initiate auto-reclosure following operation of internal protection trips which occur. In addition, auto-reclose can be initiated from external protection devices.

The auto-reclose function offers multi-shot auto-reclose control, selectable to perform up to a four shot cycle. Dead times (Note 1) for all shots (Note 2) are independently adjustable. Should a circuit breaker close successfully at the end of the dead time, a "Reclaim Time" starts. If the circuit breaker does not trip again, the auto-reclose function resets at the end of the reclaim time. If the protection trips again during the reclaim time the relay advances to the next shot in the programmed cycle, or, if all programmed reclose attempts have been made, the auto-reclose goes to lockout.

> ***Note 1:*** *"Dead Time" denotes the open (dead) interval delay of the CB*
>
> ***Note 2:*** *A "Shot" is a reclosure attempt*

18.5.2 Auto-reclose logic inputs

The auto-reclose function uses inputs in the logic, which can be assigned and activated from any of the opto-isolated inputs on the relay via the programmable scheme logic (PSL). Contacts from external equipment may be used to influence the auto-recloser via the optos, noting that the circuit breaker status (open/closed) must also be available via auxiliary contact inputs to the relay.

These logic inputs can also be assigned and activated from other sources. The function of these inputs is described below, identified by their DDB signal text. The inputs can be selected to accept either a normally open or a normally closed contact, programmable via the PSL editor.

18.5.2.1 CB healthy

The majority of circuit breakers are only capable of providing one trip-close-trip cycle. Following this, it is necessary to re-establish sufficient energy in the circuit breaker (spring charged, gas pressure healthy, etc.) before the circuit breaker can be reclosed.

The DDB “CB Healthy" input is used to ensure that there is sufficient energy available to close and trip the circuit breaker before initiating a “CB Close” command. If on completion of the dead time, the DDB “CB Healthy" input is low, and remains low for a period given by the "CB Healthy Time" timer, lockout will result and the circuit breaker will remain open

This check can be disabled by not allocating an opto input for DDB “CB Healthy". The signal defaults to high if no logic is mapped to DDB within the PSL in the relay

18.5.2.2 Inhibit auto-reclose

An external input can be used to inhibit auto-reclose. The signal is available for mapping via the PSL from an opto input or a communications input.

The signal is “Inhibit AR”, DDB (1420).

Energising the input will cause any auto-switching to be inhibited. Any auto-reclose in progress will be reset and inhibited, but not locked out. It is provided to ensure that auto-switching does not interfere with any manual switching. A typical application would be on a mesh-corner scheme where manual switching is being performed on the mesh, for which any auto-reclose would cause interference.

If a single phase auto-reclose cycle is in progress and a single pole of the circuit breaker is tripped when this signal is raised, a ‘force All phases trip output’, (“AR Force all pole”, DDB (858)) will be set. This is to force the circuit breaker to trip the other phases thereby ensuring that all poles will be in the same state (and avoiding a pole stuck condition) when subsequent closing of the circuit breaker is attempted.

18.5.2.3 Block auto-reclose

External inputs can be used to block auto-reclose. The signal “Block CB AR” DDB (448) is available for mapping via the PSL from an opto input or a communications input. The “Block CB AR” input, if asserted, will block the operation of the auto-reclose cycle and, if auto-reclose is in progress, it will force the circuit breaker to lockout.

Typically it is used where, dependent on the type of protection operation, auto-reclose may, or may not, be required. An example is on a transformer feeder, where auto-reclosing may be initiated from the feeder protection but blocked from the transformer protection. “Block CB AR” can also be used in cases where the auto-reclose cycle is likely to fail for conditions associated with the protected circuit. The input can be used for example if, anywhere during the dead time, a circuit breaker indicates that it is not capable of switching (low gas pressure or loss of vacuum alarm occurs).

18.5.2.4 Reset lockout

The “Reset Lockout” input can be used to reset the auto-reclose function following lockout and reset any auto-reclose alarms, provided that the signals which initiated the lockout have been removed.

The following DDB signal is available for mapping in PSL from opto inputs or communications inputs : DDB (446) “Reset Lockout

18.5.2.5 Pole discrepancy (Only in Auto-transformer application)

Circuit breakers with independent mechanisms for each pole normally incorporate a ‘phases not together’ or ‘pole discrepancy’ protection device which automatically trips all phases if they are not all in the same position i.e. all open or all closed.

During single pole auto-reclosing a pole discrepancy condition is deliberately introduced and the pole discrepancy device must not operate for this condition. This may be achieved by using a delayed action pole discrepancy device with a delay longer than the single pole auto-reclose dead time, “SP AR Dead Time”.

Alternatively, a signal can be given from the IED during the single pole auto-reclose dead time, “AR SPole In Prog”, DDB (845), to inhibit the external pole discrepancy device.

In the relay, the “Pole Discrepancy” input is activated by a signal from an external device indicating that All poles of the CB are not in the same position. The “Pole Discrepancy” inputs DDB (451) forces a all poles trip on the circuit breaker through PSL mapping.

The logic diagram for the pole discrepancy is shown in AR Figure 62 (logic diagram supplement).

18.5.2.6 External trip

The “External Trip APh” input and the “External Trip Cat” and “External Trip Fdr” inputs can be used to initiate All or single phase auto-reclose. Note, these signals are not used to trip the circuit breaker but do initiate auto-reclose. To trip the circuit breaker directly they could be assigned to the trip contacts of the relay in the PSL.

The following DDB signals are available for mapping in PSL from opto inputs to initiate auto-reclosing.

DDB (535): “External Trip Cat”

DDB (536): “External Trip Fdr”

DDB (534): “External Trip APh”

18.5.3 Internal signals

18.5.3.1 Trip initiate signals

The “Trip Inputs Cat” and “Trip Inputs Fdr signals are used to initiate single or all phases auto-reclose. Note, for single phase auto-reclose these signals must be mapped in the PSL as shown in the default.

18.5.3.2 Circuit breaker status

The “CB Open All ph”, “CB Open Cat ph” and “CB Open Fdr ph”, signals are used to indicate if a circuit breaker is open all or single phase. These are driven from the internal pole dead logic and the circuit breaker auxiliary inputs.

The “CB Closed All ph”, “CB Closed Cat ph” and “CB Closed Fdr ph”, signals are used to indicate if a circuit breaker is closed all or single phase. These are driven from the internal pole dead logic and the circuit breaker auxiliary inputs.

18.5.3.3 Check synch ok and system check ok

Internal signals generated from the internal system check function and external system check equipment are used by the internal auto-reclose logic to permit auto-reclosure.

DDB (883) “Check Sync1 OK” & DDB (884) “Check Sync2 OK” are output from the circuit breaker Check Sync logic and indicate conditions for the circuit breaker sync check stage1 & 2 are satisfied.

18.5.4 Auto-reclose logic outputs

The “AR SPole in prog” (DDB 845) output signal indicates that single phase auto-reclose is in progress. The output remains high from protection initiation until lockout, or successful reclosure of the circuit breaker which is indicated by the circuit breaker successful auto-reclose signal,“CB Succ 1P AR” (DDB 1571).

The “AR APole in prog” (DDB 844) output signal indicates that all phases auto-reclose is in progress. The output remains high from protection initiation until lockout, or successful reclosure of the circuit breaker which is indicated by the circuit breaker successful auto-reclose signal, “CB Succ AP AR”.

Any auto-reclose lockout condition will reset all auto-reclose in progress signals associated with the circuit breaker (e.g. “ARIP”).

18.5.5 Auto-reclose logic operating sequence

An auto-reclose cycle can be internally initiated by operation of a protection element, provided the circuit breaker is closed until the instant of protection operation.

The operation of the auto-reclose sequence is controlled by the “Dead Timers”. The user can, via settings, determine what conditions will be used to initiate the dead timers as described in section 18.5.6.7. In general, however, and for the purposes of this description, the dead timers can be considered to start on initiation of the auto-reclose cycle by the protection.

If only single phase auto-reclose “AR SP” is enabled then the logic allows only a single shot auto-reclose. For a single phase fault, the single phase dead timer "SP AR Dead Time" starts, and the single phase auto-reclose in progress signal “CB AR SPole in prog” (DDB 845) is asserted. For a multi-phase fault the logic triggers a all phase trip and goes to lockout.

If only all phases auto-reclose “AR AP” is enabled then, for any fault, the all phases dead timers: "AP AR DT Shot 1”, “AP AR DT Shot 2”, “AP AR DT Shot 3”, “AP AR DT Shot 4", (Dead Time 1, 2, 3, 4) are started and the two phase auto-reclose in progress signal “CB AR APole in prog” (DDB 844) is asserted. The logic forces a two phase trip by setting “AR Force A pole” (DDB 858) for any single phase fault if only two phase auto-reclose “AR AP” is enabled.

If single and all phases auto-reclose “ARS/AP” are enabled then, if the first fault is a single phase fault the single phase dead time "SP AR Dead Time" is started (only in auto-transformer application) and the single phase auto-reclose in progress signal “AR SPole in prog” (DDB 845) is asserted. If the first fault is a multi-phase fault the all phases dead timer "AP AR DT Shot 1" is started (in classic mode all faults starts the all phases dead time "AP AR DT Shot 1") and the all phase auto-reclose in progress signal “AR APole in prog” (DDB 844) is asserted. If the relay has been set to allow more than one reclose (“AR Shots >1”) then any subsequent faults will be converted to all phases trips by setting the signal “AR Force A pole” (DDB 858). The 2 phases dead times "AP AR DT Shot 2”, “AP AR DT Shot 3” and “AP AR DT Shot 4" (Dead Times 2, 3, 4) will be started for the 2nd, 3rd and 4th trips (shots) respectively. The all phases auto-reclose in progress signal “AR APole in prog” (DDB 844) will be asserted. If a single phase fault evolves to a multi-phase fault during the single phase dead time (“SP AR Dead Time”) then single phase auto-reclose is stopped (only use in auto-transformer mode). The single phase auto-reclose in progress signal “AR SPole in prog” (DDB 845) is reset, the all phases auto-reclose in progress signal “AR APole in prog” (DDB 844) is set, and the all phases dead timer “AP AR DT Shot 1” is started.

At the end of the relevant dead time, provided system conditions are suitable, a circuit breaker close signal is given. The system conditions to be met for closing are that the system voltages are in synchronism or that the dead line/live bus or live line/dead bus conditions exist, indicated by the internal system check synchronizing element, and that the circuit breaker closing spring, or other energy source, is fully charged as indicated by the “CB Healthy” input. The circuit breaker close signal is cut-off when the circuit breaker closes.

For single phase auto-reclose no voltage or synchronism check is required as synchronizing power is flowing in the other healthy phase.

For all phases auto-reclosing, for the first shot only, auto-reclose can be performed without checking that the voltages are in synchronism by means of a setting. This setting, “CB SC Shot 1”, can be set to “Enabled” to perform synch-checks on shot 1, or “Disabled” to not perform the checks.

When the circuit breaker has closed, the “Set CB Close” (DDB 1565) signal from the “CB autoclose logic” goes high and the reclaim time (“Reclaim Time”) starts. If the circuit breaker has remained closed and not tripped again when the reclaim timer expires, the auto-reclose cycle is complete, and signal “CB Succ SP AR” (DDB1571) or “CB Succ AP AR” (DDB 852) is generated to indicate the successful reclosure (in classic mode the indication generate always “CB Succ AP AR” (DDB 852)). These signals also increment the relevant circuit breaker successful auto-reclose shot counters “CB SUCC SPAR”, “CB SUCC APAR Shot1”, “CB SUCC APAR Shot2”, “CB SUCC APAR Shot3” and “CB SUCC APAR Shot4”, as well as resetting the circuit breaker auto-reclose in progress “ARIP” signal.

If the protection operates and circuit breaker trips during the reclaim time the relay either advances to the next shot in the programmed auto-reclose cycle, or, if all programmed reclose attempts have been made, the circuit breaker goes to lockout. Every time the relay trips the sequence counter is incremented by 1 and the reclaim time starts again after each shot, following the “Set CB Close” signal going high again.

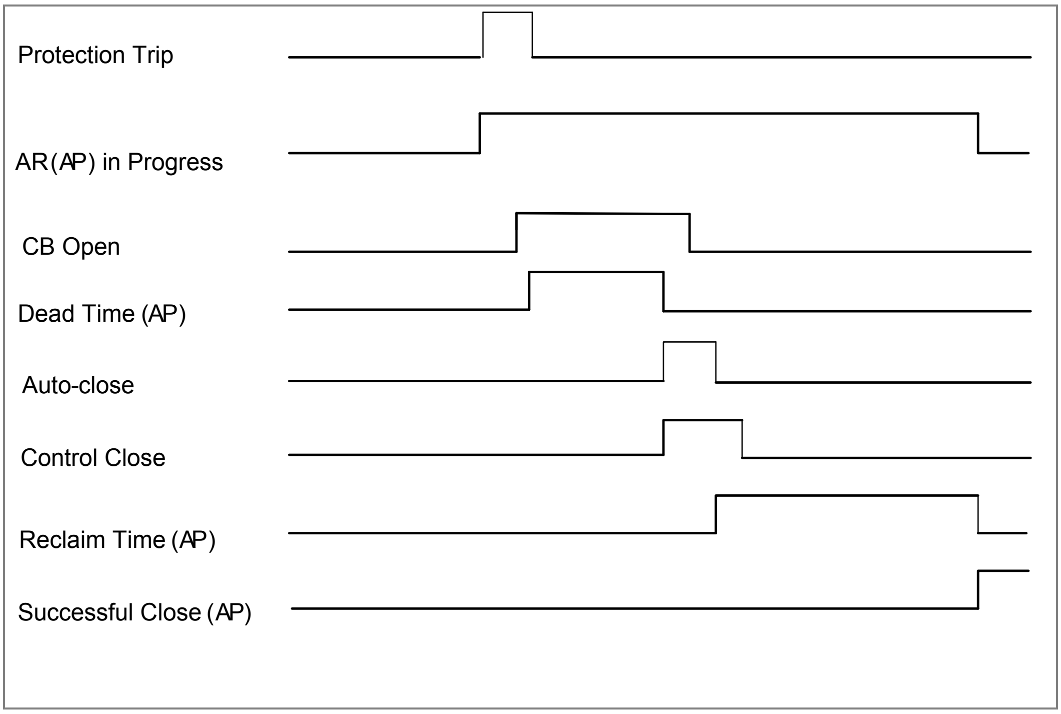


Figure 93: Auto-reclose timing diagram - single fault (AT mode)

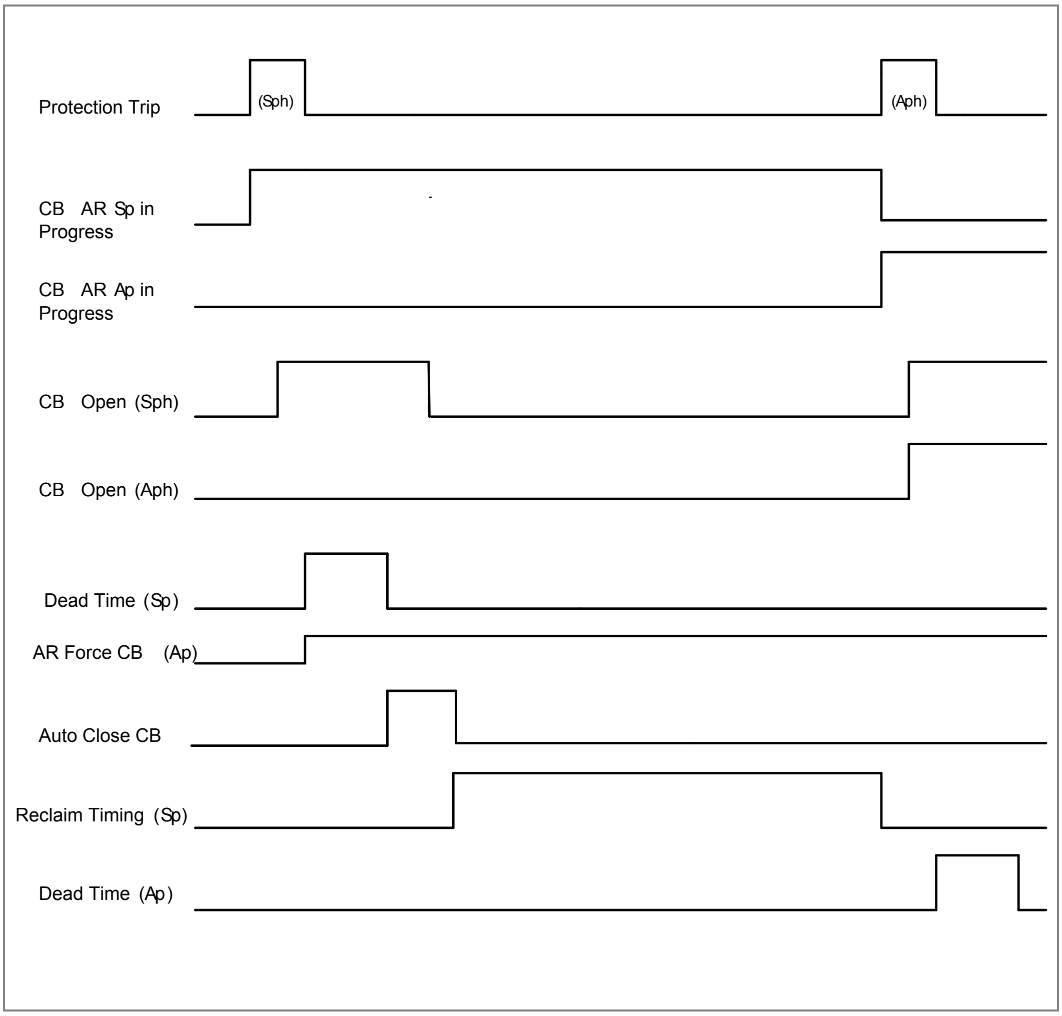


Figure 94: Auto-reclose timing diagram - repeated fault inception (AT mode)

18.5.6 Auto-reclose : main operating features

18.5.6.1 Circuit breaker in service

The circuit breaker in service logic is shown in AR Figure 4 (logic diagram supplement).

To be available for auto-reclosing, the circuit breaker has to be “in service” when the auto-reclose is initiated by a protection operation. The circuit breaker is considered to be “in service” if it has been in a closed state for a period equal to or greater than the setting “CB IS Time”.

A short adjustable time delay, “CB IS Memory Time”, allows for situations where, due to very fast acting circuit breaker auxiliary switches, when a circuit breaker trips following a fault, the circuit breaker change of state from closed to open is detected in the auto-reclose initiation logic before the “AR Initiate” signal from the protection is recognized.

Once an auto-reclose cycle has been started, the “in service” signal for the circuit breaker stays set until the end of the auto-reclose cycle.

The “CB In Service” signal resets if the circuit breaker opens, or if the corresponding circuit breaker auto-reclose in progress (ARIP) signal resets.

18.5.6.2 Auto-reclose enable

The auto-reclose enable logic is shown in AR Figure 5 (logic diagram supplement).

A master enable/disable signal provides overall control of the auto-reclose function for the circuit breakers. If the “Auto-reclose” setting cell in the CONFIGURATION column of the menu is set to “enabled” the auto-recloser can be brought into service with other commands (described below) providing further control.

In the figure, the auto-recloser is enabled when the “AR In Service” DDB (1385) is driven high. To achieve this, as well as enabling the “Auto-reclose” setting cell in the CONFIGURATION column of the menu, the following conditions below must be met:-

- Auto-reclosing needs to be enabled from an opto input mapped to the “AR Enable” DDB (1384), or one of the following 3 conditions must be met :-
- A menu command from the HMI “Auto-reclose Mode” cell in the CB CONTROL column of the menu is used to bring the auto-recloser into service, or,
- For a MiCOM P44T having IEC 60870-5-103 communications, a standardised enable auto-reclose command is received via the communications link, or,
- The auto-recloser is brought into service by the pulsing of the “AR Pulse On” DDB (1382).

The result of the logic above is the auto-reclose status. This can be seen in the data cell “AR Status” in the CB CONTROL column of the menu, and will be either “In Service” or “Out of Service”.

18.5.6.3 Auto-reclose mode (only in auto-transformer mode)Not for P445

The following auto-reclose mode setting options are available: “AR SP”, “AR S/AP”, “AR AP” & “AR Opto”.

Single phase auto-reclosing of the circuit breaker is permitted if “AR Mode” is set to “AR SP” or “AR S/AP”. All phases auto-reclosing of the circuit breaker is permitted if “AR Mode” is set to “AR AP” or “AR S/AP”.

If the “AR Mode” selection is by “AR Opto” then the reclose mode for the active circuit breaker is determined by the status of two DDB inputs: “AR Mode SP” (1497) to enable single phase auto-reclose, and “AR Mode AP” (1498) to enable all phases auto-reclose.

18.5.6.4 Force all phases trip (only in auto-transformer mode)

The “force all phases trip” logic is shown in AR Figure 10 (logic diagram supplement).

Following single phase tripping, whilst the auto-reclose cycle is in progress, and on resetting of the protection elements, an output signal, DDB (858) “AR Force Apole”, is asserted high.

This signal is applied to any associated protection trip conversion logic to force all protection trips to be converted to all phase trips for any subsequent faults that occur whilst the auto-reclose cycle remains in progress.

18.5.6.5 Auto-reclose Initiation

The auto-reclose initiation logic is shown in, AR Figure 13 (logic diagram supplement).

Auto-reclose cycles can be initiated by :-

- Protection functions hosted by the MiCOM P44T
- External protection equipment
- Trip test

Auto-reclose initiation will start an auto-reclose for the circuit breaker if it is in service and enabled for auto-reclose.

When an auto-reclose cycle is started, the circuit breaker auto-reclose in progress “ARIP” signal is set, and remains set until the end of the cycle. The end of the cycle is signified by successful reclosure, or by lockout.

An auto-reclose cycle can be initiated by operation of any of the following:

18.5.6.5.1 Auto-reclose initiation by host relay protection function

Some protection functions in the MiCOM P44T (for example Zone 1 trips, distance-aided scheme trips, time-delayed distance zones, overcurrent elements can be programmed to initiate or block auto-reclose by selecting the "Initiate AR", or "Block AR" options in the settings which are available under the “AUTORECLOSE" settings column of the menu. If an auto-reclosing option is not required then **No Action** option can be selected. Operation of a protection function selected for auto-reclose will initiate auto-reclose.

18.5.6.5.2 Auto-reclose initiation by external protection equipment

The following DDB signals are available for mapping in the PSL from opto inputs or communication inputs to initiate auto-reclosing.

DDB (535): External Trip Cat

DDB (536): External Trip Fdr

DDB (534): External Trip APh

If mapped, activation of the input to the DDB will initiate auto-reclose.

18.5.6.5.3 Auto-reclose initiation and cycle by trip test

A user command (“Test Autoreclose” under COMMISSION TESTS) in the P44T menu can be used to initiate an auto-reclose cycle. Three separate commands can be executed, each command comprising a 100 ms pulse output when the relevant “execute” option is selected. Available commands are: “Trip Pole Cat” / “Trip Pole Fdr” / “Trip APole”. There is also a “No Operation” option to exit the command field without initiating a test.

18.5.6.6 Sequence counter

The sequence counter logic is shown in AR Figure 41 (logic diagram supplement).

The auto-reclose logic includes a counter known as the sequence counter. Unless auto-reclose is in progress, the sequence counter will have a value of 0. Following a trip, and subsequent auto-reclose initiation, the sequence counter is incremented. The counter provides output signals indicating how many initiation events have occurred in any auto-reclose cycle. These signals are available as user indications and are used in the logic to select the appropriate dead timers, or, for a persistent fault, force a lockout.

The logic generates the following sequence counter outputs which are used in the auto-reclose shots counter logic (refer section 18.5.6.11).

DDB 847: “Seq. Counter = 1” is set when the counter is at 1;

DDB 848: “Seq. Counter = 2” is set when the counter is at 2;

DDB 849: “Seq. Counter = 3” is set when the counter is at 3; and

DDB 850: “Seq. Counter = 4” is set when the counter is at 4.

Every time the relay trips the sequence counter is incremented by 1. The auto-reclose logic compares the sequence counter values to the number of auto-reclose shots setting, “AR Shots”. If the counter value exceeds the setting then the auto-reclose is locked out.

In the case of a successful auto-reclose cycle the sequence counter resets to zero.

18.5.6.7 Dead time control

The dead time control logic is shown in AR Figure 22 and AR Figure 24, AR Figure 25 and (logic diagram supplement) where the circuit breaker logic is as defined for CB1L.

Once an auto-reclose cycle has started, the conditions to enable the dead time to run are determined by menu settings, circuit breaker status, protection status, the nature of the auto-reclose cycle (single phase or all phases) and opto inputs from external sources.

Three settings are involved in controlling the dead time start:

- “DT Start by Prot”
- “APDTStart WhenLD”
- “DTStart by CB Op”.

The “DT Start by Prot” setting is always visible and has three options “Protection Reset”, “Protection Op”, and “Disable”. These options set the basic conditions for starting the dead time.

The ‘dead time started by protection operation’ condition can, optionally, be qualified by a check that the line is dead.

The ‘dead time started by protection reset’ condition can, optionally, be qualified by a check, that the circuit breaker is open, as well as by an optional check that the line is dead (note*).

If the DT Start by Prot” is set to “Disable”, the circuit breaker must be open for the dead time to start. This condition can, optionally be qualified by a check that the line is dead (note*).

The qualification to check that the ‘line is dead’ is provided by setting “APDTStart WhenLD” to “Enabled”.

The qualification to check that the ‘circuit breaker is open’ is provided by setting “DTStart by CB Op” to “Enabled”.

Note*: *This is only applicable when tripping/auto-reclose is all phases.*

18.5.6.8 Circuit breaker auto close

The circuit breaker auto close logic is shown in AR Figure 32.

When the end of a dead time or the end of a follower time is indicated by one of the following internal signals, the auto close logic is executed :

- “CB1 SPDTCOMP”
- “CB1 APDTCOMP”

The auto close logic checks that all necessary conditions are satisfied before issuing a “CB1 AutoClose” signal to the circuit breaker overall control scheme as shown in the AR Figure 43 and described in section 18.4.

For any reclosure, the circuit breaker must be healthy (mechanism OK to close, and retrip if necessary) and it should not be in a lockout state.

For any single phase reclosure, the circuit breaker must be open on one phase.

For any all phase reclosure, the circuit breaker must be open on all phases and the appropriate system check conditions (live bus/dead line, synch check etc) must be satisfied.

The auto close signal sent to the circuit breaker control scheme is a pulse lasting 100 milliseconds. Another signal “Set CB Close”, DDB (1565) is set in conjunction with the auto close signal, but this remains set until either the end of the auto-reclose cycle, or the next protection operation. These signals are used to initiate the “Reclaim timing logic” and the “CB AR Shots Counters” logic, described in sections 18.5.6.9 to 18.5.6.11.

18.5.6.9 Reclaim time & successful auto-reclose

The reclaim time logic is shown in AR Figure 34 and AR Figure 35. The successful auto-reclose logic is shown in AR Figure 36 and AR Figure 37.

The “Set CB Close”, DDBs (1565) signal from the auto close logic is used to enable the reclaim timers. Depending on whether the circuit breaker has tripped single phase or all phase, and whether single phase and/or all phase reclosing is permitted for the circuit breaker, either the single phase reclaim timer “SPAR Reclaim Time” or the all phase reclaim timer “APAR Reclaim Time” is enabled (in classic mode only the timer “APAR Reclaim Time” is enabled).

If any protection re-operates before the reclaim time has timed out, the sequence counter is incremented. The counter signal advances from ‘Seq Counter = n’ to ‘Seq Counter = (n+1)’, resets any “….DTCOMP” signal and prepares the logic for the next dead time to start when conditions are suitable. The operation also resets the “Set CB Close” signal, and so the reclaim timer is also stopped and reset. The “Reclaim time” starts again if the “Set CB Close” signal goes high following completion of a dead time in a subsequent auto-reclose cycle.

If the circuit breaker is closed and has not tripped again when the reclaim time is complete, signals “CB Succ SP AR”, (DDB1571) or “CB Succ AP AR”, (DDB 852) are generated to indicate the successful reclosure.

These signals also increment the relevant circuit breaker successful auto-reclose shot counters and reset the relevant “ARIP” signal.

The “successful auto-reclose” signals generated from the logic can be reset by various commands and settings options available under CB CONTROL menu settings column.

These settings are described below:-

If “Res AROK by UI” is set to enabled, all the “successful auto-reclose" signals can be reset by user interface command “Reset AROK Ind” from the CB CONTROL settings column.

If “Res AROK by NoAR” is set to enabled, the “successful auto-reclose" signals for each circuit breaker can be reset by temporarily generating an “AR disabled” signal for each circuit breaker according to the logic described “Autoreclose Enable” logics, AR Figure 5.

If “Res AROK by Ext” is set to enabled, the “successful autoreclose" signals for can be reset by activation of the relevant input “Ext Rst CB1 AROK” or “Ext Rst CB2 AROK” (DDB1517 or 1417) mapped in the PSL.

If “Res AROK by TDly” is set to enabled, the “successful autoreclose" signals for are automatically reset after a user defined time delay as set in "Res AROK by TDly" setting.

18.5.6.10 Circuit breaker healthy & system check timers

The circuit breaker healthy and system check timers logic is shown in AR Figure 39.

This logic provides signals to cancel auto-reclosing if the circuit breaker is not healthy (e.g. low gas pressure or, for three phase auto-reclosing, the required line & bus voltage conditions are not satisfied) when the scheme is ready to close the circuit breaker.

At the completion of any dead time, the logic starts an “AR CBHealthy timer”. If the “CB Healthy” signal (DDB 436) becomes high before the set time is complete, the timer stops and, if all other relevant circuit breaker closing conditions are satisfied the scheme issues the “CB AutoClose” signal. If the “CB Healthy” signal, (DDB 436) signal stays low, then at the end of the set “AR CBHealthy time” an “AR CB Unhealthy” alarm signal (DDB 307) is set. This forces the circuit breaker auto-reclose sequence to be cancelled.

Additionally, at the completion of any all phase dead time or all phase follower time, the logic starts an “AR CheckSync Time”. If the circuit breaker synchro-check OK signal, “CB SCOK “ (DDB 1573), goes high before the set time is complete, the timer stops and, if all other relevant circuit breaker closing conditions are satisfied, the scheme issues the “CB AutoClose” signal. If the “System check OK” signal stays low, then at the end of the “AR CheckSync Time” an alarm “A/R No CheckSync” (DDB 308) is set which informs that the check synchronism is not satisfied for the circuit breaker and forces the auto-reclose sequence to be cancelled.

18.5.6.11 Circuit breaker auto-reclose shots counters

The circuit breaker auto-reclose shots counter logic is shown in AR Figure 18.

A number of counters are provided to enable analysis circuit breaker auto-reclosing history. The circuit breaker has a set of counters that are stored in non-volatile memory, so that the data is maintained even in the event of a failure of the auxiliary supply.

Logic signals from the “Sequence counters” are combined with “successful auto-reclose” signals and “auto-reclose lockout” signals to provide the following summary for the circuit breaker:

- Overall total shots (No. of reclose attempts);
  - “CB Total Shots”
- Number of successful single phase reclosures (Used only in Auto-transformer Mode);
  - “CB SUCC SPAR”
- Number of successful 1st shot all phase reclosures;
  - “CB SUCCAPARShot1”
- Number of successful 2nd shot all phase reclosures;
  - “CB SUCCAPARShot2”
- Number of successful 3rd shot all phase reclosures;
  - “CB SUCCAPARShot3”
- Number of successful 4th shot all phase reclosures;
  - “CB SUCCAPARShot4”
- Number of failed auto-reclose cycles which forced CB to lockout.
  - “CB Failed Shots”

All the counter contents are accessible through the CB CONTROL column of the menu.

These counters can be reset either by user command “Reset CB Shots” from the CB CONTROL settings column, or by activation of the relevant input “Ext Rst CB Shots” (DDB 1518) mapped in the PSL.

18.5.6.12 System checks for circuit breaker closing

The system checks for circuit breaker closing logic is shown in AR Figure 45 and AR Figure 51 (logic diagram supplement) where the circuit breaker logic is as defined for CB1L.

The system check options for each circuit breaker are enabled or disabled in the “CB SC all” setting in the AUTORECLOSE column of the menu. If set to “Disabled”, then no system checks are required on any shot, and the relevant settings are invisible. Otherwise, the system check options that can be enabled for the breaker are:

System check option	Setting
System checks not required for first shot of auto-reclose	"CB SC Shot1"
Fast synchronism check (note 2)	"CB SC ClsNoDly"
Check synchronism stage 1 (note 1)	"CB SC CS1"
Check synchronism stage 2 (note 1)	"CB SC CS2"
Dead line / Live Bus	"CB SC DLLB"
Live Line / Dead bus	"CB SC LLDB"
Dead line / Dead bus	"CB SC DLDB"

Table 20: System check settings

Note 1 : *Two separate (independent) system synchronism check stages are available. Each stage has different slip frequency and phase angle settings as described in section 17.1.*

Manual reclosing for the circuit breaker is controlled according to the settings in the SYSTEM CHECKS column of the menu. The system check options for each circuit breaker are enabled or disabled in the "CBM SC all" setting in the SYSTEM CHECKS column of the menu. If set to "Disabled", then no system checks are required for manual closure, and the relevant settings are invisible. Otherwise, the system check options that can be enabled for the circuit breaker are:

System check option	Setting
Check synchronism stage 1 (refer note 1 above)	"CBM SC CS1"
Check synchronism stage 2 (refer note 1 above)	"CBM SC CS2"
Dead line / Live Bus	"CBM SC DLLB"
Live Line / Dead bus	"CBM SC LLDB"
Dead line / Dead bus	"CBM SC DLDB"

Table 21: System check settings

18.5.6.13 Circuit breaker trip time monitor

The circuit breaker trip time monitor logic is shown in AR Figure 53 (logic diagram supplement).

This logic checks that the circuit breaker trips correctly following the issuing of a protection trip signal.

When any protection trip signal is issued a timer, "Trip Pulse Time" is started.

The "Trip Pulse Time" setting is used in the trip time monitor logic and in the circuit breaker control logic.

If the circuit breaker trips correctly (single phase or all phases, according to the trip signal and settings) the timer resets and the auto-reclose cycle, if enabled, proceeds normally. If the circuit breaker fails to trip correctly within the set time, the signal "CB Fail Pr Trip" (1575) is issued and the circuit breaker auto-reclose cycle is forced to lock out.

18.5.6.14 Auto-reclose lockout

The auto-reclose lockout logic is shown in AR Figure 55 and 55a (logic diagram supplement).

Auto-reclose lockout of a circuit breaker will be triggered by a number of events. These are outlined below:

- Protection operation during reclaim time. If, following the final reclose attempt, the protection operates during the reclaim time, the relay will be driven to lockout and the auto-reclose function will be disabled until the lockout condition is reset.
- Persistent fault. A fault is considered persistent if the protection re-operates after the last permitted shot.
- Block auto-reclose. The block auto-reclose logic can cause a lockout if auto-reclose is in progress. If asserted, the “Block CB AR” input (DDB 448) mapped in the PSL will, if auto-reclose is in progress, block auto-reclose and cause a lockout.
- Protection function selection. The protection functions can be individually selected to block auto-reclose and force lockout. The protection functions in the AUTORECLOSE column of the menu can be set to **Initiate AR, No Action** or **Block AR**. Selecting “Block AR” blocks auto-reclose and forces lockout if the protection function operates.
- Circuit breaker failure to close. If the circuit breaker fails to close because, for example, the circuit breaker springs are not charged, the gas pressure is low, or there is no synchronism between the system voltages indicated by the “AR CB Unhealthy” and “AR CB No Checksync” alarms, auto-reclose will be blocked and forced to lockout.
- Circuit breaker open at the end of the reclaim time. An auto-reclose lockout is forced if the circuit breaker is open at the end of the reclaim time.
- Circuit breaker fails to close when the close command is issued.
- Circuit breaker fails to trip correctly.
- All phases dead time started by line dead violation. If the line does not go dead within the “Dead Line Time” time setting when the dead time start is determined by the menu setting “APDTStart WhenLD”, the logic will force the auto-reclose sequence to lockout after expiry of the setting time.

If the circuit breaker is locked out, the logic generates the alarms “A/R Lockout” (DDB 306). In this condition, auto-reclose of the circuit breaker cannot be initiated until the corresponding lockout has been reset. The methods of resetting from the lockout state are discussed in the next section.

Note:	*Circuit breaker lockout, can also be caused by the circuit breaker condition monitoring functions:-*

- Maintenance lockout,
- Excessive fault frequency lockout,
- Broken current lockout,
- Circuit breaker failed to trip,
- Circuit breaker failed to close,
- Manual close failure - no check synchronism / circuit breaker unhealthy situation.

These lockout alarms are mapped to a signals “CB mon LO Alarm” (DDB 300) and “Lockout Alarm”. (DDB 860).

18.5.6.15 Reset circuit breaker lockout

The lockout conditions caused by the circuit breaker condition monitoring functions (including manual close failure) described in previous section can be reset according to the condition of the “Rst CB mon LO by” setting found in the CB CONTROL column of the menu.

The “Rst CB mon LO by” setting has two options “CB Close”, and “User interface”.

If “Rst CB mon LO By” is set to “CB Close” then closure of the circuit breaker will be a trigger for lockout reset. If set to “CB Close”, a further setting, “CB mon LO RstDly”, becomes visible. This is a timer setting that is applied between the circuit breaker closing, and the lockout being reset.

If “Rst CB mon LO By” is set to “User Interface” then a further command appears in the the CB CONTROL column of the menu, “CB mon LO reset”. This command can be used to reset the lockout.

This logic is included in Figure 88.

An auto-reclose lockout state of the circuit breaker will generate an auto-reclose circuit breaker lockout alarm (“A/R lockout”) and DDB 306 is set, corresponding to the circuit breaker being locked out, as per the logic diagrams in AR Figure 55.

The auto-reclose lockout conditions can be reset by various commands and settings options found under the CB CONTROL column of the menu.

These settings and commands are described below:-

If “Res LO by CB IS” is set to “Enabled”, the circuit breaker lockout is reset if the circuit breaker is manually closed successfully. For this the circuit breaker must remain closed long enough so that it enters the “In Service” state.

If “Res LO by UI” is set to “Enabled”, the circuit breaker lockout can be reset by the user interface command “Reset CB LO” found in the CB CONTROL column of the menu.

If “Res LO by NoAR” is set to “Enabled”, the circuit breaker lockout can be reset by temporarily generating an “AR disabled” signal according to the logic described in section 18.5.6.2, “Auto-reclose Enable” logic and AR Figure 57.

If “Res LO by ExtDDB” is set to “Enabled”, the circuit breaker lockout can be reset by activation of the relevant input DDB “Reset Lockout” (DDB 446) mapped in the PSL.

If “Res LO by TDelay” is set to “Enabled”, the circuit breaker lockout is automatically reset after a user defined time delay as set in “LO Reset Time” setting.

The reset circuit breaker auto-reclose lockout logic is shown in AR Figure 57.

19 MEASUREMENTS

19.1 Fault locator

The IED has an integral fault locator that uses information from the current and voltage inputs to provide a distance to fault location. The sampled data from the analog input circuits is written to a cyclic buffer until a fault condition is detected. The data in the input buffer is then held to allow the fault calculation to be made. When the fault calculation is complete the fault location information is available in the IED fault record.

19.1.1 Data acquisition and buffer processing

The fault locator stores the sampled data in a 12 cycle cyclic buffer at a resolution of 48 samples per cycle. When the fault recorder is triggered the data in the buffer is frozen so that the buffer contains 6 cycles of pretrigger data and 6 cycles of post-trigger data. Fault calculation commences shortly after this trigger point.

You can select the trigger for the fault recorder using the programmable scheme logic.

The fault locator can store data for up to four faults. This ensures that fault locations can be calculated for all shots on a typical multiple reclose sequence.

Phase selection is derived from the current differential protection or the superimposed current phase selector.

Phase selection and fault location calculations can only be made if the current change exceeds 5% In.

19.1.1.1 The fault location calculation

The following equation is applied to calculate the fault location

$$Vp = mIpZr + If\ Rf \qquad \text{(equation 1)}$$

The fault location, m, can be found if can be estimated allowing equation 1 to be solved.

The fault location calculation works by:

- Obtaining the vectors.
- Selecting the faulted phase(s).
- Estimating the phase of the fault current If for the faulted phase(s).
- Solving equation 1 for the fault location m at the instant of time where f = 0.

Following is the calculation diagram for fault locator:

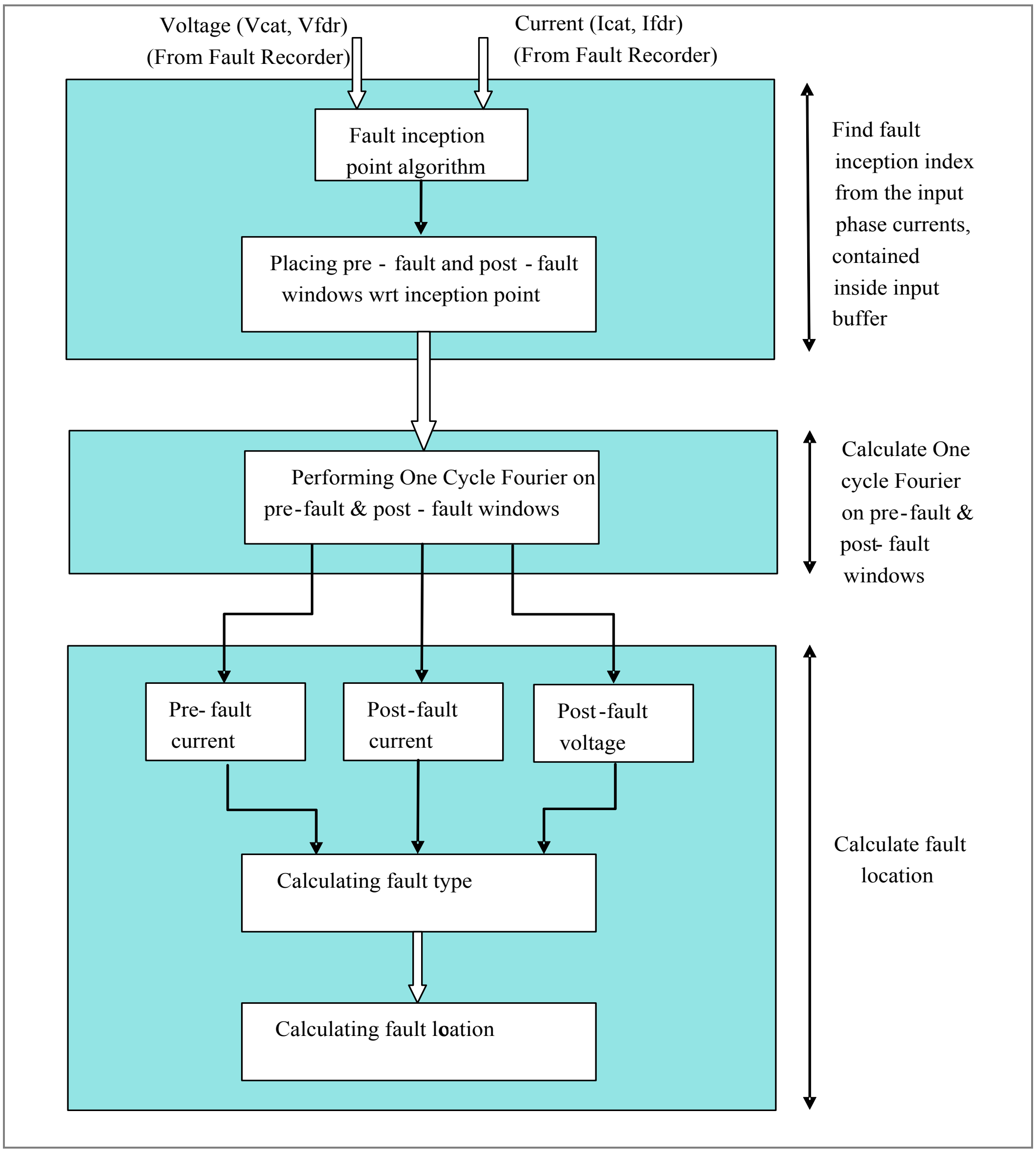


Figure 95: Fault locator Logic diagram for P44T Relay in Classic and AT Mode

19.1.2 Obtaining the vectors

Different sets of vectors are chosen depending on the type of fault identified by the phase selection algorithm. The calculation using equation 1 is applied for either a phase to ground fault or a phase to phase fault.

Therefore for a catenary to ground fault:

Vcat = Icat(Zcat/□∠ cat) (equation 2)

For a feeder to ground fault:

Vfdr = Ifdr(Zfdr/□∠ fdr) (equation 3)

For a Cat to Fdr fault:

Vcat – Vfdr = (Icat –Ifdr)(Zcat-fdr/ ∠ cat-fdr) (equation 4)

19.1.3 Solving the equation for the fault location

As the sine wave of If passes through zero, the instantaneous values of the sine waves Vp and Ip can be used to solve equation (1) for the fault location m. (The term IfRf being zero).

This is determined by shifting the calculated vectors of Vp and IpZr by the angle (90° - angle of fault current) and then dividing the real component of Vp by the real component of IpZr.

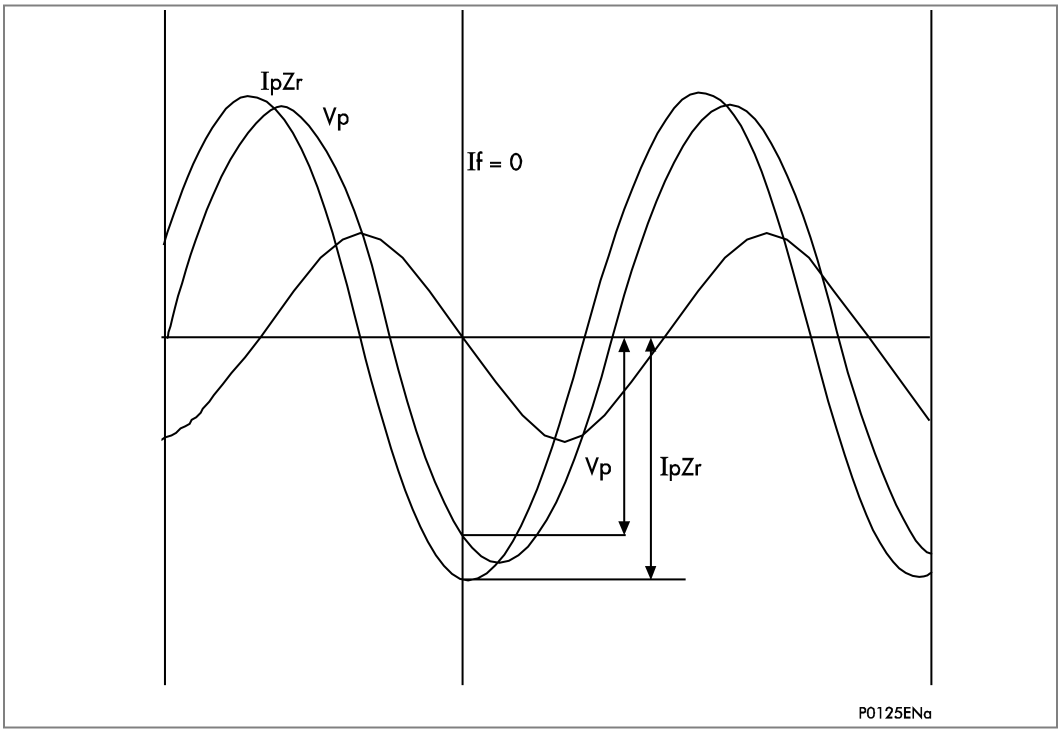


Figure 96: Fault locator selection of fault current zero

i.e.: Phase advanced vector Vp

= | Vp | [cos(s) + jsin(s)] * [sin(d) + jcos(d)]

= | Vp | [-sin(s-d) + jcos(s-d)]

Phase advanced vector IpZr

= | IpZr | [cos (e) + jsin (e)] * [sin (d) + jcos (d)]

= | IpZr | [-sin(e-d) + jcos(e-d)]

Therefore, from equation 1: m = Vp ÷ (Ip * Zr) at If = 0

= Vp sin(s-d) / (IpZr * sin(e-d))

Where: d = Angle of fault current If

s = Angle of Vp

e = Angle of IpZr

Therefore the IED evaluates m which is the fault location as a percentage of the fault locator line impedance setting and then calculates the output fault location by multiplying this by the line length setting. When calculated the fault location can be found in the fault record under the VIEW RECORDS column in the Fault Location cells. Distance to fault is available in kilometers, miles, impedance or percentage of line length.

20 COMMUNICATIONS SETTINGS

20.1 Read Only mode

With IEC 61850 and Ethernet/Internet communication capabilities, security has become a pressing issue. The Px40 IED provides a facility to allow the user to enable or disable the change in configuration remotely. This feature is available only in IEDs with Courier, Courier with IEC 60870-5-103 and Courier with IEC 61850 protocol options. It has to be noted that in IEC 60870-5-103 protocol, Read Only Mode function is different from the existing Command block feature.

20.1.1 IEC 60870-5-103 protocol on rear port 1

The protocol does not support settings but the indications, measurands and disturbance records commands are available at the interface.

Allowed:

Poll Class 1 (read spontaneous events)

Poll Class 2 (read measurands)

GI sequence (ASDU7 'Start GI', Poll Class 1)

Transmission of Disturbance Records sequence (ASDU24, ASDU25, Poll Class 1)

Time Synchronization (ASDU6)

General Commands (ASDU20), namely:

INF23 activate characteristic 1

INF24 activate characteristic 2

INF25 activate characteristic 3

INF26 activate characteristic 4

Blocked:

Write parameter (=change setting) (private ASDUs)

General Commands (ASDU20), namely:

INF16 auto-recloser on/off

INF19 LED reset

Private INFs (e.g. CB open/close, control inputs)

20.1.2 Courier protocol on rear port 1 or 2 and Ethernet

Allowed:

Read settings, statuses, measurands

Read records (event, fault, disturbance)

Time Synchronization

Change active setting group

Blocked:
Write settings

All controls, including:

Reset Indication (Trip LED)

Operate control inputs

CB operations

Auto-reclose operations

Reset demands

Test LEDs & contacts

20.1.3 IEC 61850

Allowed:
Read statuses, measurands

Generate reports

Extract disturbance records

Time synchronization

Change active setting group

Blocked:
All controls, including:

Enable/disable protection

Operate control inputs

CB operations (Close/Trip, Lock)

Reset LEDs

20.1.4 Courier database support

Three new settings, one for each remote communications port at the back of the IED are created to support the enabling and disabling of the read only mode at each port.

The **NIC Read Only** setting applies to all the communications protocols (including the Tunneled Courier) that are transmitted through the Ethernet Port. Their default values are **Disabled**.

DNP3 communication interfaces that do not support the feature ignore these settings.

20.1.5 New DDB signals

The remote read only mode is also available in the PSL via three dedicated DDB signals:

- RP1 Read Only
- RP2 Read Only
- NIC Read Only

Through careful scheme logic design, the activations of these read only signals can be facilitated via Opto Inputs, Control Inputs and Function Keys.

These DDBs are available in every build, however they are effective only in Courier, IEC 60870-5-103 build and in latest IEC 61850. The setting cells are not available in DNP3.0.

21 REAL TIME CLOCK SYNCHRONIZATION VIA OPTO-INPUTS

In modern protective schemes it is often desirable to synchronize the IEDs real time clock so that events from different IEDs can be placed in chronological order. This can be done using the IRIG-B input, if fitted, or via the communication interface connected to the substation control system. In addition to these methods MiCOM P44T range offers the facility to synchronize via an opto-input by routing it in PSL to DDB 400 (Time Sync.). Pulsing this input results in the real time clock snapping to the nearest minute. The recommended pulse duration is 20 ms to be repeated no more than once per minute. An example of the time sync. function is shown.

Time of “Sync. Pulse”	Corrected time
19:47:00 to 19:47:29	19:47:00
19:47:30 to 19:47:59	19:48:00

Table 22: Time sync function

Note: The above assumes a time format of hh:mm:ss.

To avoid the event buffer from being filled with unnecessary time sync. events, it is possible to ignore any event that is generated by the time sync. opto input. This can be done by applying the following settings:

Menu Text	Value
RECORD CONTROL	
Opto Input Event	Enabled
Protection Event	Enabled
DDB 63 - 32 (Opto Inputs)	Set “Time Sync.” associated opto to 0

Table 23: Time sync event settings

To improve the recognition time of the time sync. opto input by approximately 10 ms, the opto input filtering could be disabled. This is achieved by setting the appropriate bit to 0 in the Opto Filter Cntl. cell (OPTO CONFIG. column). Disabling the filtering may make the opto input more susceptible to induced noise. Fortunately the effects of induced noise can be minimized by using the methods described in the Software Design chapter.

22 CONTROL INPUTS

The control inputs function as software switches that can be set or reset either locally or remotely. These inputs can be used to trigger any function that they are connected to as part of the PSL. There are three setting columns associated with the control inputs that are: CONTROL INPUTS, CTRL. I/P CONFIG. and CTRL. I/P LABELS. The function of these columns is described below:

Menu text	Default setting	Setting range	Step size
CONTROL INPUTS			
Ctrl I/P Status	00000000000000000000000000000000		
Control Input 1	No Operation	No Operation, Set, Reset	
Control Input 2 to 32	No Operation	No Operation, Set, Reset	

Table 24: Control inputs settings

The Control Input commands can be found in the 'Control Input' menu. In the 'Ctrl. I/P status' menu cell there is a 32 bit word which represent the 32 control input commands. The status of the 32 control inputs can be read from this 32-bit word. The 32 control inputs can also be set and reset from this cell by setting a 1 to set or 0 to reset a particular control input. Alternatively, each of the 32 Control Inputs can be set and reset using the individual menu setting cells 'Control Input 1, 2, 3' etc. The Control Inputs are available through the IED menu as described above and also via the rear communications.

In the programmable scheme logic editor 32 Control Input signals, DDB 191 - 223, which can be set to a logic 1 or On state, as described above, are available to perform control functions defined by the user.

Menu text	Default setting	Setting range	Step size
CTRL. I/P CONFIG.			
Hotkey Enabled	11111111111111111111111111111111		
Control Input 1	Latched	Latched, Pulsed	
Ctrl Command 1	Set/Reset	Set/Reset, In/Out, Enabled/Disabled, On/Off	
Control Input 2 to 32	Latched	Latched, Pulsed	
Ctrl Command 2 to 32	Set/Reset	Set/Reset, In/Out, Enabled/Disabled, On/Off	

Table 25: Control I/P config settings

Menu text	Default setting	Setting range	Step size
CTRL. I/P LABELS			
Control Input 1	Control Input 1	16 character text	
Control Input 2 to 32	Control Input 2 to 32	16 character text	

Table 26: Control I/P labels settings

The CTRL. I/P CONFIG. column has several functions one of which allows the user to configure the control inputs as either 'latched' or 'pulsed'. A latched control input remains in the set state until a reset command is given, either by the menu or the serial communications. A pulsed control input, however, remains energized for 10 ms after the set command is given and then resets automatically (no reset command required).

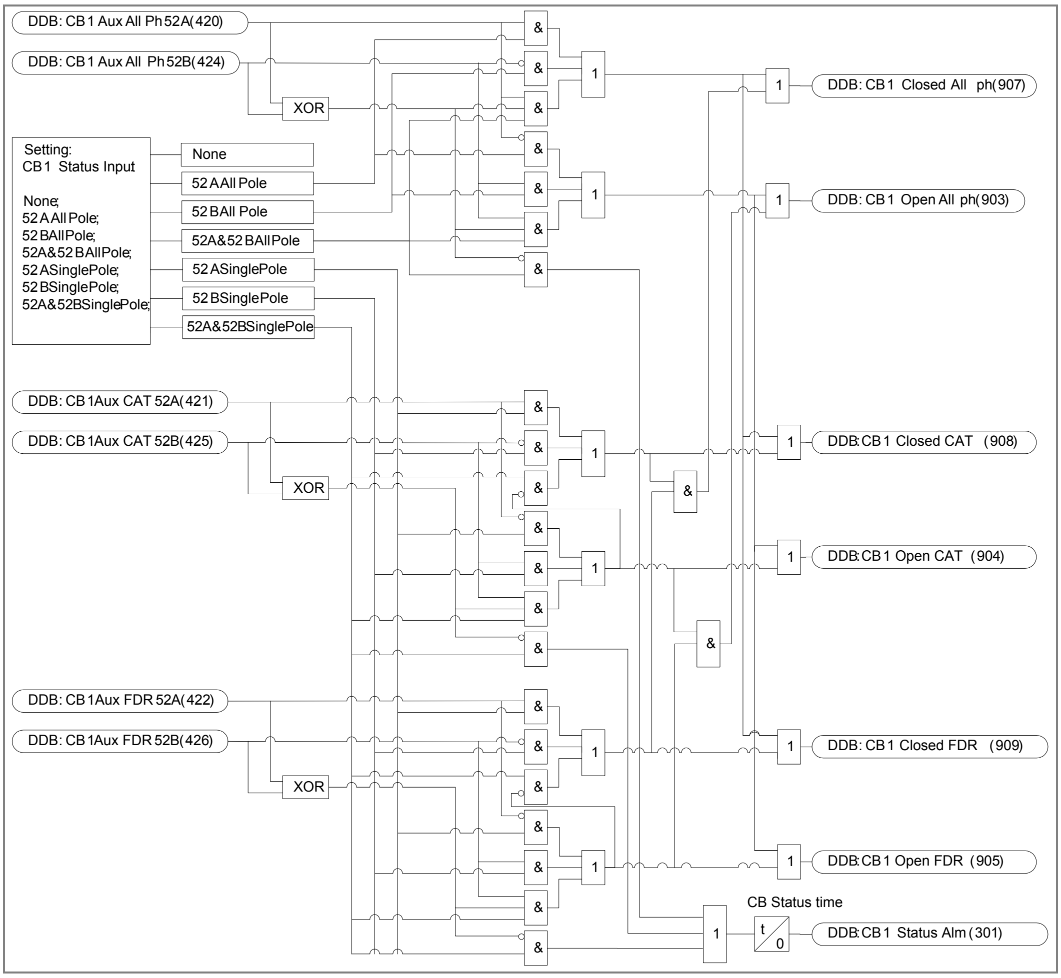
In addition to the latched/pulsed option this column also allows the control inputs to be individually assigned to the Hotkey menu by setting '1' in the appropriate bit in the Hotkey Enabled cell. The hotkey menu allows the control inputs to be set, reset or pulsed without the need to enter the CONTROL INPUTS column. The Ctrl. Command cell also allows the SET/RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as ON/OFF, IN/OUT etc.

The CTRL. I/P LABELS column makes it possible to change the text associated with each individual control input. This text is displayed when a control input is accessed by the hotkey menu, or it can be displayed in the PSL.

> *Note: Except for pulsed operation, the status of the control inputs is stored in non volatile memory. If the auxiliary supply is interrupted, the status of all inputs is recorded. Once the auxiliary supply is restored, the status of the control inputs is restored to that of before the supply failure. If the battery is missing or discharged, the control inputs are set to logic 0 once the auxiliary supply is restored.*

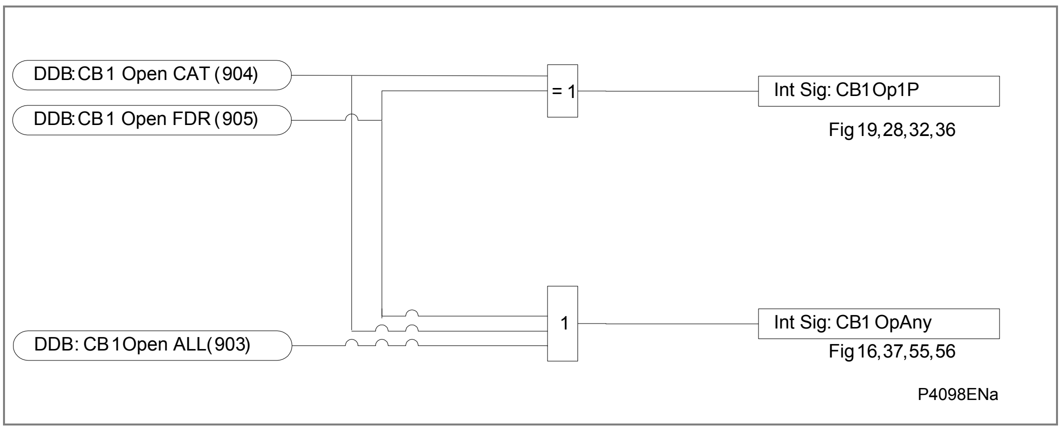
23 LOGIC DIAGRAM SUPPLEMENT (AR FIGURES)

23.1 CB Circuit Breaker Control and AUTO-RECLOSE Figures

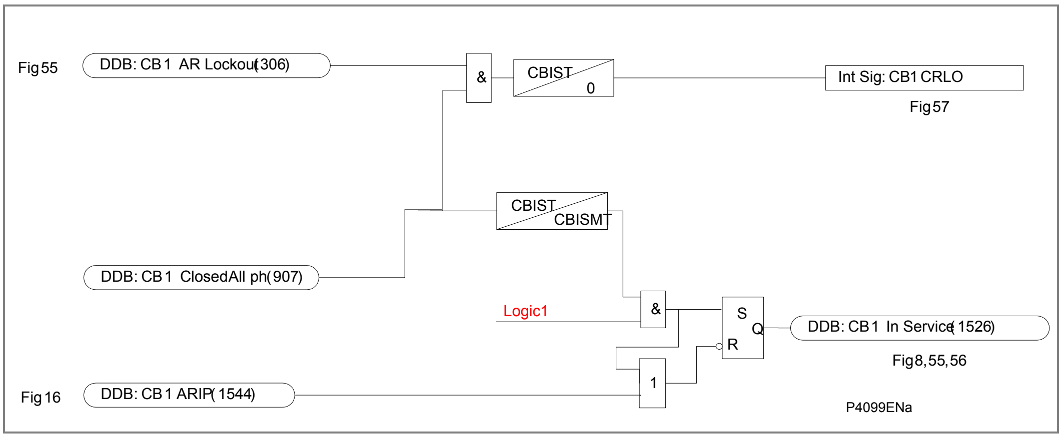


AR Figure 1: CB state monitor

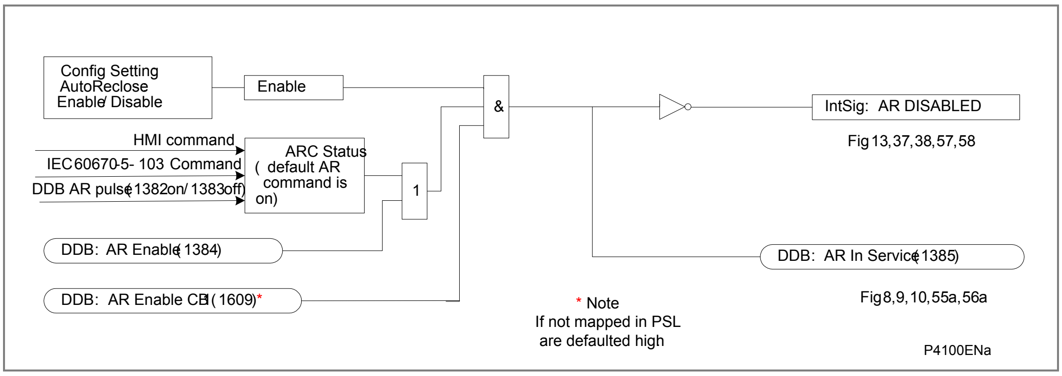
AR Figure 2: Intentionally blank from dual CB



AR Figure 3: CB Open State



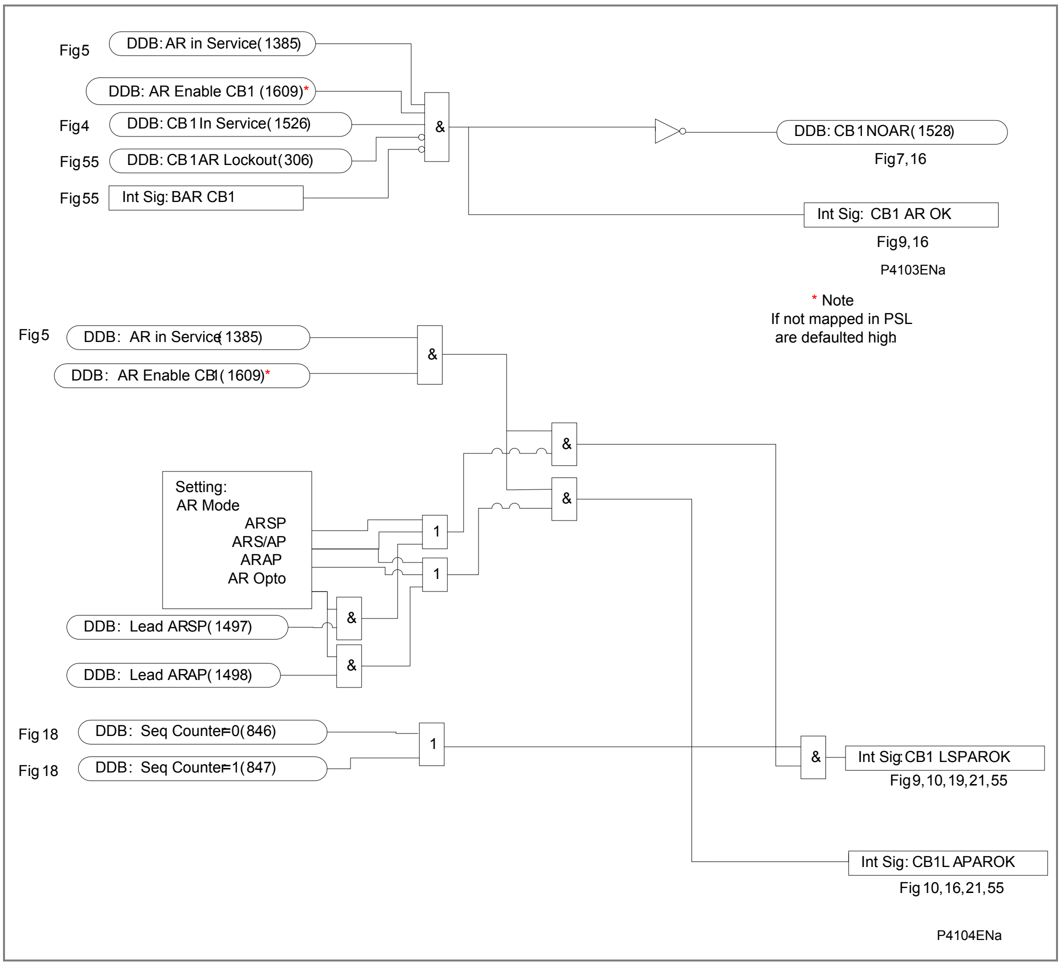
AR Figure 4: Circuit breaker in service



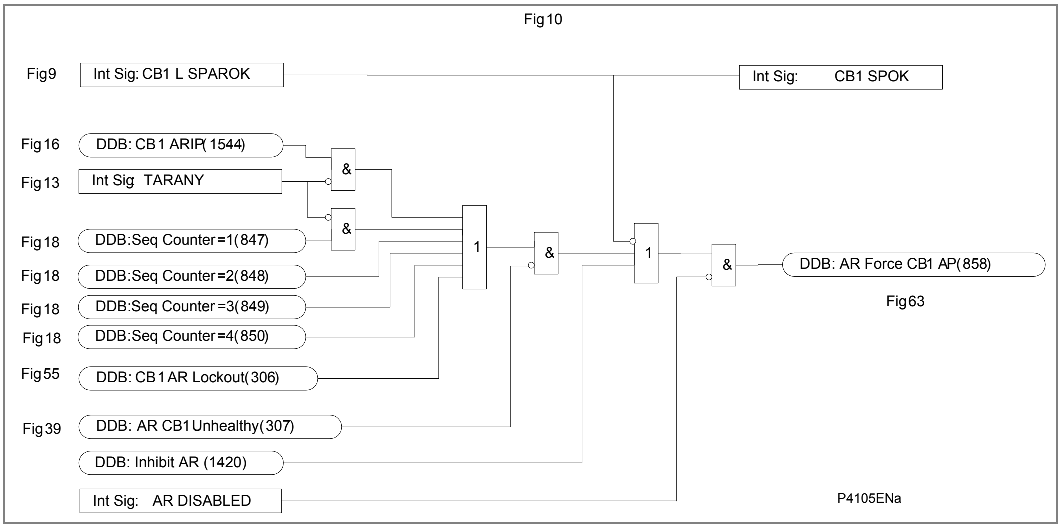
AR Figure 5: Auto-reclose enable

AR Figure 6: Intentionally blank from dual CB

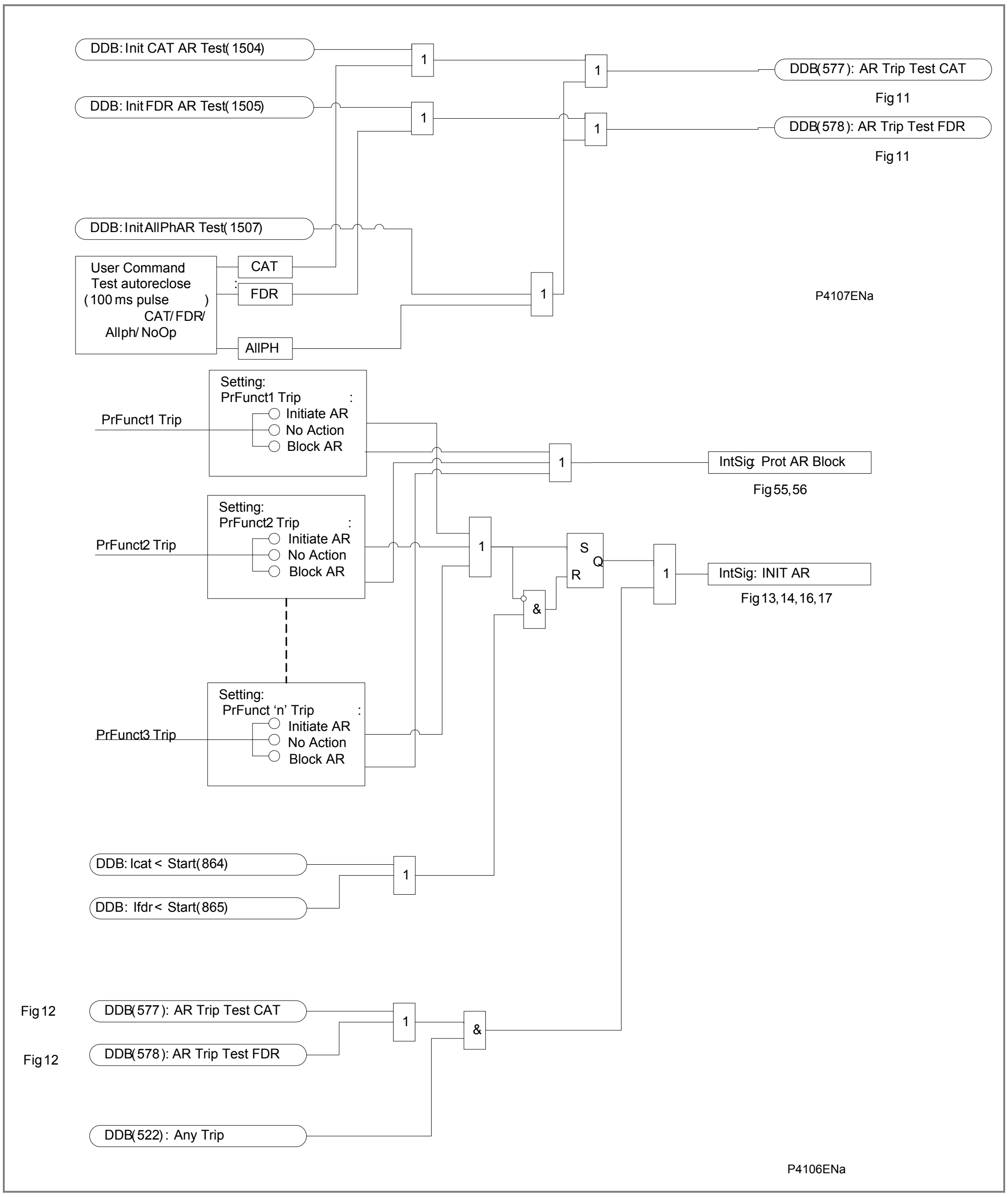
AR Figure 7: Intentionally blank from dual CB



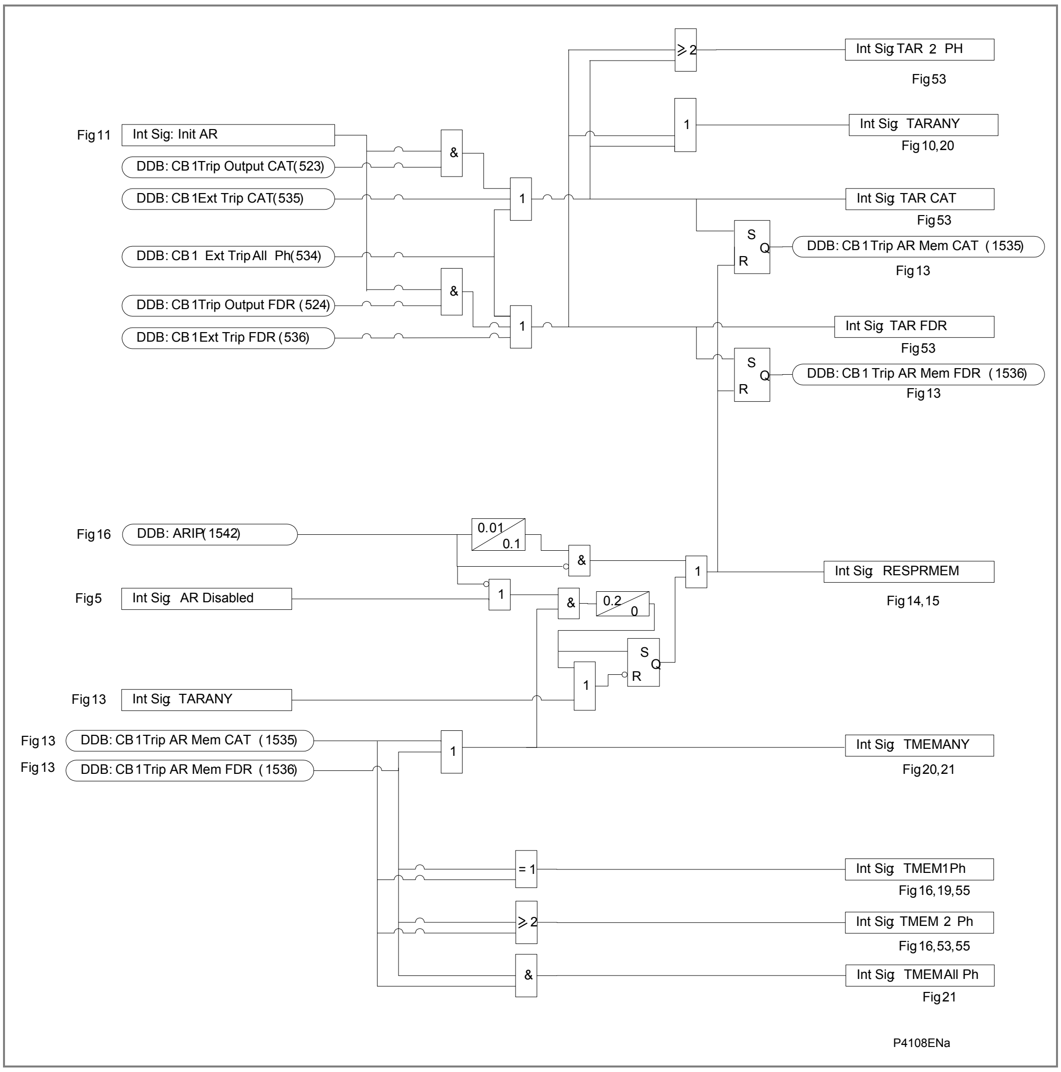
AR Figure 8: AR OK logic and AR Figure 9: AR modes enable



AR Figure 10: Force all phase trip

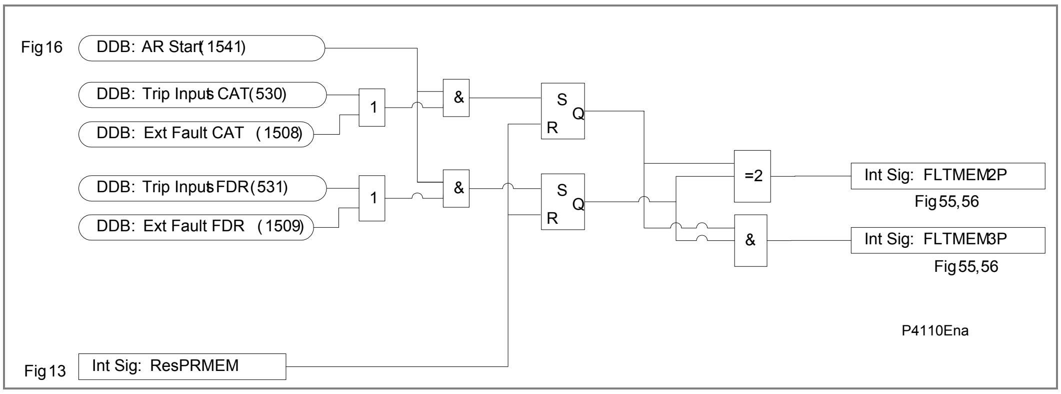


AR Figure 11: Auto-reclose initiation and AR Figure 12: Test trip & AR initiation

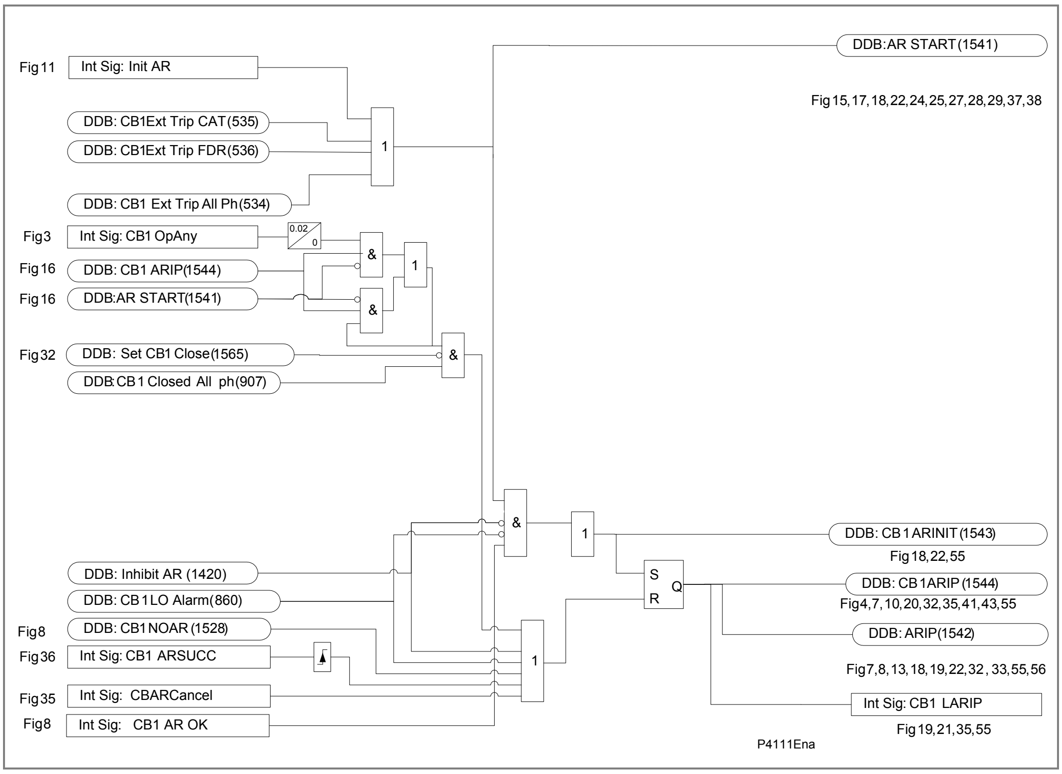


AR Figure 13: Trip Memory during auto-reclose cycle

AR Figure 14: Intentionally blank from dual CB

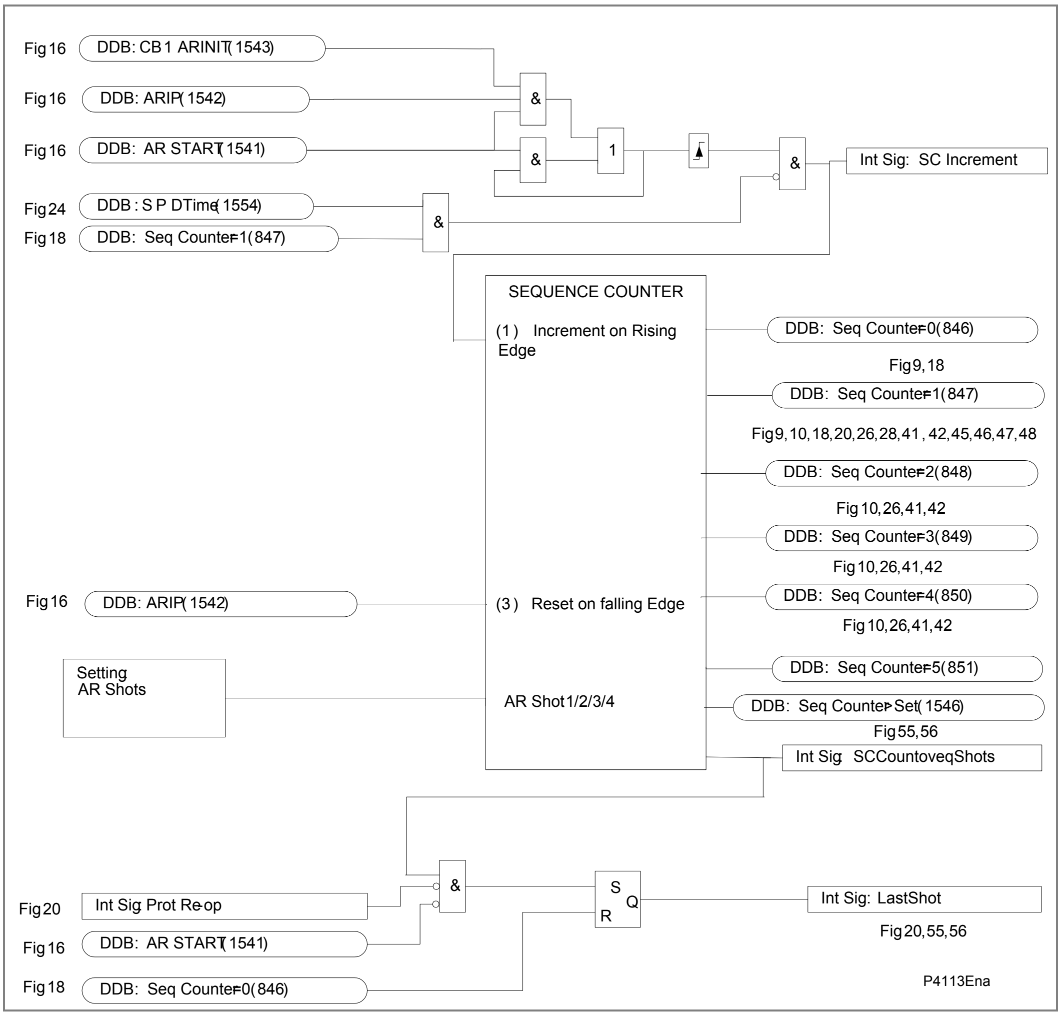


AR Figure 15: Fault memory

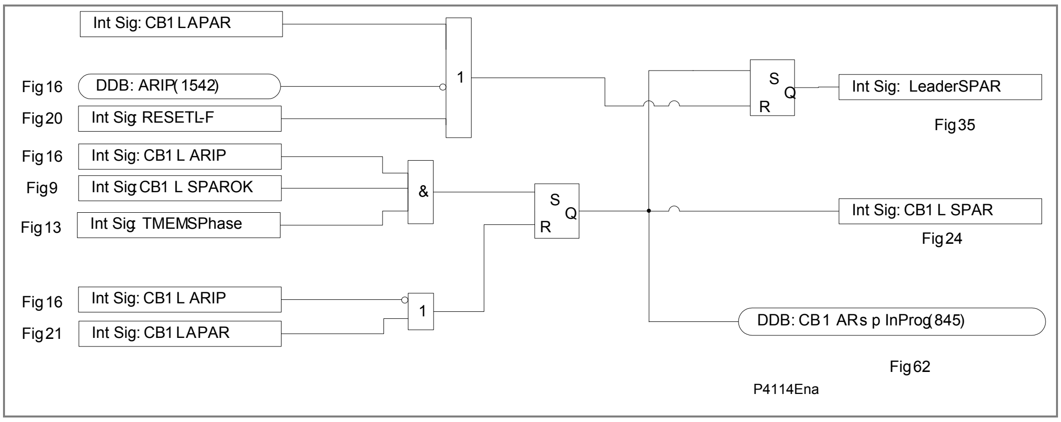


AR Figure 16: Auto-reclose in progress

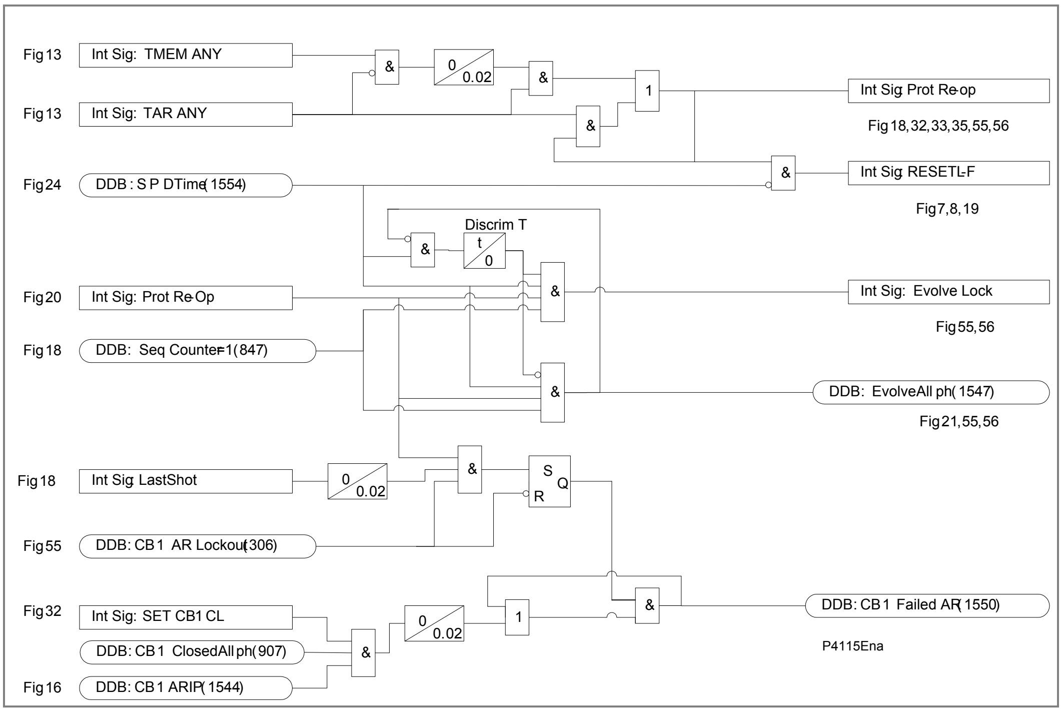
AR Figure 17: Intentionally blank from dual CB



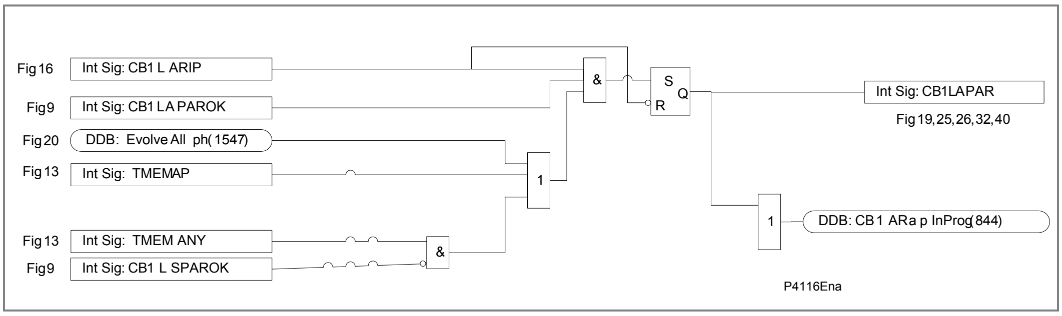
AR Figure 18: Sequence counter



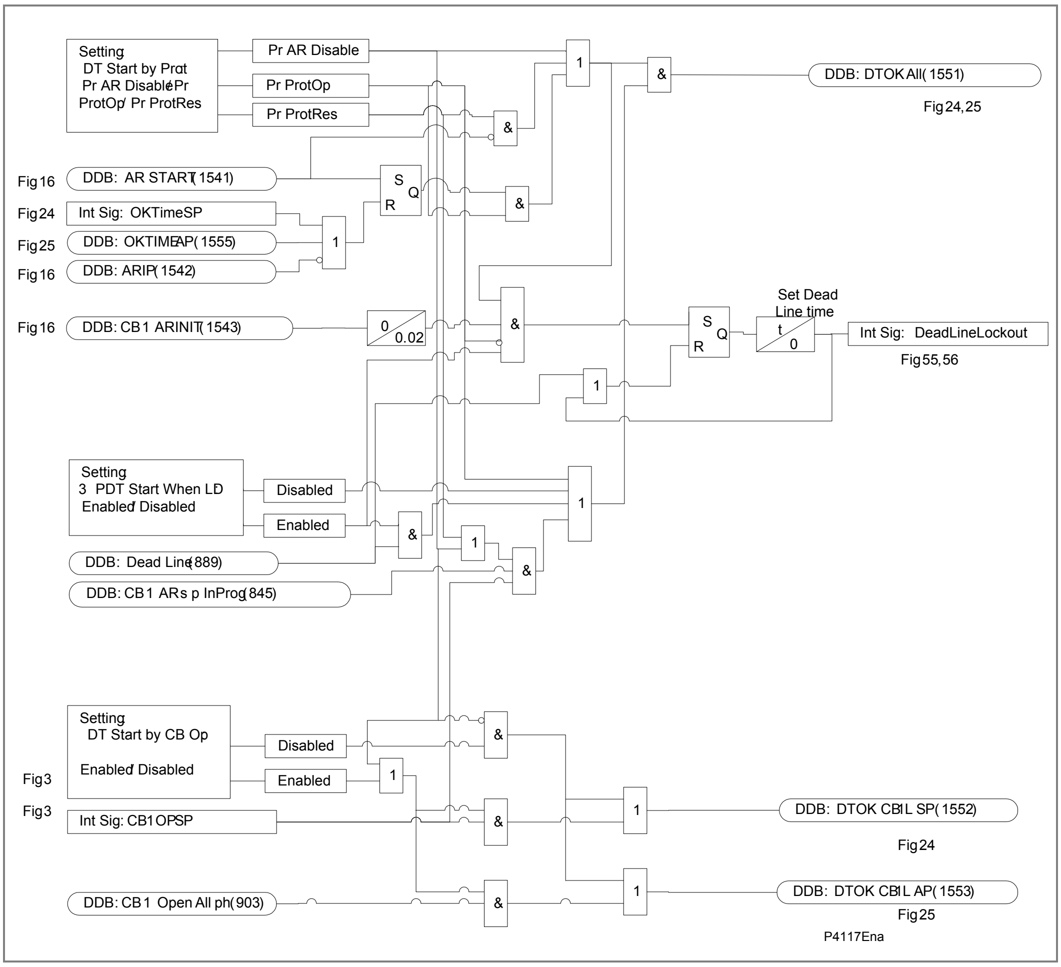
AR Figure 19: Single phase AR cycle selection



AR Figure 20: Protection re-operation + evolving fault + persistent fault

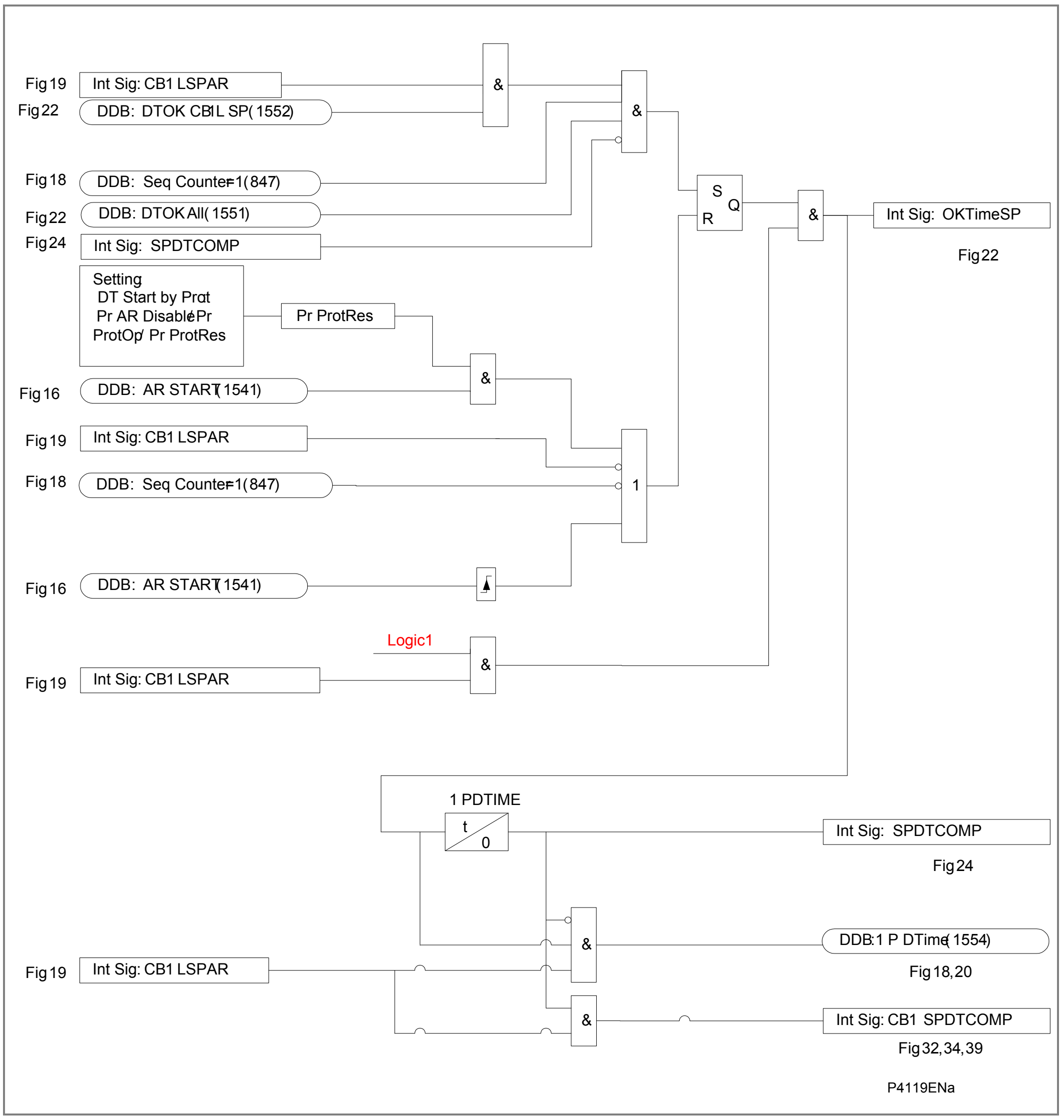


AR Figure 21: All phase AR cycle selection

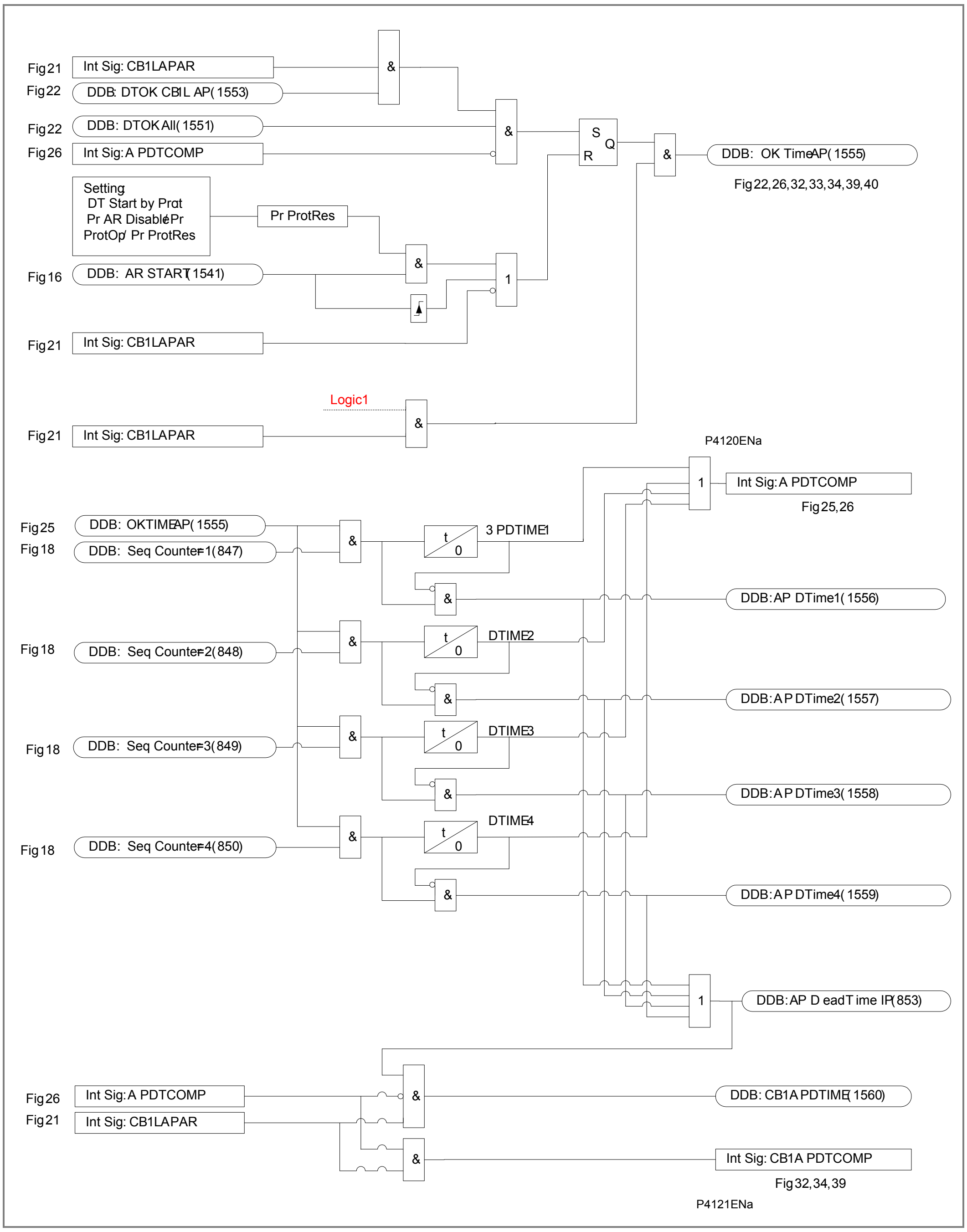


AR Figure 22: Dead time start enable

AR Figure 23: Intentionally blank from dual CB



AR Figure 24: Single phase AR dead time



AR Figure 25: All phase AR dead time enable and AR Figure 26: All phase AR dead time

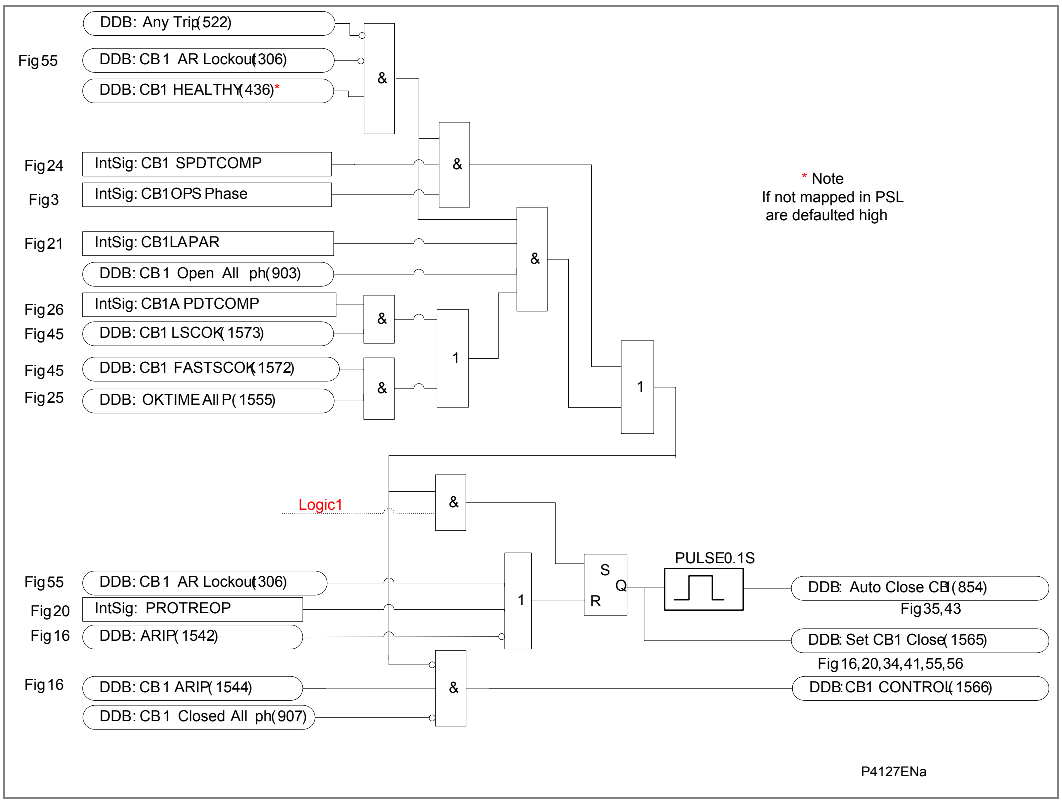
AR Figure 27: Intentionally blank from dual CB

AR Figure 28: Intentionally blank from dual CB

AR Figure 29: Intentionally blank from dual CB

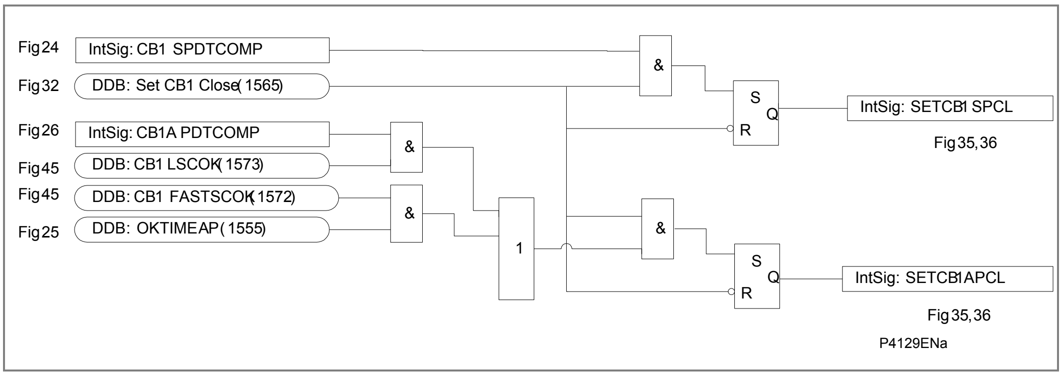
AR Figure 30: Intentionally blank from dual CB

AR Figure 31: Intentionally blank from dual CB

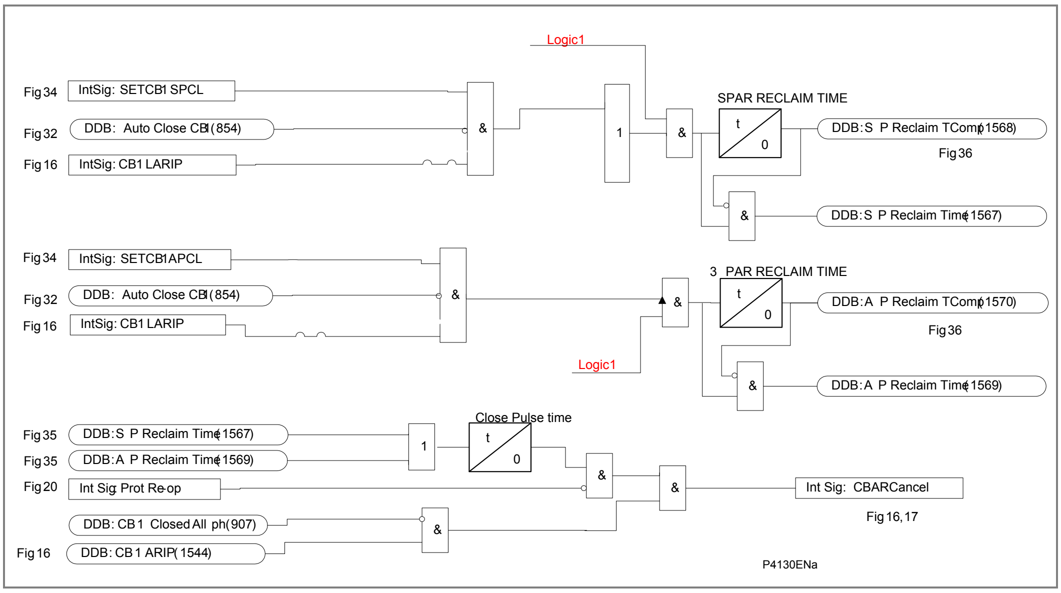


AR Figure 32: CB Auto close

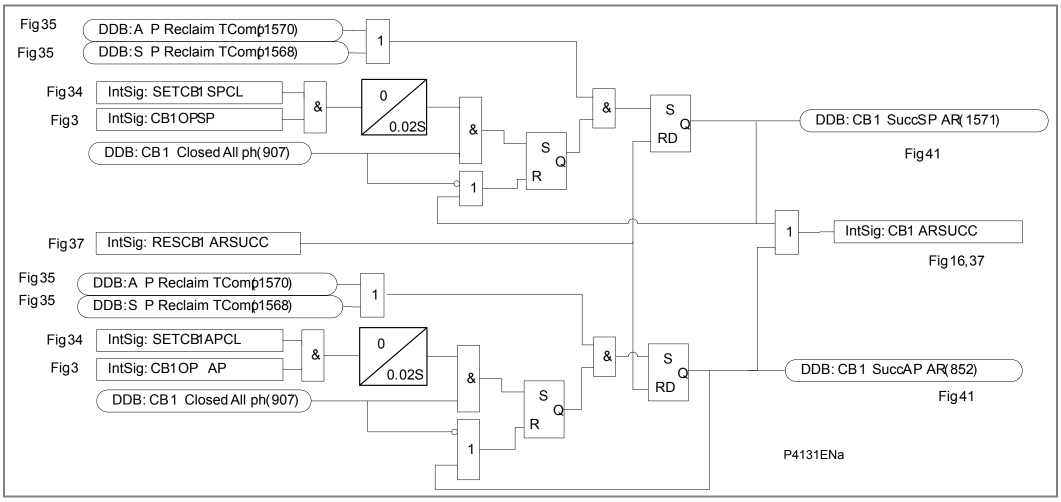
AR Figure 33: Intentionally blank from dual CB



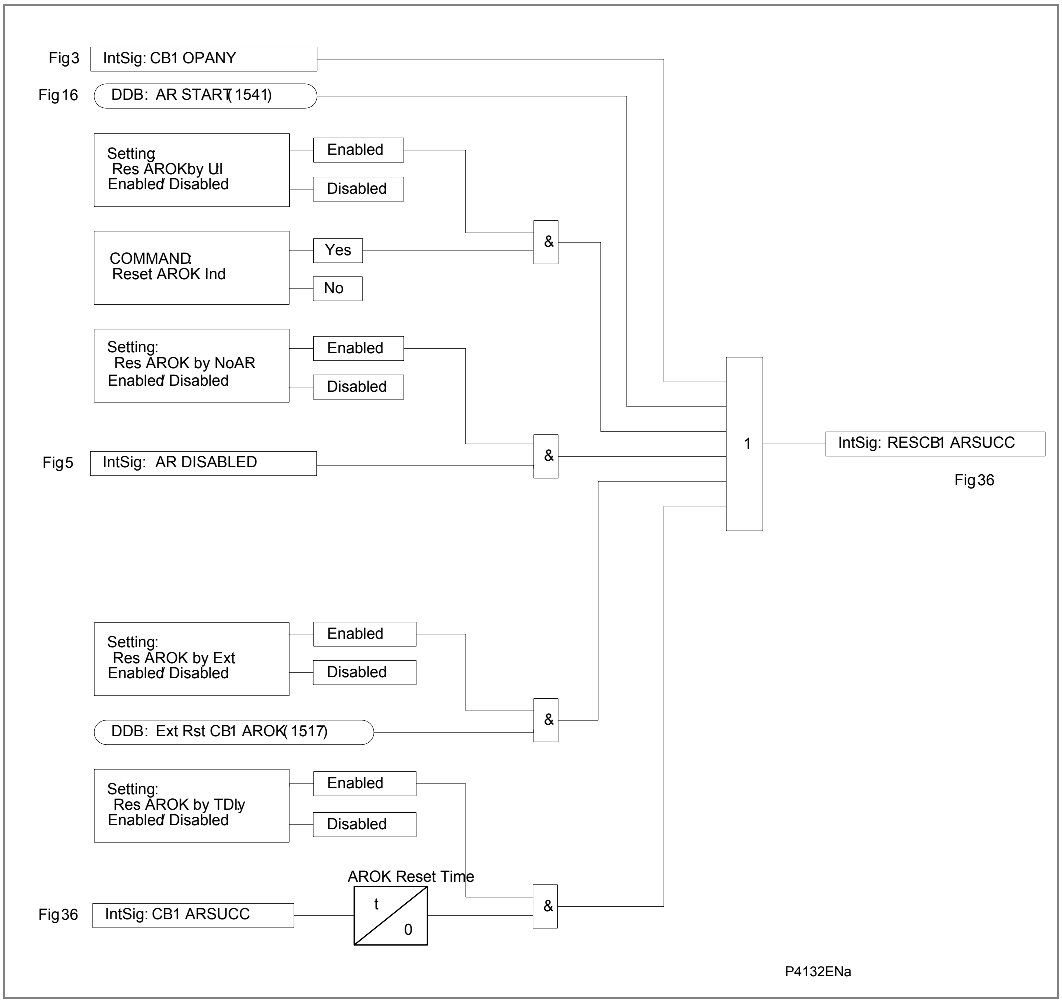
AR Figure 34: Prepare reclaim initiation



AR Figure 35: Reclaim time

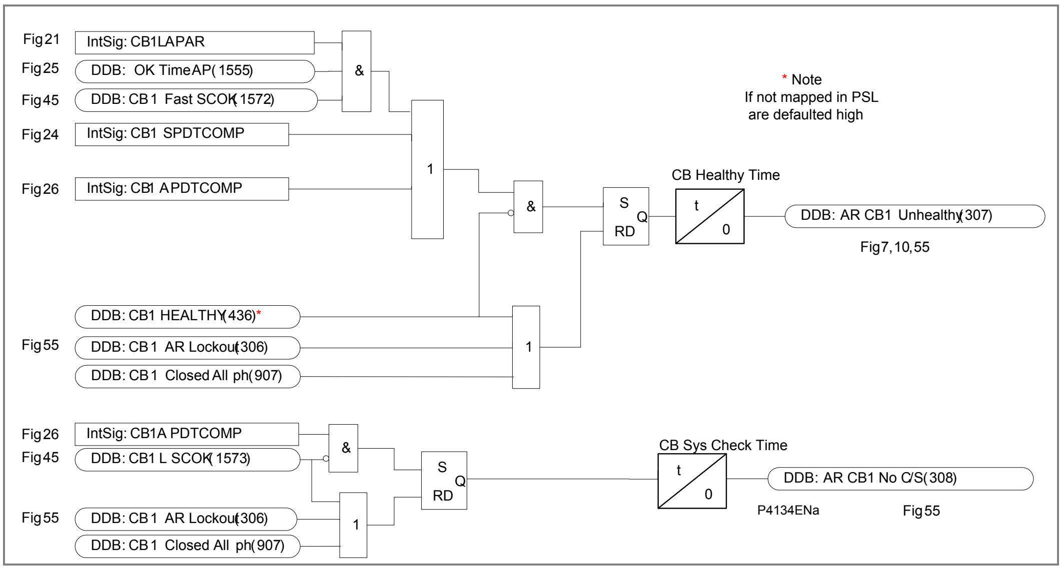


AR Figure 36: Successful auto-reclose signals



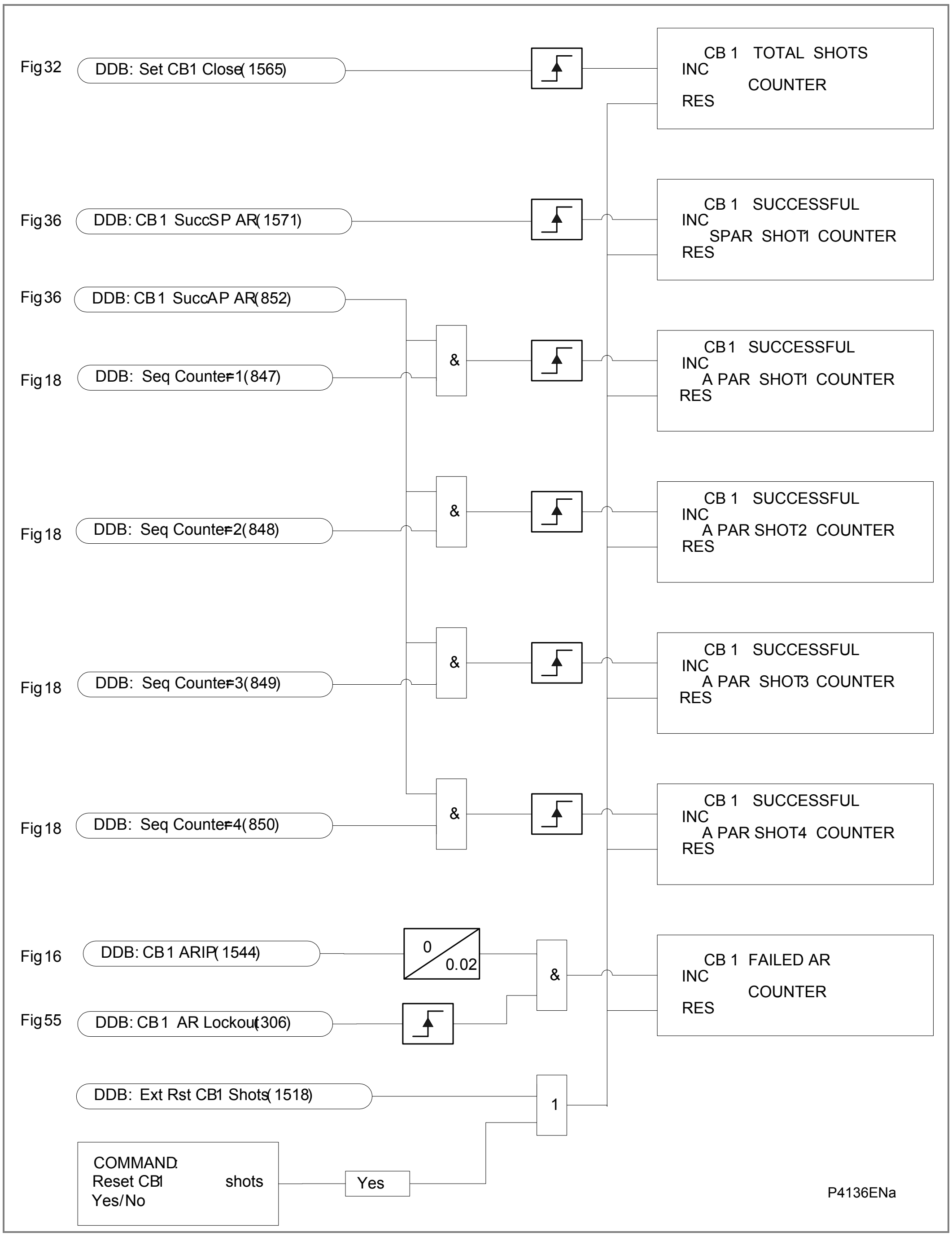
AR Figure 37: Reset successful AR indication

AR Figure 38: Intentionally blank from dual CB



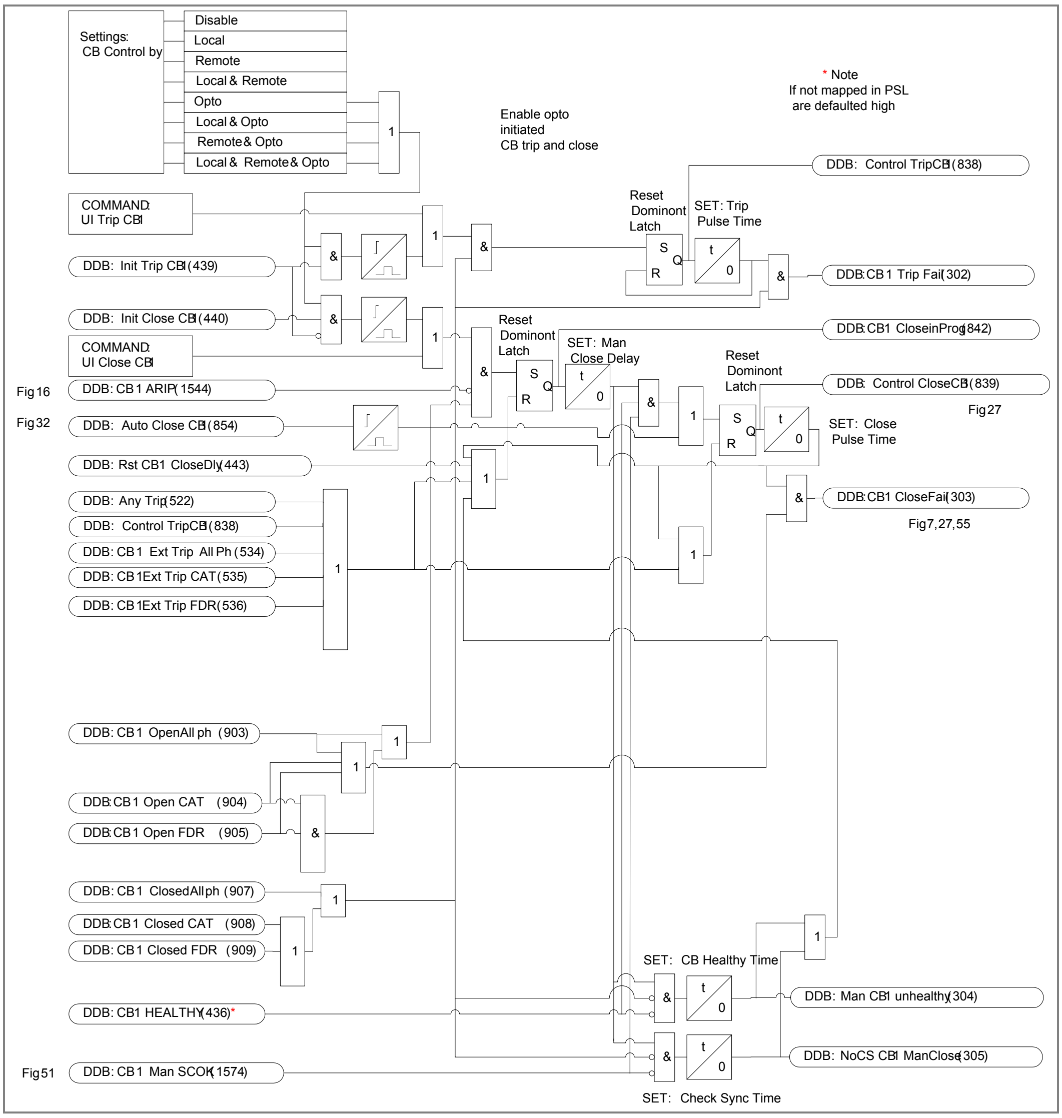
AR Figure 39: CB healthy & system check timers

AR Figure 40: Intentionally blank from dual CB



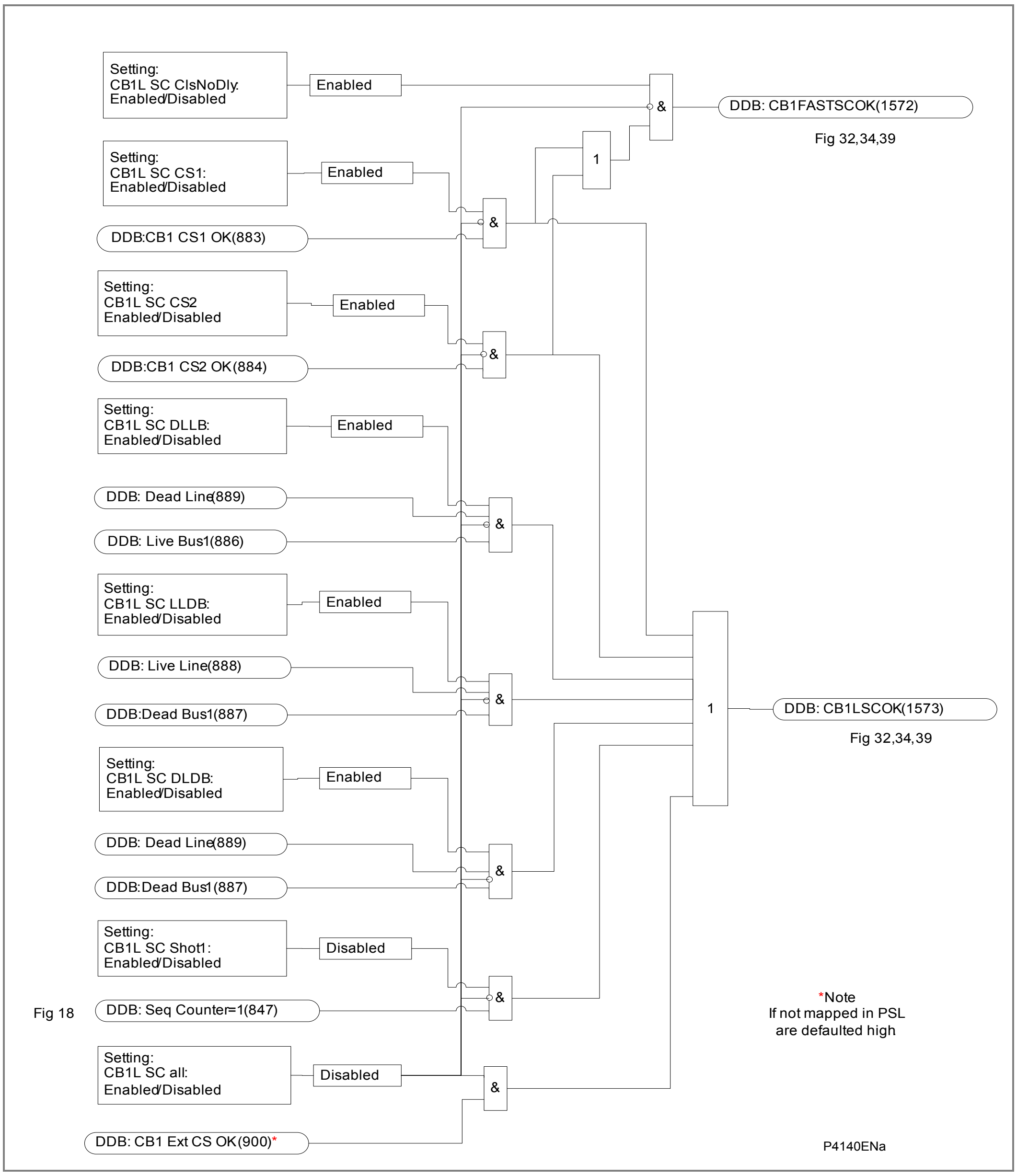
AR Figure 41: AR shots counters

AR Figure 42: Intentionally blank from dual CB



AR Figure 43: Circuit breaker control

AR Figure 44: Intentionally blank from dual CB



AR Figure 45: All Pole AR system check

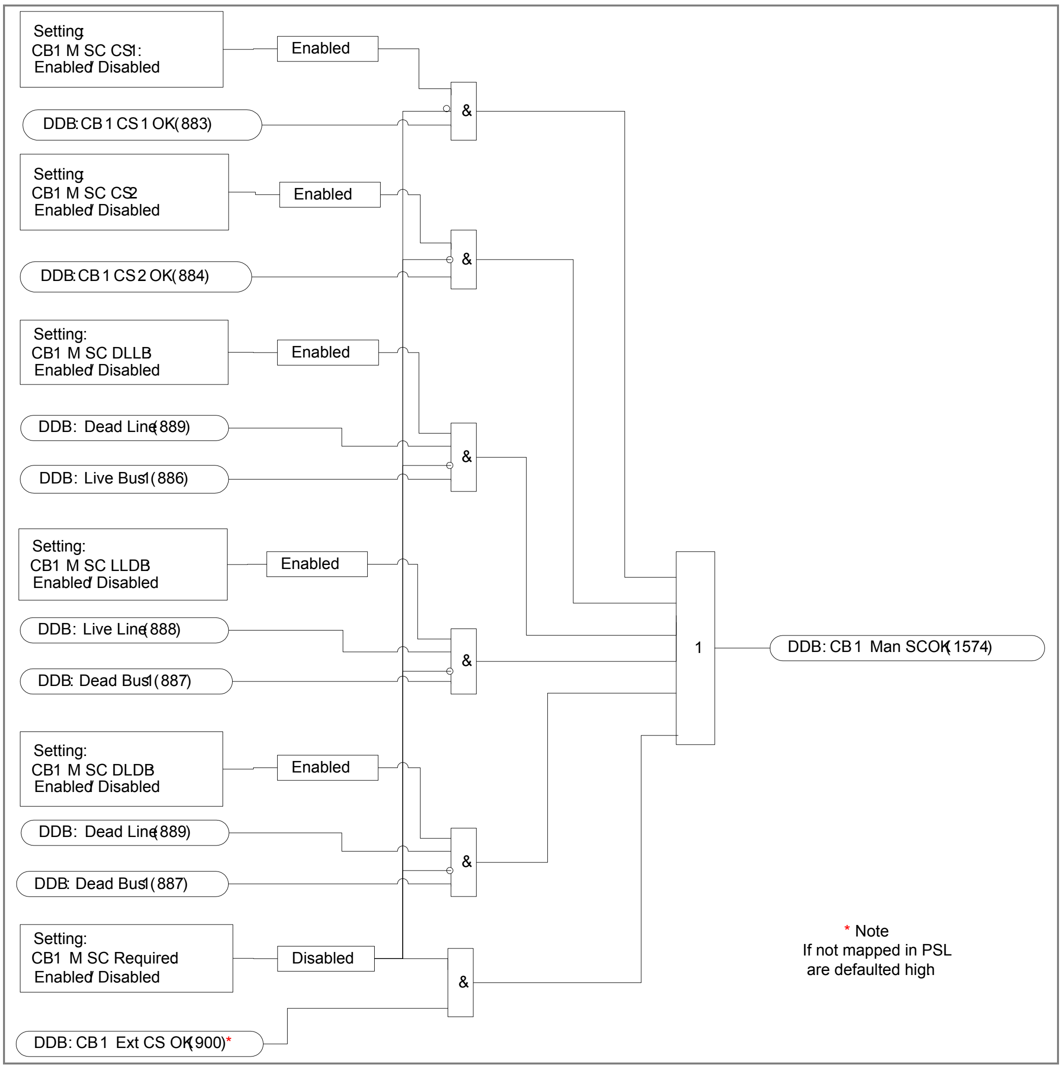
AR Figure 46: Intentionally blank from dual CB

AR Figure 47: Intentionally blank from dual CB

AR Figure 48: Intentionally blank from dual CB

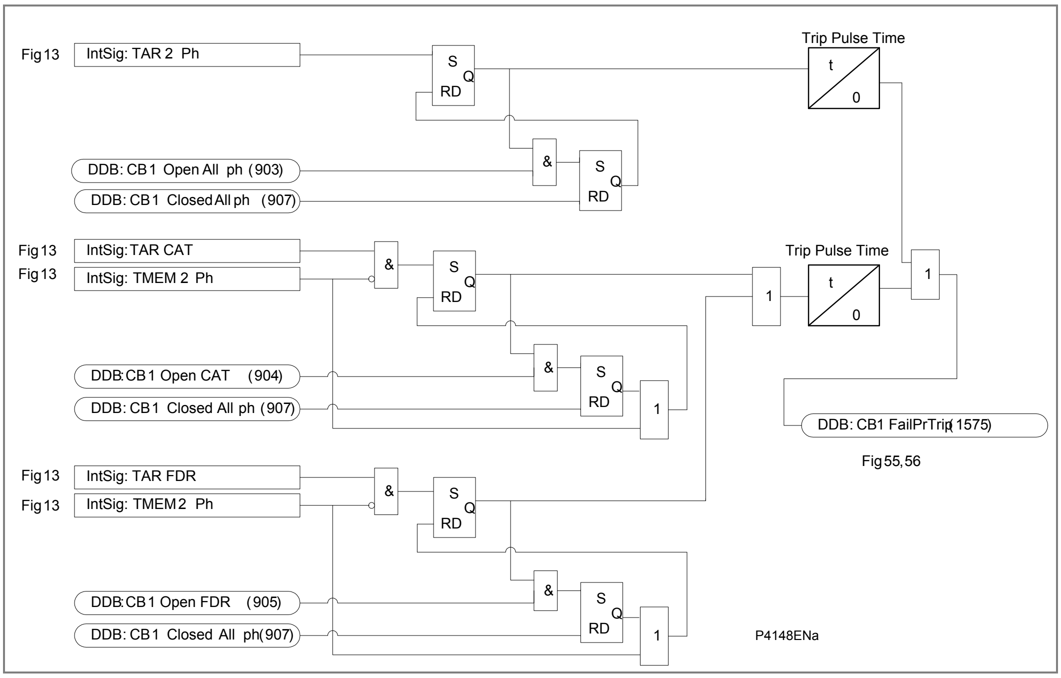
AR Figure 49: Intentionally blank from dual CB

AR Figure 50: Intentionally blank from dual CB



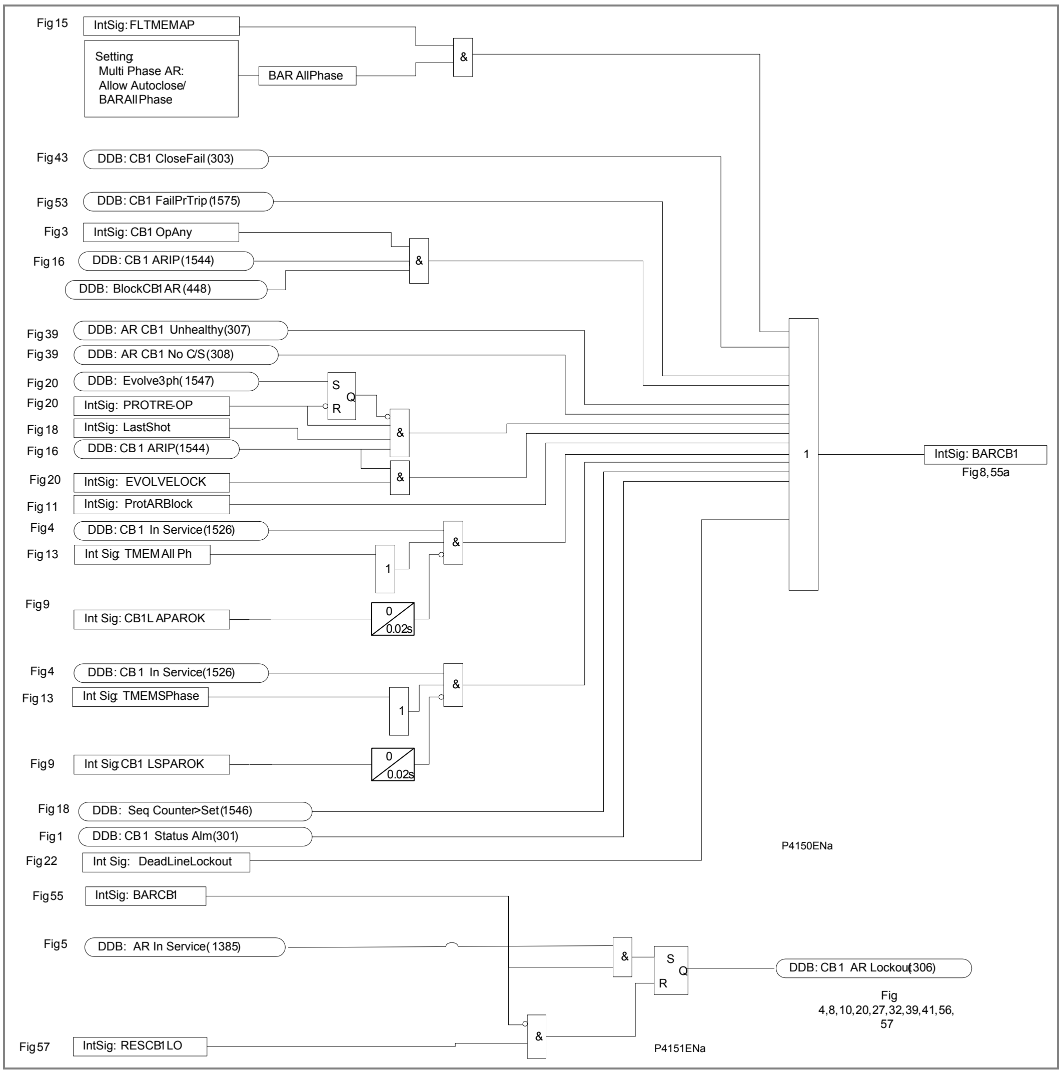
AR Figure 51: CB man. close system check

AR Figure 52: Intentionally blank from dual CB



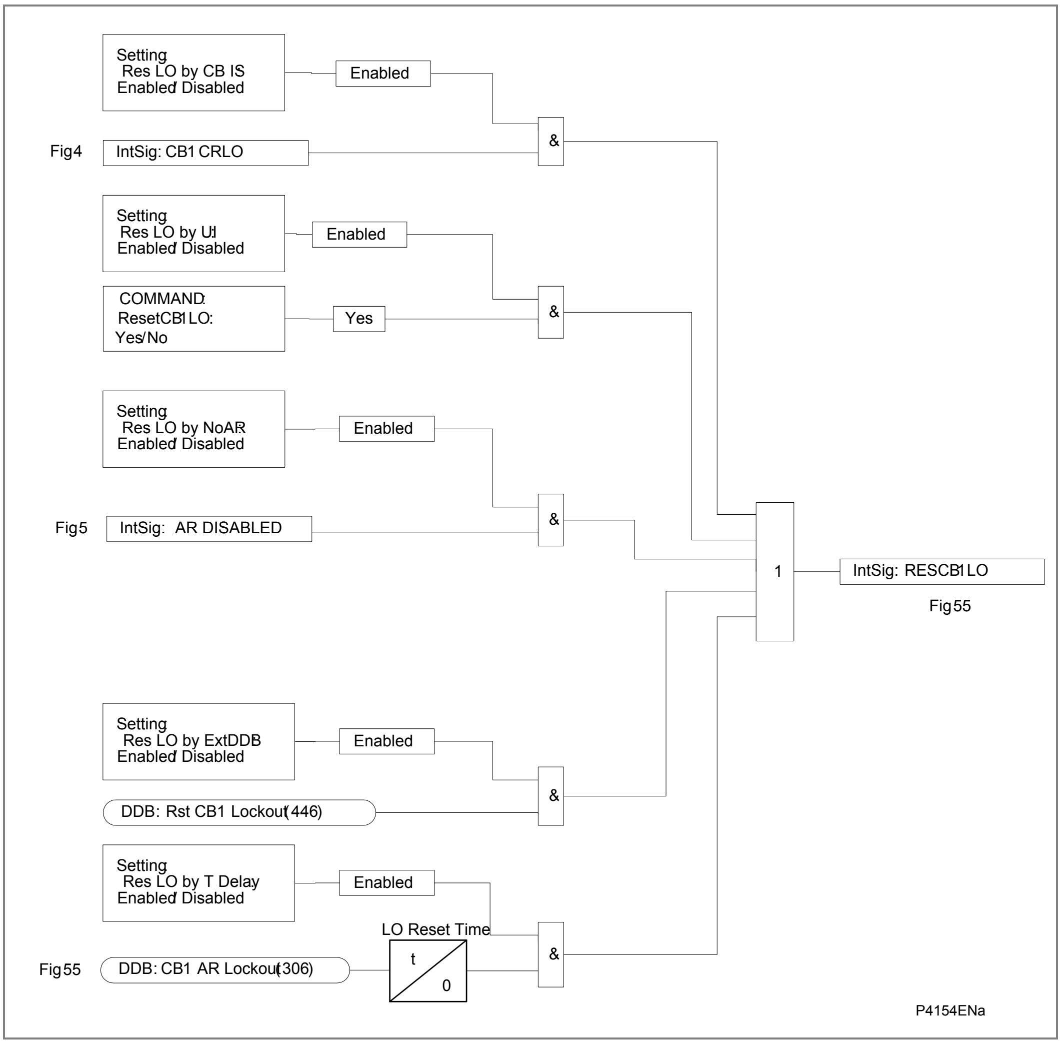
AR Figure 53: CB trip time monitor

AR Figure 54: Intentionally blank from dual CB



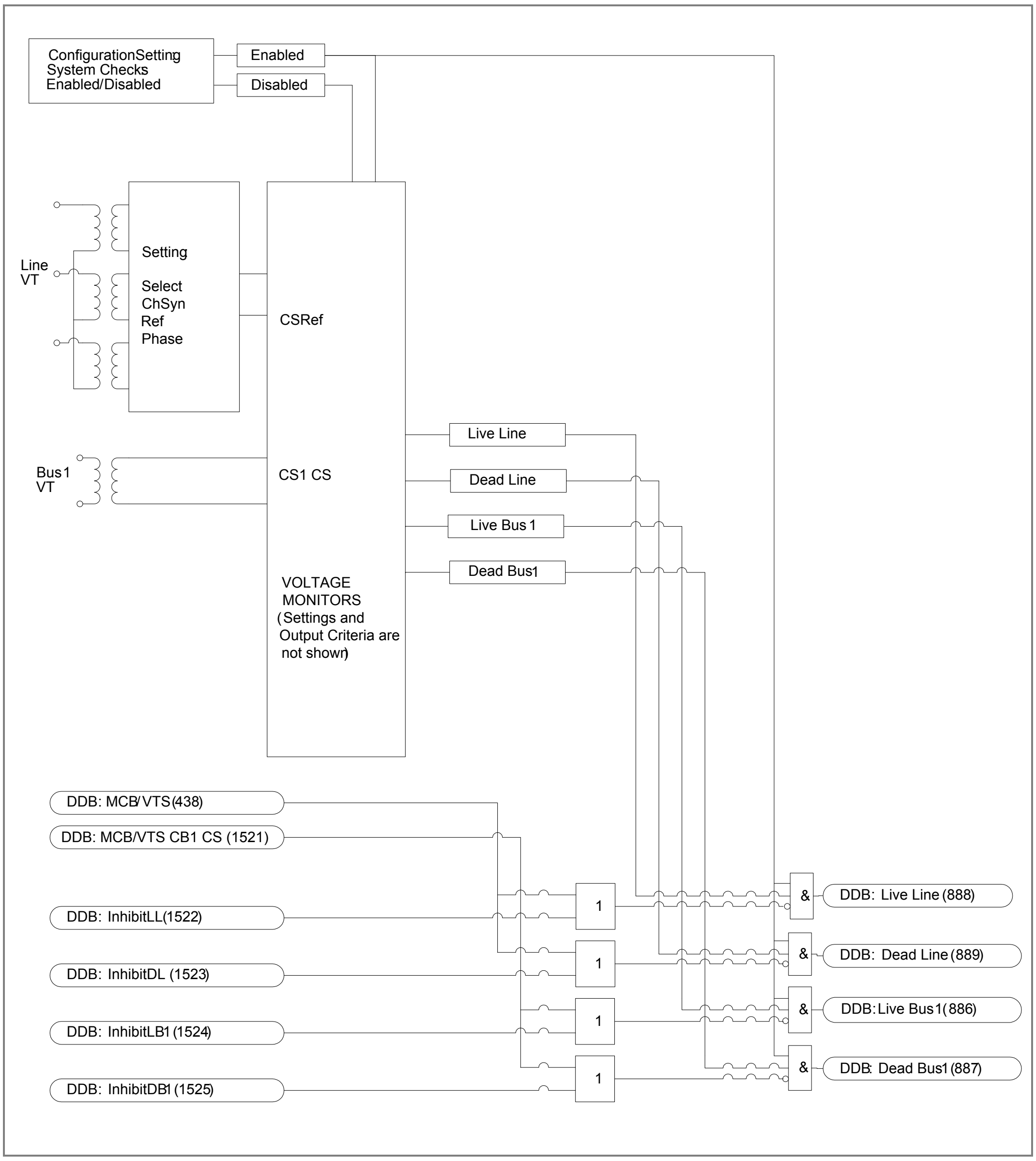
AR Figure 55: Auto-reclose lockout and AR Figure 55a: Auto-reclose lockout

AR Figure 56: Auto-reclose lockout

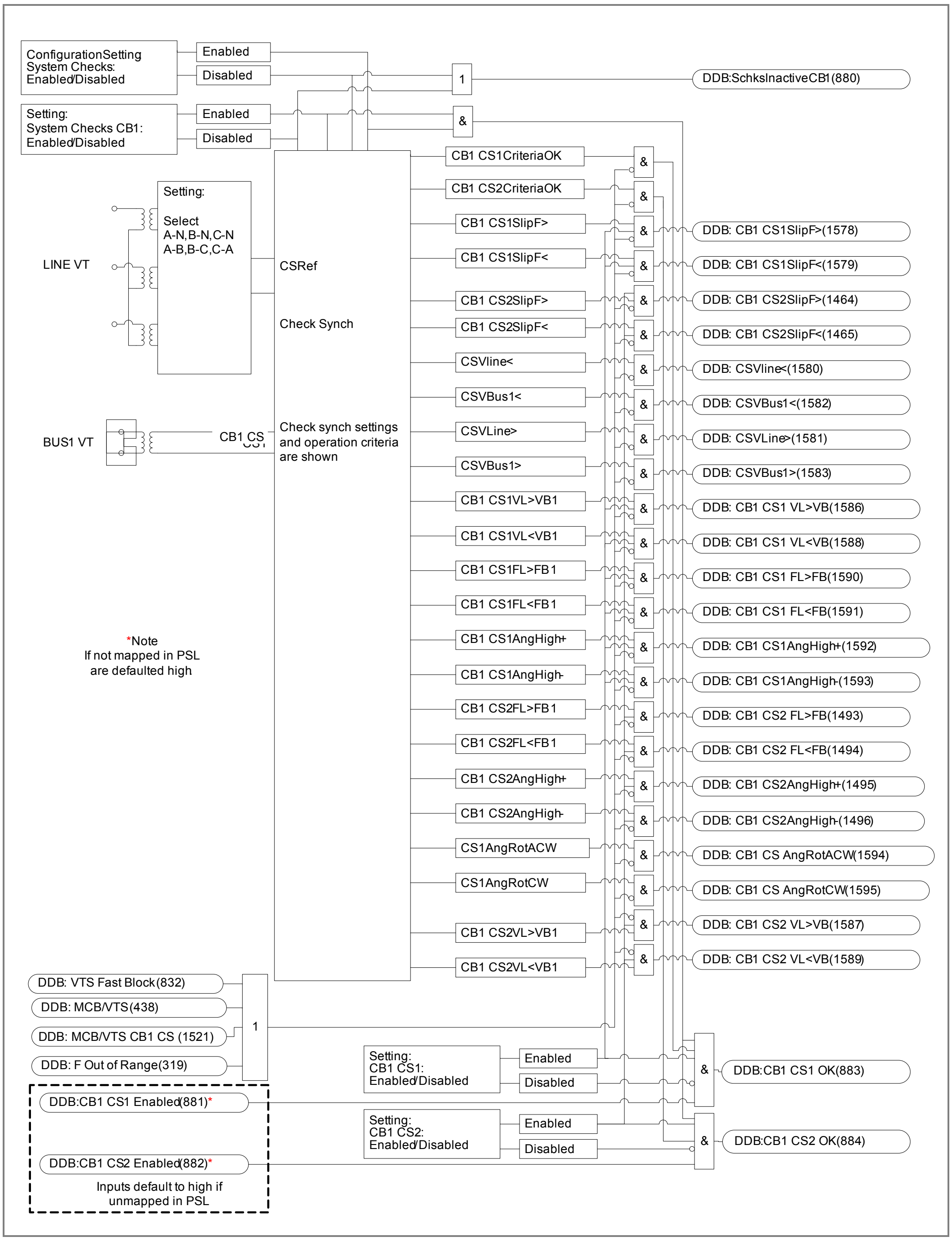


AR Figure 57: Reset CB1 lockout

AR Figure 58: Intentionally blank from dual CB

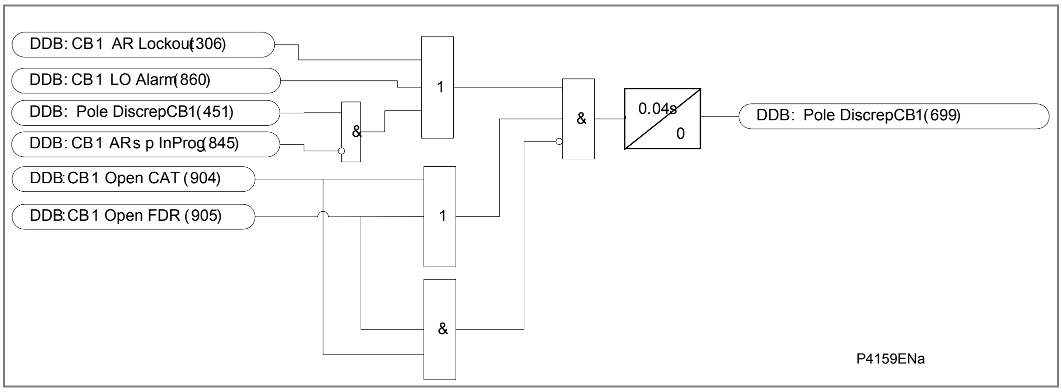


AR Figure 59: System checks – voltage monitor

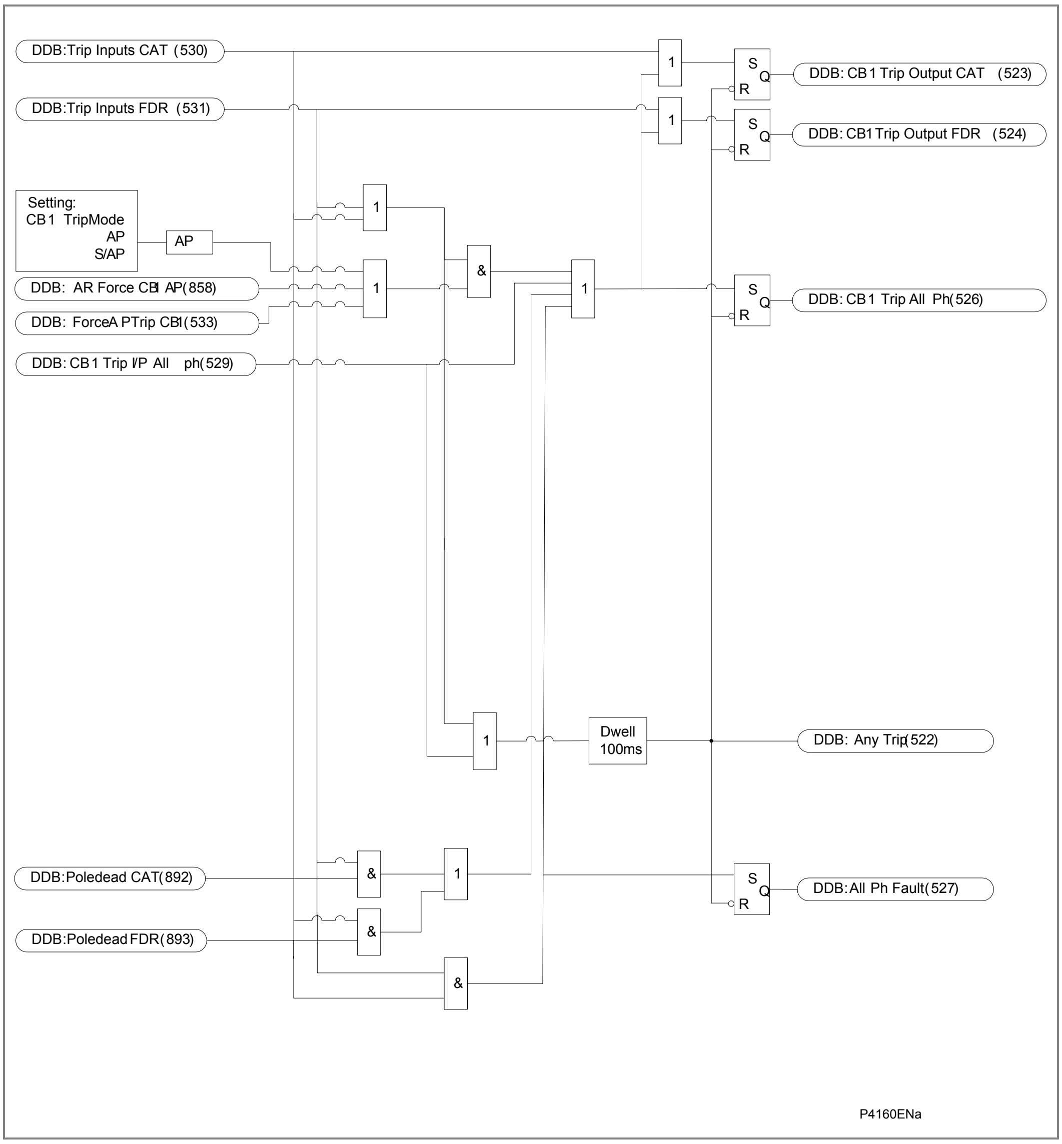


AR Figure 60: CB1 synch check signals

AR Figure 61: Intentionally blank from dual CB



AR Figure 62: Pole discrepancy



AR Figure 63: CB trip conversion

24 CIRCUIT BREAKER CONTROL AND AUTO-RECLOSE LOGIC (INTERNAL SIGNAL DEFINITIONS)

This section lists only the hard-coded internal signals used in the circuit breaker control. The DDB signals featuring in the logic are described in Appendix C of this manual.

Name	Description
APDTCOMP	Int Sig: All phase dead time complete
AR DISABLED	Int Sig: Overall autoreclosing disabled
BAR CB1	Int Sig from "Autoreclose Lockout – CB1"
CB1 APDTCOMP	Int Sig: CB1 APAR dead time complete
CB1 APOK	Int Sig: CB1 OK for AP AR (leader or follower)
CB1 ARSUCC	Int Sig: CB1 auto-reclose sucessful
CB1 CS1 AngHigh-	Int Sig + DDB: Line/Bus1 phase angle in range: -CB1 CS1 Angle to -180deg
CB1 CS1 AngHigh+	Int Sig + DDB: Line/Bus1 phase angle in range: +CB1 CS1 Angle to +180deg
CB1 CS1 FL<FB	Int Sig + DDB: Bus1 F > (Line F + "CB1 CS1 SlipFreqf")
CB1 CS1 FL>FB	Int Sig + DDB: Line F > (Bus1 F + "CB1 CS1 SlipFreqf")
CB1 CS1 OK	Int Sig + DDB: CB1 CS1 is enabled and Line and Bus 1 voltages meet CB1 CS1 settings
CB1 CS1 SlipF<	Int Sig + DDB: Line-Bus 1 slip freq < CB1 CS1 SlipFreq setting
CB1 CS1 SlipF>	Int Sig + DDB: Line-Bus 1 slip freq > CB1 CS1 SlipFreq setting
CB1 CS1 VL<VB	Int Sig + DDB: Bus1 V > (Line V + "CB1 CS1 VDiff")
CB1 CS1 VL>VB	Int Sig + DDB: Line V > (Bus1 V + "CB1 CS1 VDiff")
CB1 CS2AngHigh-	Int Sig + DDB: Line/Bus1 phase angle in range: -CB1 CS2 Angle to -180deg
CB1 CS2AngHigh+	Int Sig + DDB: Line/Bus1 phase angle in range: +CB1 CS2 Angle to +180deg
CB1 CS2FL<FB	Int Sig + DDB: Bus1 F > (Line F + "CB1 CS2 SlipFreqf")
CB1 CS2FL>FB	Int Sig + DDB: Line F > (Bus1 F + "CB1 CS2 SlipFreqf")
CB1 CS2OK	Int Sig + DDB: CB1 CS2 is enabled and Line and Bus 1 voltages meet CB1 CS2 settings
CB1 CS2SlipF<	Int Sig + DDB: Line-Bus 1 slip freq < CB1 CS2 SlipFreq setting
CB1 CS2SlipF>	Int Sig + DDB: Line-Bus 1 slip freq > CB1 CS2 SlipFreq setting
CB1 CS2VL<VB	Int Sig + DDB: Bus1 V > (Line V + "CB1 CS2 VDiff")
CB1 CS2VL>VB	Int Sig + DDB: Line V > (Bus1 V + "CB1 CS2 VDiff")
CB1 LARIP	Int Sig : CB1 ARIP as leader
CB1 Op1P	Int Sig: CB1 open single phase
CB1 OpAny	Int Sig: CB1 open on 1 or all phases
CB1 SPOK	Int Sig: CB1 OK for SP AR (leader or follower)
CB1 SysCh Off	Int Sig + DDB: CB1 CS1 & CB1 CS2checks disabled
CB1CRLO	Int Sig: CB1 in service – reset CB1 lockout
CB1LAPAR	Int Sig from "All Phase AR Cycle Selection"
CB1LAPAROK	Int Sig: CB1 OK to APh AR as leader
CB1LFRC	Int Sig: CB1 failed to reclose as leader
CB1LFRC	Int Sig from "Leader/Follower Logic – 1"
CB1LSPAR	Int Sig from "Single Phase AR Cycle Selection"
CB1LSPAROK	Int Sig: CB1 OK to SP AR as leader
CB1SPDTCOMP	Int Sig: CB1 SP dead time complete

Name	Description
CBARCancel	Int Sig: Stop and reset CB1 and CB2 AR In progress
CS VBus1<	Int Sig + DDB: Bus1 Volts < CS UV setting
CS VBus1>	Int Sig + DDB: Bus1 Volts > CS OV setting
CS VBus2<	Int Sig + DDB: Bus2 Volts < CS UV setting
CS VBus2>	Int Sig + DDB: Bus2 Volts > CS OV setting
CS VLine<	Int Sig + DDB: Line Volts < CS UV setting
CS VLine>	Int Sig + DDB: Line Volts > CS OV setting
CS1 Ang Rot ACW	Int Sig + DDB: Line freq > (Bus1 freq + 0.001Hz) (CS1 Angle Rotating Anticlockwise)
CS1 Ang Rot CW	Int Sig + DDB: Bus1 freq > (Line freq + 0.001Hz) (CS1 Angle Rotating Clockwise)
CS2 Ang Rot ACW	Int Sig + DDB: Line freq > (Bus2 freq + 0.001Hz) (CS2 Angle Rotating Anticlockwise)
CS2 Ang Rot CW	Int Sig + DDB: Bus2 freq > (Line freq + 0.001Hz) (CS2 Angle Rotating Clockwise)
Dead Bus 1	Int Sig + DDB: CS1 V magnitude < Dead Bus 1 setting
Dead Bus 2	Int Sig + DDB: CS2 V magnitude < Dead Bus 2 setting
Dead Line	Int Sig + DDB: Line V magnitude < Dead Line setting
DeadLineLockout	Int Sig: When setting “3PDT Start When LD” is set to Enabled and the line does not go dead for a time set by “Dead Line Time”, this signal forces the auto-reclose sequence to lockout.
ENABLE CB1APDT	Int Sig: Enable dead time for CB1 APAR
ENABLE CB1SPDT	Int Sig: Enable dead time for CB1 SPAR
EVOLVE LOCK	Int Sig: Lockout for 2nd trip after Discrim Tim
F Out of Range	Int Sig from frequency tracking logic
Foll CB1	Int Sig from “Leader & Follower Logic – 2”
INIT AR	Int Sig: Host protection required to initiate AR
Invalid AR Mode	Int Sig: An invalid state is being indicated by the logic that determines AR mode by opto.
Last Shot	Int Sig: the last shot
Live Bus 1	Int Sig + DDB: CS1 V magnitude >= Live Bus 1 setting
Live Bus 2	Int Sig + DDB: CS2 V magnitude >= Live Bus 2 setting
Live Line	Int Sig + DDB: Line V magnitude >= Live Line setting
OK Time SP	Int Sig from “Single Phase AR Lead CB Dead Time”
Prot AR Block*	Int Sig: Host protection required to block AR
Prot Re-op	Int Sig from “Protection Re-operation + Evolving Fault”
RESCB1ARSUCC	Int Sig from “Reset CB1 Successful AR Indication
RESCB1LO	Int Sig from “Reset CB1 Lockout”
RESPRMEM	Int Sig: Reset “trip & AR” memory
SC Increment	Int Sig: Increment the sequence counter
SCCountoveqShots	Int Sig: Sequence counter has exceeded setting
SET CB1CL	Int Sig from “CB1 Auto Close”
SET LCB1	Int Sig: CB1 selected leader
SET LCB1	Int Sig from “Leader/Follower Logic – 1”
SETCB1APCL	Int Sig: CB1 three phase close given
SETCB1SPCL	Int Sig: CB1 single phase close given
SPDTCOMP	Int Sig: Single phase dead time complete
TAR APh	Int Sig: APh trip & AR initiation
TAR Cat	Int Sig: Cat trip & AR initiation

Name	Description
TARANY	Int Sig from “CB1 Single Pole / A Pole Trip + AR Initiation”
TARANY	Int Sig: Any trip & AR initiation
TAR Fdr	Int Sig: Fdr Ph trip & AR initiation
TMEM SPh	Int Sig: CB1 SPh trip +AR AR initiation memory
TMEM APh	Int Sig: CB1 aPh trip +AR AR initiation memory
TMEM ANY	Int Sig: Any Ph trip & AR initiation memory

Table 27: Internal Signal Definitions

APPLICATION EXAMPLES

CHAPTER 8

1 CHAPTER OVERVIEW

The Application chapter describes how the MiCOM P44T can be applied, providing application examples where appropriate.

This chapter consists of the following sections:

2 INTRODUCTION

2.1 Railway Protection

High speed, regional and urban rail networks worldwide are electrified to provide the motive power for trains. The electrification system distributes the power and acts as the interface to transfer power to each train. Power can be distributed using an overhead catenary above the track with current collection by a pantograph. Alternatively the rails can be electrified, with current collection through contact shoes. Overhead catenaries are generally viewed to be safer, as they are above the track, out of reach of rail personnel and the public, and can use high feeding voltages. The nominal feeding voltage is typically 11 to 50kV with respect to the running rails. It uses single phase ac, although 1500V and 3kV dc catenaries are predominant in some countries. Using live rail feeding, the system voltage is generally 600V to 1700V dc.

These application notes cover protection associated with HV overhead catenary electrification. Worked examples are used to help setting the most frequently-applied elements in the MiCOM P44T IED. Line faults can be common, often amounting to one fault per year for every kilometre of track. The number of faults, coupled with the high tension in the contact wire (typically 6 to 20 KN) makes fast fault clearance imperative. If faults are not cleared quickly, the conductors that make up the catenary may break due to intense overheating, risking further severe damage.

2.2 Classic Railway System

2.2.1 Classical Single Phase Feeding

Electrification at 50 or 60Hz, single phase ac has become the standard and the P44T has been designed for this application. The following diagram shows classical 25 kV feeding with booster transformers (BT) used to force return current to flow in a return conductor. This limits traction current returning through the rails and earth, and reduces electromagnetic interference with any adjacent communication circuits. The traction supply is generally provided by a transformer connected phase-to-phase across one phase pair of the utility grid. Power is fed to the train through the overhead catenary, with the return current flowing through the rails and the return conductor.

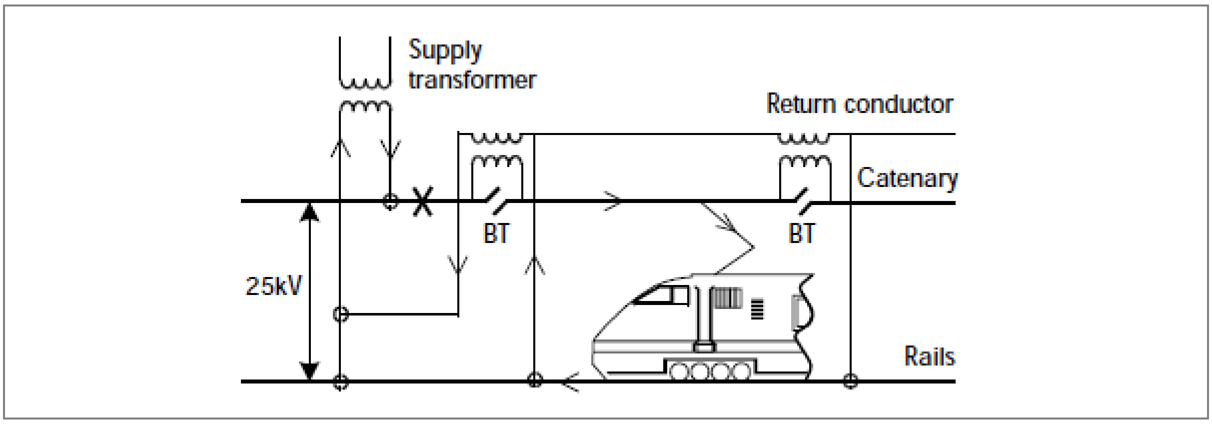
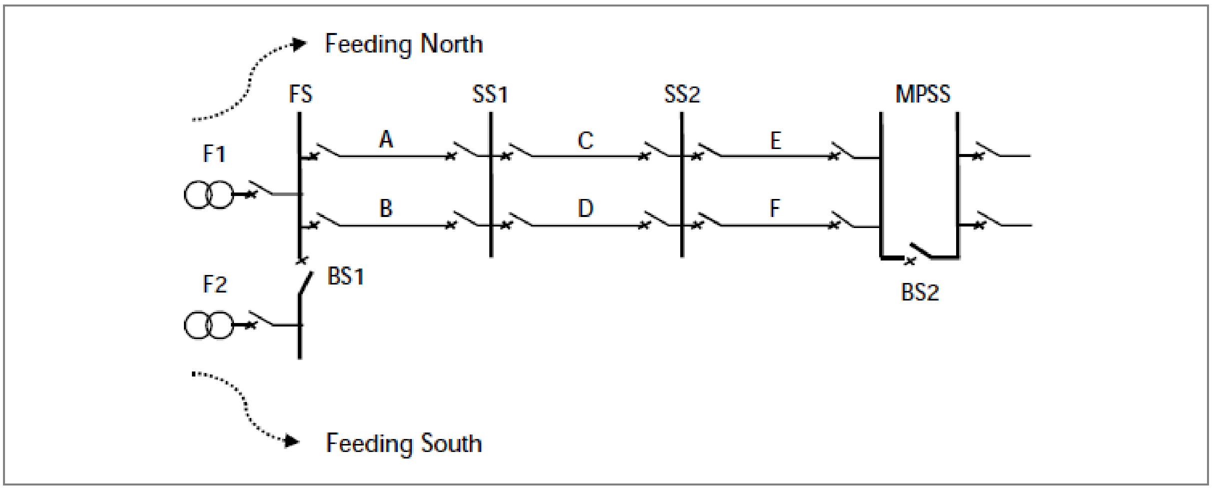


Figure 1: Simple 25kV feeding with booster transformers

As the running rails are regularly bonded to earth and are nominally at earth potential, it is only necessary to disconnect the supply to the catenary if there is a fault. Therefore it uses single pole switchgear tripping the catenary circuit only.

2.2.2 Classical System Feeding Diagram

Single track railway lines are rare and two or four parallel tracks are more common. The overhead line equipment consists of two or four electrically independent catenaries running in parallel.



FS = Feeder Station

SS1 / SS2 = Sectioning Substations

BS1 / BS2 = Bus Section

MPSS = Mid Point Section Substation

Figure 2: Typical two track railway electrified with classical 25 kV single phase ac

The infeed to the tracks in the “north” direction is through grid transformer F1 at the Feeder Station (FS). The power is then distributed through catenaries A and B to the trains. At intervals it is usual to couple the two catenaries. This allows the load current to flow in parallel paths, reducing the feeding impedance and line voltage drops. This is done at paralleling or sub-sectioning substations SS1 and SS2. Circuit breakers for each of the outgoing feeds to the catenaries allow sub sectioning. This is the ability to disconnect supply from sections of catenary if there is a fault or to allow maintenance work. A fault on catenary A would trip circuit breaker A at the feeder station, and breaker A at SS1. The infeed to the double-end fed section would be removed and the feeding to healthy sections B, C, D, E and F would be unaffected.

The infeed from F1 generally feeds only as far as the normally open bus section circuit breaker (BS2) at the mid-point substation (MPSS). Beyond the MPSS there is a mirror image of the feeding shown F1 to BS2, with the remote end feeder station often 40 to 60 km from F1. BS2 must remain open during normal feeding. This avoids paralleling of supplies that may be derived from different phase pairs on the utility grid. For example, Phase A-B at F1 and B-C at the next FS north. The same is true for BS1, which normally remains open. This is because F1 and F2 feeds are generally from unlike phase pairs in an attempt to balance the loading on the three phase utility grid.

2.2.3 Classical System Protection Philosophy

The grid infeed transformers often are rated at 10 to 25 MVA, with a relatively high reactance of around 10%. Therefore even for a fault at the Feeder Station busbar, the maximum prospective short circuit current is low in comparison to a utility system. This is typically only 10 times the rating of a single catenary. When faults occur further down the track, the additional ohms/km characteristic impedance of the catenary and return conductor need to be added in the fault loop. One ohm per mile (0.6Ω/km) is typical. Therefore for a fault at the remote end of a protected section (Catenary section A in Figure 2), the current measured at the upstream circuit breaker location (circuit breaker A at the FS) may be twice the rated current. Therefore overcurrent protection can be applied at Feeder Stations.

This is because there is a sufficient margin between the maximum continuous load current and the fault current at the remote end of sections.

However, overcurrent protection is often used only as time-delayed back-up protection on railways for the following reasons:

- The protection needs to be discriminative and should only trip the two circuit breakers associated with the faulted line section. Therefore the protection needs to be directionalised. This ensures that it responds to fault current flowing into the section and not reverse fault current flow. For example, at location SS1 the protection for catenaries A and B looks back towards the grid infeed. For a fault close to the FS on catenary A, the remote end protection measures only the proportion of fault current that flows through unfaulted catenary B, and then a “hairpin” path to SS1 and back along catenary A to the location of the fault. This fault current contribution may be less than the rated load current.
- For protection at SS1, SS2 and MPSS, the prospective fault current levels are progressively smaller. The measured fault current may be lower than the rated current.
- During outages of grid supply transformers, alternative feeding may be necessary. One possibility is to extend the feeding by closing the bus section circuit breaker at the MPSS. Beyond the MPSS, the prospective fault current levels are then much lower than normal.

Distance protection has been the most proven method of protecting railway catenaries. This is due to its ability to remain stable for heavy load current while tripping for low levels of fault current. Fault current generally lags the system voltage by a greater phase angle than is usual under load conditions. This phase angle measurement is an important part of a distance IED’s trip characteristics.

2.3 Auto-transformer Railway System

2.3.1 Auto-transformer Phase Feeding

Auto-transformer feeding is typical for high speed routes with trains running at speeds of 200 km/h (125 mph). Each train is rated at around 8 MW and the heavy load currents drawn cause significant voltage drops across the catenary feeding impedance. To avoid a decrease in train performance, feeder stations and paralleling substations for classical systems would need to be very short distances apart.

Auto-transformer feeding uses a centre-tapped high voltage system. Trains are typically supplied at half this voltage between the catenary and rail, connected using a pantograph. Each catenary has a feeder wire which has a supply voltage in antiphase to the catenary. The feeder wire is aerially mounted, supported on insulators along the back of the overhead line masts.

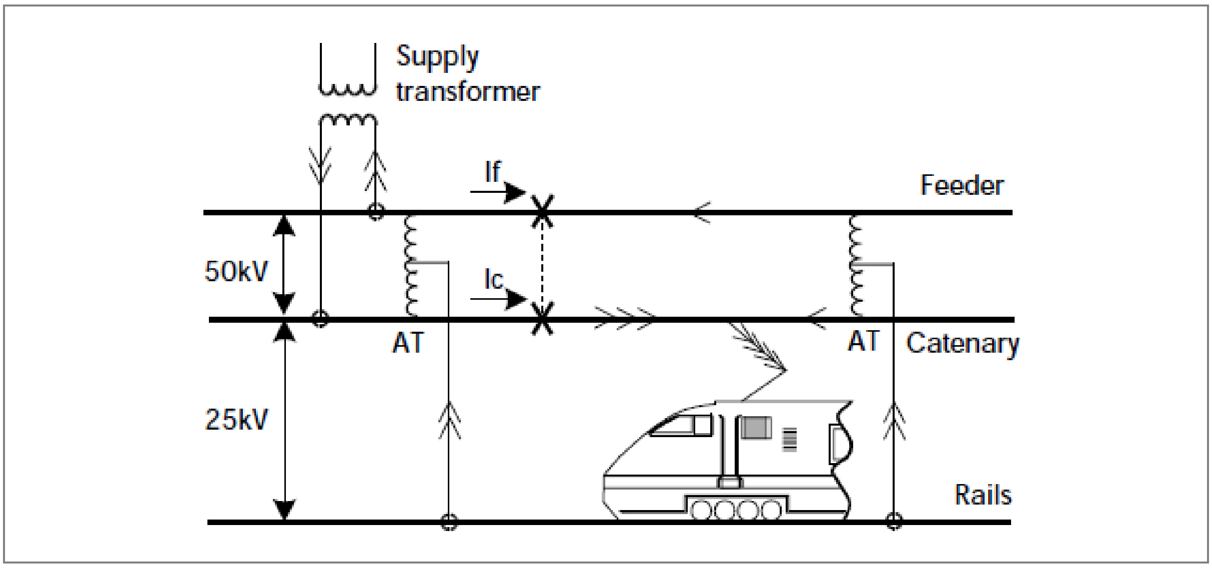


Figure 3: Typical Western European 25-0-25kV auto-transformer feeding

Auto-transformers (AT) allow distribution losses lower than for simple 25 kV feeding. They also allow high power 25 kV traction units to run. The switchgear shown is double pole, isolating both the feeder and catenary circuits if there is a line fault. Alternatively they can be single pole with one distance protection IED for each catenary or for each feeder.

The P44T can be set to provide single or double pole tripping. The IED then protects the two halves of the system independently. In this case Zone 1 and Zone 2 protection is set to typically 85% and 120% of the section, similar to the protection of a classical system.

Figure 3 shows the distribution of load current for a train situated midway between AT locations. Each arrow shows a unit of current equal to ¼ of the train load. Assume that two units of current are drawn from the 50 kV supply, with the flow to the train through the catenary. This current returns to the supply transformer through the upper half of the AT windings, with the load shared between the neighbouring ATs.

Each unit of current in the AT winding sets up an equal and opposite current in the lower winding, due to the 1:1 turns ratio. The only path for these currents is to circulate through a catenary-train-rail loop. This doubles the train current compared with the current drawn directly from the supply transformer.

The topology of the AT system is often similar to the classical system shown in Figure 2. However, the secondary winding of the supply transformer is wound as a centre-tapped AT winding. ATs are connected catenary-rail-feeder at each downstream substation such as SS1 and SS2 in Figure 2.

2.3.2 Auto-transformer System Protection Philosophy

Figure 3. shows that wherever the catenary current and the inverted feeder current is added in the system (Icat – Ifdr), the sum equals the load downstream. The same is true for fault current. Adding these currents by a parallel connection of CT secondaries, or by adding them in the IED, forms the basis of most protection methods.

Distance protection is commonly used to discriminate between load and faults, using the current input (Icat – Ifdr). The voltage input is generally the catenary-to-rail voltage. This is because the low reactance of the ATs ensures that any fault voltage drop on the feeder is mirrored on the catenary. The reactance of the ATs is typically 1% on a 10 MVA base.

When using distance zones to protect AT systems tripping double pole, it is not possible to provide fully-discriminative protection. This is because when a catenary and feeder current are combined, the linear relationship between distance to fault and measured impedance is lost. It then becomes difficult to set an underreaching Zone 1, and overreaching Zone 2 element in the normal way. It is better to detect all faults on any catenary or track from the Feeder Station to the Mid-Point Substation. This is done using distance IEDs installed at the Feeder Station. If there is a fault, the supply to all tracks is isolated by simultaneous tripping of all track feeder circuit breakers at the FS. This removes supply to more sections of track than necessary. Autoreclosure is therefore needed to restore supply to all sections of catenary and feeder, except those which are permanently faulted.

The momentum of moving trains ensures that little speed is lost during the dead time of autoreclose. The infrequent supply losses cause few operational problems. All line faults are isolated by tripping circuit breakers at the FS. Therefore there is no need to have switchgear at downstream substations which are rated at the interrupt fault current. For economy, load-breaking switches can be used instead of breakers at SS1 and SS2 in Figure 2.

3 APPLICATION OF INDIVIDUAL PROTECTION FUNCTIONS

The following sections detail the individual protection functions in addition to where and how they may be applied. Worked examples are provided to show how the settings are applied to the IED.

3.1 Distance Protection and Aided Scheme

3.1.1 Line Parameters Settings

Usually the data relating to 100% of the protected line is entered here. Input the Line Impedance that correctly corresponds to either Primary or Secondary, whichever has been chosen as the basis for Settings Values in the Configuration column.

3.1.2 Distance Operating Characteristic

3.1.2.1 Phase and Earth Characteristic

For railway applications a quadrilateral selection is used.

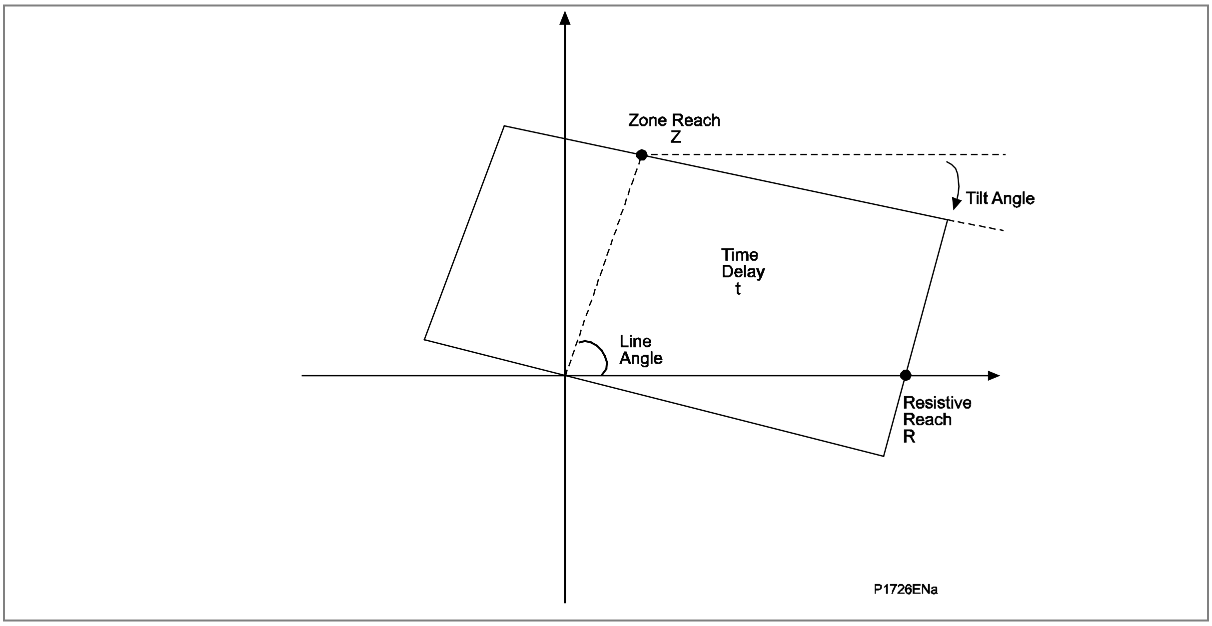


Figure 4: Settings to configure a forward-looking quadrilateral zone (blinder not shown)

3.1.3 Classical System Zone Reaches - recommended settings

Distance IEDs applied to a classical single phase system have two measurement inputs. One is a catenary-to-rail voltage input measured from a line or busbar-connected voltage transformer. The other is a track feeder current input measured from a current transformer for the circuit breaker feeding the protected section. Distance IEDs divide the vectors Voltage (V) / Current (I) to determine the load or fault impedance (Z). Typical IED characteristics are shown in the R + jX impedance plane, as shown in Figure 5.

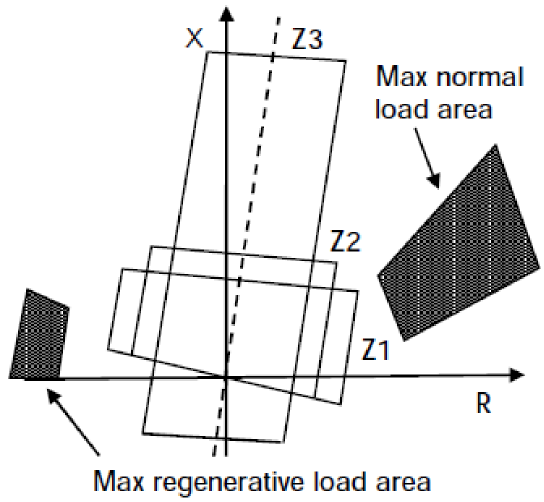


Figure 5: Polar impedance plot of typical trip characteristics

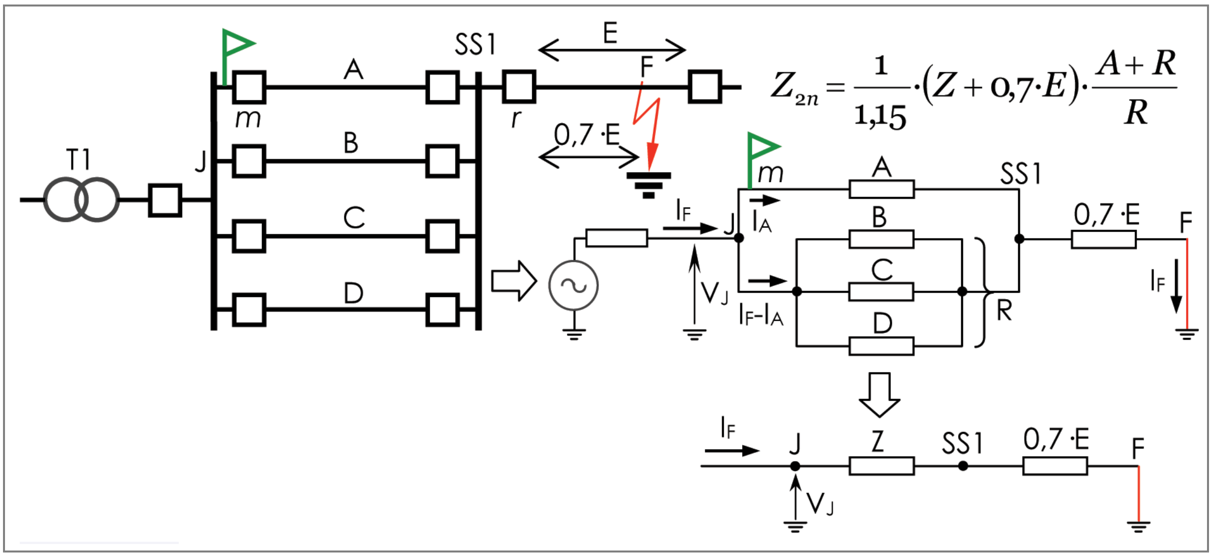
Faults on the catenary present impedance to the IED along the dotted line shown in Figure 5. The quadrilateral characteristics shown are directionalised to match the expected fault impedance of usually 70 to 75 degrees leading the resistive axis. The closer the fault is to the IED, the lower the measured fault impedance. Therefore the trip decision is given when the measured fault impedance falls within the tripping zones. Three zones (shown Z1, Z2, Z3) are commonly applied. The reach along the resistive axis is constrained to avoid tripping of the load current. All impedance reaches for distance zones are calculated in polar form: $Z \angle \Phi$, where Z is the reach in ohms and Φ is the line angle setting in degrees. For railway systems, where all catenaries share the same line angle, you can add and subtract section impedances algebraically, treating Z as a scalar quantity.

3.1.3.1 Zone 1

The Zone 1 elements of a distance IED are designed to protect as much of the immediate catenary section as possible. This is done without overreaching and tripping for faults out of section. In most applications the Zone 1 reach (Z1) cannot respond to faults beyond the protected catenary. Therefore instantaneous operation is set and there is no intentional time delay for tripping. For an underreaching application, the Zone 1 reach must be set to account for any possible overreaching errors. These errors come from the IED, the VTs and CTs, and inaccurate line impedance data. Restrict the reach of the Zone 1 elements to 85% of the protected line impedance and set Zone 2 elements to cover the final 15% of the line.

3.1.3.2 Zone 2

Set zone 2 elements to cover the 15% of the line not covered by Zone 1. They are time-delayed in their operation. Allowing for underreaching errors, set the Zone 2 reach (Z2) at more than 115% of the protected line impedance for all fault conditions. Set Zone 2 to reach further than this minimum to provide faster back-up protection for uncleared downstream faults. However, Zone 2 does not reach beyond the Zone 1 reach of downstream catenary protection. This principle is shown in Figure 6, for a four track system, where the local breaker for section E has failed to trip.



A = Protected Section Impedance

E = Shortest Following Section

Z = Equivalent Impedance of A, B, C, D in Parallel

R = Equivalent Impedance of B, C, D in Parallel

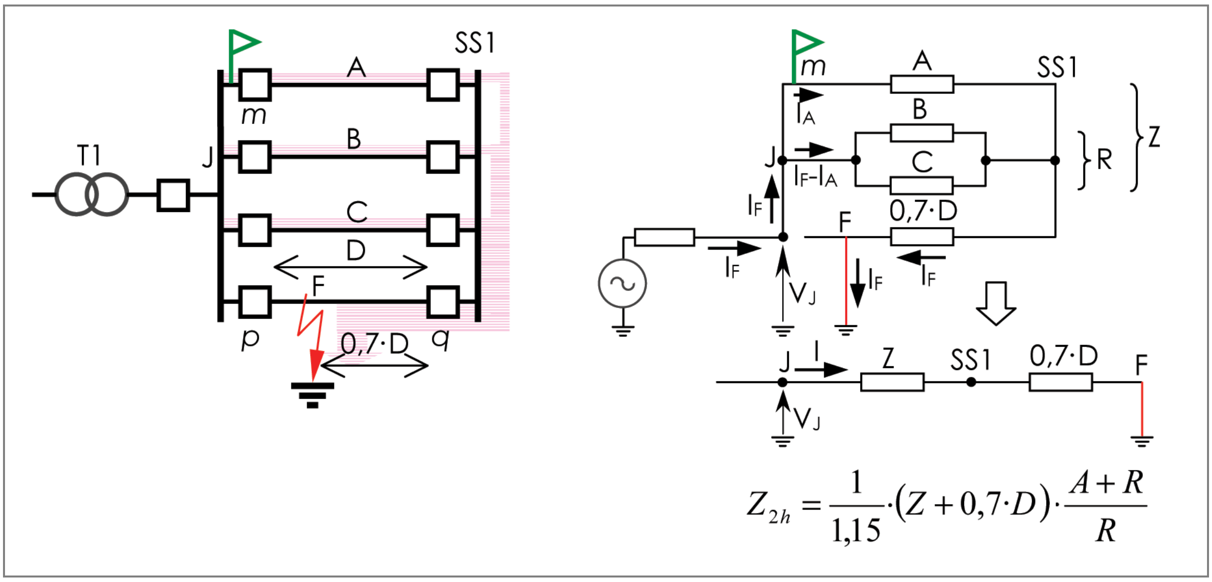
Figure 6: Fault considered for Zone 2 reach constraint (normal feeding)

To calculate Z2 for the left-most circuit breaker of protected catenary A, a fault is imagined to occur at 70% of the shortest following section. This is the closest location that unwanted overlap could occur with Z2 main protection for catenary E. The 70% figure is the nominal 85% Z1 reach for catenary E protection minus 15% for composite measuring errors at that location. The apparent impedance of the fault is then calculated as viewed from catenary A. Any fault impedance beyond the right-most busbar appears to be approximately four times its actual ohmic impedance. This is due to the fault current paralleling along four adjacent tracks. The setting applied to the IED is the result of this calculation, reduced by a further 15% to accommodate any measurement errors at IED A.

The equation for the Zone 2 reach becomes:

$$Z2 = (Z + 0.7 E) \times ((A+ R)/R) / 1.15$$

The possibility of current following an out and back hairpin path to faults has already been described. The IED must not overreach under these conditions. The feeding is shown in Figure 7.



A = Protected Section Impedance

D = Shortest Hairpin Fed Section

Z = Equivalent Impedance of A, B, C, in Parallel

R = Equivalent Impedance of B, C, in Parallel

Figure 7: Fault considered for Zone 2 reach constraint (hairpin feeding)

Figure 7 shows a fault that has been cleared at one end only, with the remote end breaker for section D failing to trip. The fault is assumed to be on the lowest impedance catenary, which is an important consideration when there are more than two tracks. In a four track system, mutual induction can cause inner (middle) track catenaries to have an ohms/km impedance 13% higher than the outside tracks.

The calculation is similar to that for normal feeding, except that the fault current is paralleled along three adjacent tracks (the number of tracks minus one). The three catenaries are the protected catenary A and the remainder of the unfaulted catenaries (R). In this case R represents catenaries B and C.

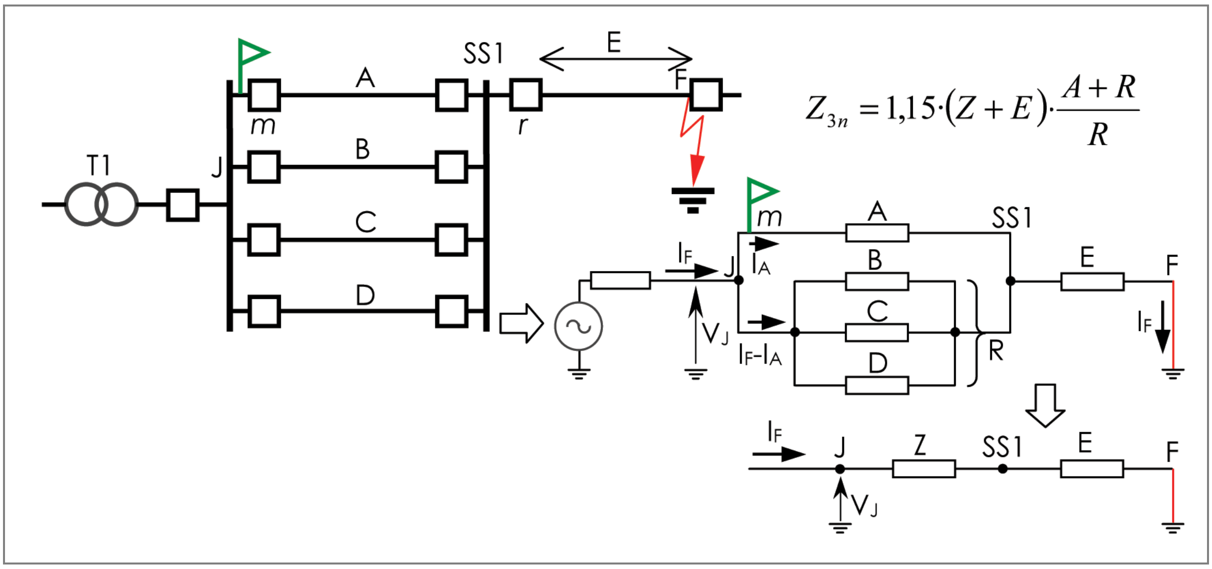
The equation for the hairpin Zone 2 reach becomes:

$$Z2 = (Z + 0.7\ D) \times ((A + R)/R)\ /\ 1.15$$

To avoid overreaching for both normal feeding and hairpin fed faults, the lower of the two calculated impedances is used as the Zone 2 reach setting.

3.1.3.3 Zone 3

Zone 3 elements are usually used to provide overall back-up protection for downstream catenary sections. The zone 3 reach (Z3) is therefore set to at least 115% of the combined apparent impedance of the protected catenary plus the longest downstream catenary. Figure 8 shows the feeding.



A = Protected Section Impedance

E = Longest Following Section

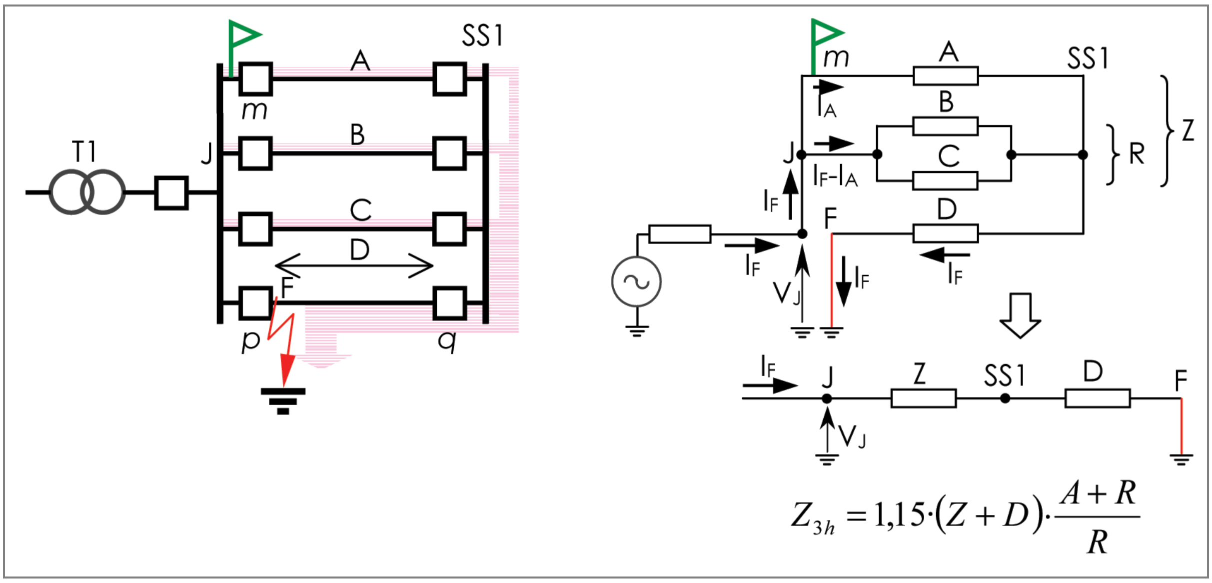
Z = Equivalent Impedance of A, B, C, D in Parallel

R = Equivalent Impedance of B, C, D in Parallel

Figure 8: Fault considered for zone 3 minimum reach (normal feeding)

The equation for the Zone 3 reach (normal feeding) becomes:

Z3 = (Z + E) x ((A + R)/R) x 1.15



A = Protected Section Impedance

D = Longest Hairpin Fed Section

Z = Equivalent Impedance of A, B, C, in Parallel

R = Equivalent Impedance of B, C, in Parallel

Figure 9: Fault considered for zone 3 minimum reach (hairpin feeding)

The equation for the Zone 3 reach (hairpin feeding) becomes:

$$Z3 = (Z + D) \times ((A + R)/R) \times 1.15$$

To avoid underreaching for both normal feeding and hairpin fed faults, the higher of the two calculated impedances is used as the Zone 3 reach setting. Occasionally the zone 3 reach requirement can be raised further to offset the effects of regenerative braking. This provides an additional current infeed to the fault. An additional 5% reach increase is generally sufficient.

3.1.3.4 Reverse Zones

Reverse directional zones typically provide back-up protection for the local busbar where the offset reach is set to 25% of the Zone 1 reach of the IED. Typically Zone 3 is set with a reverse reach to satisfy the requirements for Switch on to Fault protection.

3.1.4 Auto-transformer System Zone Reaches - recommended settings

Figure 10 shows how for any one track at the FS, the variation of the P44T impedance is calculated as:

Z = (V catenary – V feeder) / (I catenary – I feeder), varies with distance to fault.

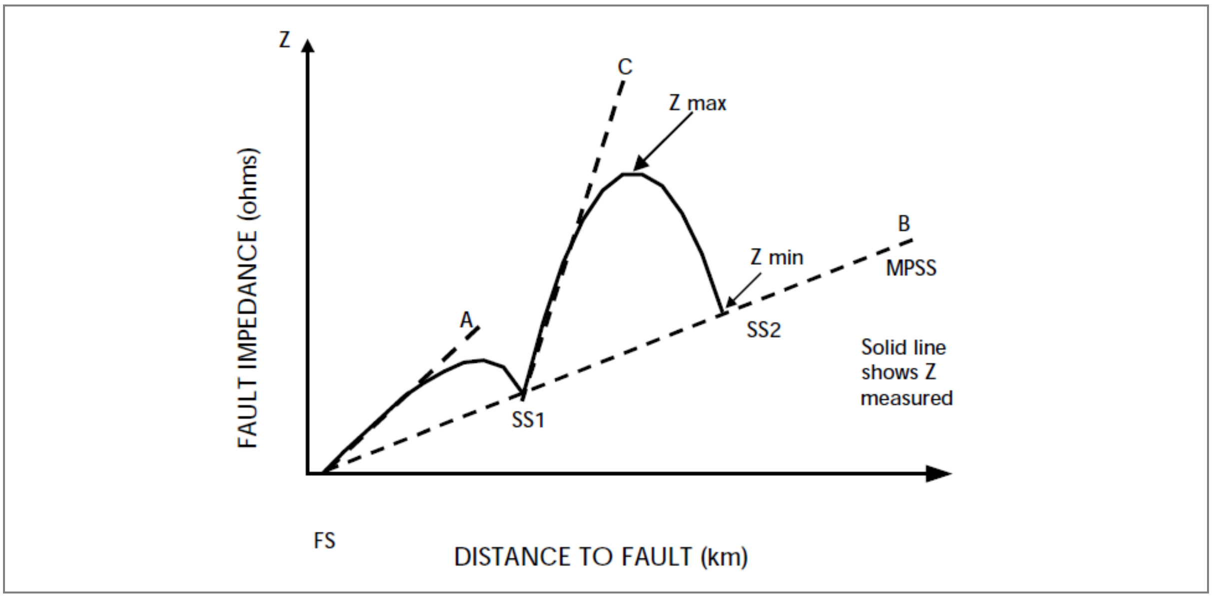


Figure 10: Variation of impedance measurement with fault location along track

For clarity, only the impedances measured for a catenary to earth fault located upstream of SS2 are plotted. The hump-like characteristic has a number of noticeable trends:

- The initial slope of the characteristic in ohms/km is shown as line A. This is equal to the characteristic impedance of a catenary-to-rail out-and-back fault loop (the 25 kV loop in Figure 3).
- At AT locations, slope B shows the effective ohms/km trend. This is equal to half the characteristic impedance of a catenary-to-feeder out-and-back loop (the 50 kV loop in Figure 3). This is lower due to the feeder being a better conductor than the rails.
- Beyond SS1, the paralleling effect means that slope C is greater than slope A. In Figure 3 a four-track system is simulated, so the gradient of C is approximately four times that of A. It is marginally higher than four for the inner tracks and less than four for the outer tracks.

The following sections describe how distance IED reaches would typically be calculated.

3.1.4.1 Zone 1

The Zone 1 elements of a distance IED should not overreach and trip for faults beyond the MPSS when the mid-point bus section breaker is closed. If it is known that the MPSS is definitely open, there is no real reach constraint for distance protection.

However, if the mid-point breaker is closed, or no status information is communicated to the IED, the IED must not trip for the lowest impedance fault out of zone. In Figure 10 this fault impedance is equivalent to a fault like Z min but is located at the MPSS busbar following slope B. In this case the applied Zone 1 setting is restricted to 85% of this impedance to allow for tolerance errors.

Depending on the response of IED characteristics to inrush current, a lower reach setting can be applied. This avoids the IED mistakenly interpreting AT inrush current at switch-on as an in-zone fault. For IEDs that have magnetising inrush restraint, such current does not cause a problem and this reach constraint is unnecessary.

3.1.4.2 Zone 2

Allowing for underreaching errors, set the Zone 2 reach (Z2) more than 115% of the protected line impedance for all fault conditions. The relevant impedance in Figure 10 is the Z max peak between SS2 and MPSS. The Z max figure for the highest “hump” is used, which must then be increased by 15% or more. A higher figure of 120% x Z max would also offset regenerative braking effects. Therefore with Z1 and Z2 applied, the IEDs at the Feeder Station provide complete protection up to the MPSS.

3.1.4.3 Zone 3

Zone 3 can be applied to protect for faults beyond the MPSS. Alternatively it can be applied with a longer reach to cover instances where ATs are switched out of service and the effective feeding impedance becomes higher.

3.1.5 Quadrilateral Ground Tilting

The P44T has a fixed tilt angle on the ground distance element. This is used in applications where the power flow is unidirectional.

3.1.6 Quadrilateral Phase Fault Zone Settings

Each zone has two additional settings:

- A tilt angle on the top line of any quadrilateral set for phase faults,
- A minimum current sensitivity setting.

By factory defaults, the Top Line of the quadrilateral characteristics is not fixed as a horizontal reactance line. To account for phase angle tolerances in the line CT, VT and IED, the line is tilted downwards, at a “droop” of –3º. This tilt down helps to prevent Zone 1 overreach.

Set the current **Sensitivity** for each zone to the minimum current that must flow in each of the faulted phases before a trip can occur. Leave these settings at their default. The exception is where the IED is made more insensitive to match the lesser sensitivity of older IEDs in the power system, or to grade with the pickup setting of any ground overcurrent protection for tee-off circuits.

3.1.7 Directional Element for Distance Protection

Distance zones are directionalised by the delta decision. For delta directional decisions, the RCA settings must be based on the average source + line impedance angle for a fault anywhere internal or external to the line. Typically, the **Delta Char Angle** is set to 60º, as it is not essential for this setting to be precise. When a fault occurs, the delta current is never close to the characteristic boundary, so an approximate setting is satisfactory.

The 60° angle is associated with mainly inductive sources and works well for most applications.

Distance Setup - Filtering, Load Blinding and Polarizing.

3.1.7.1 Digital Filtering

In most applications, it is recommended that standard filtering is used. The resulting non-fundamental harmonics could affect the reach point accuracy of the IED. To prevent the IED being affected, a Special set of filters are available.

3.1.7.2 CVT Filtering

Passive CVT filter could be applied.

3.1.8 Wrong Phase Coupling

The WPC elements of an IED should not overreach and trip for faults detected by distance function. For that reason the trip characteristics definition can be set for all complete range.

Five settings are necessary to define the WPC trip Zone. Typically the impedance threshold is set between 10 and 30 ohm and the left and right angles are set between 100 and 150 degrees.

The above settings should follow the following condition on limits: WPC LH angle> WPC line angle > WPC RH angle. If above is against; P44T relay will indicate an alarm.

Figure 11 shows the WPC trip characteristics.

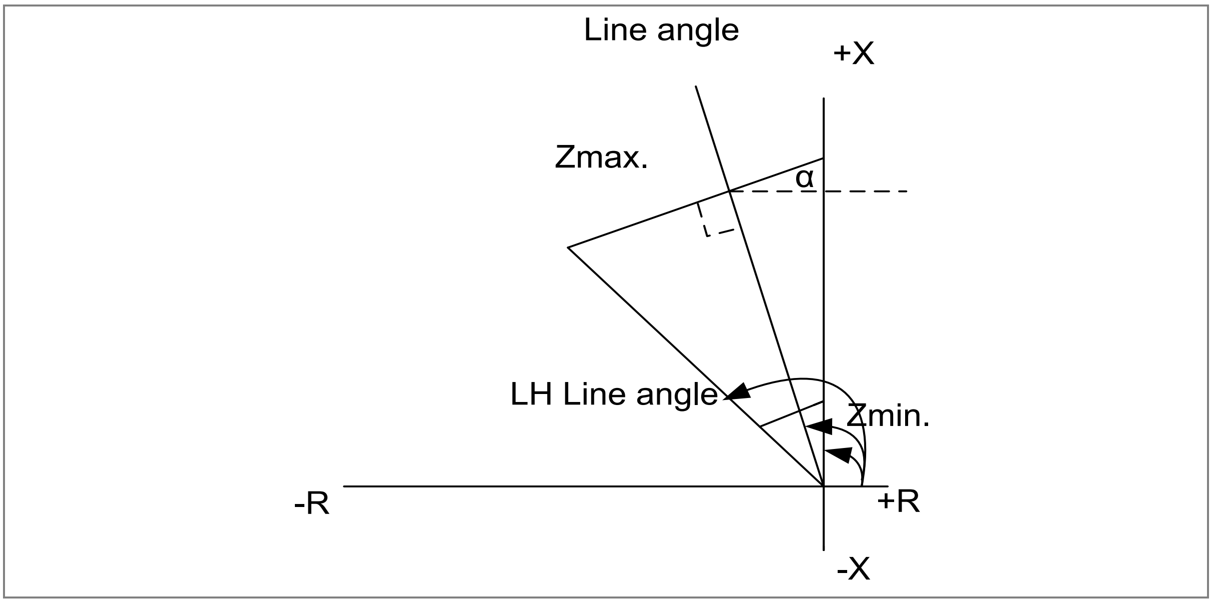


Figure 11: Resistive reach settings for WPC

3.1.9 Load Blinding (Load Avoidance)

Figure 12 shows how the distance IED trip characteristics must avoid regions of the polar plot where the traction load may be present. This has historically been achieved using shaped trip characteristics such as the lenticular or lens aspect. Since the 1990s, the benefits of applying quadrilateral characteristics have been realised, where the right-most line (resistive reach line) of the quadrilateral is used as a load blinder. Quadrilateral (or polygon) characteristics allow the resistive reach line to be set independently of the calculated zone reach, which sets the position of the top line of the quadrilateral. The resistive reach is then calculated to avoid the traction load by a suitable margin and to provide as much coverage for faults of a resistive nature as is possible.

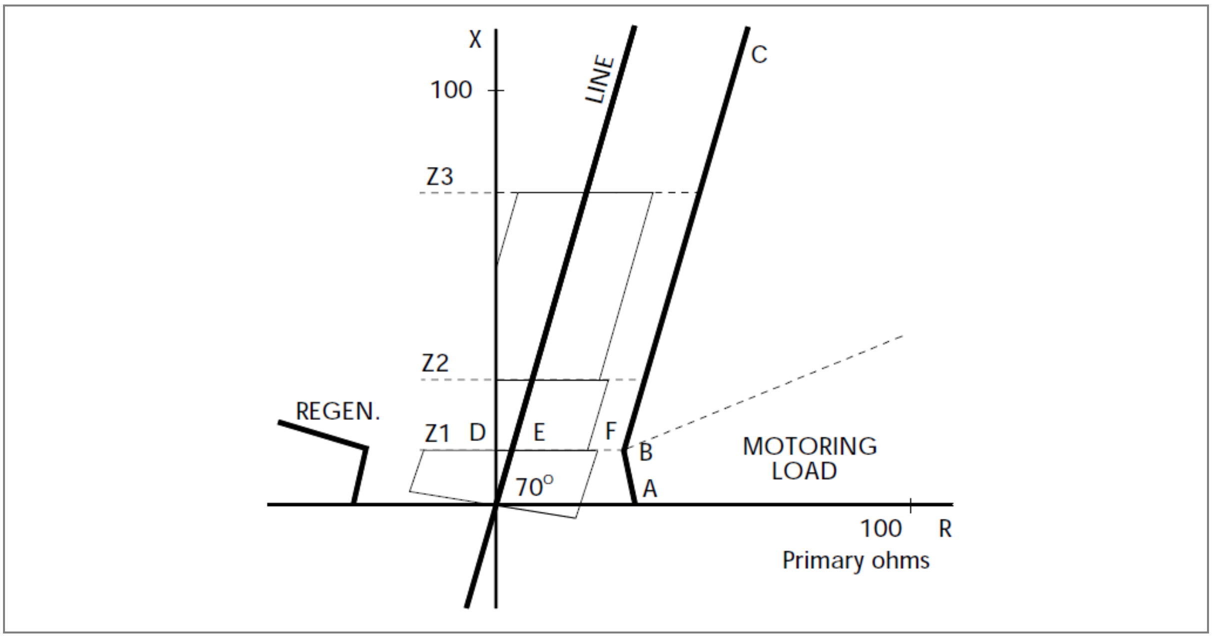


Figure 12: Resistive reach settings for load avoidance

For polygon characteristics, impedance point B is the critical loading to avoid. The magnitude of the impedance is calculated from Z = V / I. This uses the minimum operational catenary voltage and the maximum short-term catenary current. It is not uncommon for the catenary voltage to fall to 80% of the nominal value and for short term loading to be 160% of the nominal value. These worst-case measured values should be used when aiming to find the lowest load impedance.

To find the phase angle of B with respect to the resistive axis, this is determined as:

$$\theta = \cos^{-1} \text{(Maximum lagging power factor)}$$

The diagram shows how resistive reach E-F for Zone 1 has been chosen to avoid the worst-case loading by a suitable margin of 10 to 20%. Zones 2 and 3 reach further, so the effect of any angular errors introduced by CTs and VTs is more pronounced. It is therefore common to set the resistive reaches progressively marginally smaller for zones with longer reaches. This is a practical setting constraint to ensure that zones with long reaches are not too narrow and are not overly affected by tolerances of angle measurements. Generally the aspect ratio of any zone is best within the 1 to 7 range:

$$1/7\text{th} \leq \text{Z reach / R reach setting} \leq 7$$

Certain systems may demand reverse operation of zones, although for the Zone 1 characteristic shown, forward-only operation is common. For systems with regenerative braking, trains usually regenerate at a leading power factor to avoid creating overvoltages on the catenary. Where a regenerating train contributes to fault current, the fault impedance measured by distance IEDs may shift up to 10 degrees greater than α. To ensure that the fault impedance remains within the trip characteristic and does not stray outside the top left-hand resistive boundary of the polygon, set the reverse resistive reach (Rrev) greater than the forward resistive reach (Rfwd). For most applications Rfwd is set equal to Rrev.

3.1.10 Distance Zone time Delay Settings

The Zone 1 time delay (tZ1) is generally set to zero, giving instantaneous operation.

The Zone 2 time delay (tZ2) is set to co-ordinate with Zone 1 fault clearance time for downstream catenaries. The total fault clearance time consists of the downstream Zone 1 operating time plus the associated breaker operating time. Allow time for the Zone 2 elements to reset after an adjacent line fault has been cleared, and for a safety margin. A typical minimum Zone 2 time delay is 200 ms. This may have to be adjusted where the IED needs to grade with slower forms of back-up protection or circuit breakers for downstream circuits.

The zone 3 time delay (tZ3) is typically set with the same considerations made for the Zone 2 time delay, except that the delay needs to co-ordinate with the downstream Zone 2 fault clearance. A typical minimum zone 3 operating time is 400 ms. Again, this may need to be modified to co-ordinate with slower forms of back-up protection for adjacent circuits.

The Zone 4 time delay (tZ4) needs to coordinate with any protection for downstream catenaries in the IED's reverse direction.

The principles used for auto-transformers are identical to those for classical feeding, with just one exception. Zone 1 may sometimes be subjected to a short time delay of around 50 ms if magnetising inrush current is expected to be severe. The P44T 2nd Harmonic Restraint can be used to avoid unwanted tripping on inrush. This avoiding any need for a delayed Zone 1 element.

Note (1): The MiCOM P44T allows separate time delays to be applied to both phase and earth fault zones. For example, where earth fault delays are set longer to time grade with external ground/earth overcurrent protection.

Note (2): Any zone ("#") which may reach through a power transformer reactance, and measure secondary side faults within that impedance zone should have a small time delay applied. This is to avoid tripping on the inrush current when energizing the transformer. As a general rule, if: Z# Reach $_{setting}$ > 50% XT transformer reactance, set: tZ# $\geq$ 100 ms. Alternatively, the 2nd harmonic detector that is available in the PSL can be used to block zones that may be at risk of tripping on inrush current. Settings for the inrush detector are in the SUPERVISION menu column.

3.2 Switch onto Fault (SOTF) Mode

To ensure fast isolation of faults on energization, (for example a closed earth/grounding switch) enable this feature with appropriate zones or **Current No Volt** (CNV) level detectors, depending on utility practices.

When busbar VTs are used, the **Pole Dead** signal is not produced and you need to connect circuit breaker auxiliary contacts for correct operation. This is not necessary if the SOTF is activated by an external pulse.

SOTF delay	The time chosen should be longer than the slowest delayed-auto-reclose dead time, but shorter than the time in which the system operator might re-energize a circuit once it had opened/tripped. 110 seconds is recommended as a typical setting.
SOTF pulse	Typically this would be set to at 500 ms. This time is enough to establish the voltage memory of distance protection.
TOC reset delay	500 ms is recommended as a typical setting. This is in excess of the 32 cycles length of memory polarizing, allowing full memory charging before normal protection resumes.

3.3 Trip on Reclose (TOR) Mode

This ensures fast isolation of all persistent faults after the circuit breaker is reclosed. Enable this feature with appropriate zones selected or **Current No Volt** (CNV) level detectors.

TOC Delay	The TOR is activated after TOC Delay has expired. The setting must not exceed the minimum AR Dead Time setting to make sure that the TOR is active immediately on the reclose command.
TOC reset delay	500 ms is recommended as a typical setting (the same as SOTF).

3.4 VT Supervision

Distance protection requires both a current and voltage input to measure impedance. A distance IED is an under-impedance IED. If the VT input to the IED is lost, the division of voltage (now zero) by any flowing load current, gives a result of zero and risks a spurious trip. VT Supervision monitors the health of the VT circuit, and is used to detect a VT fuse blow, or inadvertent removal. In both cases this happens quickly enough so the IED automatically blocks the distance protection, preventing it from maloperation.

To enable detection of a fuse failure, set cell: 014.204 Settings/Function Settings/Setting Group SG1: VTS/Fuse Fail. Enable = "Yes" (Example for setting group 1).

Use this function rather than the V< V-monitoring function. This is because the undervoltage function may pick up an alarm under genuine operational conditions when the VT is dead due to isolations or switching.

3.5 Channel Aided Schemes

The MiCOM P44T has two sets of aided channel ("pilot") schemes, which can be operated in parallel.

Aided Scheme 1	Can be keyed by distance or delta directional comparison.
Aided Scheme 2	Can be keyed by distance or delta directional comparison.

When schemes share the same channel, the same generic scheme type must be applied. This means ALL Permissive Overreach, or ALL Blocking.

3.5.1 Distance Scheme PUR - Permissive Underreach Transfer Trip

This scheme is similar to that used in the LFZP Optimho distance IEDs. It allows an instantaneous Z2 trip on receipt of the signal from the remote end protection.

Send logic:	Zone 1
Permissive trip logic:	Zone 2 plus Channel Received

Set the **Dist dly** trip time to Zero, for fast fault clearance.

3.5.2 Distance Scheme POR - Permissive Overreach Transfer Trip

This scheme is similar to that used in the LFZP Optimho distance IEDs.

> *Note: The POR scheme also uses the reverse looking Zone 4 of the IED as a reverse fault detector. This is used in the current reversal logic and in the optional weak infeed echo feature.*

Send logic:	Zone 2
Permissive trip logic:	Zone 2 plus Channel Received

Set the **Dist dly** trip time to Zero for fast fault clearance.

3.5.3 Permissive Overreach Trip Reinforcement

For any trip command at the local end, the IED's POR logic sends a channel signal to the remote end(s). This maximizes the chances for the fault to be isolated at all ends. The send signal can be configured using **Any Trip** or **AnyZ1/Aided Trip** or **none**, depending on local practice. It is sent on both channels, Ch1 and Ch2, if more than one channel is in use. This feature is termed permissive trip reinforcement and ensures that synchronous tripping occurs at all line ends.

3.5.4 Permissive Overreach Scheme Weak Infeed Features

Where weak infeed tripping is used, a typical voltage setting is 70% of the rated phase-neutral. Weak infeed tripping is time delayed according to the WI Trip Delay value, usually set at 60 ms.

3.5.5 Distance Scheme Blocking

To allow time for a blocking signal to arrive, a short time delay on aided tripping, **Dist dly** must be used, as follows:

Recommended Dly setting = Max. Signalling channel operating time + 1 power frequency cycle.

This scheme is similar to that used in the LFZP Optimho.

Send logic: Reverse Zone 4

Trip logic: Zone 2, plus Channel NOT Received, delayed by Tp

> *Note: Two variants of a Blocking scheme are provided, Blocking 1 and Blocking 2. Both schemes operate identically, except that the reversal guard timer location in the logic changes. Blocking 2 may sometimes allow faster unblocking when a fault evolves from external to internal, resulting in a faster trip.*

3.5.6 Permissive Overreach Schemes Current Reversal Guard

The recommended setting is:

tREVERSAL GUARD = Maximum signalling channel reset time + 35 ms.

3.5.7 Blocking Scheme Current Reversal Guard

The recommended setting is:

- Where Duplex signalling channels are used:
  tREVERSAL GUARD = Maximum signalling channel operating time + 20 ms.
- Where Simplex signalling channels are used:
  tREVERSAL GUARD = Maximum signalling channel operating time - minimum signalling channel reset time + 20 ms.

3.5.8 Delta Scheme POR - Permissive Overreach Transfer Trip

This scheme is similar to that used in the LFDC IED.

Send logic: Δ Fault Forward

Permissive trip logic: Δ Fault Forward plus Channel Received.

The Delta Delay trip time setting should be set to zero for fast fault clearance.

3.6 Loss of Load Accelerated Tripping (LoL)

For circuits with load tapped off the protected line, take care when setting the loss of load feature to ensure that the **I**< level detector setting is above the tapped load current. When selected, the loss of load feature operates with the main distance scheme that is selected. This provides high speed clearance for end zone faults when the **Basic** scheme is selected. Alternatively, with permissive signal aided tripping schemes, it provides high speed back-up clearance for end zone faults if the channel fails.

3.7 Defrost Protection

In some systems, icing could occur on the catenary during winter nights. To solve this problem, the catenaries are switched in series and heated with a small current. The defrost protection measures the feed and return currents and subjects them to a sensitive differential element to detect short-circuits.

3.8 Phase Fault Overcurrent Protection

Settings for the time delayed overcurrent element should be selected to ensure discrimination with surrounding protection.

> **Caution** **The IEEE C.37.112 standard for IDMT curves allows some freedom to manufacturers at which Time Dial (TD) value the reference curve applies. Rather than pick a mid-range value, for the MiCOM P44T the reference curve norm applies at a time dial of 1. The time dial is a multiplier on the reference curve to achieve the desired tripping time. Take care when grading with other suppliers' IEDs which may take TD = 5, or TD = 7 as a mid-range value to define the IDMT curve. The equivalent MiCOM P44T setting to match those IEDs is achieved by dividing the imported setting by 5 or 7.**

Railway systems often use overcurrent protection as time-delayed back-up to the main distance protection elements. Two different philosophies of setting overcurrent elements are typical:

- Definite-time overcurrent protection continually in service, in parallel to the distance elements.
- Back-up overcurrent protection switched in service only during periods when the distance protection is out of service. A typical example is where a VT supervision or measuring circuit monitoring function detects a VT fuse blow. In such instances the distance protection is automatically blocked. The overcurrent elements can then be automatically brought into service so that catenary protection is not lost.

3.8.1 Directional Overcurrent Characteristic Angle Settings

The RCA is the angle by which the current applied to the IED must be displaced from the voltage applied to the IED to obtain maximum sensitivity. This is set in cell **I>Char Angle** in the **overcurrent** menu. You can set the characteristic angles can anywhere in the range –95° to +95°.

You can set the RCA to exactly match the system fault angle. These settings have been shown to provide satisfactory performance and stability under a wide range of system conditions.

The phase fault elements of the IEDs are internally polarized by the phase-phase voltages, as shown in the following table.

	Time constant τ (minutes)	**Limits**	**Limits**
Single Phase	Catenary Phase	Icat	Vcat
Auto-transformer	Catenary Phase	Icat	Vcat-Vfdr
	Feeder Phase	Ifdr	Vcat-Vfdr

Table 1: Parallel voltage polarisation

Under system fault conditions, the fault current vector lags its nominal phase voltage by an angle depending on the system X/R ratio. The IED must therefore operate with maximum sensitivity for currents lying in this region. This is done using the IED characteristic angle (RCA) setting.

3.9 Panto Flash Over

One side of the insulated overlap can become dead while other section is live due to the tripping of respective feeder CB on fault or manual tripping. This condition can take place on normal condition or at feed extended condition.

The function identifies such situation and trip the feeder circuit breaker connected to the live side of the overlap. The relay continuous monitors the voltage status and CB at the respective section and depends upon logic give trip command to respective CB. The relay has separate under voltage setting, if voltage is less than set under voltage relay close respective NO contact which can be used for flasher light to give advance warning to train driver to take necessary action.

3.10 Thermal Overload Protection

Thermal overload protection can be used to prevent electrical plant from operating at temperatures in excess of the designed maximum withstand. Prolonged overloading causes excessive heating, which may result in premature ageing of the insulation or in extreme cases insulation failure.

It is essential that railway catenaries remain in the correct position relative to the track. This ensures a good connection with the train pantographs and therefore a good flow of current. The catenary is designed to operate continuously at a temperature corresponding to its full load rating, where heat generated is balanced with heat dissipated by radiation. Overtemperature therefore occurs when currents exceed the rating for a set period. The temperature rise and fall during heating and cooling is exponential with respect to time. If the catenary overheats, the contact wire supporting arms move beyond acceptable limits. It is then no longer in the correct position above the track and the pantograph does not contact correctly.

The tension in the catenary is often maintained by balance weights. These are suspended at each end of contact wire lengths. Overtemperature causes the catenary to stretch, with the balance weights eventually touching the ground. Further heating then causes a loss of tension and excessive sagging of the contact wire.

3.10.1 Single Time Constant Characteristic

The current setting is calculated as:

Thermal Trip = Permissible continuous loading of the plant item/CT ratio.

Typical time constant values are given in the following table. The IED setting, ‘Time Constant 1’, is in minutes.

	Time constant τ (minutes)	Limits
Air-core reactors	40	
Capacitor banks	10	
Overhead lines	10	Cross section ≥ 100 mm2 Cu or 150 mm2 Al
Cables	60 - 90	Typical, at 66 kV and above
Busbars	60	

Table 2: Single Time Constant Values

An alarm can be raised on reaching a thermal state corresponding to a percentage of the trip threshold. A typical setting might be ‘Thermal Alarm’ = 70% of thermal capacity.

3.10.2 Dual Time Constant Characteristic

The current setting is calculated as:

Thermal Trip = Permissible continuous loading of the transformer / CT ratio.

Typical time constants:

	τ1 (minutes)	τ2 (minutes)	Limits
Oil-filled transformer	5	120	Rating 400 - 1600 kVA

Table 3: Dual Time Constant Values

An alarm can be raised on reaching a thermal state corresponding to a percentage of the trip threshold. A typical setting might be ‘Thermal Alarm’ = 70% of thermal capacity.

Note: The thermal time constants given in the above tables are typical only. Refer to the plant manufacturer for accurate information.

3.11 Train Startup

When heavily loaded lines, high train start-up loads or long lines, P44T zones 2 and or 3 may pick up and incorrectly trip the line. To avoid this problem, this feature is used to detect these conditions and change the zone 2 timers and/or Zone 3 timer to a longer value, one the other hand, when one fault occurs, the relay switch the zone 2 timer and/or Zone 3 timer to a shorter value and issue a fast trip.

3.12 Undervoltage Protection

In the majority of applications, undervoltage protection is not needed to operate during system earth (ground) fault conditions. If this is the case, select the element in the menu to operate from a phase-to-phase voltage measurement. This quantity is less affected by single phase voltage depressions due to earth faults. The measuring mode (ph-N or ph-ph) and operating mode (single phase or All phases) for both stages can be set independently.

For the undervoltage protection, set the voltage threshold below the values expected in normal system operating conditions. This threshold depends on the system but typical healthy system voltage excursions may be -10% of the nominal value.

The time delay setting for this element depends on the time for which the system is able to withstand a depressed voltage.

3.13 Overvoltage Protection

The inclusion of the two stages and their respective operating characteristics allows for several possible applications;

- Use of the IDMT characteristic gives the option of a longer time delay if the overvoltage condition is only slight but results in a fast trip for a severe overvoltage. As the voltage settings for both of the stages are independent, the second stage could then be set lower than the first to provide a time delayed alarm stage if required.
- Alternatively, if preferred, both stages could be set to definite time and configured to provide the required alarm and trip stages.
- If only one stage of overvoltage protection is required, or if the element is required to provide an alarm only, the remaining stage can be disabled in the IED menu.

This type of protection must be coordinated with any other overvoltage IEDs at other locations on the system. This should be done in a similar way to that for grading current operated devices. The measuring mode (ph-N or ph-ph) and operating mode (single phase or 2 phases) for both stages can be set independently.

3.14 Circuit Breaker Fail Protection (CBF)

3.14.1 Breaker Fail Timer Settings

Typical timer settings to use are as follows:

CB fail reset mechanism	tBF time delay	Typical delay for 2 ½ cycle circuit breaker
Initiating element reset	CB interrupting time + element reset time (max.) + error in tBF timer + safety margin	50 + 45 + 10 + 50 = 155 ms
CB open	CB auxiliary contacts opening/closing time (max.) + error in tBF timer + safety margin	50 + 10 + 50 = 110 ms
Undercurrent elements	CB interrupting time + undercurrent element (max.) + safety margin	50 + 25 + 50 = 125 ms

Table 4: Breaker fail timer settings

Note: All CB Fail resetting involves the operation of the undercurrent elements. If you use element reset or CB open resetting, use the undercurrent time setting if this proves to be the worst case.

Where auxiliary tripping IEDs are used, add 10-15 ms to allow for trip IED operation.

3.14.2 Breaker Fail Undercurrent Settings

Set the phase undercurrent (I<) less than the load current. This ensures that I< operation shows if the circuit breaker pole is open. A typical setting for overhead line circuits is 20% In.

3.15 Communication between IEDs

3.15.1 Data Rate

Set the data rate for signalling between the two or three ends may to either 64 kbit/sec or 56 kbit/sec as appropriate.

If there is a direct fibre connection between the ends, set the data rate to 64 kbit/sec as this gives a slightly faster trip time.

If there is a multiplexer network between the ends, this determines the data rate to be used by the MiCOM P44T system. The electrical interface to the multiplexer (G.703 co-directional, V.35, or X.21) is provided on either a 64 kbit/sec or 56 kbit/sec channel. Set the MiCOM P44T at each end to match this data rate.

North American multiplexer networks are usually based on 56 kbit/sec channels and multiples of this. Multiplexer networks in the rest of the world are based on 64 kbit/sec channels and multiples of this.

This setting is not applicable if IEEE C37.94 mode is selected.

3.16 Integral Intertripping

The MiCOM P44T supports integral Intertripping in the form of InterMiCOM. InterMiCOM can use an auxiliary EIA(RS)232 connection (MODEM InterMiCOM), or it can use an integral optical fibre communication connection (fibre InterMiCOM, or InterMiCOM^{64}). EIA(RS)232 (MODEM) InterMiCOM provides a single, full duplex communication channel, suitable for connection between two MiCOM P44T devices. The fibre InterMiCOM (InterMiCOM^{64}) can provide up to two full-duplex communications channels. It can be used to connect two MiCOM P44T using a single channel or redundancy can be added by using dual communications. Alternatively, InterMiCOM^{64} can be used to connect three MiCOM P44T devices in a triangulated scheme for the protection of Teed feeders. MODEM InterMiCOM and InterMiCOM^{64} are completely independent. They have separate settings, are described by separate DDB signals.

Generally InterMiCOM^{64} is preferred where possible as it is faster and has high immunity to electromagnetic interference. If the high speed communication channel requirement of InterMiCOM^{64} is not available, EIA(RS)232 provides a cost-effective alternative.

Because of the differences between the implementation of EIA(RS)232 InterMiCOM and InterMiCOM^{64}, the settings associated with each implementation are different. There are settings to prevent inadvertent cross-connection or loopback of communications channels (address settings). There are settings to accommodate different channel requirements (baud rate, clock source, channel selection). There are settings used for channel quality monitoring and signal management actions if there are channel failures.

The received InterMiCOM signals are continually monitored for quality and availability. If the quality or availability of the received signals falls below set levels, an alarm can be raised.

Note: *An alarm indicating the signalling has failed, refers only to the incoming signals. The remote IED monitors the quality of transmission on the communications link in the other direction. If you need to indicate the quality of the signal transmitted from the local IED for reception at the remote IED, use one of the InterMiCOM command channels to reflect this back.*

3.16.1 EIA(RS)232 InterMiCOM (Modem InterMiCOM)

The settings needed for the implementation of MODEM InterMiCOM are in two columns of the IED menu structure. The first column entitled **INTERMICOM COMMS** contains all the information to configure the communication channel and also contains the channel statistics and diagnostic facilities. The second column entitled **INTERMICOM CONF** selects the format of each signal and its fallback operation mode.

The settings required for the InterMiCOM signalling are largely dependant on whether a direct or indirect (modem/multiplexed) connection between the scheme ends is used.

Direct connections are either short metallic or dedicated fibre optic. The fibre optic uses suitable EIA(RS) 232 to optical fibre converters. You can then use the highest signalling speed of 19200 b/s. Due to this high signalling rate, the difference in operating speed between the direct, permissive and blocking type signals is so small that the most secure signalling (direct intertrip) can be selected without any significant loss of speed. The direct intertrip signalling needs the full checking of the message frame structure and CRC checks. Therefore it is safer to set the **IM# Fallback Mode** to **Default** with a minimal intentional delay by setting **IM# FrameSyncTim** to 10 msecs. Whenever two consecutive messages have an invalid structure, the IED immediately reverts to the default value until a new valid message is received.

For indirect connections, the settings become more dependent on applications and communication media. Use the fastest baud rate for the direct connections although this usually increases the cost of the necessary modem or multiplexer. Devices operating at these high baud rates may suffer from data jams during periods of interference. Also any communication interruptions may need longer to resynchronise. Both of these factors reduce the effective communication speed, leading to a recommended baud rate setting of 9.6 kbit/s. Lower baud rates increase reliability with fewer interruptions but increase the signalling times.

When using slower baud rates, the choice of signalling mode becomes important. However, once you have chosen the signalling mode, consider what happens during periods of noise when the message structure and content can be lost. If **Blocking Mode** is selected, only a small amount of the total message is used to provide the signal. This means that in a noisy environment the chances of receiving a valid message are quite high. In this case, set the **IM# Fallback Mode** to **Default** with a reasonably long **IM# FrameSyncTim**. A typical default selection of Default = 1 (blocking received substitute) would generally apply as the failsafe assignment for blocking schemes.

If you select **Direct Intertrip** mode, the whole message structure must be valid and checked to provide the signal. This means that in a very noisy environment the chances of receiving a valid message are quite small. In this case, set the **IM# Fallback Mode** to **Default** with a minimum **IM# FrameSyncTim** setting. Whenever a non-valid message is received, InterMiCOM uses the set default value. A typical default selection of Default = 0 (intertrip NOT received substitute) generally applies as the failsafe assignment for Intertripping schemes.

If you select **Permissive** mode, the change of receiving a valid message is between that of the **Blocking** and **Direct Intertrip** modes. In this case the **IM# Fallback Mode** can be set to **Latched**. Table 5 shows the recommended **IM# FrameSyncTim** settings for the different signalling modes and baud rates:

Baud rate	Minimum recommended "IM# FrameSyncTim" Setting		Minimum setting (ms)	Maximum setting (ms)
	Direct intertrip mode	Blocking mode		
600	100	250	100	1500
1200	50	130	50	1500
2400	30	70	30	1500
4800	20	40	20	1500
9600	10	20	10	1500
19200	10	10	10	1500

Table 5: Recommended IM# FrameSyncTim settings

Note: *No recommended setting is given for the Permissive mode since it is presumed that **Latched** operation is selected. However, if you select **Default mode**, set **IM# FrameSyncTim** greater than the minimum settings listed above. If you set **IM# FrameSyncTim** lower than the minimum setting listed above, the IED monitors a correct change in message as a corrupted message.*

A setting of 25% is recommended for the communications failure alarm.

3.16.2 InterMiCOM^{64}

IMx Command Type

Due to the fast data rate there is not so much difference in performance between the three generic modes of teleprotection (Direct Intertrip, Permissive and Blocking). Therefore only two of these modes are implemented for InterMiCOM^{64}. Direct Intertripping is available with the second mode a combined mode for Permissive/Blocking (the latter is named as Permissive in the menu). To increase the security for Intertripping (Direct transfer tripping), the InterMiCOM^{64} Direct command is issued only when two valid consecutive messages are received. The recommended setting is:

- For Blocking schemes set 'Permissive'
- For Permissive scheme set 'Permissive'
- For Transfer (inter)tripping set 'Direct'

The setting files provide independent settings for each of the first 8 commands. Due to the fast data rate, there is minimal speed difference between the two mode options. Both give a typical operating time as shown in the following table. The operating time is the PSL trigger at the sending IED to the PSL state change at the receiving IED.

Channel mode setting	Application	Typical delay (ms)	Maximum (ms)	Comments
Permissive	Direct Fibre	3 to 7	9	Assuming no repeaters (no source of digital noise)

Channel mode setting	Application	Typical delay (ms)	Maximum (ms)	Comments
	Multiplexed Link	5 to 8 + MUX	12 + MUX	For channel bit error rate up to 1 x 10-3
Direct Intertrip	Direct Fibre	4 to 8	10	Assuming no repeaters (no source of digital noise)
	Multiplexed link	6 to 8 + MUX	13 + MUX	For channel bit error rate up to 1 x 10-3

Table 6: Typical operating times in ms

When using InterMiCOM^{64} to implement Aided Scheme 1 or Aided Scheme 2, assume a conservative worst-case channel delay of 15 ms (pickup and reset delay), for blocking and reversal guard calculations. Add the delay of the multiplexer if applicable, taking into account longer standby path reroutings iif there is self-healing in a SONET/SDH telecomm network.

When using InterMiCOM^{64} as a standalone feature in 3-terminal applications, longer times may be experienced. In 3-terminal applications, fallback to “chain” topology is possible if one communications leg in the triangle fails. In fallback mode the message is retransmitted so the path length is doubled, which also doubles overall command times to the final end.

IMx Fallback Mode

When the ‘Default’ setting is selected, the following **IMx Default Value** settings are recommended: For Intertripping schemes set **0**, for blocking schemes set **1**. In Permissive applications, you can latch the last healthy received state for a period of time.

4 WORKED PROTECTION EXAMPLE AND OTHER TIPS

4.1 Distance Protection Setting Example

Figure 13 shows a typical 25 kV system. The settings for the IED protecting track feeder TB-1 at Trent Bridge substation are to be calculated. The inputs to the IED are derived from the track feeder CT adjacent to the circuit breaker, and a busbar voltage transformer. A catenary side VT individual to TB-1 section would be equally suitable.

Other system data:

- Each catenary has primary impedance characteristics of 0.26 + j 0.68 Ω/km.
- Booster transformers are sited every 3 km, each with an impedance of 0.051 + j 0.21Ω.
- Vacuum circuit breakers are used with a max. trip time of 65 ms.
- The maximum assumed Zone 1 protection trip time is 45 ms.
- The measured load current never exceeds 150% of the CT primary rating.
- The catenary current is rated at 540 A, at 20°C ambient temperature.
- The limiting catenary temperature for a train running at full speed is 48°C.
- The catenary trip temperature to prevent mechanical damage is 56°C.

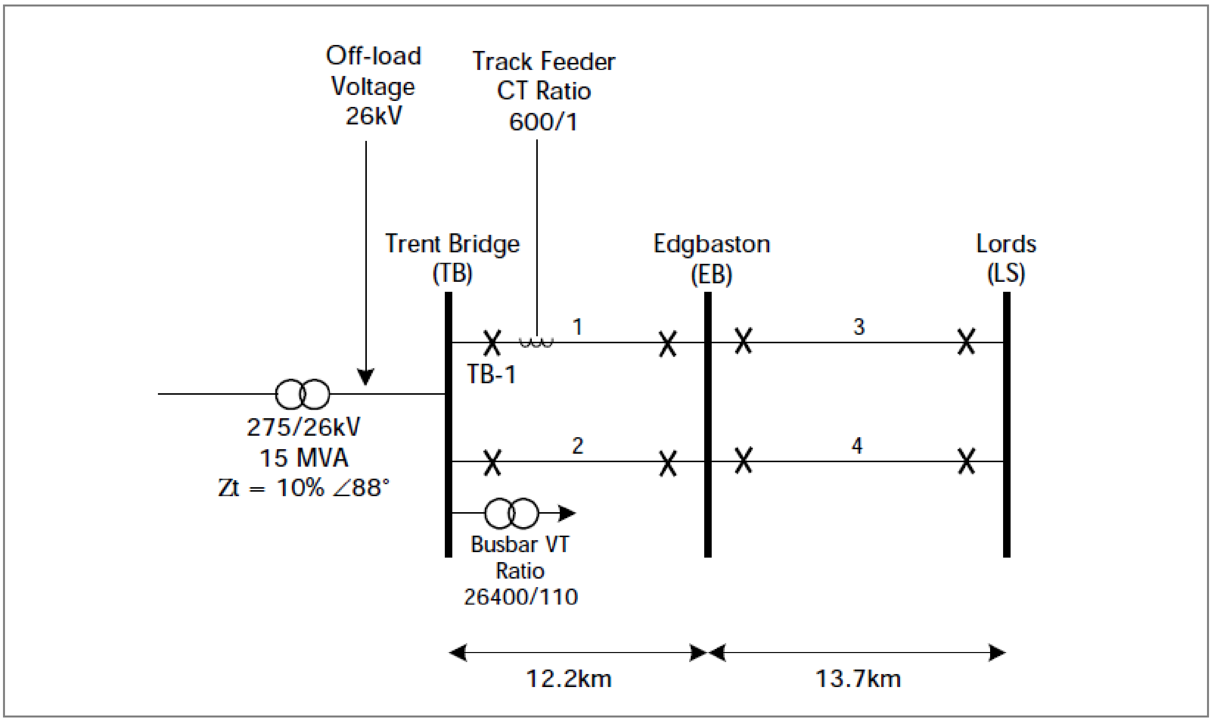


Figure 13: Assumed major feeding diagram, VT and CT locations

Calculate the primary impedance for the catenary sections which are to be protected. Zone 1 for IED TB-1 protects section 1. However, the backup protection offered by Zones 2 and 3 must discriminate with downstream IEDs. Therefore the impedance of sections 2, 3 and 4 needs to be calculated too. In this example, each pair of catenaries runs between the same two substations so the impedance of adjacent sections is identical. This would not be the case for four track railways or feeding configurations where the two tracks follow different routes and could be of dissimilar length.

The equivalent section impedance per kilometer is as follows:

= Line impedance per km + (BT impedance / BT spacing)

= (0.26 + j 0.68) + ((0.051 + j0.21) / 3) = 0.277 + j 0.75 Ω/km

$= 0.8 \angle 69.7^{o}$ Ω/km

This is rounded up to an assumed 70^{o} common characteristic line angle, Φ, set on the IED.

Most protection IEDs are set and injection tested in secondary impedance terms. Theresfore actual (primary) impedances on the system must be converted to secondary.

Zs (secondary impedance) = Zp (primary impedance) x CT ratio / VT ratio

Zs = Zp x (600/1) / (26400/110)

= Zp x 2.5

Section impedance calculations:

- Sections 1 and 2: Zp = 12.2 km x 0.8 Ω/km = 9.76Ω
  Zs = 9.76 x 2.5 = 24.4Ω
- Sections 3 and 4: Zp = 13.7 km x 0.8 Ω/km = 10.96Ω
  Zs = 10.96 x 2.5 = 27.4Ω

Zone 1 Reach Calculation for TB-1:

Forward Reach: **Z1fwd** = 24.4 x 85% = **20.75Ω**

Reverse Reach: Z1rev = Blocked (forward directional operation required)

Zone 2 Reach Calculation for TB-1:

Figure 7 shows the follow-on fed fault, with two track feeding only in the Trent Bridge area. To calculate this:

Z2 = (Z + 0.7 E) x ((A+ R)/R) / 1.15

<u>Where</u>: Z = Impedance of sections 1 and 2 in parallel

= 24.4 / 2 = 12.2Ω

A = The track of interest, section 1 = 24.4Ω

R = Parallel fault current path (section 2) = 24.4Ω

E = Shortest following section (3 or 4) = 27.4Ω

Z2 = (12.2 + (0.7 x 27.4)) x 2 / 1.15 = 54.6Ω

Notice how for two track feeding, (A + R)/R above becomes 2, due to a fault current split between two identical parallel paths.

For hairpin feeding, referring to Figure 7, with only two tracks, inner tracks B and C are not present (B = C = ∞). Once circuit breaker TB-2 at Trent Bridge is open, the impedance to the fault is 170% times the impedance of track section 1 or 2. Therefore:

Z2 = (24.4 + (0.7 x 24.4)) / 1.15 = 36.1Ω

For Zone 2, always the lower of the two calculated results is used:

- Forward Reach: **Z2fwd** = **36.1Ω**
- Reverse Reach: Z2rev = Blocked (forward directional operation required)

Zone 3 Reach Calculation for TB-1:

Figure 8 shows the follow-on fed fault, with two tracks. The calculation is the same as for the Zone 2 follow-on, except that the multiplier of 0.7 (70%) is replaced by 1 (100%). Also as Zone 3 must tend to overreach rather than underreach, we can take 120% of the fault impedance calculated.

$$Z3 = (12.2 + 27.4) \times 2 \times 1.20 = 95.1\Omega$$

Repeating the same for hairpin feeding:

$$Z3 = (24.4 + 24.4) \times 1.20 = 58.6\Omega$$

For Zone 3 always the higher of the two calculated results is used:

- Forward Reach: **Z3fwd** = **95.1Ω**
- Reverse Reach: **Z3rev** = Z1fwd x 25% = **5Ω**

4.1.1 Zone Time Delays

Zone 1 is set to instantaneous operation (tZ1 = 0). It is not common practice to time-grade with primary protection onboard trains.

Zone 2 (tZ2) should be delayed as follows:

t2 ≥ CB max. trip time + IED max. trip time + 50ms margin

= 65 + 45 + 50 = **160ms** (or greater).

As all of the protection and circuit breakers are alike, the 160 ms figure can be set as tZ2. If downstream IEDs are electromechanical (40 to 70 ms slower than numerical), or the circuit breakers are oil insulated (OCBs are 40 to 60 ms slower than VCBs), extend the tZ2 delay accordingly.

The Zone 3 time delay can typically be set to double the minimum calculated above. However, as Zone 3 is often most at risk of unwanted pickup due to train starting currents or momentary overloads, use a longer setting of: **tZ3 = 500ms**.

Additional settings:

- I> sets the current sensitivity of the distance protection, typically 10% In.
- Wrong phase coupling (WPC) is often not used so is not explained in detail.

4.2 Overcurrent Protection Setting Example

Overcurrent protection can be applied to the 25kV system in Figure 13. As overcurrent protection is most commonly used non-directional for railways, the easiest application is for track feeders at Feeder Stations, such as TB-1. At this location and with normal feeding, any fault current will naturally be flowing away from the busbar, and so no reverse operation can occur. At downstream substations it is not possible to apply overcurrent protection in a similar way. Therefore any elements enabled tend to be set with long time delays to ensure that the distance protection zones are all given chance to trip beforehand.

Phase Fault Overcurrent at Feeder Stations

If the distance protection is out of service, two overcurrent elements can be set. Firstly a high set overcurrent element, typically I>> is set to underreach the protected section, mimicking Zone 1 operation. This can be set for instantaneous tripping. Secondly, a lower set overcurrent element can be applied to complete protection for TB-1 section, overreaching the end of the protected section at Edgbaston.

I> is set for this purpose, operating with a definite time delay.

To determine the overcurrent settings, the fault current measured by TB-1 CT for a fault next to the Edgbaston busbar needs to be calculated.

Example 1
Fault current for a fault at the end of section 1, with two tracks in-service

If (TB-1) = Source volts / (Zt + (Section 1 and 2 parallel impedance)) / 2

Where: Zt = (kV^2 / MVA) x % impedance

= (26^2 / 15) x 10% = 4.5 Ω

If (TB-1) = Source voltage / (Zt + (Section 1 and 2 parallel impedance)) / 2

= $26000 / [(4.5 \angle 88^o) + ((9.76 \angle 70^o) / 2)] / 2$ = 1.4 kA

Note that the fault current splits into two parallel paths, fed through TB-1 and TB-2, and so the final division by 2 in the equation results in the per track current being calculated.

Example 2
Current for a fault at the end of section 1, with section 2 isolated for maintenance. If (TB-1)

= Source voltage / (Zt + (Section 1 impedance))

= $26000 / [(4.5 \angle 88^o) + (9.76 \angle 70^o)]$ = 1.84 kA

Overcurrent Setting for Instantaneous Stage
To prevent overreach, set at least 20% above the higher of the two fault examples:

I>> ≥ 1840 x 1.2 = 2.2 kA

The secondary current setting on the IED is found by dividing by the CT ratio:

I>> = 2.2kA / 600 = 3.68 A

Overcurrent Setting for Delayed Stage
To ensure complete coverage for short circuits in the protected section, set at least 20% less than the lower of the two fault examples:

I> ≤ 1400 x 0.8 = 1.1 kA

I> = 1.1kA / 600 = 1.86 A (secondary)

A setting no less than the Zone 2 distance time delay would tend to be used, possibly tI> set to 250 ms.

All overcurrent protection must have a pickup in excess of the maximum expected load current. Assuming that the maximum overloading would never exceed 150% of CT rating, the I> and I>> settings look acceptable.

Definite Time Overcurrent:

It is not general practice to set instantaneous protection elements running in parallel to the distance zones. Therefore often just one definite time delayed stage is used. This setting can be applied common to all locations and must be more than the maximum load and overload current expected.

I> ≥ 600A full load x 150% overloading allowance = 900A

I> = 900 / 600 = 1.5 A (secondary)

The time delay applied must be longer than the t3 distance zone delay, so tI > = 800 ms would be acceptable.

4.3 Thermal Protection Setting Example

Thermal protection can be applied to the 25 kV system in Figure 13. The thermal ratings shown are for typical UK catenaries (a temperate climate) with characteristics:

- Catenary design temperature range for correct tension -18°C to 38°C
- Typical assumed max. winter temperature (610 A rating) 10°C
- Typical assumed max. spring/autumn temp (540 A rating) 20°C
- Typical assumed summer temperature (515A rating) 23°C
- Worst-case assumed hottest ambient 28°C
- Balance weights touch ground 38°C
- 20% loss of tension, train speeds must be restricted 48°C
- Possible damage due to clashing of supports at overlaps 56°C

The protection element uses an absolute temperature replica to accurately mimic the heating of catenaries. The heating model is used to estimate the real or absolute temperature reached by the catenary.

The P44T requires a thermal rated current or reference current, Iref, to be set that corresponds to full load current. This rated current is qualified by stating the ambient temperature at which this applies. For the UK example, Iref should be set to:

Iref = 540 A

The secondary current setting on the IED is found by dividing by the CT ratio:

Iref = 540 / 600 = 0.9 A

The (default) ambient “Coolant temp.” at which 540 A is the rated current is set at 20°C. The catenary temperature at which mechanical damage may begin to occur is 56°C. This must correspond to the P44T thermal trip command, and so t**Max. Object temp** is set at **56°C**.

If you use ambient temperature compensation, mount the probe to most accurately model the coolant air around the catenary:

- If the catenary is exposed to direct sunlight for the majority of the protected section, mount the probe to face the sun.
- If the catenary is shaded from sunlight, such as running in a tunnel, mount the probe on an exterior wall facing away from the sun.
- If the catenary runs in a cutting, shielded from wind, mount the probe in the lee of the substation.

- If the catenary is exposed to the wind, mount the probe on an exposed wall.

To avoid chattering of contacts when the load current is close to the trip threshold, a hysteresis setting is provided on reset. Typically the hysteresis is set to 2%, such that following a trip the thermal model must cool by 2% before the trip contacts will reset.

An alarm should be issued to warn the rail operator when speed restrictions are necessary to avoid the risk of dewirements. This should occur at 48°C in the UK example. The appropriate setting is:

θ alarm = 48°C

If you are not using ambient temperature compensation, choose a default coolant ambient temperature. In the example, if the ambient is assumed as 20°C, this would provide adequate protection except for a calculated risk on certain hot summer days. Iref is the rated thermal current at this ambient temperature.

Once you have set the current and temperature, define how fast or slow the catenary temperature responds to changes in load current. This is done by setting heating and cooling time constants. For most catenaries, the heating and cooling time constants are expected to be equal. However, in the UK catenary example, the time constant often varies from 5 minutes during daytime, to 5 to 7 minutes at night. Use the following conservative settings that assume the worst case time constants for heating and ensure protection at all times during the day.

- Heating time constant, “Time const. 1” = 5 minutes
- Cooling time constant, “Time const. 2” = 7 minutes

4.4 Trip Circuit Supervision (TCS)

In most protective schemes the trip circuit extends beyond the IED enclosure and passes through components such as fuses, links, relay contacts, auxiliary switches and other terminal boards. This complex arrangement, coupled with the importance of the trip circuit, has led to dedicated schemes for its supervision.

Several trip circuit supervision scheme variants are offered. Although there are no dedicated settings for TCS, in the MiCOM P44T the following schemes can be produced using the PSL. A user alarm in the PSL issues an alarm message on the IED. You can rename the user alarm using the menu text editor to show there is a fault with the trip circuit.

4.4.1 TCS Scheme 1

4.4.1.1 Scheme Description

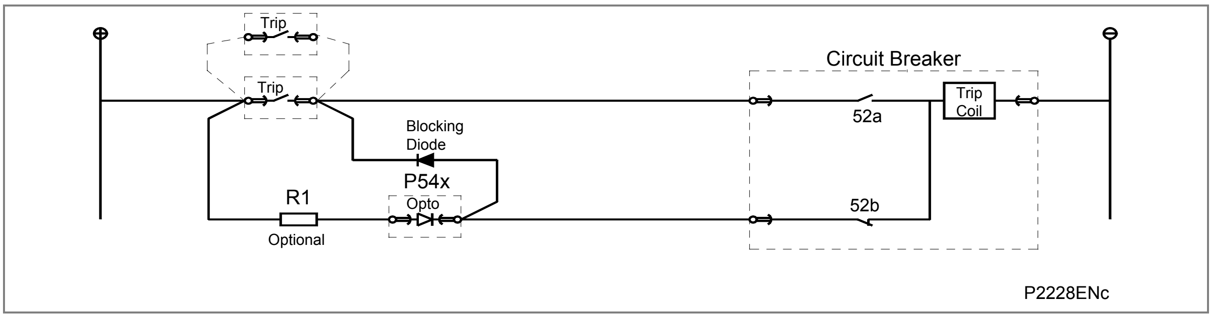


Figure 14: TCS scheme 1

This scheme provides supervision of the trip coil with the breaker open or closed, however, preclosing supervision is not provided. This scheme is also incompatible with latched trip contacts, as a latched contact will short out the opto for greater than the recommended DDO timer setting of 400 ms. If breaker status monitoring is required, a further 1 or 2 opto inputs must be used.

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

When the breaker is closed, supervision current passes through the opto input, blocking diode and trip coil. When the breaker is open, current still flows through the opto input and into the trip coil using the 52b auxiliary contact. Therefore no supervision of the trip path is provided while the breaker is open. Any fault in the trip path is only detected when the CB closes, after a 400 ms delay.

Resistor R1 is an optional resistor that can be fitted to prevent mal-operation of the circuit breaker if the opto input is inadvertently shorted, by limiting the current to <60 mA. Do not fit the resistor for auxiliary voltage ranges of 30/34 volts or less, as satisfactory operation can no longer be guaranteed. Table 7 shows the appropriate resistor value and voltage setting (OPTO CONFIG menu) for this scheme.

This TCS scheme functions correctly even without resistor R1 since the opto input automatically limits the supervision current to less that 10 mA. However, if the opto is accidentally shorted, the circuit breaker may trip.

Auxiliary voltage (Vx)	Resistor R1 (ohms)	Opto voltage setting with R1 fitted
48/54	1.2 k	24/27
110/250	2.5 k	48/54
220/250	5.0 k	110/125

Table 7: Resistor values and voltage settings for TCS scheme 1

> *Note: When R1 is not fitted, set the opto voltage equal to the supply voltage of the supervision circuit.*

4.4.1.2 Scheme 1 PSL

Figure 15 shows the scheme logic diagram for the TCS scheme 1. Any of the available opto inputs can be used to show whether or not the trip circuit is healthy. The delay on drop off timer operates as soon as the opto is energized, but takes 400 ms to drop off or reset if there is a trip circuit failure. The 400 ms delay prevents a false alarm. This is due to voltage dips caused by faults in other circuits or during normal tripping operations 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 alarms while the IED is powering up, following an auxiliary supply interruption.

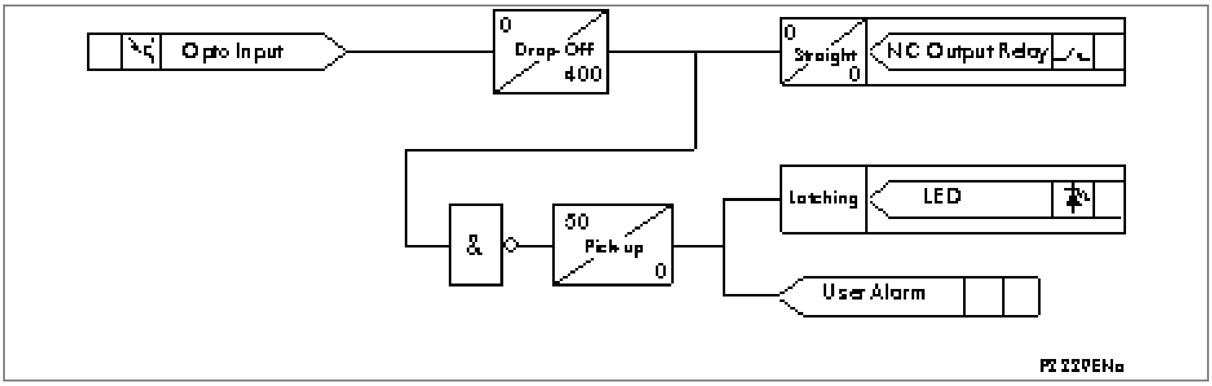


Figure 15: PSL for TCS schemes 1 and 3

4.4.2 TCS Scheme 2

4.4.2.1 Scheme Description

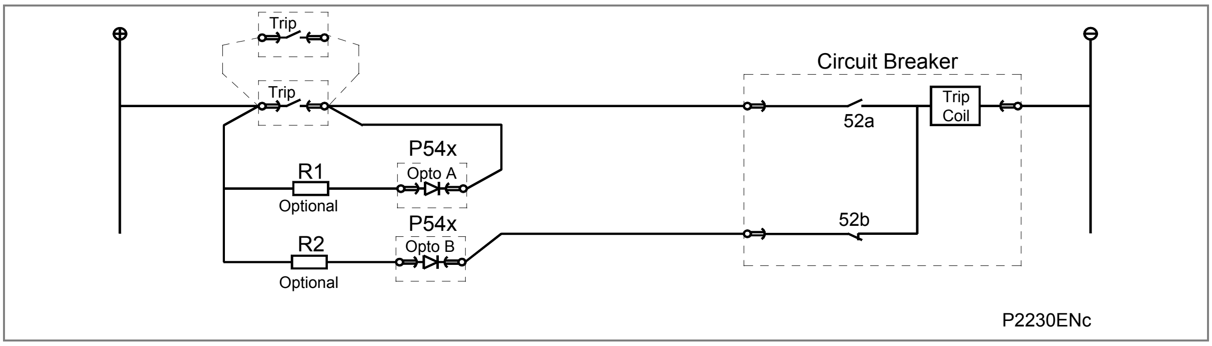


Figure 16: TCS scheme 2

Much like scheme 1, this scheme provides supervision of the trip coil with the breaker open or closed and also does not provide preclosing supervision. 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 A to the 52a contact and Opto B to the 52b contact. Provided the Circuit Breaker Status is set to 52a and 52b (CB CONTROL column) the IED correctly monitors the status of the breaker. This scheme is also fully compatible with latched contacts as the supervision current is maintained through the 52b contact when the trip contact is closed.

When the breaker is closed, supervision current passes through opto input A and the trip coil. When the breaker is open, current flows through opto input B and the trip coil. As with scheme 1, no supervision of the trip path is provided while the breaker is open. Any fault in the trip path is only detected when the CB closes, after a 400 ms delay.

As with scheme 1, optional resistors R1 and R2 can be added to prevent tripping of the CB if either opto is shorted. The resistor values of R1 and R2 are equal and can be set the same as R1 in scheme 1.

4.4.2.2 Scheme 2 PSL

The PSL for this scheme (Figure 16) is almost the same as that of scheme 1. The main difference is that both opto inputs must be off before a trip circuit fail alarm is given.

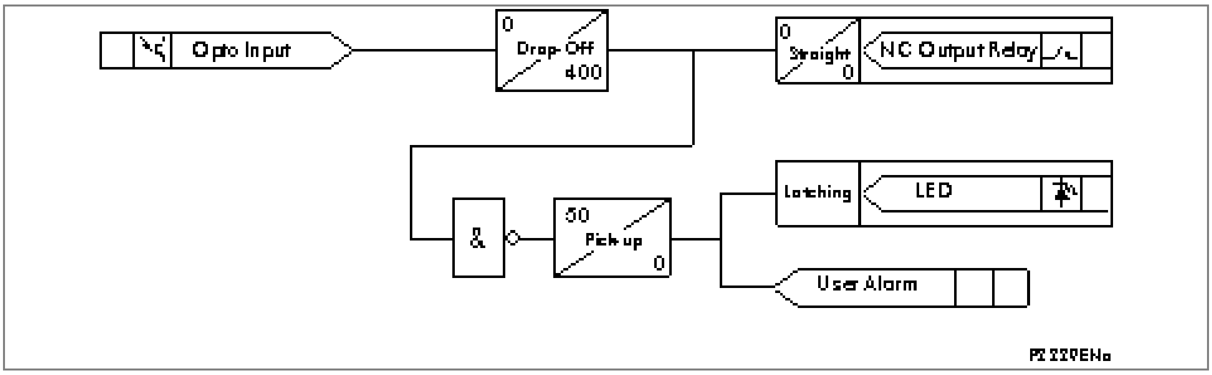


Figure 17: PSL for TCS scheme 2

4.4.3 TCS Scheme 3

4.4.3.1 Scheme Description

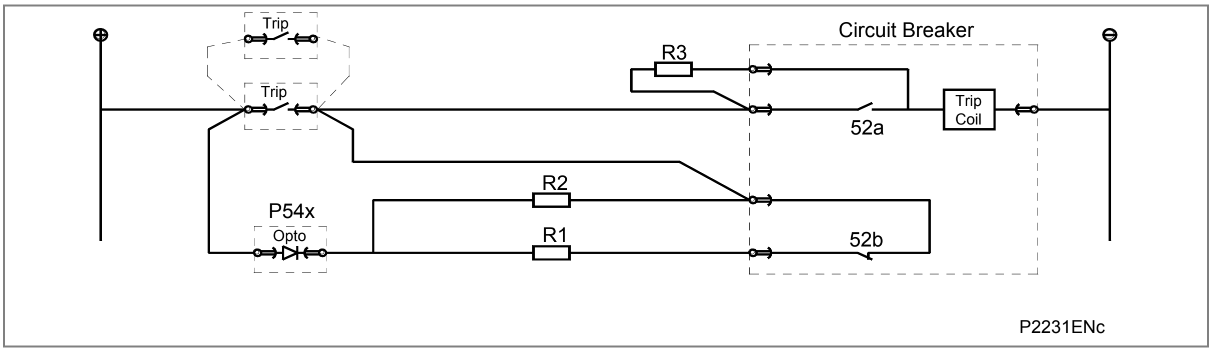


Figure 18: TCS scheme 3

Scheme 3 is designed to provide supervision of the trip coil with the breaker open or closed. Unlike schemes 1 and 2, it also provides preclosing supervision. Since only one opto input is used, this scheme is not compatible with latched trip contacts. If CB status monitoring is required, a further 1 or 2 opto inputs must be used.

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

As with schemes 1 and 2, resistors R1 and R2 are used to prevent false tripping, if the opto-input is accidentally shorted. However, unlike the other two schemes, this scheme depends on the position and value of these resistors. Removing them results in incomplete trip circuit monitoring. Table 8 shows the resistor values and voltage settings required for satisfactory operation.

Auxiliary voltage (Vx)	Resistor R1 & R2 (ohms)	Resistor R3 (ohms)	Opto voltage setting
48/54	1.2 k	0.6 k	24/27
110/250	2.5 k	1.2 k	48/54
220/250	5.0 k	2.5 k	110/125

Table 8: Resistor values and Voltage settings for TCS scheme 3

Note: Scheme 3 is not compatible with auxiliary supply voltages of 30/34 volts and below.

4.4.3.2 Scheme 3 PSL

The PSL for scheme 3 is identical to that of scheme 1 (see Figure 15).

4.5 Intermicom^{64} Application Example

An example of how to apply an InterMiCOM^{64} scheme is given below. This example should be read in conjunction with the InterMiCOM^{64} section of the Operation chapter.

4.5.1 InterMiCOM^{64} Mapping Application – BLOCKING or PUR Example

The following figure shows a suggested InterMiCOM^{64} mapping:

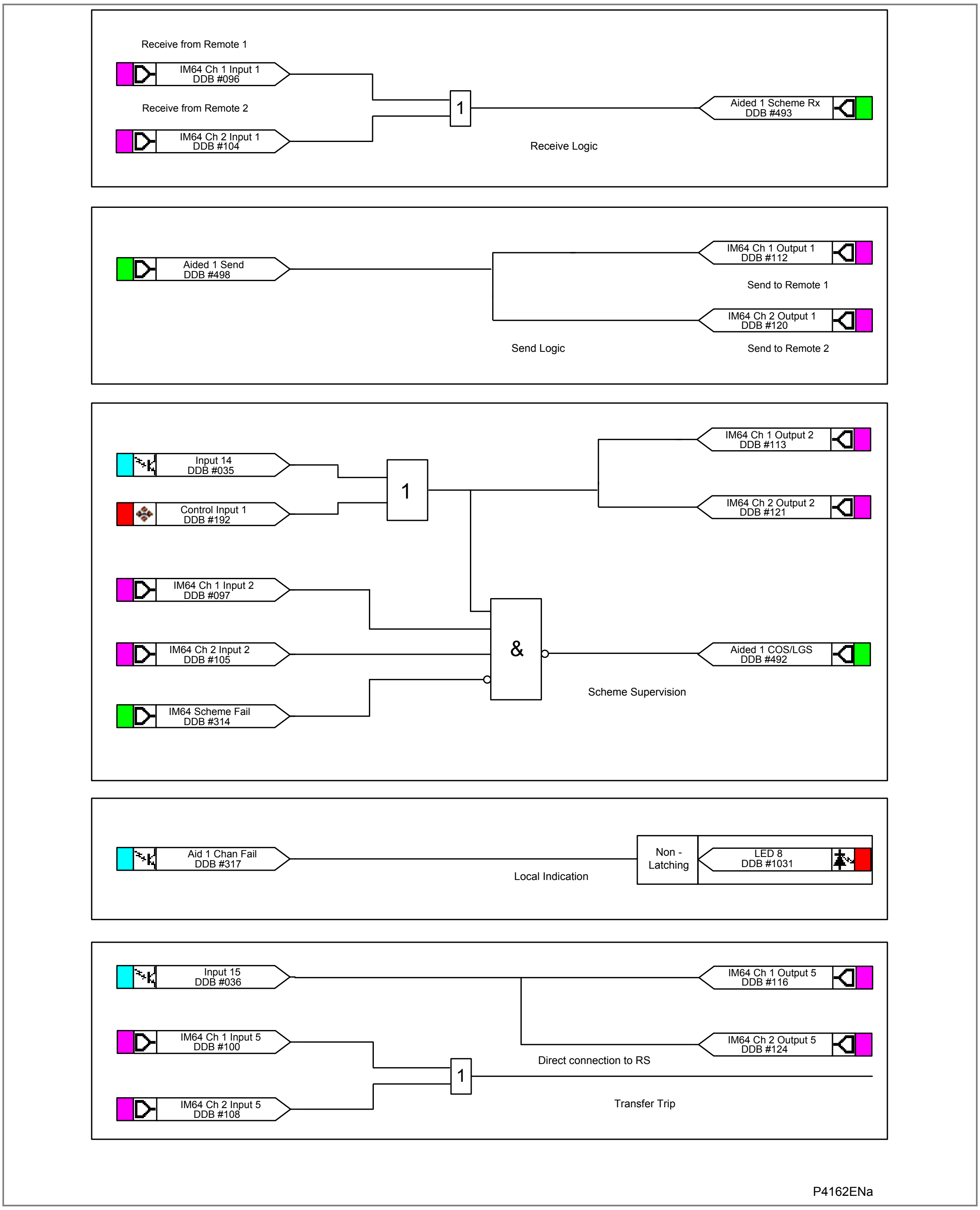


Figure 19: InterMiCOM^{64} mapping in a three ended application

4.5.2 Intermicom^{64} Application Example General Advice

MiCOM IEDs contain standard aided scheme logic that has been preconfigured. Therefore, it is not necessary to draw the zone logic for Permissive Underreach, Permissive Overreach or Blocking schemes in the PSL. To gain the benefit of selecting a proven and tested scheme, use the standard aided scheme logic.

When InterMiCOM64 is being used as the transmission medium for the aided channel signal(s), all that is required is to create a one-to-one mapping between the aided scheme logic, and the InterMiCOM64 (IM64) signals to be used. Use the PSL editor to perform the simple mapping required.

To configure the signal SEND logic:

- Route the required Aided send DDB signal to the IM64 Output to be used.

To configure the signal RECEIVE logic:

- Route the required IM64 Input signal to the Aided scheme Rx DDB input.

4.5.3 Intermicom^{64} Application Example Scheme Description

The scheme in Figure 15 is assumed as a case study. The top half of the page shows the mapping of the send and receive logic as previously described. The first InterMiCOM bit (Input 1) is used for the purposes of Aided scheme 1.

> Notes: *Two Aided schemes are available, Aided 1 and Aided 2. This allows for example an independent Distance aided scheme, and a DEF aided scheme to be configured. Whether Aided 1 is used alone, or Aided 2 is used too depends on the utility preferences*
>
> *The InterMiCOM^{64} bits are duplex. InterMiCOM^{64} bit 1 between the IED at line end A and B is completely independent of the same bit traveling from end B to A.*
>
> *For simplicity, it is recommended that Aided scheme 1 is mapped to IM64 bit 1.*
>
> *Likewise, where Aided scheme 2 is applied, it is more logical to assign IM64 bit 2, providing that it is not already used in the PSL for some other function.*

4.5.4 Intermicom^{64} Application Example Channel Supervision

For teleprotection schemes, it is commonplace to configure alarms for a channel failure. The third dotted box on the case study provides full monitoring of the scheme in three-ended applications. IM64 bit 2 is permanently energized when the channel is healthy. The OR gate shows how an opto input (L4) and a Control Input can be used as prerequisites for healthy signaling:

- An opto input can be used to check that correct DC battery voltages are present for local teleprotection. Alternatively it can be used to check that a selector switch has not taken the scheme out of service.
- Control Input allows the teleprotection to be switched in or out using menu commands on the relevant IED. This provides convenient in-out switching of the entire teleprotection scheme by visiting or addressing just one line end IED.

The logic to declare the local “signalling healthy” condition depends on the utility’s practices. In the example shown, this logic condition is mapped to IM64 Output 2 (bit 2), for transmitting to the two remote line ends.

To declare that the signalling scheme is healthy, bit 2 (the assigned health-check bit) must be received from both remote ends. This can be combined with a general check on InterMiCOM^{64} messaging, DDB #314. The AND gate shows that signalling is only healthy if:

- The local DC battery voltage or control state is set to allow teleprotection operation,
- The remote end health-check bits are both received successfully,
- The scheme alarms have not detected messaging failures (IM64 Scheme Fail).

A logical AND combination is used, with the gate output inverted to feed into the aided scheme logic. This scheme failure output then feeds the standard Channel out of Service (COS) logic.

The fourth dotted box shows how the same scheme failure alarm (COS) can then be simply mapped to any LED indication or output contact for alarms.

Note: For a simpler scheme, you don't need to assign a health-check bit. The IM64 Scheme Fail alarm alone can then be used to drive COS. However, if a test mode selection disables the aided scheme at one end, the other line ends would have no way of knowing. For this reason it is advisable to use the health-check bit.

4.5.5 Intermicom^{64} Application Example Transfer Trip

The case study scheme shows a suggested Transfer Trip ("Intertrip") in the lower dotted box area. This is an optional addition (or alternative) with any aided scheme. The example shows an opto input (L5) which is being used to initiate the intertrip, mapped to send IM64 bit 5 to both remote ends. On receipt of the intertrip bit from any remote line end, the OR gate is used to map the received intertrip to whichever output relay trips the local breaker. In the diagram, IED 3 is shown as an example. The InterMiCOM^{64} sent and received signals are controlled using PSL.

4.5.6 InterMiCOM^{64} Application Example - Mapping for Two Ended Application

The same scheme principle as shown in Figure 19 applies in a two-ended application. The scheme will be simplified, whereby Aided Send signals are mapped directly to IM64 bits, on a one-to-one mapping. The IM64 bit received from the remote end is also mapped directly to the Aided Scheme Rx signal, requiring no AND or OR logic combination.

4.5.7 Intermicom^{64} Application Example - Dual Redundant Communications Channels

In dual redundant operation, the user has the option to send end-end signals through two paths. The two paths (channels) are defined as Ch1 and Ch2. Several factors can be taken into account when using this mode:

- The assignment of IM64 bits is completely independent, per channel. For example if all 8 possible bits per channel are assigned to discrete functions, this allows a total of 16 end-end signals.
- The receive logic should employ AND ("both") or OR ("any") logic gate functions to combine the dual redundant signals, as appropriate to the desired operation.

4.5.8 Intermicom^{64} Application Example - Scheme Coordination Timers

Distance and DEF delta directional aided schemes use scheme coordination timers to ensure correct operation. The function of these is documented in the OP sections of the Technical Manual. However, when using InterMiCOM^{64} as the teleprotection channel, the time delays applied can be different to those used for traditional channels. This is due, mainly, to the fact that the response time of opto inputs and output contacts is bypassed. An output contact will take typically 3 to 5 ms to close, and an opto input will take 1 to 2 ms to recognize a change of state. Therefore using InterMiCOM^{64} will save around 5-6 ms for I/O response time.

The new time delays appropriate for Dist Dly and Current Reversal Guard timers are as listed in the following sections. Where direct fibre connections are used for InterMiCOM^{64}, ignore the + MUX addition. Where a multiplexed link is used, the + MUX figure should account for the multiplexer response time. If this is unknown, it can be obtained for the specific installation using the appropriate measurement in the MEASUREMENTS 4 menu column.

4.5.8.1 InterMiCOM^{64} Application Example - Distance PUR Permissive Underreach

- Dist dly = zero

4.5.8.2 InterMiCOM^{64} Application Example - Distance POR Permissive Overreach

- Dist dly = zero
- tREV. Guard = 40 ms + MUX

4.5.8.3 InterMiCOM^{64} Application Example - Distance Blocking

- Dist dly (50 Hz) = 25 ms + MUX
- Dist dly (60 Hz) = 22 ms + MUX
- tREV. Guard = 25 ms + MUX

4.5.8.4 InterMiCOM^{64} Application Example - Delta Directional POR Permissive Overreach

- Delta dly = zero
- tREVERSAL GUARD = 40 ms + MUX

4.5.8.5 InterMiCOM^{64} Application Example - Delta Directional Blocking

- Delta dly = 14 ms + MUX
- tREVERSAL GUARD = 25 ms + MUX

> *Note:* *When adding any multiplexer delays, the maximum response time of the multiplexed link should be assumed. This should include any addition for rerouting in self-healing networks.*

4.5.9 Fallback Mode for InterMiCOM^{64} Bits

On temporary loss of the InterMiCOM^{64} channel, the user may select to latch the last healthy signal for a period of time, or to fallback to a chosen default value.

For Intertripping schemes, reverting to a default state of 0 is recommended;

For blocking schemes set, reverting to a default state of 1 is recommended;

For Permissive applications, latching the last healthy received state is recommended.

5 APPLICATION OF NON PROTECTION FUNCTIONS

5.1 Single and All Phase Auto-Reclosing

During the dead time of the first autoreclose shot there can be repetitive tripping of unfaulted catenary sections. To avoid this, remove all paralleling between tracks. This is done by opening motorized isolators at all SS and MPSS locations. On reclosure, the tracks are then radial fedS and a persistent fault would cause tripping of the faulted track only.

Once radial-fed, the IEDs at the FS only need to trip their own track. They do not need to cross-trip the parallel tracks as before.

Protection at the FS will also trip for downstream AT faults. As there are no circuit breakers at SS and MPSS auto-transformer locations, AT protection waits for loss of line voltage during the dead time of FS circuit breakers, and only then opens switches locally. Therefore when the FS breakers are reclosed, the faulted AT are already disconnected.

It is common to used multiple shots of autoreclose, with radial fed tracks. For the last shot, it is common to disconnect all ATs downstream of the FS before the reclosure attempt. This is because with all ATs and paralleling removed, the IED can then apply a linear relationship to the distance-to-fault measurement. The impedance measured in ohms is directly proportional to the distance to fault, allowing conventional fault location algorithms to be applied. Fault rectification crews can then be directed to the correct site to investigate a permanent fault.

5.1.1 Time Delayed and High Speed Auto-Reclosing

An analysis of faults on any overhead line network has shown that 80-90% are transient.

Usually if a faulty line is immediately tripped out, and time is allowed for the fault arc to de-ionize, when the the circuit breakers are reclosed, the line is successfully re-energized. Auto-reclose schemes automatically reclose a switching device a set time after it has been opened. This is because transient and semi-permanent faults are common.

The main benefit of auto-reclosing overhead line feeders is improved continuity of the supply. It can also reduce costs since fewer personnel may be needed. On some systems, high speed auto-reclose may allow a higher level of power to be transferred, while retaining transient stability for most common faults.

High speed single-phase auto-reclosure can increase the power transfer limit and reduce the stress on reclosing.

5.1.2 Auto-reclose Logic Operating Sequence

The standard scheme logic is configured to allow control of one circuit breaker only.

For high speed auto-reclose, only the instantaneous protection would normally be set to initiate auto-reclose. This is because when applying high speed auto-reclose to improve a system stability limit, the fault should be cleared as quickly as possible from both line ends.

5.1.3 Auto-Reclose Setting Guidelines

5.1.3.1 Circuit Breaker Healthy

The MiCOM P44T monitors the state of the auxiliary contacts (52A, 52B) of the controlled circuit breakers to determine healthy circuit breaker status before allowing auto-reclose. Monitoring of the auxiliary contacts is recommended. However, this check can be disabled by not allocating opto inputs to this function and deliberately applying logic 1 onto the corresponding DDB signals in the PSL.

5.1.3.2 Number of Shots

An important consideration is the ability of the circuit breaker to perform several trip close operations in quick succession and the effect of these operations on the maintenance period.

The fact that 80 - 90% of faults are transient highlights the advantage of single shot schemes. If statistical information for the power system shows that a moderate percentage of faults are semi-permanent, further DAR shots can be used if system stability is not threatened.

Note: DAR shots will always be All pole reclose.

5.1.3.3 Dead Timer Setting

High speed auto-reclose may be required to avoid delay to trains but is not always permitted on railway. Dead time is typically between 3 and 60s.

For high speed auto-reclose the system disturbance time should be minimized by using fast protection <30 ms.

The minimum system dead time considering just the CB is the trip mechanism reset time plus the CB closing time.

Minimum IED dead time settings are governed primarily by two factors:

- Circuit breaker characteristics

Also it is essential that the protection fully resets during the dead time, so that correct time discrimination will be maintained after reclosure onto a fault. For high speed auto-reclose instantaneous reset of protection is required.

5.1.3.4 Example Minimum Dead Time Calculation

The following circuit breaker and system characteristics are to be used:

- CB Operating time (Trip coil energized → Arc interruption): 50 ms (a);
- CB Opening + Reset time (Trip coil energized → Trip mechanism reset): 200 ms (b);
- Protection reset time: < 80 ms (c);
- CB Closing time (Close command → Contacts make): 85 ms (d).
- 560 ms (e) for a single pole trip.

The minimum IED dead time setting is the greater of:

- (a) + (c) = 50 + 80 = 130 ms, to allow protection reset;
- (a) + (e) - (d)= 50 + 560 - 85 = 525 ms.

In practice a few additional cycles would be added to allow for tolerances, so Dead Time 1 could be chosen as ≥ 300 ms, and 1Pole Dead Time could be chosen as ≥ 600 ms. The overall system dead time is found by adding (d) to the chosen settings, and then subtracting (a). (This gives 335 ms and 635 ms respectively here).

5.1.3.5 Reclaim Timer Setting

Several factors influence the choice of the reclaim timer, such as:

- Fault incidence/Past experience - Small reclaim times may be required where there is a high incidence of recurrent lightning strikes to prevent unnecessary lockout for transient faults

- Spring charging time - For high speed auto-reclose the reclaim time may be set longer than the spring charging time. A minimum reclaim time of >5s may be needed to allow the CB time to recover after a trip and close before it can perform another trip-close-trip cycle. This time will depend on the duty (rating) of the CB. For delayed auto-reclose there is no need as the dead time can be extended by an extra CB healthy check AR Inhibit Time window time if there is insufficient energy in the CB
- Switchgear Maintenance - Excessive operation resulting from short reclaim times can mean shorter maintenance intervals
- The Reclaim Time setting is not permitted but when is, is between 3 and 60s and generally set greater than the tZ2 distance zone delay

5.2 Circuit Breaker (CB) Condition Monitoring

5.2.1 Setting the Σ I^ Thresholds

Where overhead lines are prone to frequent faults and are protected by oil circuit breakers (OCBs), oil changes account for a large proportion of the life cycle cost of the switchgear. Generally, oil changes are performed at a fixed interval of circuit breaker fault operations. However, this may result in premature maintenance where fault currents tend to be low, so oil degradation is slower than expected. The Σ I^ counters monitor the cumulative severity of the duty placed on the interrupter allowing a more accurate assessment of the circuit breaker condition to be made.

For OCBs, the dielectric withstand of the oil generally decreases as a function of Σ I2t. This is where 'I' is the fault current broken, and 't' is the arcing time within the interrupter tank (not the interrupting time).

For circuit breakers operating on higher voltage systems, practical evidence suggests that the value of "Broken I^" = 2 may be inappropriate. In such applications "Broken I^" may be set lower, typically 1.4 or 1.5. An alarm in this instance may indicate the need for gas/vacuum interrupter HV pressure testing, for example. The setting range for "Broken I^" is variable between 1.0 and 2.0 in 0.1 steps. It is imperative that any maintenance program must be fully compliant with the switchgear manufacturer's instructions.

5.2.2 Setting the Number of Operations Thresholds

Every operation of a circuit breaker results in some degree of wear for its components. Therefore, routine maintenance, such as oiling of mechanisms, may be based on the number of operations. Suitable setting of the maintenance threshold will allow an alarm to be raised, indicating when preventative maintenance is due. If maintenance is not carried out, the IED can be set to lock out the auto-reclose function on reaching a second operations threshold. This prevents further reclosure when the circuit breaker has not been maintained to the standard demanded by the switchgear manufacturer's maintenance instructions.

Certain circuit breakers, such as oil circuit breakers (OCBs) can only perform a certain number of fault interruptions before requiring maintenance attention. This is because each fault interruption causes carbonizing of the oil, degrading its dielectric properties.

The maintenance alarm threshold, **No. CB Ops Maint** can be set to indicate the requirement for oil sampling for dielectric testing, or for more comprehensive maintenance. The lockout threshold **No CB Ops. Lock** can be set to disable auto-reclosure when repeated further fault interruptions could not be guaranteed. This minimizes the risk of oil fires or explosion.

5.2.3 Setting the Operating Time Thresholds

Slow circuit breaker operation is also indicative of the need for mechanism maintenance. Therefore, alarm and lockout thresholds CB Time Maint./CB Time Lockout) are provided and are settable in the range of 5 to 500 ms. This time is set in relation to the specified interrupting time of the circuit breaker.

5.2.4 Setting the Excessive Fault Frequency Thresholds

Persistent faults will generally cause auto-reclose lockout, with subsequent maintenance attention. Intermittent faults such as clashing vegetation may repeat outside of any reclaim time, and the common cause might never be investigated. For this reason it is possible to set a frequent operations counter on the IED which allows the number of operations **Fault Freq. Count** over a set time period **Fault Freq. Time** to be monitored. Separate alarm and lockout thresholds can be set.

5.3 Read Only Mode

With IEC 61850 and Ethernet/Internet communication capabilities, security has become a pressing issue. Px40 IEDs allow the user to remotely enable or disable the configuration change.

Read only mode can be enabled/disabled for the following rear ports:

- Rear Port 1 - IEC 60870-5-103 and Courier protocols
- Rear Port 2 (if fitted) Courier protocol
- Ethernet Port (if fitted) Courier protocol (tunneled)

6 CURRENT TRANSFORMER (CT) REQUIREMENTS

6.1 Recommended CT Classes (British and IEC)

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

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

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

Where:

VA = Volt-ampere burden rating

ALF = Accuracy limit factor

In = CT nominal secondary current

6.2 Distance Protection CT Requirements

6.2.1 Zone 1 Reach Point Accuracy (RPA)

$Vk \geq K_{RPA} \times IF Z1 \times (1+ X/R). (RCT + 2RL)$

Where:

Vk = Required CT knee point voltage (volts)

K_{RPA} = Fixed dimensioning factor = **always 0.35**

IFZ1= Max. secondary fault current at Zone 1 reach point (A)

X/R = Primary system reactance/resistance ratio

RCT= CT secondary winding resistance (Ω)

RL = Single lead resistance from CT to IED (Ω)

6.3 Zone 1 Close-up Fault Operation

$Vk \geq Kmax \times IF max \times (RCT + 2RL)$

Where:

Kmax = Fixed dimensioning factor = **always 0.95**

IF max = Max. secondary fault current (A).

Then, the higher of the two calculated knee points must be used.

6.4 Time Delayed Distance Zones

When a time delayed distance zone is being used, there is no need to calculate the required Vk separately. This is due to the employed time delay (usually more than 3 times the primary time constant for a fault at the remote bus of the protected feeder), which overrides the transient conditions. When If it is necessary to do some calculations for the time delayed distance zone, then we should use the following equation

$Vk > If (RCT + 2RL)$

Where If is the current for a fault at the remote bus of the protected feeder .

6.5 Worked Example for CT Requirements

A typical 25kV Railway system as given in section 4.1 is used here to calculate CT requirements.

6.5.1 Important notes to be considered

- Distance Zone1 reach point case – Both If and X/R are to be calculated for a fault at Zone1 reach point
- For calculating the CT requirements, the bus bar short time symmetrical fault rating shall be considered as the bus fault level.
- If only indicative X/Rs are available, the circuit breaker's dc breaking capacity is used to derive the primary time constant and therefore the primary system X/R.

6.5.2 System Data

In the following example, the following parameters have been considered for the CT calculations:

System voltage - 26 kV

System frequency - 50 Hz

System grounding - solid

Single circuit operation between Trent Bridge and Edgbaston

CT ratio - 600/1

Line length – 12.2 kms

Line positive sequence impedance Z1 = 0.277 + j 0.75 ohm / km Note *

Bus fault level – 12.5 kA

Primary time constant = 45 ms

*Note * Assumes composite impedance including booster transformer*

6.5.3 Calculation of Primary X/R

Primary X/R till the Trent Bridge bus = 2 * π * f * primary time constant in s

= 2 * π * 50 * 0.045

Primary X/R till the bus = 14.1

6.5.4 Calculation of Source Impedance Zs

Source Impedance Zs = 26 kV / 12.5 kA
= 2.08 ohms

Source angle = $\tan^{-1}$ (X/R)

= $\tan^{-1}$ (14.1)

= 85.94 deg

Hence, Zs = 0.147 + j 2.075 ohms

6.5.5 Calculation of Full Line Impedance (full 12.2 km)

Z1 = 12.2 km x (0.277 + j 0.75 ohm / km)

ZL = 3.38 + j 9.15 ohms

ZL = 9.76 ohms with an angle 69.7 deg

6.5.6 Calculation of Total Impedance up to Remote Busbar

ZT = Zs + ZL = (0.147 + j 2.075) + (3.38 + j 9.15) ohms

= 3.53 + j 11.22 ohms

= 11.77 ohms with an angle of 72.6 deg

6.5.7 Calculation of Remote Busbar Fault X/R

X/R rem = 11.22 / 3.53

= 3.18

6.5.8 Calculation of Remote Busbar Fault If

If rem = 26kV / 11.77

= 2.21 KA primary

= 3.68 A (secondary)

6.5.9 Calculation of Line Impedance up to Zone1 Reach Point (10.4 km)

Zzone1 = 0.85 * ZL = 2.87 + j 7.78 ohms

= 8.29 ohms with an angle of 69.7 deg

6.5.10 Calculation of Total Impedance up to Zone1 Reach Point

ZTzone1 = Zs + Zzone1

= 3.02 + j 9.85 ohms

= 10.305 ohms with an angle of 73 deg

6.5.11 Calculation of X/R up to Zone1 Reach Point

X/R Zone1 = 9.85 / 3.02

= 3.26

6.5.12 Calculation of Fault Current up to Zone1 Reach Point

If Zone1 = 26 kV / 10.305

= 2.523 kA (primary)

= 4.21 A (secondary)

6.5.13 CT Vk for Distance Zone1 Reach Point

Vk ≥ KRPA x IF z1 x (1+ X/R). (RCT + 2RL) -- From section 6.2

Vk > 0.35 * 4.21 * (1+3.26) * (RCT+2RL)

Vk > 6.28 (RCT + 2RL)

6.5.14 CT Vk for Distance Zone1 Close-up Fault

Close-up fault current = 12.5 kA (primary) = 20.83 A (secondary)

Vk ≥ Kmax x IF max x (RCT + 2RL) -- From section 6.3

Vk > 0.95 * 20.83 * (RCT + 2RL)

Vk > 19.79 (RCT + 2RL)

6.5.15 CT Vk for Distance Time Delayed Zones

Vk > If (RCT + 2RL) -- From section 6.4

Vk > If rem * (RCT + 2RL)

Vk > 3.68 (RCT + 2RL)

6.5.16 Vk to be considered

Using the above sections, the different Vk requirements are to be calculated for all the functions that will be enabled, or that will be brought into operation. Then the highest Vk shall be considered for the CT design.

7 HIGH BREAK OUTPUT CONTACTS

The high break contacts allow the elimination of auxiliary IEDs. This in turn helps in the provision of cost effective solutions, minimizing space, wiring, commissioning time, etc.

According to the model selected, in addition to standard output relay boards, one or two 'high break' output relay boards can be fitted. Each house four normally open output contacts suitable for breaking loads higher than can be broken with the standard contacts. The performance and possible applications of these contacts are described in the Hardware and Software Design chapters of this manual.

8 AUXILIARY SUPPLY FUSE RATING

In the Safety section of this manual, the maximum allowable fuse rating of 16 A is quoted. To allow time grading with fuses upstream, a lower fuse link current rating is often preferable. Use of standard ratings of between 6 A and 16 A is recommended. Low voltage fuse links, rated at 250 V minimum and compliant with IEC 60269-2 general application type gG are acceptable, with high rupturing capacity. This gives equivalent characteristics to HRC "red spot" fuses type NIT/TIA often specified historically.

The table below recommends advisory limits on IEDs connected per fused spur. This applies to MiCOM Px40 series devices with hardware suffix C and higher, as these have inrush current limitation on switch-on, to conserve the fuse-link.

Maximum number of MiCOM Px40 IEDs recommended per fuse				
Battery nominal voltage	6 A	10 A fuse	15 or 16 A fuse	Fuse rating > 16 A
24 to 54 V	2	4	6	Not permitted
60 to 125 V	4	8	12	Not permitted
138 to 250 V	6	10	16	Not permitted

Table 9: Recommended advisory limits on IEDs connected per fused spur

Alternatively, Miniature Circuit Breakers (MCB’s) may be used to protect the auxiliary supply circuits.

SCADA COMMUNICATIONS

CHAPTER 9

1 CHAPTER OVERVIEW

The MiCOM Px40 series supports substation 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. General Electric's MiCOM Px40 products support both of these communication technologies.

This chapter consists of the following sections:

2 COMMUNICATION INTERFACES

The MiCOM P44T IEDs 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, IEC60870-5-103, DNP3.0 (order option)
Rear Port 1 (RP1 fibre)	Optional	Fibre	SCADA Remote settings	Courier, IEC60870-5-103, DNP3.0 (order option)
Rear Port 2 (RP2)	Optional	RS232 / RS485 / K-Bus	SCADA Remote settings	Courier
Ethernet	Optional	Ethernet	IEC 61850 or DNP3 Remote settings	IEC 61850, Courier (tunnelled) or DNP3.0 (order option)

Notes:

1. *Optional communications boards are always fitted into slot A and only slot A.*
2. *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.*
3. *It is only possible to fit one optional communications board, therefore RP2 and Ethernet communications are mutually exclusive.*

3 SERIAL COMMUNICATION

Serial communication is possible over metallic or optical fibre cables.

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

- EIA(RS)232 (often abbreviated to RS232)
- EIA(RS)485 (often abbreviated to RS485)
- K-Bus (a proprietary customization of RS485)
- Serial communication over optical fibre

RS232 is for point-to-point communication over very short distances.

RS485 is for longer distances and allow daisy-chaining and multi-dropping of IEDs.

K-Bus is very similar to RS485, but cannot be mixed on the same link as RS485. Unlike RS485, K-Bus signals applied across two terminals are not polarized.

Serial links over fibre use a proprietary low level protocol based on HDLC.

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. A full description of these physical layer protocols is available from a number of sources including the published standards.

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 polarized.

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.

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. Figure 2 shows a typical biasing arrangement.

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

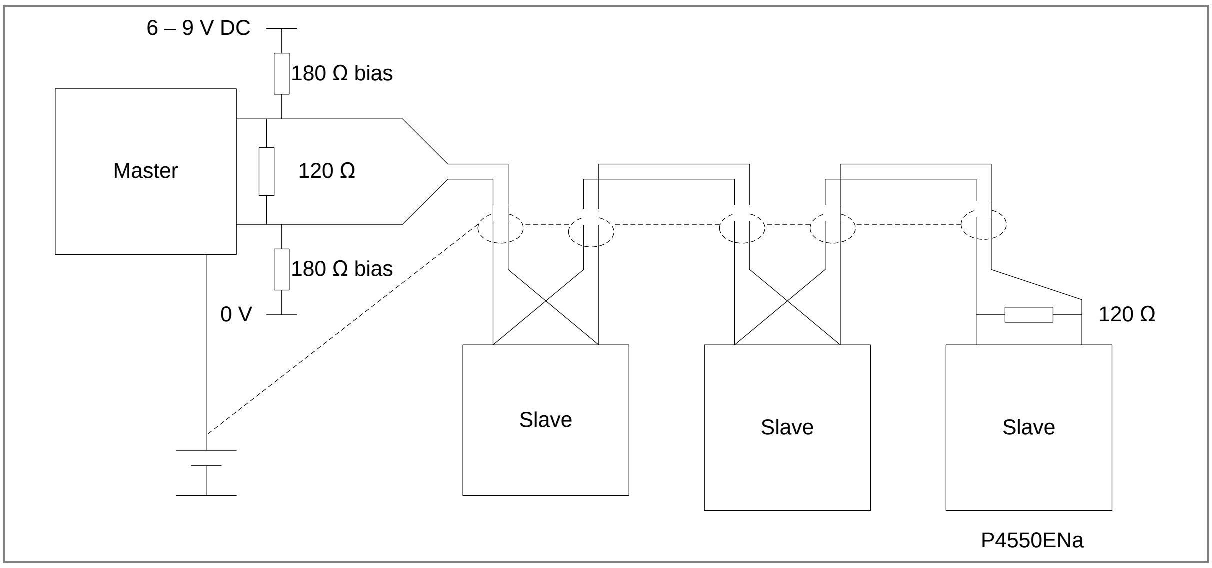


Figure 1: RS485 bus biasing arrangements

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 spur can be up to 1000 m in length. The K-Bus twisted pair connection is non-polarized.

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 General Electric for information regarding the specification and supply of KITZ devices. The following figure demonstrates a typical K-Bus connection.

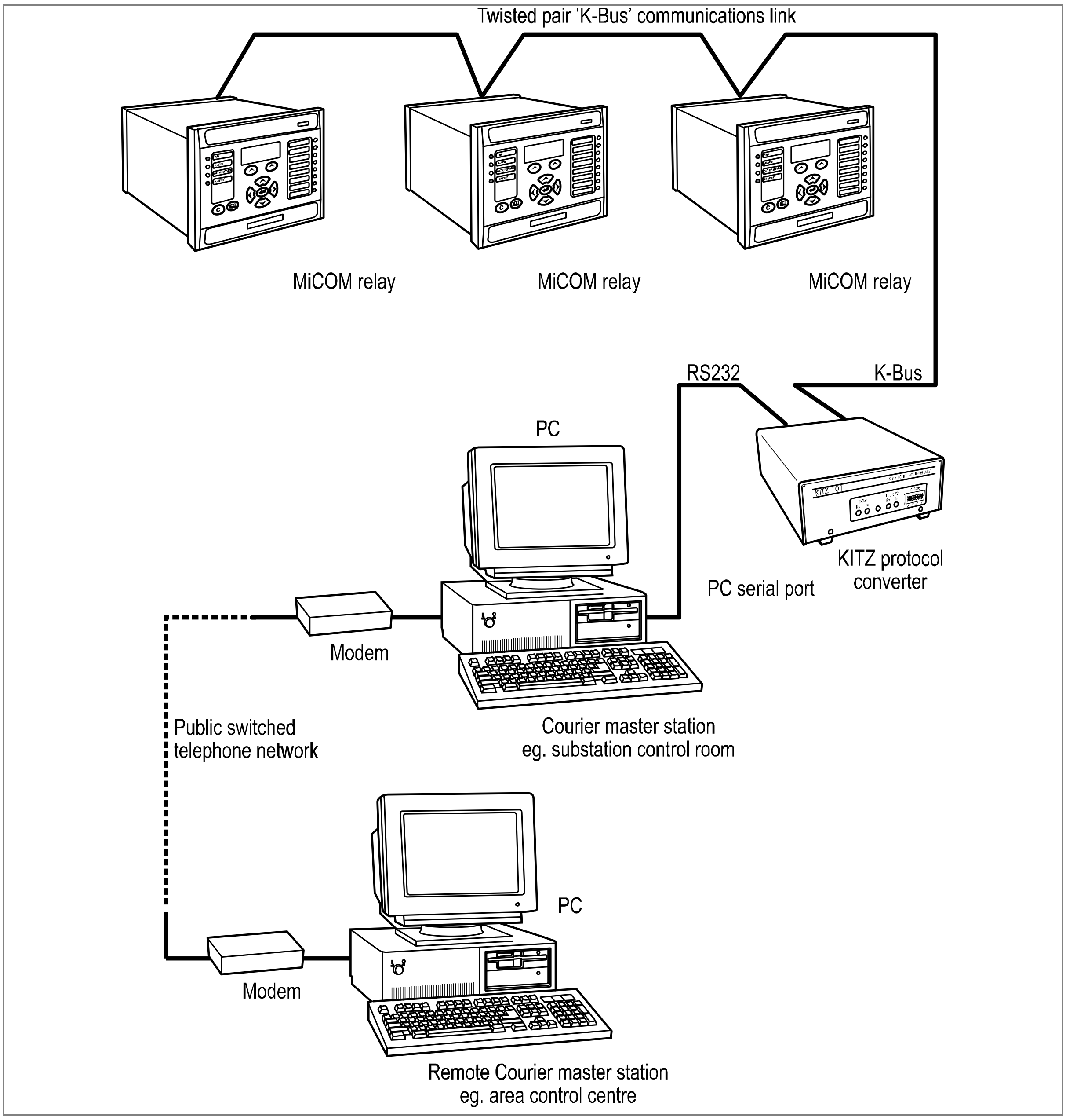


Figure 2: Remote communication using K-Bus

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

3.4 Optical Fibre

It is also possible to use optical fibre as a physical medium for serial communications. An optional fibre optic board is available for this purpose. This board allows the RS485 frames to be transmitted over optical fibres. This communication board is available for all available serial data protocols.

850nm multimode 50/125 µm or 62.5/125 µm fibres are used and are presented on BFOC 2.5 ST connectors.

4 STANDARD ETHERNET COMMUNICATION

Several different types of Ethernet board are available for use depending 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 Agile 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.

Table 1 shows the signals and pins on the RJ45connector.

Pin	Signal name	Signal definition
1	TXP	Transmit (positive)
2	TXN	Transmit (negative)
3	RXP	Receive (positive)
4	-	Not used
5	-	Not used
6	RXN	Receive (negative)
7	-	Not used
8	-	Not used

Table 1: Ethernet signals

Note: *For Redundant Ethernet, please see separate chapter*

5 REDUNDANT ETHERNET COMMUNICATION

Redundancy is transparent backup. It is required where a single point of failure cannot be tolerated, and is thus required in critical applications such as substation automation. Redundancy acts as an insurance policy, providing an alternative route in the event that one route fails.

The Redundant Ethernet Board (REB) designed for the Px40 series assures "bumpless" redundancy at the intelligent electronic device (IED) level. "Bumpless" in this context is a term used to describe the transferring from one communication path to another without noticeable consequences.

5.1 Redundancy Protocols

There are three redundancy protocols available:

- RSTP (Rapid Spanning Tree Protocol)
- SHP (Self-Healing Protocol)
- DHP (Dual Homing Protocol)

The protocol must be selected at the time of ordering.

5.1.1 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.

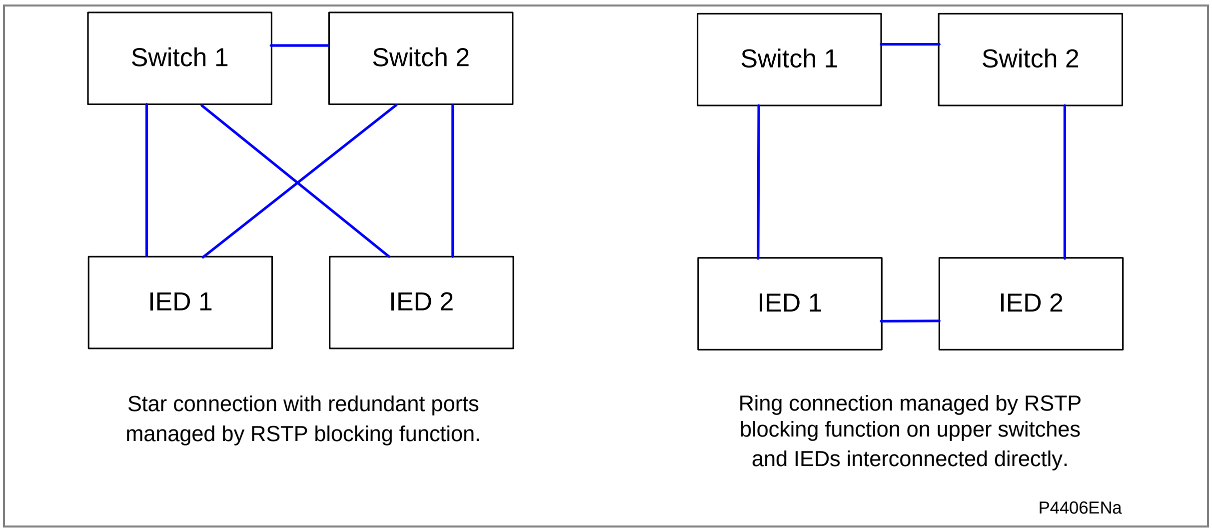


Figure 3: Px4x attached to a redundant Ethernet star or ring circuit

The RSTP solution is based on open standards. It is therefore compatible with other Manufacturers' IEDs that use the RSTP protocol. The RSTP recovery time is typically 300 ms but it increases with network size, therefore cannot achieve the desired bump less redundancy.

5.1.2 Self-Healing Protocol (SHP)

Unlike RSTP, the General Electric 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 NS Agile 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.

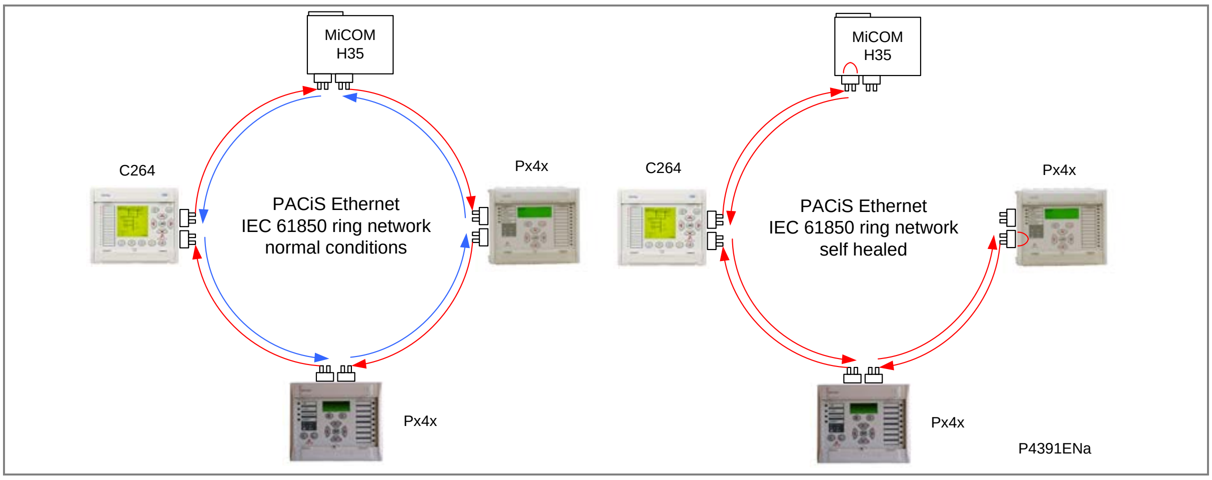


Figure 4: MiCOM products in a self-healing ring

The devices shown in Figure 4 are repeaters with a standard 802.3 Ethernet switch plus the Self-Healing Manager (SHM). Figure 5 shows the internal architecture of such a device.

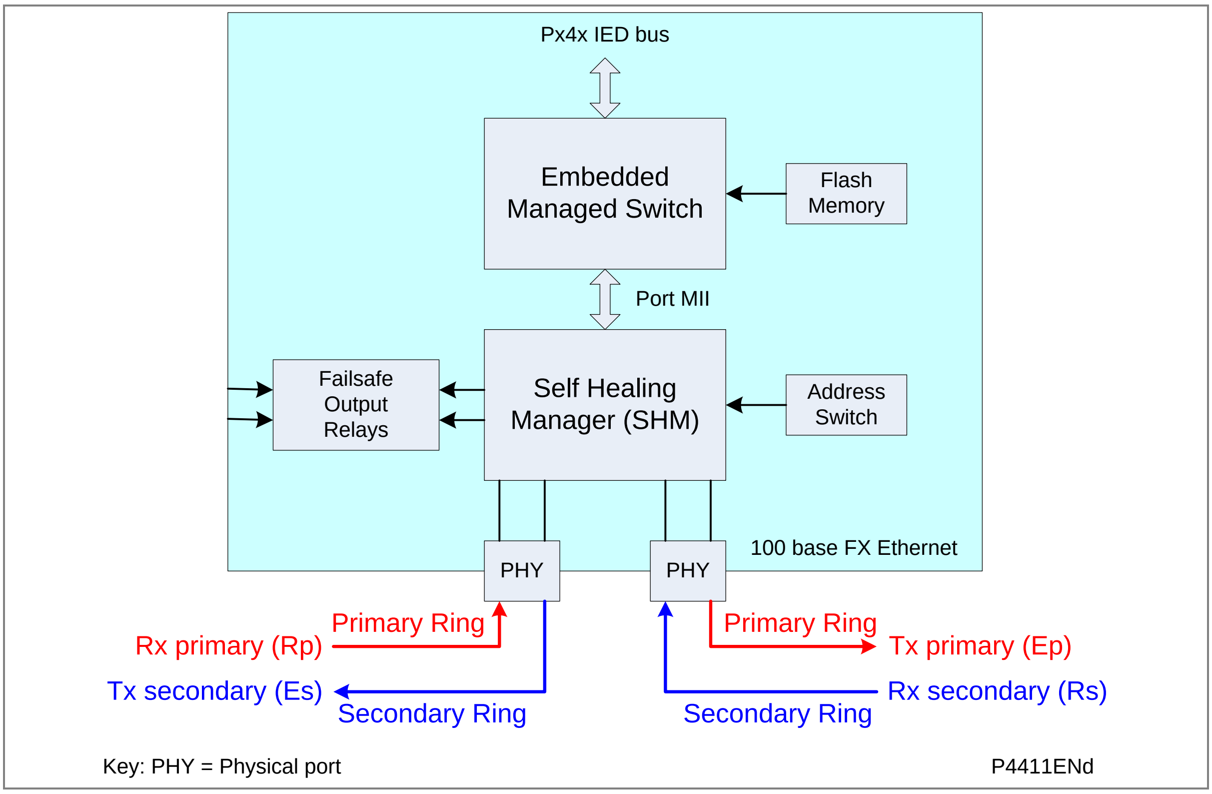


Figure 5: SHM Internal architecture

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.

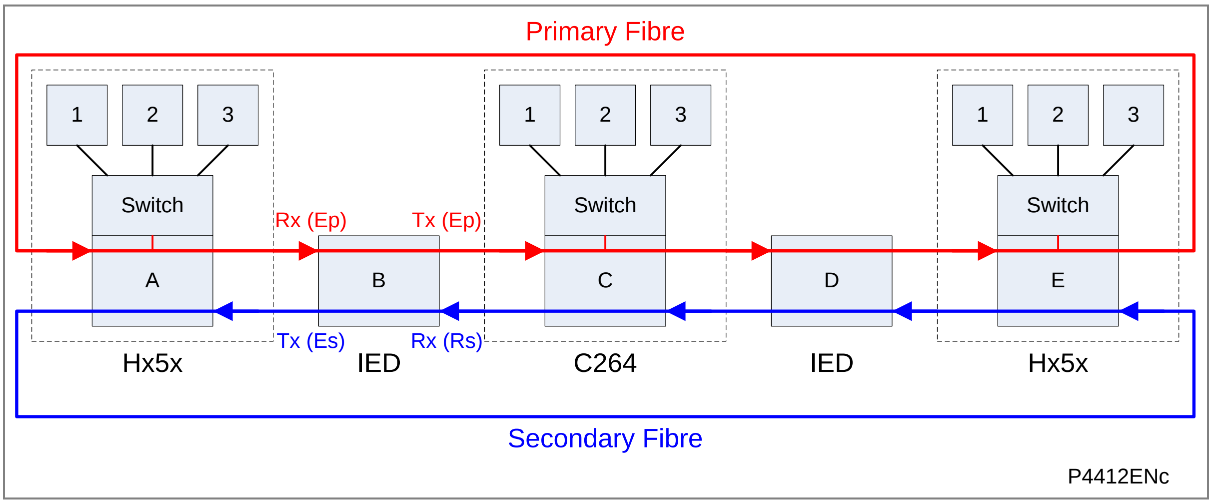


Figure 6: Nominal redundant Ethernet ring architecture

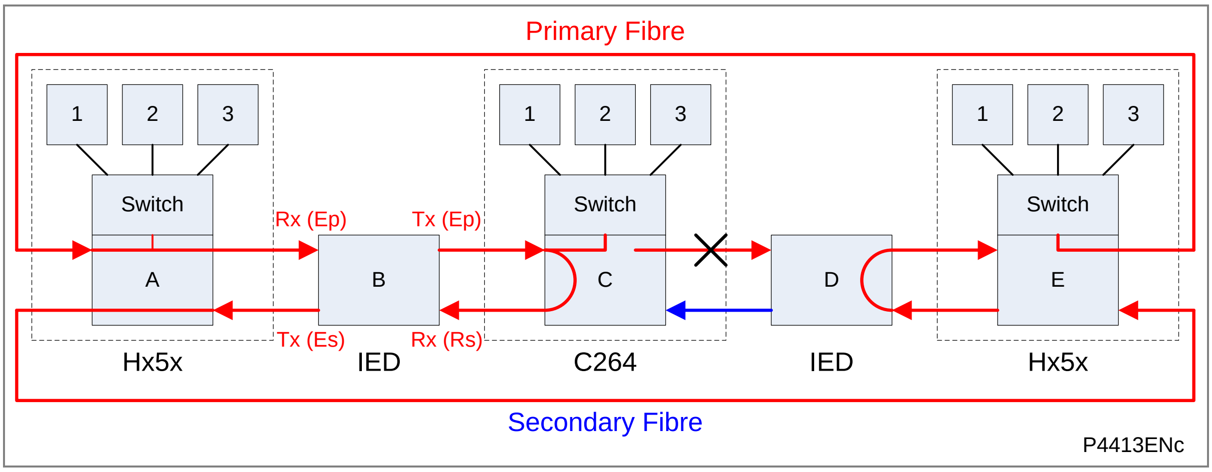


Figure 7: Ethernet ring architecture after failure

5.1.3 Dual-Homing Protocol (DHP)

Unlike RSTP, the General Electric 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 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.

General Electric'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.

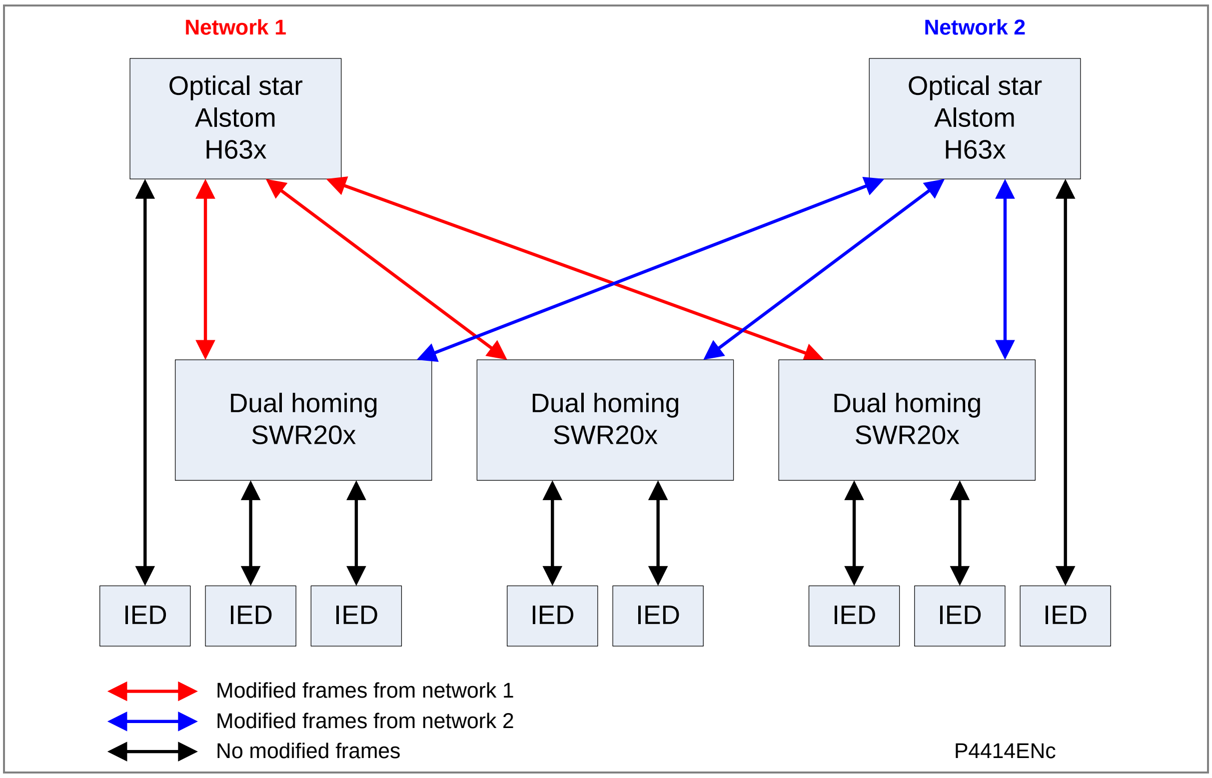


Figure 8: Dual homing mechanism

The H36x is a repeater with a standard 802.3 Ethernet switch, plus the DHM. Figure 9 shows the internal architecture of such a device.

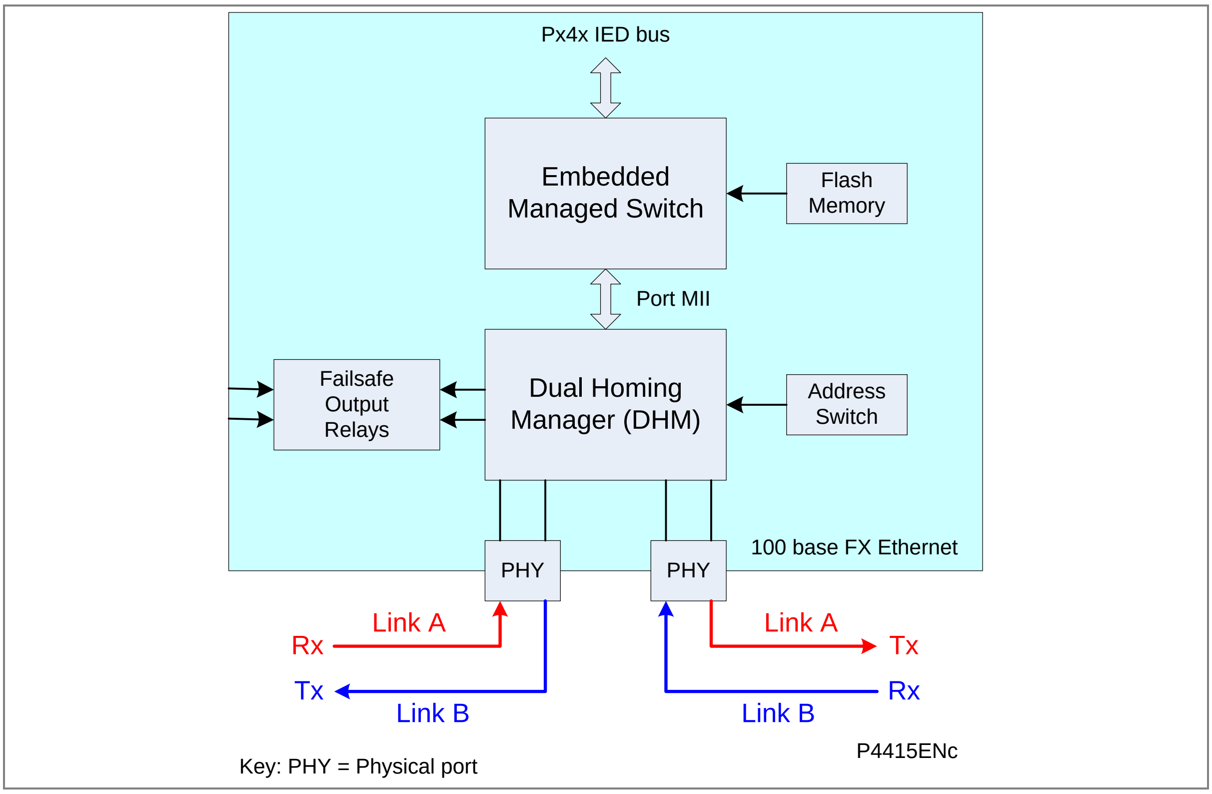


Figure 9: DHM Internal architecture

Figure 10 shows a star-connected network, using DHP at substation level.

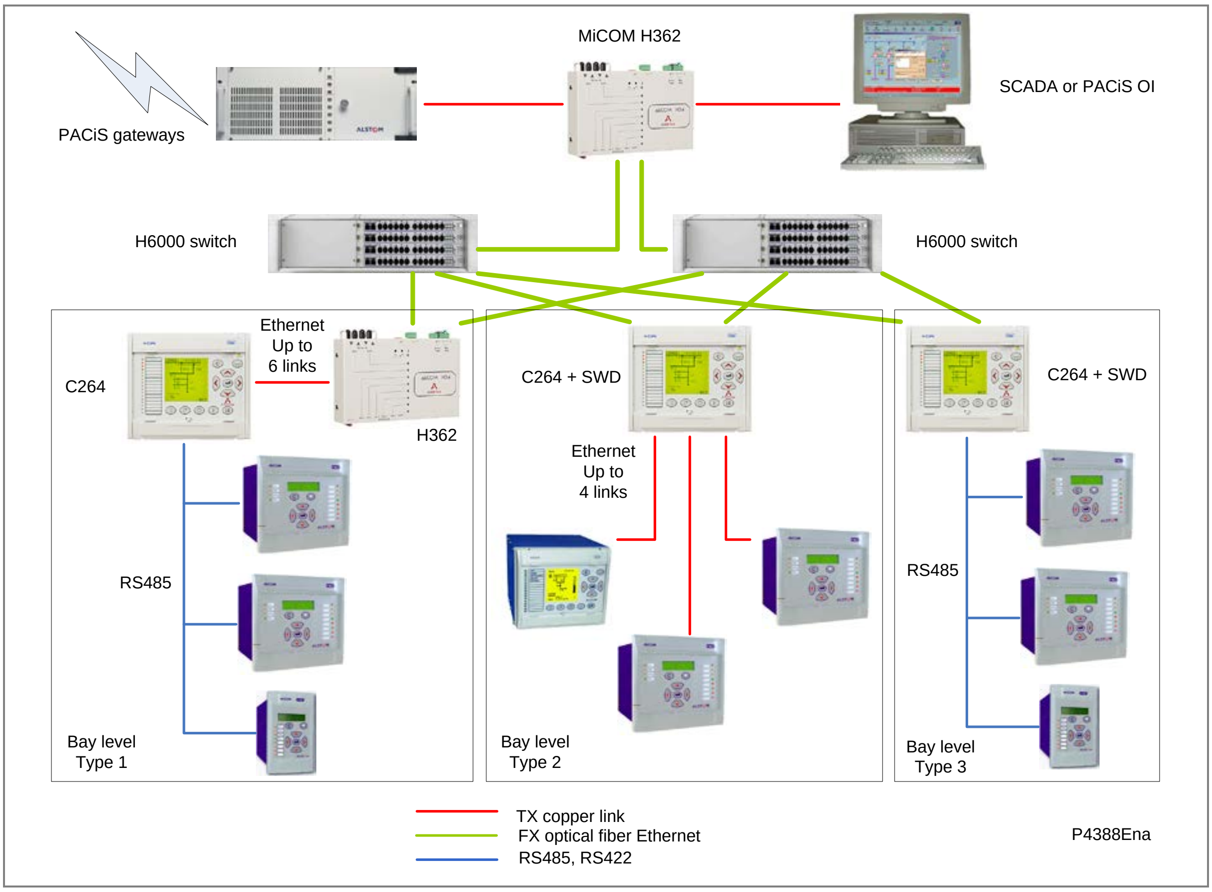


Figure 10: Dual homing star-connected network at substation level

5.2 Forwarding

The MiCOM 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 switches do not forward error packets, 802.3x pause frames, or local packets.

5.3 Priority Tagging

802.1p priority tagging is enabled on all ports.

5.4 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.

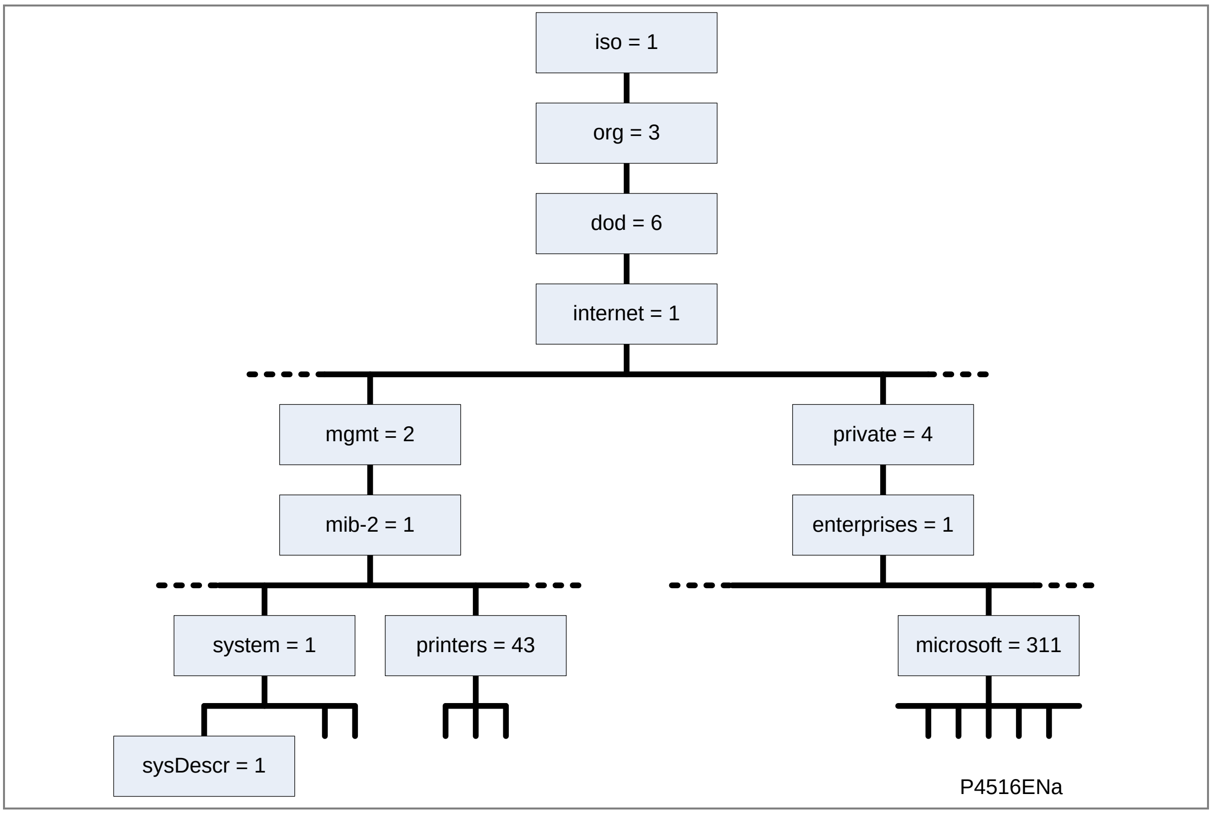


Figure 11: MIB tree structure

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 General Electric.

Redundant Ethernet board MIB Structure

The General Electric MIB uses three types of OID:

- sysDescr
- sysUpTime
- sysName.

These are shown shaded in Table 2:

Address												Name
0												CCITT
	1											ISO
		3										Org
			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

Table 2: Redundant Ethernet Board MIB Structure

Various SNMP client software tools can be used. General Electric recommends using an SNMP MIB browser, which can perform the basic SNMP operations such as GET, GETNEXT and RESPONSE.

Note: There are two IP addresses visible when communicating with the Redundant Ethernet Card via the fibre optic ports: One for the IED itself and one for the on-board Ethernet switch. To access the network using SNMP, use the IP address of the on-board Ethernet Switch and not that of the IED REB. See the configuration chapter for further information.

5.5 Simple Network Time Protocol (SNTP)

Simple Network Time Protocol (SNTP) is supported by both the IED and the redundant Ethernet switch. SNTP is used to synchronize the clocks of computer systems over packet-switched, variable-latency data networks, 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.

The IED is synchronized by the SNTP server. This is achieved by entering the IP address of the SNTP server into the IED using the IED Configurator software described in the *Configuration* chapter.

6 OVERVIEW OF DATA PROTOCOLS

The Px40 series 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.

Data Protocol	Layer 1 protocol	Description
Courier	K-Bus, RS232, RS485, Ethernet and fibre	Standard for SCADA communications developed by General Electric.
MODBUS	RS485 and fibre	Standard for SCADA communications developed by Modicon.
IEC 60870-5 CS103	RS485 and fibre	IEC standard for SCADA communications
DNP 3.0	RS485, Ethernet and fibre	Standard for SCADA communications developed by Harris. Used mainly in North America.
IEC 61850	Ethernet only	IEC standard for substation automation. Facilitates interoperability.

Table 3: SCADA data protocols

The relationship of these protocols to the lower level physical layer protocols is shown in Figure 12.

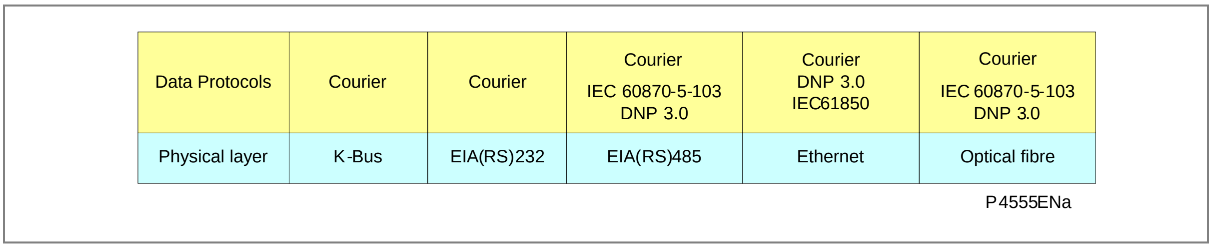


Figure 12: SCADA data protocols

7 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 General Electric 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.

7.1 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 a suitable application such as MiCOM S1 Studio.

7.2 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.

7.3 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.

7.4 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 Studio, or for issuing preconfigured control commands.

7.5 Setting Transfer Mode

To transfer all of the settings to or from the unit, use the Setting Transfer cell (location BF03) in the COMMS SYS DATA column. When this cell is set to 1, all of the settings are made visible. Any setting changes made in this mode are stored in scratchpad memory, including control and support settings. When the cell is set back to 0, all setting changes are verified and committed to non-volatile memory.

7.6 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.

7.6.1 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.

7.6.2 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.

7.7 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. MiCOM S1 Studio automatically does this.

7.8 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 programmable scheme-logic settings can be uploaded and downloaded to and from the IED using this mechanism. MiCOM S1 Studio must be used to edit the settings. MiCOM MiCOM S1 Studio also performs checks on the validity of the settings before they are transferred to the IED.

7.9 Configuration

To configure the IED for Courier, please see the Configuration chapter

8 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. For situations where the level of information contained in this manual is insufficient, a further publication (R6510) is available on request.

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 IEC60870-5-103.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

8.1 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.

For either of the two connection modes, both the IED address and baud rate can be selected using the front panel menu or by a suitable application such as MiCOM S1 Agile.

8.2 Initialization

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 General Electric separately if required.

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

8.3 Time Synchronization

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.

8.4 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.

8.5 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.

8.6 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 measurements at 2.4 times the rated value of the analogue value, as required by the CS103 protocol.

8.7 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’.

8.8 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’.

8.9 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.

8.10 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

8.11 Configuration

To configure the IED for IEC 60870-1-5-103, please see the Configuration chapter.

9 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 www.dnp.org.

9.1 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 a suitable application such as MiCOM S1 Agile.

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

9.2 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.

9.3 DNP 3.0 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.

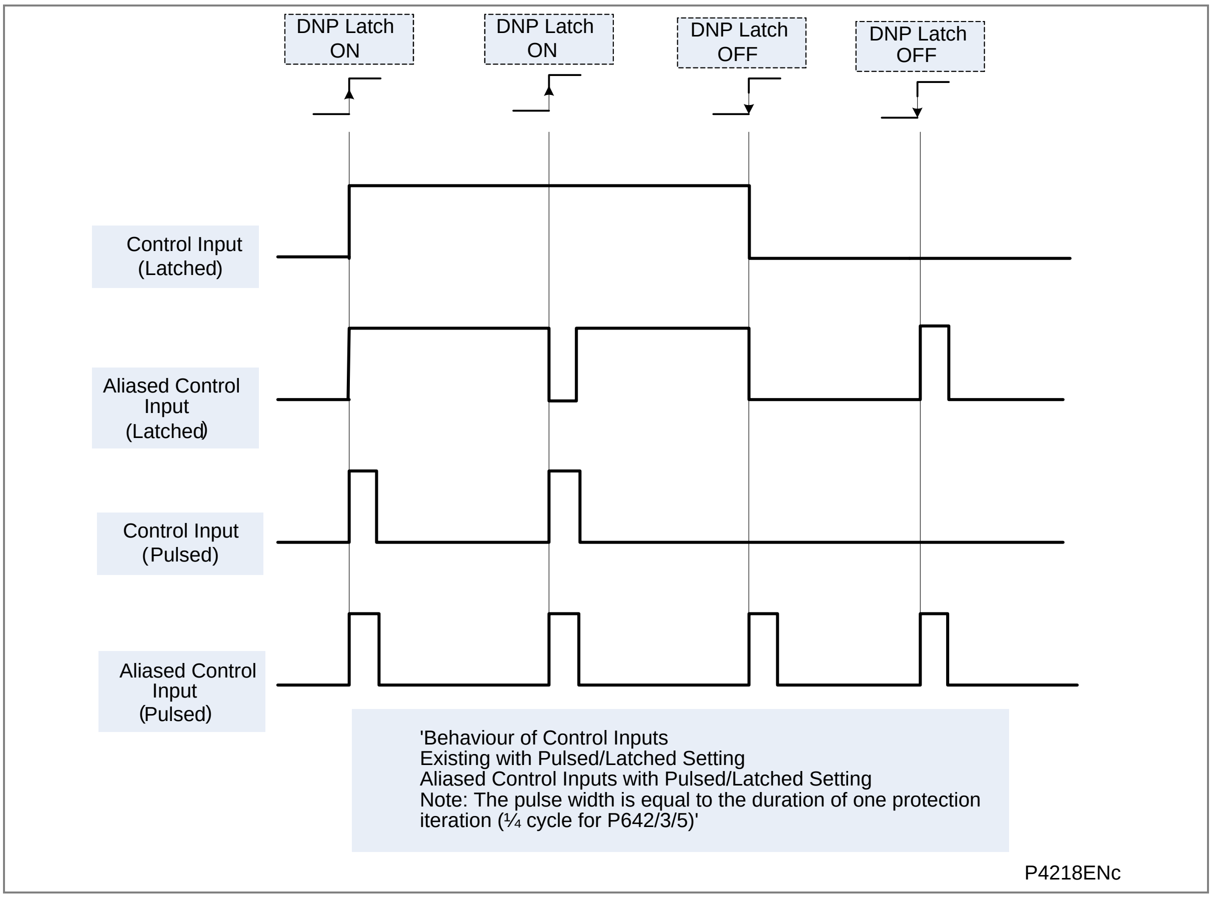


Figure 13: Control input behaviour

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

9.4 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.

9.5 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 DNP 3.0 Communications Column in the IED. Corresponding dead band settings can be displayed in terms of a primary, secondary or normalized value. Dead band point values can be reported and written using Object 34 variations.

The dead band 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 dead band 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).

9.6 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.

9.7 Configuration

To configure the IED for DNP 3.0, please see the Configuration chapter

10 IEC 61850

This section describes how the IEC 61850 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 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 thus 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 10’s 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.

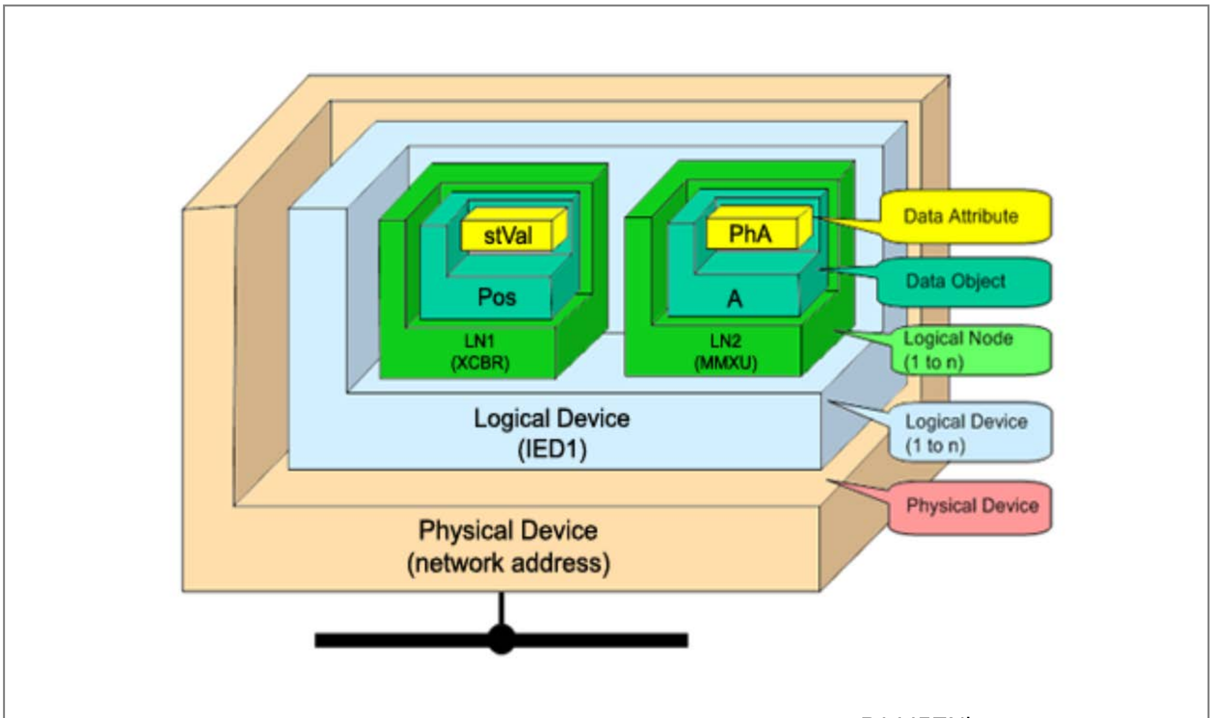


Figure 14: Data model layers in IEC 61850

The levels of this hierarchy can be described as follows:

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

Table 4: Data Frame format

10.4 IEC 61850 in MiCOM IEDs

In the 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.

In order 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 NS Agile 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
- GOOSE communications of statuses.
- Disturbance record extraction by file transfer. The record is extracted as an ASCII format COMTRADE file.

Note: Setting changes are not supported in the current IEC 61850 implementation. Currently these setting changes are carried out using General Electric MiCOM S1 Agile Settings & Records application.

10.5 The IEC 61850 Data Model of MiCOM IEDs

The data model naming adopted in the MiCOM IEDs has been standardized for consistency. Hence 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 if required.

10.6 The IEC 61850 Communication Services of MiCOM IEDs

The IEC 61850 communication services which are implemented in the MiCOM IEDs are described in the Protocol Implementation Conformance Statement (PICS) document, which is available as a separate document if required.

10.7 IEC 61850 Peer-to-peer (GSSE) communications

The implementation of IEC 61850 Generic Substation Event (GSSE) enables faster communication between IEDs offering the possibility for a fast and reliable system-wide distribution of input and output data values. The GSSE 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 specialized equipment.*

Each new message is re-transmitted at configurable intervals, to counter for possible corruption due to interference, and collisions, thus ensuring delivery. In practice, the parameters controlling the message transmission cannot be calculated. Time must be allocated to the testing of GSSE 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. All published GOOSE signals are BOOLEAN values

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 IED Configurator tool available in the MiCOM S1 Agile Support Software.

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.

CYBER SECURITY

CHAPTER 10

1 OVERVIEW

In the past, substation networks were traditionally isolated and the protocols and data formats used to transfer information between devices were more often than not 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 can't 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 standardization of networks and data interchange within substations. Today, devices within substations use standardized protocols for communication. Furthermore, substations can be interconnected with open networks, such as the internet or corporate-wide networks, which use standardized 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 General Electric's range of Intelligent Electronic Devices (IEDs).

The chapter contains the following sections:

2 THE NEED FOR CYBER SECURITY

Cyber-security provides protection against unauthorized disclosure, transfer, modification, or destruction of information and/or information systems, whether accidental or intentional. To achieve this, there are several security requirements:

- Confidentiality (preventing unauthorized access to information)
- Integrity (preventing unauthorized modification)
- Availability / Authentication (preventing the denial of service and assuring authorized 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 analyze 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 (e.g. users keep passwords on their computer)
- Bypassing of controls (e.g. users turn off security measures)
- Bad practice (users do not change default passwords, or everyone uses the same password to access all substation equipment)
- Inadequate technology (e.g. substation is not firewalled)

Examples of availability issues are:

- Equipment overload, resulting in reduced or no performance
- Expiry of a certificate prevents access to equipment.

To help tackle these issues, standards organizations have produced various standards, by which compliance significantly reduces the threats associated with lack of cyber security.

3 STANDARDS

There are several standards, which apply to substation cyber security (see Table 1).

	Country	
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

Table 1: Standards applicable to cyber security

The standards currently applicable to General Electric IEDs are NERC and IEEE1686.

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 bulk electric 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.

The group of CIP standards is listed in Table 2.

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 perimeter where Critical Cyber Assets reside and 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

Table 2: NERC CIP standards

The following sections provide further details about each of these standards, describing the associated responsibilities of the utility company and where the IED manufacturer can help the utilities with the necessary compliance to these standards.

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:	General Electric'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:	General Electric'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 having 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:	General Electric'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:	General Electric'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:	General Electric's contribution:
Provide physical security controls and perimeter monitoring. Ensure that people who have access to critical cyber assets don't have criminal records General Electric's contribution.	General Electric 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:	General Electric'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:	General Electric's contribution:
To provide an incident response team and have appropriate processes in place.	General Electric 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:	General Electric'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 to General Electric Px40 relays:

- 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.
- Record of an audit trail 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 PX40 CYBER SECURITY IMPLEMENTATION

The General Electric 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, 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:

- Four-level Access
- Password strengthening
- Disabling of unused application and physical ports
- Inactivity timer
- Storage of security events (logs) in the IED
- NERC-compliant default display

External to the IEDs, the following cyber security measures have been implemented:

- Antivirus
- Security patch management

4.1 Four-level Access

The menu structure contains four levels of access three of which are password protected. These are summarized in Table 3.

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 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 (IED Config - IEC61850) 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 (IED Config - IEC61850) Enable / Disable Device ports (in SECURITY CONFIG column) Level 3 password setting

Table 3: Password levels

4.1.1 Default Passwords

Default passwords are blank for Level 1 and **AAAA** for Levels 2 and 3.

4.1.2 Password Rules

- 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

4.1.3 Access Level DDBs

In additional to having the 'Access level' cell in the 'System data' column (address 00D0), the current level of access for each interface is also 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

Where HMI is the Human Machine Interface.

Each pair of DDB signals indicates the access level as follows:

- Lvl 1 off, Lvl 2 off = 0
- Lvl 1 on, Lvl 2 off = 1
- Lvl 1 off, Lvl 2 on = 2
- Lvl 1 on, Lvl 2 on = 3

4.2 Password Strengthening

NERC compliant passwords result in a minimum level of complexity, and include these 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 Password validation

The IED checks for NERC compliance. If the password is entered through the front panel then this is reflected on the panel Liquid Crystal Display (LCD) display.

If the entered password is NERC compliant, the following text is displayed

```
NERC COMPLIANT
P/WORD WAS SAVED
```

The IED does not enforce NERC compliance. It is the responsibility of the user to ensure that compliance is adhered to as and when necessary. In the case that 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 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 IED will store the password, irrespective of whether it is or isn't NERC-compliant, and then uses appropriate response codes to inform the client that the password was NERC-compliant or not. The client then can choose if he/she wishes to enter a new password that is NERC-compliant or leave the entered one in place.

4.3.1 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 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 lower level password is not blank.

Blank Passwords affect 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.

4.4 Password Management

The user is locked out temporarily, after a defined number of failed password entry attempts. The number of password entry attempts, and the blocking periods are configurable. These settings are shown in Table 4.

The first invalid password entry sets the attempts count (actual text here) to 1 and initiates an 'attempts timer'. Further invalid passwords during the timed period increments the attempts count. When the maximum number of attempts has been reached, access is blocked. If the attempts timer expires, or the correct password is entered *before* the 'attempt count' reaches the maximum number, then the 'attempts count' is reset to 0.

Once the password entry is blocked, a 'blocking timer' is initiated. Attempts to access the interface whilst the 'blocking timer' is running results in an error message, irrespective of whether the correct password is entered or not. Only after the 'blocking timer' has expired will access to the interface be unblocked, whereupon the attempts counter is reset to zero.

Attempts to write to the password entry whilst it is blocked results in the following message, which is displayed for 2 seconds.

```
NOT ACCEPTED
ENTRY IS BLOCKED
```

Appropriate responses achieve the same result if the password is written through a communications port.

The attempts count, attempts timer and blocking timer can be configured, as shown in Table 4.

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

Table 4: Password blocking configuration

4.5 Password Recovery

Password recovery is the means by which the passwords can be recovered on a device if the customer should mislay the configured passwords. To obtain the recovery password the customer must contact the General Electric Contact Centre and supply two pieces of information from the IED – namely the *Serial Number* and its *Security Code*. The Contact Centre will use these items to generate a Recovery Password which is then provided to the customer.

The security code is a 16-character string of upper case characters. It is a read-only parameter. The IED 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 display, 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 will be displayed on confirmation, whereupon the validity timer will be started. Note that the security code can only be read from the front panel.

4.5.1 Entry of the Recovery Password

The recovery password is intended for recovery only. It is not a replacement password that can be used continually. It can only be used once – for password recovery.

Entry of the recovery password 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 appropriate for the function for which they are intended, 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.

4.5.2 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.

4.6 Port Disablement

4.6.1 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
```

Two to four ports can be disabled, depending on the model.

- Front port
- Rear port 1
- Rear port 2 (not implemented on all models)
- Ethernet port (not implemented on all models)

Note: It is not possible to disable a port from which the disabling port command originates.

4.6.2 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

Caution **Disabling the Ethernet port will disable all Ethernet based communications.**

If it is not desirable to disable the Ethernet port, it is possible to disable selected protocols on the Ethernet card and leave others functioning.

Three protocols can be disabled:

- IEC61850
- DNP3 Over Ethernet
- Courier Tunnelling

Note: If any of these protocols are enabled or disabled, the Ethernet card will reboot.

4.7 Logging out

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

```
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 <x>
```

Where x is the current fallback level.

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

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

Where x is the current access level.

4.8 Events

The implementation of NERC-compliant cyber security necessitates the generation of a range of Event records, which log security issues such as the entry of a non-NERC-compliant password, or the selection of a non-NERC-compliant default display. Table 5 lists all Security events.

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 -

Table 5: Security event values

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 event is identified with a unique number that is incremented for each new event so that it is possible to detect missing events as there will be a ‘gap’ in the sequence of unique identifiers. 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

4.9 Cyber Security Settings

Cyber Security is important enough to warrant its own IED column called SECURITY CONFIGURATION, located at column number 25. In addition to this new group, settings are affected in the SYSTEM DATA, COMMS SYS DATA and VIEW RECORDS columns.

A summary of the relevant columns is shown in Table 6. A complete listing of the settings criteria is described in the Settings and Records chapter.

Parameter	Cell col row	Default Setting	Available Setting	Interface Applicability	In Setting file?
Password	00 02		ASCII 33 to 122	All	Yes
Access Level	00 D0		0 = Read Some, 1 = Read All, 2 = Read All + Write Some, 3 = Read All + Write All	All	Yes, Not Settable
Password Level 1	00 D2		ASCII 33 to 122	All	Yes
Password Level 2	00 D3		ASCII 33 to 122	All	Yes
Password Level 3	00 D4		ASCII 33 to 122	All	Yes
Security Feature	00 DF		1	All	Yes, Not Settable
SECURITY CONFIG	25 00			All	Yes
Use Banner	25 01	ACCESS ONLY FOR AUTHORISED USERS	ASCII 32 to 163	All	Yes
Attempts Limit	25 02	3	0 to 3 step 1	All	Yes
Attempts Timer	25 03	2	1 to 3 step 1	All	Yes
Blocking Timer	25 04	5	1 to 30 step 1	All	Yes
Front Port	25 05	Enabled	0 = Disabled or 1 = Enabled	All	No
Rear Port 1	25 06	Enabled	0 = Disabled or 1 = Enabled	All	No

Parameter	Cell col row	Default Setting	Available Setting	Interface Applicability	In Setting file?
Rear Port 2	25 07	Enabled	0 = Disabled or 1 = Enabled	All	No
Ethernet Port*	25 08	Enabled	0 = Disabled or 1 = Enabled	All	No
Courier Tunnel*†	25 09	Enabled	0 = Disabled or 1 = Enabled	All	No
IEC61850*†	25 0A	Enabled	0 = Disabled or 1 = Enabled	All	No
DNP3 OE*†	25 0B	Enabled	0 = Disabled or 1 = Enabled	All	No
Attempts Remain	25 11			All	Yes, Not Settable
Blk Time Remain	25 12			All	Yes, Not Settable
Fallbck PW Level	25 20	0	0 = Password Level 0, 1 = Password Level 1, 2 = Password Level 2, 3 = Password Level 3	All	Yes, Not Settable
Security Code	25 FF			UI Only	No
Evt Unique Id (Normal Extraction)	01 FE			All	No
Evt Iface Source ± (Bits 0 – 7 of Event State)	01 FA			All	No
Evt Access Level ± (Bits 15 – 8 of Event State)	01 FB			All	No
Evt Extra Info 1 ± (Bits 23 – 16 of Event State)	01 FC			All	No
Evt Extra Info 2 ±Ω (Bits 31 – 24 of Event State)	01 FD			All	No

Table 6: Security Cells Summary

Where:

* - These cells will not be present in a non-Ethernet product

†- These cells will be invisible if the Ethernet port is disabled.

± - These cells invisible if event is not a Security event

Ω – This cell is invisible in current phase as it does not contain any data. It is reserved for future use.

PSL EDITOR

CHAPTER 11

1 CHAPTER OVERVIEW

The purpose of the Programmable Scheme Logic (PSL) is to allow you to configure an individual scheme to suit your own particular application. This is achieved through the use of programmable logic gates and delay timers. This chapter describes the PSL Editor, which allows you to do this. It consists of the following sections:

2 INTRODUCTION TO THE PSL EDITOR

The programmable scheme logic (PSL) editor is provided to map the digital inputs of the MiCOM Px40 products, to combine these inputs with internally generated digital signals using logic gates and timers, and to map the resultant signals to the digital outputs of the MiCOM Px40 products.

The PSL is built around a concept called the digital data bus (DDB). The DDB is parallel data bus containing all of the digital signals (inputs, outputs, and internal signals), which are available for use in the PSL.

Inputs to the PSL include:

- Opto-isolated digital inputs (opto-inputs)
- IEC 61850 GOOSE inputs
- Control inputs
- Function keys

Outputs from the PSL include:

- Relay outputs
- Light emitting diodes
- IEC 61850 GOOSE outputs
- Trigger signals

Internal signals include “inputs” to the PSL (i.e. signals generated within the product that can be used to affect the operation of the scheme logic) and “outputs” from the PSL (i.e. signals that can be driven from the PSL to activate specific functions in the product). Examples of internal inputs and outputs include:

- I>1 Trip: an input that is asserted if the Stage 1 Overcurrent fault protection trip operates
- Thermal Trip: an input that is asserted if the thermal trip operates
- Reset Relays/LED : an output that can be asserted to reset the output relays and LEDs

The PSL consists of software 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.

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 that is used by the PSL.

The system gives you flexibility to create your own scheme logic design. This also means that the PSL can be configured into a very complex system, so you need a suitable PC support package to allow you to design your PSL scheme. This PC support package is provided in the form of the S1 Studio suite of tools, which includes the PSL Editor.

With the Px40 PSL Module you can:

- Start a new PSL diagram
- Extract a PSL file from a Px40 IED
- Download a PSL file to a Px40 IED
- Open a diagram from a PSL file
- Add logic components to a PSL file

- Move components in a PSL file
- Edit links in a PSL file
- Add links to a PSL file
- Highlight a path in a PSL file
- Use a conditioner output to control logic
- Print PSL files

You can start the PSL editor in two ways:

- From the S1 Agile main menu, select: **Tools > PSL editor (Px40)**
- By creating a model system in S1 Agile with the correct model number and opening the default PSL and open it.

For more information on the PSL editor, see the online help built into the PSL Editor.

2.1 Warnings

Checks are made before a scheme is downloaded to the IED. Various warning messages may be displayed as a result of these checks.

In most cases, the model number of the unit will match that of the model number stored in the PSL software on the PC. The Editor first reads in the model number of the connected unit, then compares it with its stored model number using a "wildcard" comparison. If a model mismatch occurs, a warning is generated before sending starts. Both the stored model number and the number read from the IED are displayed with the warning.

It is up to the user to decide whether the settings to be downloaded are compatible, and to be aware that incompatible settings could lead to undesirable behavior of the unit.

If there are any obvious potential problems, a list is generated. The types of potential problems that the program attempts to detect are:

- One or more gates, LED signals, contact signals, or timers have their outputs linked directly back to their inputs. An erroneous link of this sort could lock up the IED, or cause other problems to arise.
- A programmable gate has its ITT (Inputs to Trigger) value set to greater than the number of actual inputs. This will mean the gate can never activate. There is no check for the case where the ITT value is lower than the number of inputs. A 0-value does not generate a warning.
- Too many gates. There is a theoretical upper limit of 256 gates in a scheme, but the practical limit is determined by the complexity of the logic. In practice the scheme would have to be very complex, and this error is unlikely to occur.
- Too many links. There is no fixed upper limit to the number of links in a scheme. However, as with the maximum number of gates, the practical limit is determined by the complexity of the logic. In practice the scheme would have to be very complex, and this error is unlikely to occur.

3 PSL EDITOR TOOLBAR

There are a number of toolbars available to help with navigating and editing the PSL.

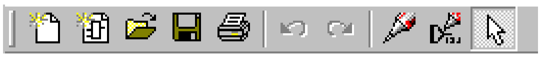
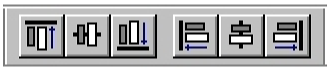
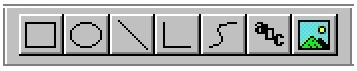
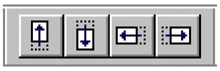
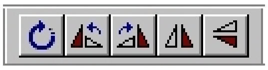
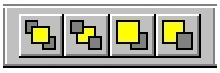
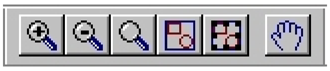
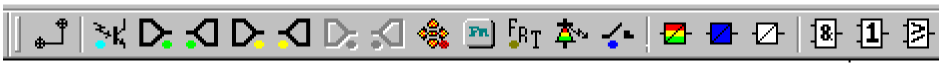
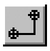
Toolbar	Description
	Standard tools: For file management and printing
	Alignment tools: To snap logic elements into horizontally or vertically aligned groupings
	Drawing tools : To add text comments and other annotations, for easier reading of PSL schemes
	Nudge tools: To move logic elements
	Rotation tools: Tools to spin, mirror and flip
	Structure tools: To change the stacking order of logic components
	Zoom and pan tools: For scaling the displayed screen size, viewing the entire PSL, or zooming to a selection

Table 1: Toolbars

3.1 Logic Symbols



The logic symbol toolbar provides icons to place each type of logic element into the scheme diagram. Not all elements are available in all devices. Icons will only be displayed for those elements available in the selected device.

Symbol	Function	Explanation
	Link	Create a link between two logic symbols
	Opto Signal	Create an opto signal
	Input Signal	Create an input signal
	Output Signal	Create an output signal
	GOOSE In	Create an input signal to logic to receive a GOOSE message transmitted from another IED. Used in either UCA2.0 or IEC 61850 GOOSE applications only
	GOOSE Out	Create an output signal from logic to transmit a GOOSE message to another IED. Used in either UCA2.0 or IEC 61850 GOOSE applications only.
	Control In	Create an input signal to logic that can be operated from an external command.
	InterMiCOM In	Create an input signal to logic to receive an InterMiCOM command transmitted from another IED.
	InterMiCOM Out	Create an output signal from logic to transmit an InterMiCOM command to another IED.
	Function Key	Create a function key input signal.
	Trigger Signal	Create a fault record trigger

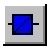
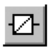
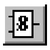
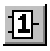
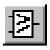
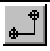
Symbol	Function	Explanation
	LED Signal	Create an LED input signal that repeats the status of tri-color LED
	Contact Signal	Create a contact signal
	LED Conditioner	Create an LED conditioner
	Contact Conditioner	Create a contact conditioner
	Timer	Create a timer
	AND Gate	Create an AND Gate
	OR Gate	Create an OR Gate
	Programmable Gate	Create a programmable gate

Table 2: Logic symbol toolbar

4 PSL LOGIC SIGNALS PROPERTIES

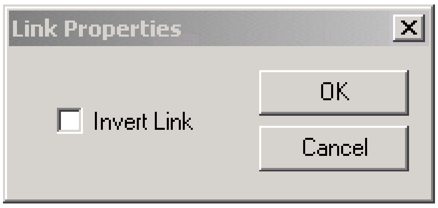
1. Use the logic toolbar to select logic signals. This is enabled by default but to hide or show it, select **View > Logic Toolbar**.
2. Zoom in or out of a logic diagram using the toolbar icon or select **View > Zoom Percent**.
3. Right-click any logic signal and a context-sensitive menu appears.

Certain logic elements show the **Properties…** option. If you select this, a **Component Properties** window appears. The contents of this window and the signals listed will vary according to the logic symbol selected. The following sections describe each of the available logic symbols. The actual DDB numbers are dependent on the model and are provided in the DDB table in the PSL Schemes chapter.

4.1 Link Properties: 

Links form the logical link between the output of a signal, gate or condition and the input to any element. Any, which is connected to the input of a gate, can be inverted. To do this:

4. Right-click the input
5. Select Properties…. The Link Properties window appears.



6. Check the box to invert the link. Or uncheck for a non-inverted link

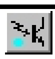
An inverted link is shown with a small circle on the input to a gate. A link must be connected to the input of a gate to be inverted.

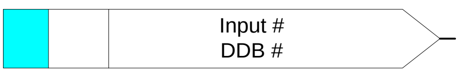
Links can only be started from the output of a signal, gate, or conditioner, and must end at an input to any element.

Signals can only be an input or an output. To follow the convention for gates and conditioners, input signals are connected from the left and output signals to the right. The Editor automatically enforces this convention.

A link is refused for the following reasons:

- There has been an attempt to connect to a signal that is already driven. The reason for the refusal may not be obvious because the signal symbol may appear elsewhere in the diagram. In this case you can right-click the link and select **Highlight** to find the other signal. Click anywhere on the diagram to disable the highlight.
- An attempt has been made to repeat a link between two symbols. The reason for the refusal may not be obvious because the existing link may be represented elsewhere in the diagram.

4.2 Opto Signal Properties: 

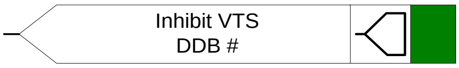


Each opto-input can be selected and used for programming in PSL. Activation of the opto-input will drive an associated DDB signal.

4.3 Input Signal Properties:

IED logic functions provide logic output signals that can be used for programming in PSL. Depending on the IED functionality, operation of an active IED function will drive an associated DDB signal in PSL.

4.4 Output Signal Properties:



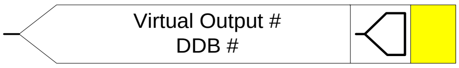
Logic functions provide logic input signals that can be used for programming in PSL. Depending on the output relay functionality, activation of the output signal will drive an associated DDB signal in PSL and cause an associated response to the output relay function.

4.5 GOOSE Input Signal Properties:

The Programmable Scheme Logic interfaces with the GOOSE Scheme Logic by means of 32 Virtual inputs. The Virtual Inputs can be used in much the same way as the opto-input signals.

The logic that drives each of the Virtual Inputs is contained within the GOOSE Scheme Logic file. It is possible to map any number of bit-pairs, from any subscribed device, using logic gates onto a Virtual Input (see S1 documentation for further details).

4.6 GOOSE Output Signal Properties:



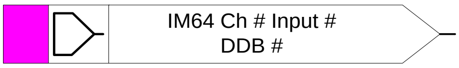
The Programmable Scheme Logic interfaces with the GOOSE Scheme Logic by means of 32 Virtual outputs.

It is possible to map virtual outputs to bit-pairs for transmitting to any subscribed devices (see S1 documentation for further details).

4.7 Control in Signal Properties:

There are 32 control inputs which can be activated via the menu, the hotkeys or via courier communications. Depending on the programmed setting that is, latched or pulsed, an associated DDB signal will be activated in PSL when a control input is operated.

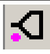
4.8 InterMiCOM In Properties: 

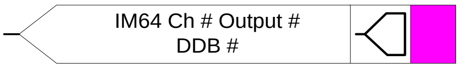


There are 16 InterMiCOM inputs that can be used for teleprotection and remote commands. “InterMiCOM In” is a received signal from remote end that can be mapped to a selected output relay or logic input.

IED End B

At end B, InterMiCOM Input 1 is mapped to the command “Clear Statistics”.

4.9 InterMiCOM Out Properties: 



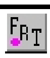
There are 16 InterMiCOM outputs that can be used for teleprotection and remote commands. “InterMiCOM Out” is a send command to a remote end that can be mapped to any logic output or opto-input. This will be transmitted to the remote end as a corresponding “InterMiCOM In” command.

IED End A

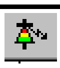
At end A, InterMiCOM Output 1 is mapped to the command indication “Clear Statistics” (issued at end A).

4.10 Function Key Properties: 

Each function key can be selected and used for programming in PSL. Activation of the function key will drive an associated DDB signal. The DDB signal will remain active according to the programmed setting (toggled or normal). Toggled mode means the DDB signal will remain in the new state until the function key is pressed again. In Normal mode, the DDB will only be active for the duration of the key press.

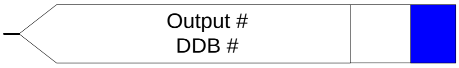
4.11 Fault Recorder Trigger Properties: 

The fault recording facility can be activated, by driving the fault recorder trigger DDB signal.

4.12 LED Signal Properties: 

All programmable LEDs will drive associated DDB signals when the LED is activated.

4.13 Contact Signal Properties: 



All output relay contacts will drive associated DDB signal when the output contact is activated.

4.14 LED Conditioner Properties: 

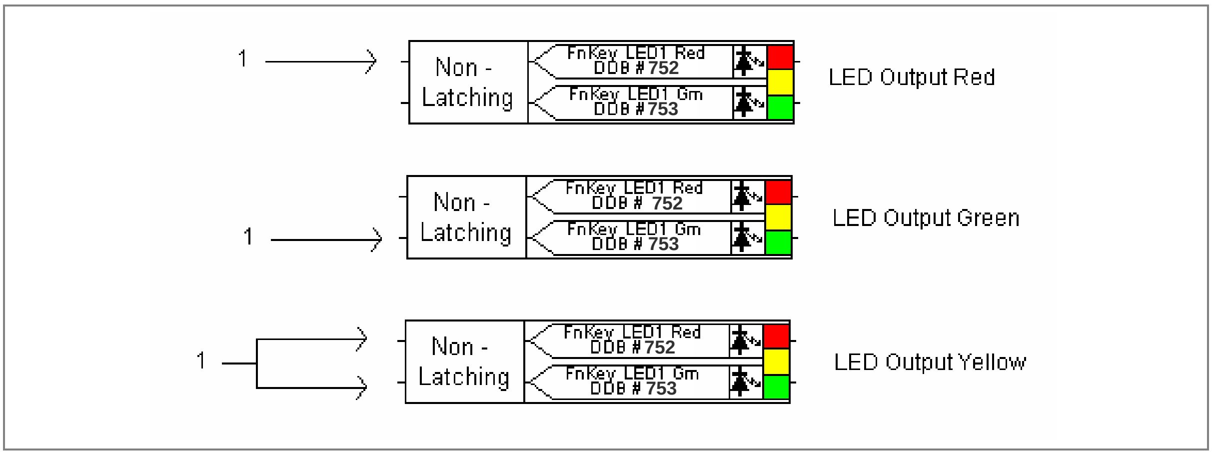
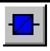


Figure 1: LED conditioner properties

1. Select the LED name from the list (only shown when inserting a new symbol)
2. Configure the LED output to be Red, Yellow or Green
3. Configure a Green LED by driving the Green DDB input
4. Configure a RED LED by driving the RED DDB input
5. Configure a Yellow LED by driving the RED and GREEN DDB inputs simultaneously
6. Configure the LED output to be latching or non-latching

4.15 Contact Conditioner Properties: 

Each contact can be conditioned with an associated timer that can be selected for pick up, drop off, dwell, pulse, pick-up/drop-off, straight-through, or latching operation.

Straight-through means it is not conditioned at all whereas **Latching** is used to create a sealed-in or lockout type function.

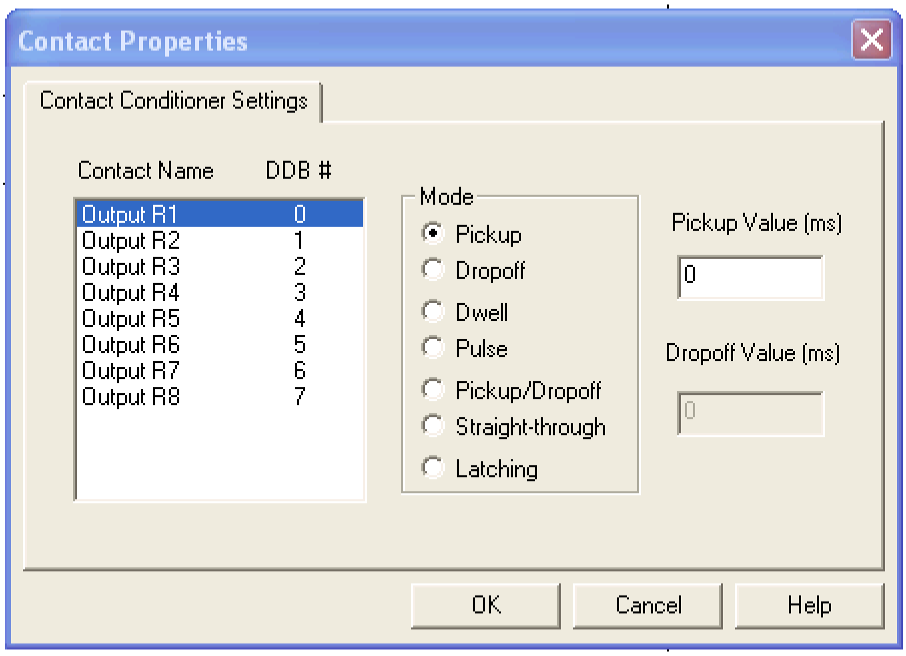
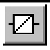


Figure 2: Contact properties

1. Select the contact name from the Contact Name list (only shown when inserting a new symbol)
2. Choose the conditioner type required in the Mode tick list
3. Set the Pick-up Time (in milliseconds), if required
4. Set the Drop-off Time (in milliseconds), if required

4.16 Timer Properties: 

Each timer can be selected for pick up, drop off, dwell, pulse or pick-up/drop-off operation.

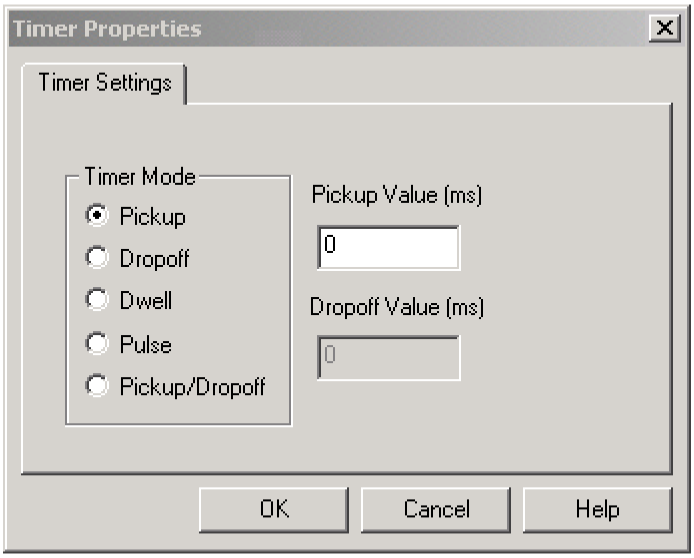


Figure 3: Timer properties

1. Choose the operation mode from the Timer Mode tick list
2. Set the Pick-up Time (in milliseconds), if required
3. Set the Drop-off Time (in milliseconds), if required

4.17 Gate Properties:

A Gate may be an AND, OR, or programmable gate.

- An **AND** gate requires that all inputs are TRUE for the output to be TRUE.
- An **OR** gate requires that one or more input is TRUE for the output to be TRUE.
- A **Programmable** gate requires that the number of inputs that are TRUE is equal to or greater than its ‘Inputs to Trigger’ setting for the output to be TRUE.

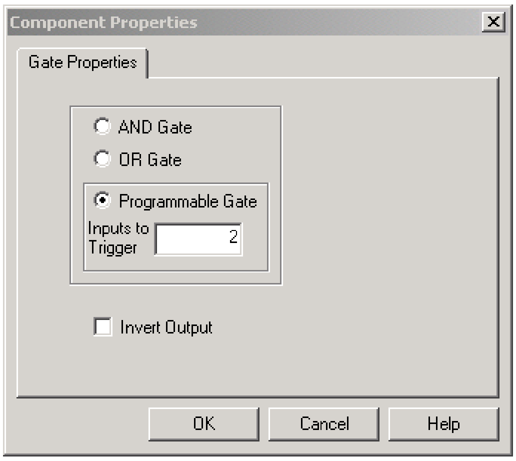


Figure 4: Gate properties

1. Select the Gate type AND, OR, or Programmable.
2. Set the number of inputs to trigger when Programmable Gate is selected.
3. Select if the output of the gate should be inverted using the Invert Output check box. An inverted output is indicated with a "bubble" on the gate output.

4.18 SR Programmable Gate Properties

A **Programmable** SR gate can be selected to operate with the following three latch properties:

S input	R input	O - Standard	O – Set input dominant	O – Reset input dominant
0	0	0	0	0
0	1	0	0	0
1	0	1	1	1
1	1	0	1	1

Table 3: SR programmable gate properties

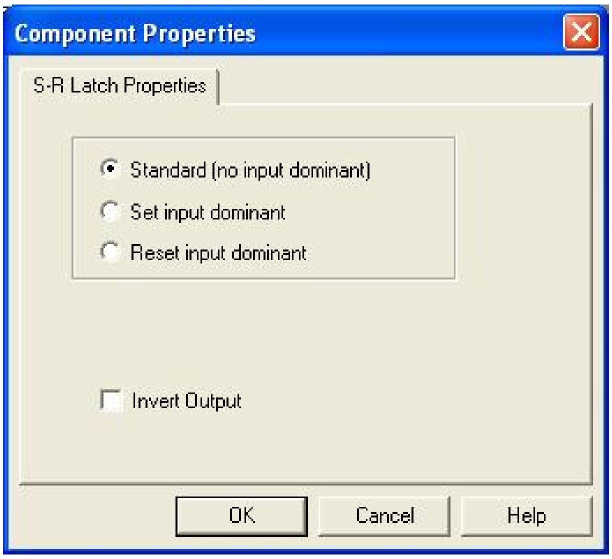


Figure 5: SR latch properties

Select if the output of the gate should be inverted using the Invert Output check box. An inverted output is indicated with a "bubble" on the gate output.

PSL SCHEMES

CHAPTER 12

1 OVERVIEW

This chapter describes the PSL scheme and mappings specific to the devices in question. It contains the following sections:

2 DESCRIPTION OF LOGIC NODES

General Electric Px40 products are supplied with pre-loaded default PSL schemes and. If these schemes suit your requirements, you do not need to take any action. However, if you want to change the input-output mapping, or to implement custom scheme logic, you will need to know the details of the logic nodes (also referred to as digital data bus – DDB) signals. This section provides a complete listing of the PSL mappings. For a complete list of the DDB signals, see Appendix C.

Note: *The DDB numbers are displayed as part of the associated symbol in the PSL editor.*

3 MAPPINGS

3.1 Logic Input Mappings

Opto input	Default Menu Text	Function	1/2 Cycle Filter
Opto-input 1	Input L1	Not Used	Yes
Opto-input 2	Input L2	Not Used	Yes
Opto-input 3	Input L3	Aid 1 Receive	No
Opto-input 4	Input L4	Aid 1 COS/LGS	Yes
Opto-input 5	Input L5	Reset LEDs	Yes
Opto-input 6	Input L6	External TripCat	Yes
Opto-input 7	Input L7	External TripFdr	Yes
Opto-input 8	Input L8	Allow Defrost	Yes
Opto-input 9	Input L9	CB Aux Cat 52-B	Yes
Opto-input 10	Input L10	CB Aux Fdr 52-B	Yes
Opto-input 11	Input L11	Not Used	Yes
Opto-input 12	Input L12	MCB/VTS	No
Opto-input 13	Input L13	CB Close Manual	Yes
Opto-input 14	Input L14	Reset Lockout	Yes
Opto-input 15	Input L15	CB Healthy	No
Opto-input 16	Input L16	BAR	Yes

Table 1: Opto-input mappings – P44T models A and B

Opto input	Default Menu Text	Function	1/2 Cycle Filter
Opto-input 1	Input L1	Not Used	Yes
Opto-input 2	Input L2	Not Used	Yes
Opto-input 3	Input L3	Aid 1 Receive	No
Opto-input 4	Input L4	Aid 1 COS/LGS	Yes
Opto-input 5	Input L5	Reset LEDs	Yes
Opto-input 6	Input L6	External TripCat	Yes
Opto-input 7	Input L7	External TripFdr	Yes
Opto-input 8	Input L8	Allow Defrost	Yes
Opto-input 9	Input L9	CB Aux Cat 52-B	Yes
Opto-input 10	Input L10	CB Aux Fdr 52-B	Yes
Opto-input 11	Input L11	Not Used	Yes
Opto-input 12	Input L12	MCB/VTS	No
Opto-input 13	Input L13	CB Close Manual	Yes
Opto-input 14	Input L14	Reset Lockout	Yes
Opto-input 15	Input L15	CB Healthy	No
Opto-input 16	Input L16	BAR	Yes
Opto-input 17	Input L17	Not Used	Yes
Opto-input 18	Input L18	Not Used	Yes
Opto-input 19	Input L19	IM64 1	Yes
Opto-input 20	Input L20	IM64 2	Yes
Opto-input 21	Input L21	IM64 3	Yes
Opto-input 22	Input L22	IM64 4	Yes

Opto input	Default Menu Text	Function	1/2 Cycle Filter
Opto-input 23	Input L23	Not Used	Yes
Opto-input 24	Input L24	Not Used	Yes

Table 2: Opto-input mappings – P44T models C and D

3.2 Standard Output Relay Mappings

Default Menu Text	Relay Conditioner	Function	Relay type (High-break or Standard)
Output R1	Straight-through	Trip Zone 1	Standard
Output R2	Straight-through	Any Start	Standard
Output R3	Dwell 100 ms	Any Trip	Standard
Output R4	Dwell 500 ms	General Alarm	Standard
Output R5	Straight-through	Dist Inst Trip	Standard
Output R6	Dwell 100 ms	CB Fail Time1	Standard
Output R7	Straight-through	Cntl CB Close	Standard
Output R8	Straight-through	Cntl CB Trip	Standard
Output R9	Dwell 100 ms	Trip Cat	Standard
Output R10	Dwell 100 ms	Trip Fdr	Standard
Output R11	Straight-through	Dist Dly Trip	Standard
Output R12	Straight-through	AR in Prog	Standard
Output R13	Straight-through	Success Close	Standard
Output R14	Straight-through	AR Lockout	Standard
Output R15	Straight-through	AR In Service	Standard
Output R16	Straight-through	BAR	Standard

Table 3: Output relay mappings – P44T model A

Default Menu Text	Relay Conditioner	Function	Relay type (High-break or Standard)
Output R1	Straight-through	Trip Zone 1	Standard
Output R2	Straight-through	Any Start	Standard
Output R3	Dwell 100 ms	Any Trip	Standard
Output R4	Dwell 500 ms	General Alarm	Standard
Output R5	Straight-through	Success Close	Standard
Output R6	Dwell 100ms	CB Fail Time1	Standard
Output R7	Straight-through	Cntl CB Close	Standard
Output R8	Straight-through	Cntl CB Trip	Standard
Output R9	Dwell 100 ms	Trip Cat	High-break
Output R10	Dwell 100 ms	Trip Fdr	High-break
Output R11	Straight-through	AR Lockout	High-break
Output R12	Straight-through	AR in Prog	High-break

Table 4: Output relay mappings – P44T models B

Default Menu Text	Relay Conditioner	Function	Relay type (High-break or Standard)
Output R1	Straight-through	Trip Zone 1	Standard
Output R2	Straight-through	Any Start	Standard
Output R3	Dwell 100 ms	Any Trip	Standard
Output R4	Dwell 500 ms	General Alarm	Standard
Output R5	Not used	Not used	Standard
Output R6	Dwell 100 ms	CB Fail Time1	Standard
Output R7	Straight-through	Cntl CB Close	Standard
Output R8	Straight-through	Cntl CB Trip	Standard
Output R9	Dwell 100 ms	Trip Cat	Standard
Output R10	Dwell 100 ms	Trip Fdr	Standard
Output R11	Not used	Not used	Standard
Output R12	Straight-through	AR in Prog	Standard
Output R13	Straight-through	Success Close	Standard
Output R14	Straight-through	AR Lockout	Standard
Output R15	Straight-through	AR In Service	Standard
Output R16	Straight-through	BAR	Standard
Output R17	Dwell 100 ms	Trip Cat	Standard
Output R18	Dwell 100 ms	Trip Fdr	Standard
Output R19	Not used	Not used	Standard
Output R20	Straight-through	Dist Inst Trip	Standard
Output R21	Straight-through	Dist Delay Trip	Standard
Output R22	Not used	Not used	Standard
Output R23	Not used	Not used	Standard
Output R24	Straight-through	Aided 1 Send	Standard
Output R25	Straight-through	Not Used	Standard
Output R26	Straight-through	Not Used	Standard
Output R27	Straight-through	VTS	Standard
Output R28	Straight-through	IM64 1	Standard
Output R29	Straight-through	IM64 2	Standard
Output R30	Straight-through	IM64 3	Standard
Output R31	Straight-through	IM64 4	Standard
Output R32	Not used	Not Used	Standard

Table 5: Output relay mappings – P44T model C

Default Menu Text	Relay Conditioner	Function	Relay type (High-break or Standard)
Output R1	Straight-through	Trip Zone 1	Standard
Output R2	Straight-through	Any Start	Standard
Output R3	Dwell 100 ms	Any Trip	Standard
Output R4	Dwell 500 ms	General Alarm	Standard
Output R5	Not used	Not used	Standard
Output R6	Dwell 100 ms	CB Fail Time1	Standard
Output R7	Straight-through	Cntl CB Close	Standard

Default Menu Text	Relay Conditioner	Function	Relay type (High-break or Standard)
Output R8	Straight-through	Cntl CB Trip	Standard
Output R9	Dwell 100 ms	Trip Cat	Standard
Output R10	Dwell 100 ms	Trip Fdr	Standard
Output R11	Not used	Not used	Standard
Output R12	Straight-through	AR in Prog	Standard
Output R13	Straight-through	Success Close	Standard
Output R14	Straight-through	AR Lockout	Standard
Output R15	Straight-through	AR In Service	Standard
Output R16	Straight-through	Aid 1 Send	Standard
Output R17	Dwell 100 ms	Trip Cat	High-break
Output R18	Dwell 100 ms	Trip Fdr	High-break
Output R19	Not used	Not used	High-break
Output R20	Dwell 100 ms	Any Trip	High-break
Output R21	Dwell 100 ms	Trip Cat	High-break
Output R22	Dwell 100ms	Trip Fdr	High-break
Output R23	Not used	Not used	High-break
Output R24	Dwell 100 ms	Any Trip	High-break

Table 6: Output relay mappings – P44T model D

> ***Note:*** *A fault record can be generated by connecting one or several contacts to the **Fault Record Trigger** in PSL. It is recommended that the triggering contact is **self reset** and not **latching**. If a latching contact is used, the fault record is not generated until the contact has fully reset.*

3.3 Programmable LED Output Mappings

Default Menu Text	Latched	Function Red LED	Function Yellow LED	Function Green LED
LED 1	Latching	Zone 1/Aided Dist Trip	Not used	Not used
LED 2	Latching	Dist Delay Trip	Not used	Not used
LED 3	Latching	Defrost Trip	Not used	Not used
LED 4	Not used	Not used	Not used	Not used
LED 5	Latching	Zone 4 Trip	Not used	Not used
FnKey 1	Non-latching	CB Open Cat ph	Not used	CB Closed Cat ph
FnKey 2	Non-latching	CB Open Fdr ph	Not used	CB Closed Fdr ph
FnKey 3	Not used	Not used	Not used	Not used
FnKey 4	Non-latching	AR Lockout	Not used	Not used
FnKey 5	Non-latching	Not used	AR In Prog	AR Successful
FnKey 6	Non-latching	Not used	AR In Service	Not used
FnKey 7	Not used	Not used	Not used	Not used
FnKey 8	Not used	Not used	Not used	Not used

Table 7: LED output mappings – all P44T models

3.4 Fault Recorder Start Mappings

The default mappings for the signal which initiates a fault record is as shown in Table 8

Initiating Signal	Fault Trigger
DDB Any Trip	Initiate fault recording from main protection trip

Table 8: Fault recorder start mappings

3.5 PSL DATA Column

The unit contains a PSL DATA column that can be used to track PSL modifications. A total of 12 cells are contained in the PSL DATA column, 3 for each setting group. The function for each cell is shown in Table 9:

Menu text	Description
Grp. PSL Ref	When downloading a PSL to the IED, you will be prompted to enter the relevant group and a reference identifier. The first 32 characters of the reference ID will be displayed in this cell. The cursor keys can be used to scroll through 32 characters, as only 16 can be displayed at any one time
18 Aug 2008 08:59:32.047	This cell displays the date and time when the PSL was downloaded to the IED
Grp. 1 PSL ID - 2062813232	This is a unique number for the PSL that has been entered. Any change in the PSL will result in a different number being displayed

Table 9: PSL Data Column

> ***Note:*** *The above cells are repeated for each setting group.*

4 VIEWING AND PRINTING PSL DIAGRAMS

It is possible to 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 to print them:

1. Close MiCOM S1 Agile.
2. Select **Programs** > **Alstom Grid** > **S1 Agile** > **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 Studio.
9. Select **Tools** > **PSL Editor (Px40)**.
10. In the PSL Editor select **File > New > Default Scheme**.
11. In the dialogue select the IED type
12. Use the advance button to select the software and then select the required model number.
13. Highlight the required PSL diagram and select **File** > **Print**.

Caution **Read the notes in the default PSL diagrams, as these provide critical information**

INSTALLATION

CHAPTER 13

1 CHAPTER OVERVIEW

This chapter describes the installation of the unit and consists of the following sections:

2 HANDLING THE GOODS

MiCOM products are of robust construction but require careful treatment before installation on site. This section discusses the requirements for receiving and unpacking the goods, and the 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.**

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 General Electric promptly.

Return any units that are not intended for immediate installation to their protective polythene bags and delivery carton.

Unpacking

When unpacking and installing the unit, 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.

Note: *With the lower access cover open, the red tab of the battery isolation strip protrudes from the positive battery terminal. Do not remove this strip because it prevents battery drain during transportation and storage; it will be removed as part of the commissioning process.*

The site should be well lit to aid inspection, clean, dry and reasonably free from dust and excessive vibration. This particularly applies to installations, which are being carried out at the same time as construction work.

Storage

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 by gently heating the bag for about an hour before replacing it in the carton.

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 unit can be stored between –25º to +70ºC (-13ºF to +158ºF).

3 PRE-INSTALLATION REQUIREMENTS

If your IED is equipped with a redundant Ethernet board (REB), you may be required to partially dismantle it in order to set the IP address. You will only have to do this if the last octet of the IP address you need is different from that of the delivered configuration.

The IP address of the REB is configured in both software and hardware. The first three octets are configured with software, but the last octet is configured in hardware.

Configuring the First Two Octets of the Board IP Address

If using SHP or DHP, the first two octets are configured using Switch Manager 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 Rapid Spanning Tree Protocol (RSTP), the first two octets are configured using the RSTP Configurator software tool or using an SNMP MIB browser.

Configuring the Third Octet of the Board IP Address

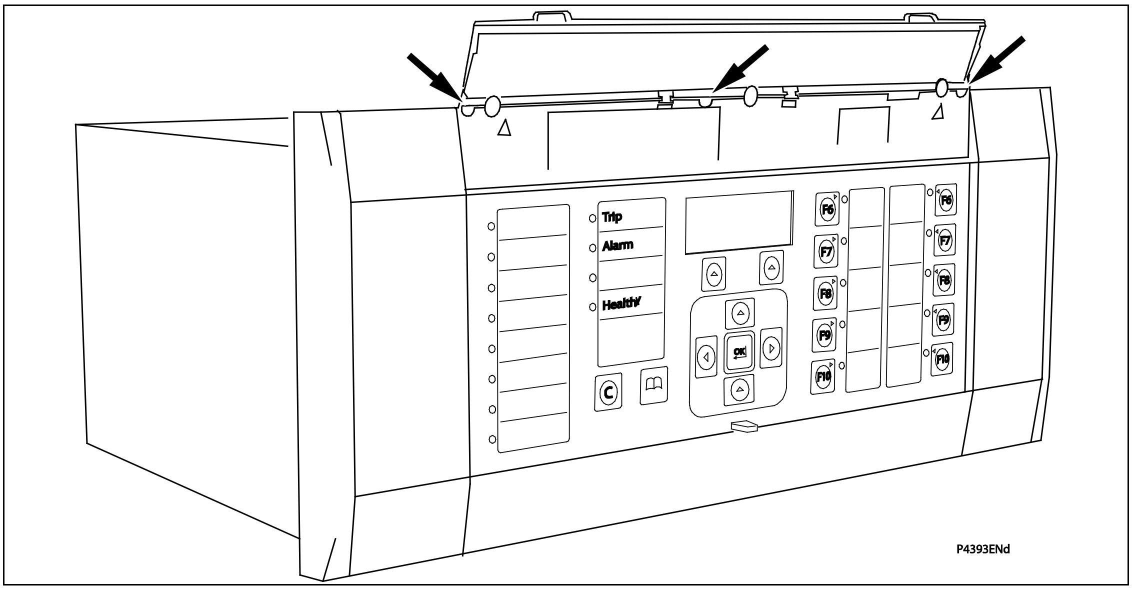
The third octet is fixed at 254 (FE hex, 11111110 binary, regardless of the protocol).

Configuring the Last Octet of the Board IP Address

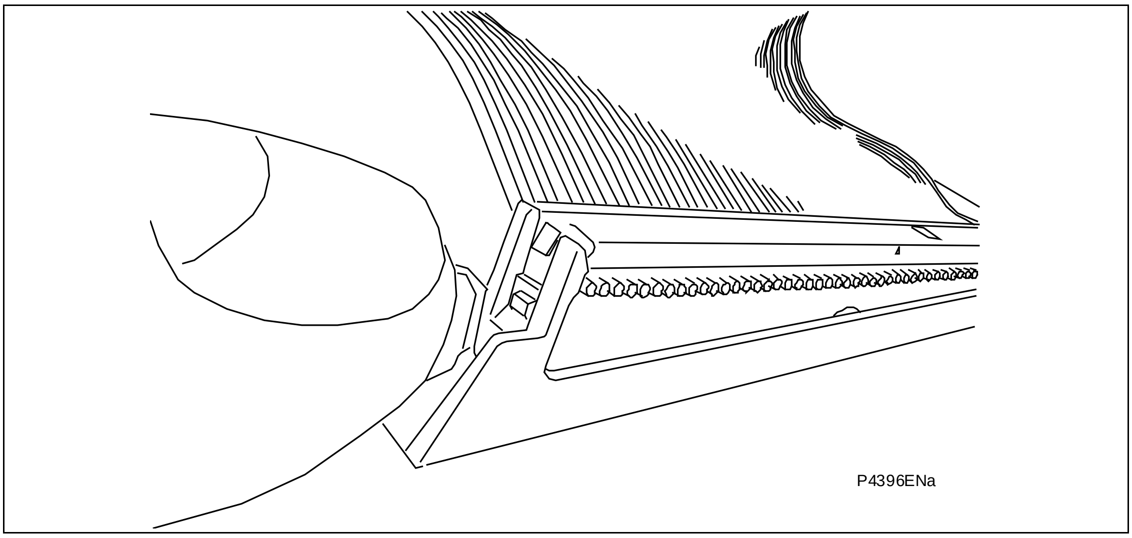
The last octet is configured using board address switch SW2 on the board. It is necessary to first remove the IED front cover to gain access to the board address switch.

Caution	**This hardware configuration should ideally take place before the unit is installed.**

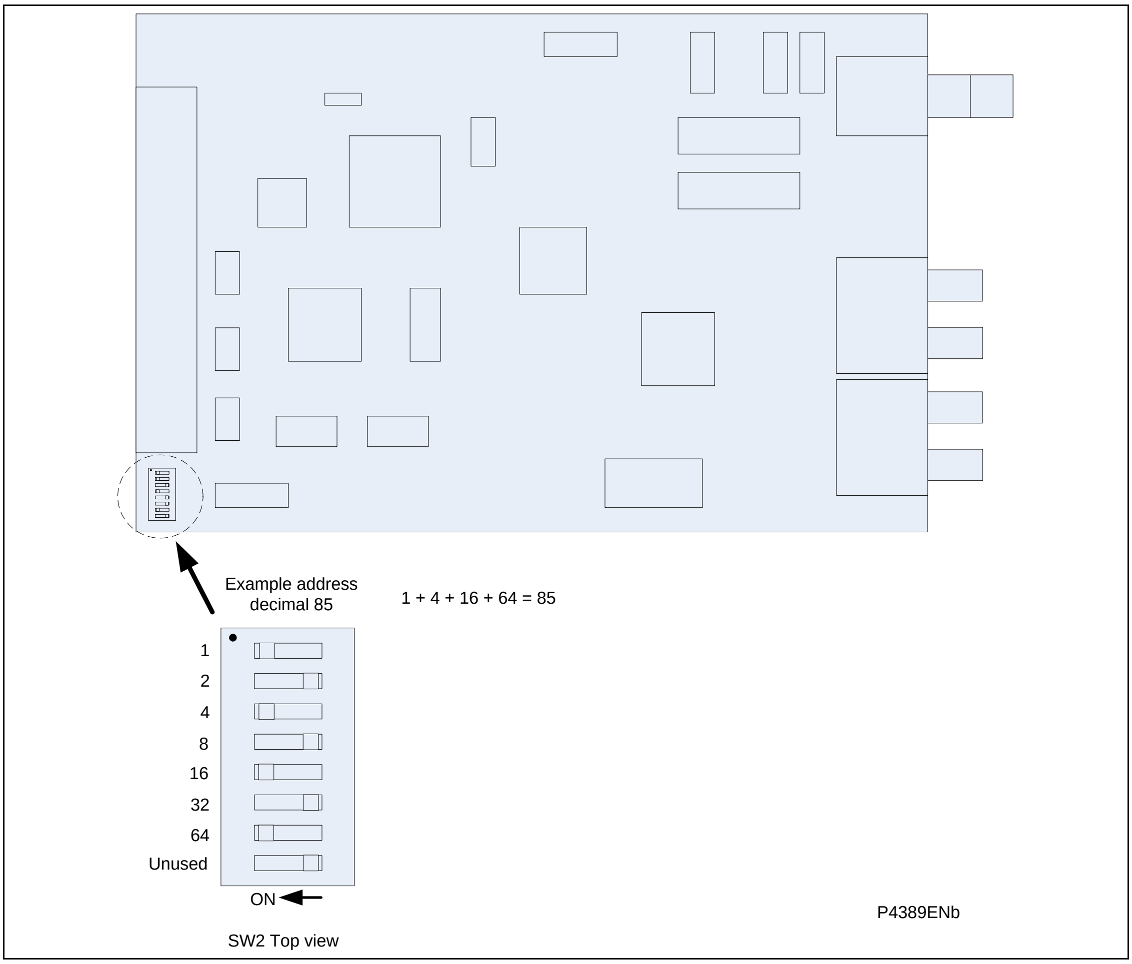
1. Make sure you are familiar with the safety section of this technical manual.
2. Switch off the IED. Disconnect the power and all connections.
3. Before the front cover is removed take precautions to prevent electrostatic discharge damage, according to the ANSI/ESD-20.20 -2007 standard.
4. Wear a 1 MΩ earth strap and connect it to the earthing point (M4 earthing stud), located in the bottom left hand corner on the back of the IED.
5. Lift the upper and lower flaps. Remove the six screws securing the front panel and pull the front panel outwards.



6. Press the levers either side of the connector to disconnect the ribbon cable from the front panel.



7. You now have access to the address switches on the dual Ethernet board, which is situated in slot A on the right hand side of the unit looking from the front.



8. Set the last octet of the board IP address by setting the DIP switches.
9. Once you have set the IP address, reassemble the relay, following the above instructions in the reverse order.

Caution **Take care not to damage the pins of the ribbon cable connector on the front panel when reinserting the ribbon cable.**

4 MOUNTING THE UNIT

MiCOM 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 cutouts and hole centers. These are shown in section 6 Case Dimensions.

MiCOM 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 minimizes 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. See Figure 1.

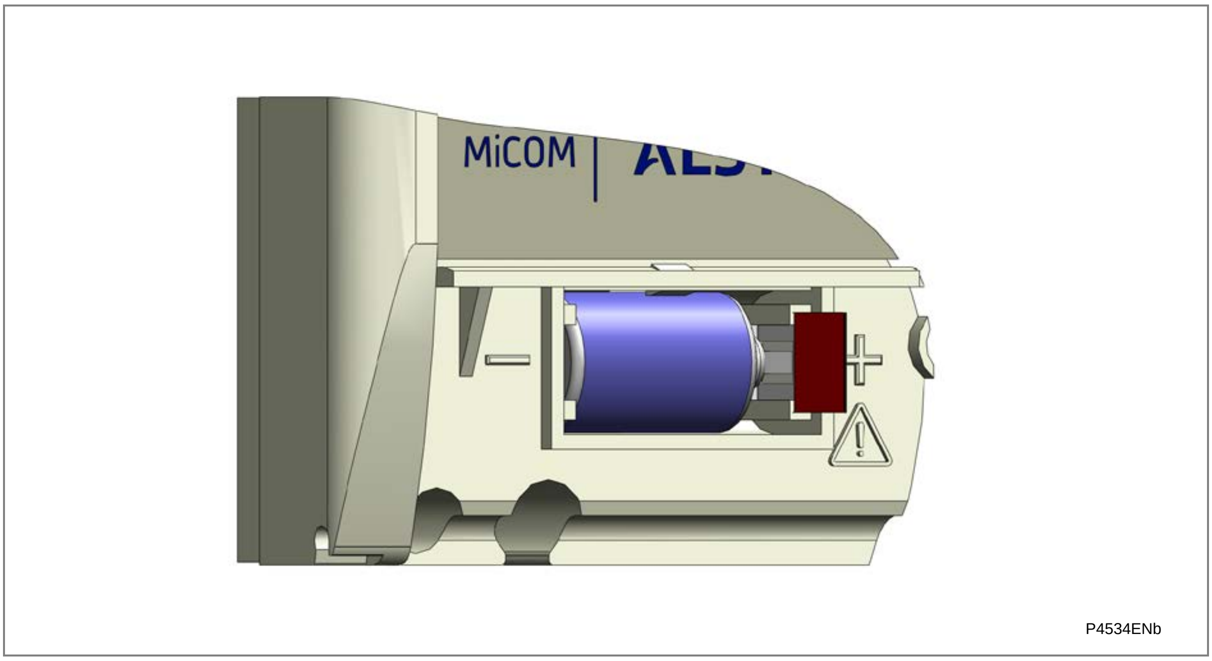


Figure 1: Location of battery isolation strip

Panel mounting

Panel-mounted variants can be flush mounted into panels using M4 SEMS Taptite self-tapping screws with captive 3 mm thick washers (also known as a SEMS unit).

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.**

Alternatively tapped holes can be used 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.

Note: *Fastening MiCOM products with pop rivets is not advised because it does not allow easy removal if repair is necessary.*

Rack mounting

Panel-mounted variants can also be rack mounted using single-tier rack frames (our part number FX0021 101), as shown in Figure 2. 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).

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.

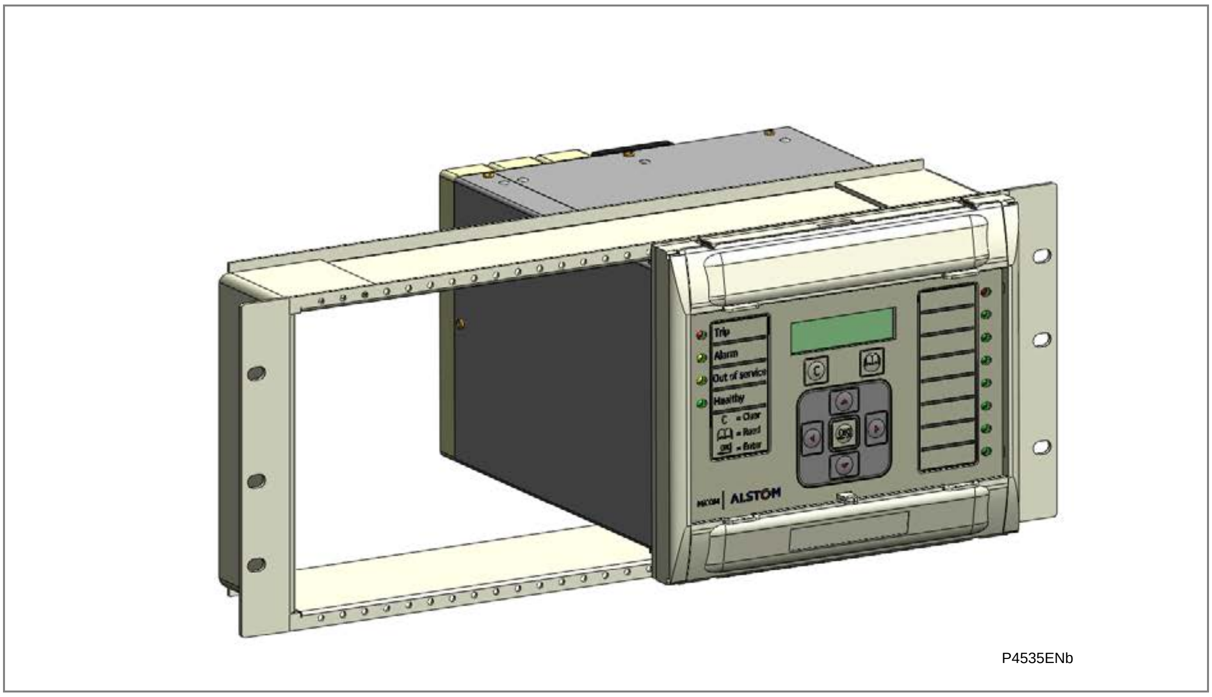


Figure 2: Rack mounting of products

Products can be mechanically grouped into single tier (4U) or multi-tier arrangements using the rack frame. This enables schemes using products from the MiCOM and MiDOS product ranges to be pre-wired together before mounting.

Use blanking plates if there are empty spaces. The spaces may be for future installation of products or because the total size is less than 80TE on any tier. Blanking plates can also be used to mount ancillary components. Table 2 shows the sizes that can be ordered.

For further details on mounting MiDOS products, see publication R7012, MiDOS Parts Catalogue and Assembly Instructions.

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

Table 1: Blanking plates

5 CABLES AND CONNECTORS

This section is a guide to selecting the appropriate cable and connector type for each terminal on the product.

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.**

5.1 Terminal blocks

The unit may use one or more of the terminal block types shown in Figure 3:

- Heavy duty terminal blocks: For CT and VT circuits
- Medium duty 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

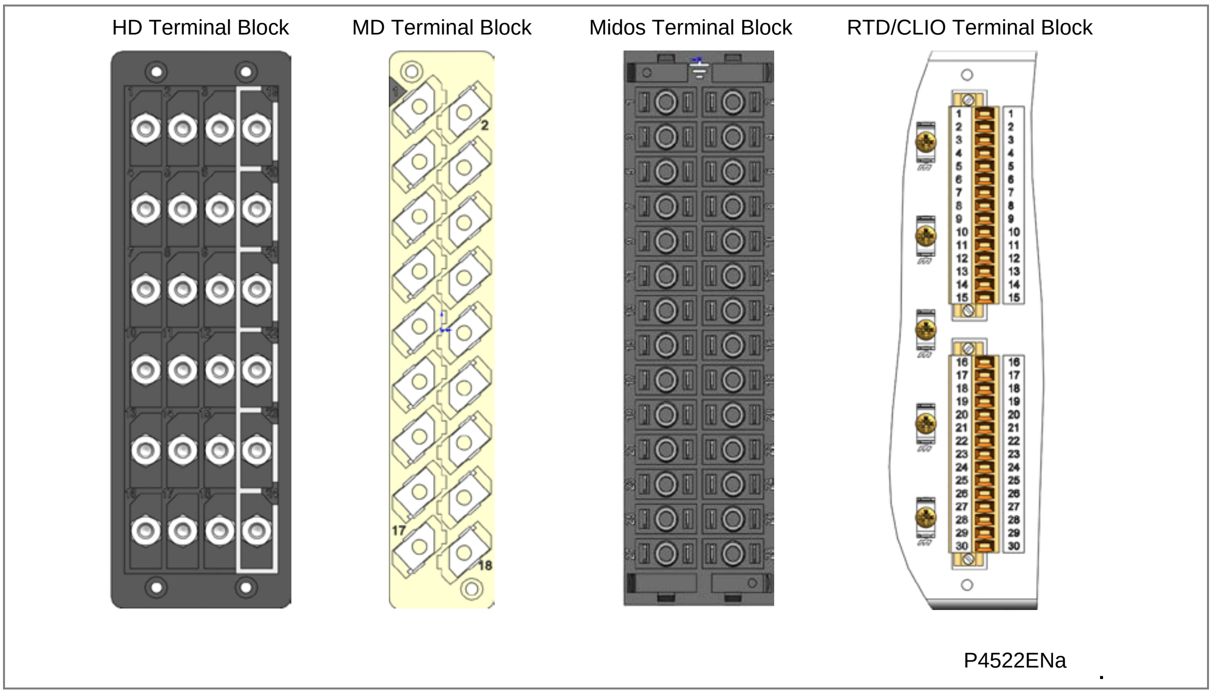


Figure 3: Terminal block types

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

Table 2: M4 90° crimp ring terminals

Caution **For safety reasons always fit an insulating sleeve over the ring terminal.**

5.2 Wire Sizes

The following minimum wire sizes are recommended:

- Current Transformers: 2.5 mm^2
- Auxiliary Supply, Vx: 1.5 mm^2
- Other Circuits: 1: 1.0 mm^2

Due to the limitations of the ring terminal, the maximum wire size that can be used for any of the medium or heavy duty terminals is 6.0 mm^2 using ring terminals that are not pre-insulated. If using only pre-insulated ring terminals, the maximum wire size that can be used is reduced to 2.63 mm^2 per ring terminal. If you need a larger wire size, use two wires in parallel, each terminated in a separate ring terminal at the product.

With the exception of the EIA(RS)485 port, the wire used for all connections to the medium and heavy duty terminal blocks, should have a minimum voltage rating of 300 V RMS.

Each opto-input has a selectable preset ½ cycle filter. This makes the input immune to noise induced on the wiring. Although this is secure it can be slow, particularly for intertripping. If you switch off the ½ cycle filter, either use double pole switching on the input, or screened twisted cable on the input circuit.

Caution **Current transformer circuits must never be fused. Other circuits should be appropriately fused to protect the wire used.**

5.3 Power Supply Terminals

Connections to the power supply terminals are made using pins 1 and 2 on the power supply terminal block. This is always the terminal block on the far right hand-side when viewing the product from the rear.

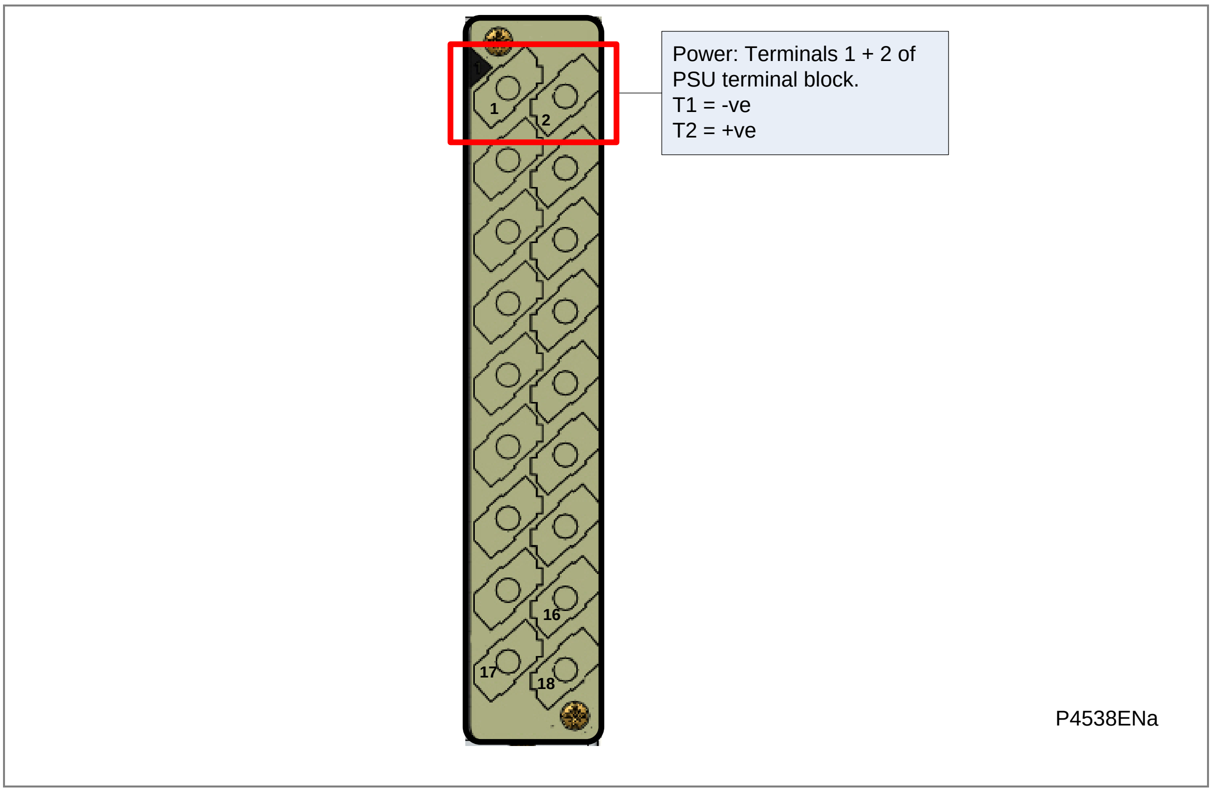


Figure 4: Power supply connections

Protect the auxiliary power supply wiring with a 16 A high rupture capacity (HRC) type NIT or TIA fuse.

5.4 EIA(RS)485 rear port (RP1)

Connections to the rear EIA(RS)485 port are made using ring terminals. 2-core screened cable is recommended 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 copper conductors, PVC insulated
- Nominal conductor area: 0.5 mm^2 per core
- Screen: Overall braid, PVC sheathed

The connections are made to pins 16, 17 and 18 as shown in Figure 5

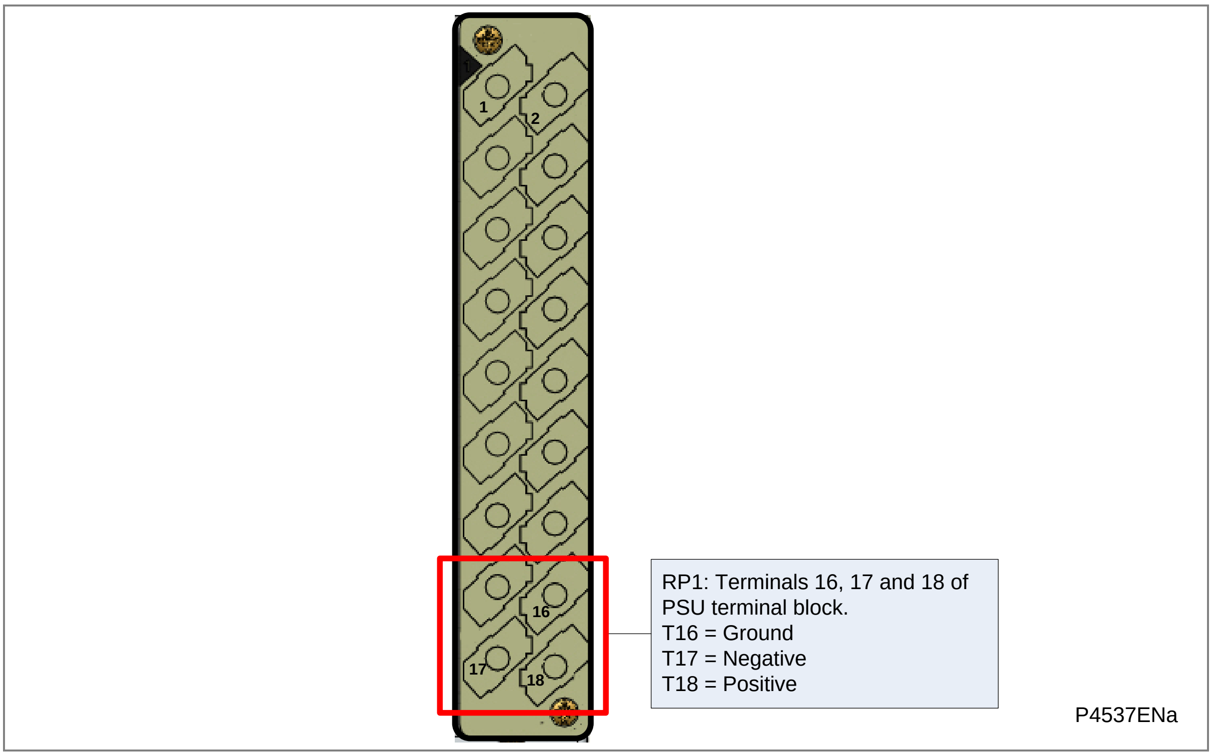


Figure 5: EIA(RS)485 connections

5.5 IRIG-B port

The IRIG-B input and BNC connector have a characteristic impedance of 50 Ω. 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.

5.6 GPS Fibre-optic port

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.

5.7 Ethernet Fibre-optic ports

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:*** *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.*

5.8 Current Differential / IM64 ports

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.

5.9 Ethernet RJ-45 metallic port

If the unit has a metallic Ethernet connection, it can be connected to either a 10Base-T or a 100Base-TX Ethernet hub; the port automatically senses which type of hub is connected. Due to noise sensitivity this connection type is recommended for short-term short distance connections, ideally where the products and hubs are in the same cubicle.

The connector for the Ethernet port is a shielded RJ-45. Table 4 shows the signals and pins on the connector.

Pin	Signal name	Signal definition
1	TXP	Transmit (positive)
2	TXN	Transmit (negative)
3	RXP	Receive (positive)
4	-	Not used
5	-	Not used
6	RXN	Receive (negative)
7	-	Not used
8	-	Not used

Table 3: RJ45 Ethernet connections

5.10 EIA(RS)232 front port

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.

5.11 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.

5.12 Earth connection

Every product must be connected to the cubicle earthing bar using the M4 earthing studs in the bottom left-hand corner of the product case. The minimum recommended wire size is 2.5 mm^2 and should have a ring terminal at the product end.

Due to the limitations of the ring terminal, the maximum wire size that can be used for any of the medium or heavy duty terminals is 6.0 mm^2 per wire. If a greater cross-sectional area is required, two parallel connected wires, each terminated in a separate ring terminal at the product, or a metal grounding bar could be used.

> ***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.*

6 CASE DIMENSIONS

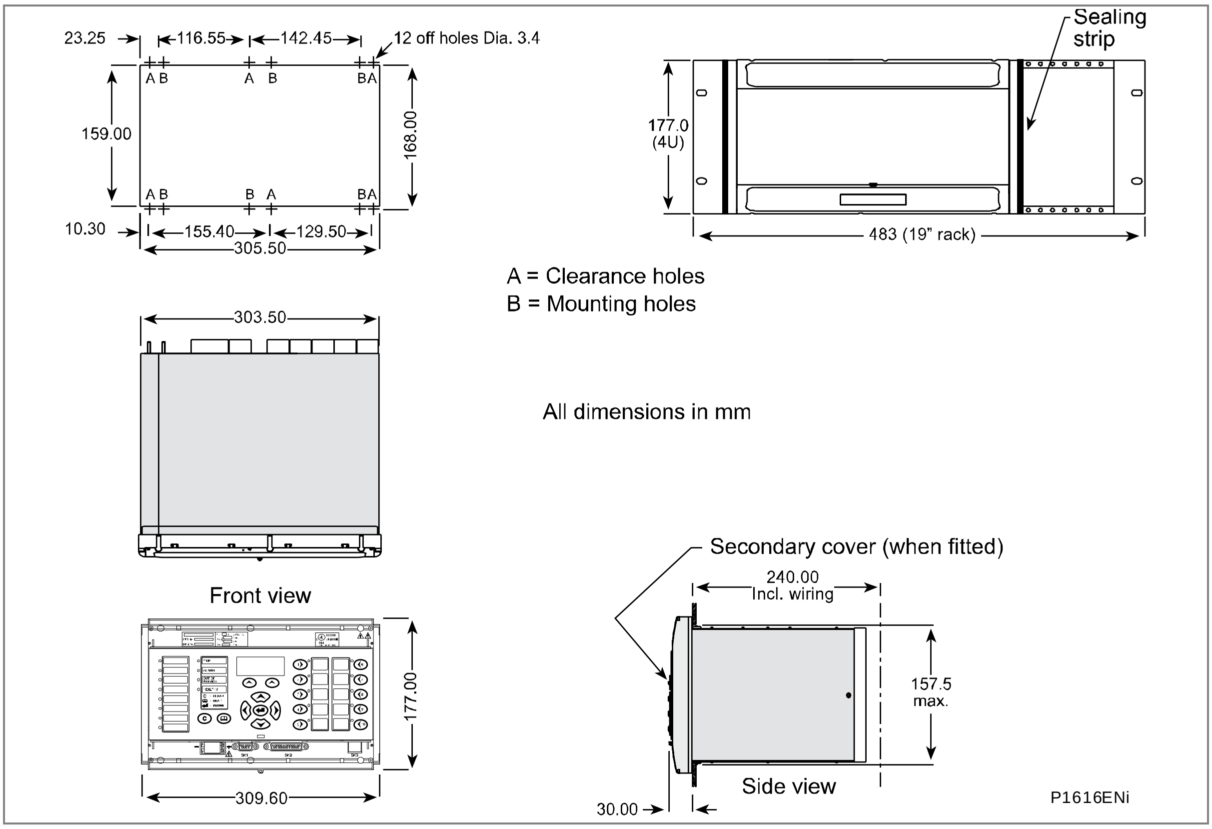


Figure 6: 60TE case dimensions

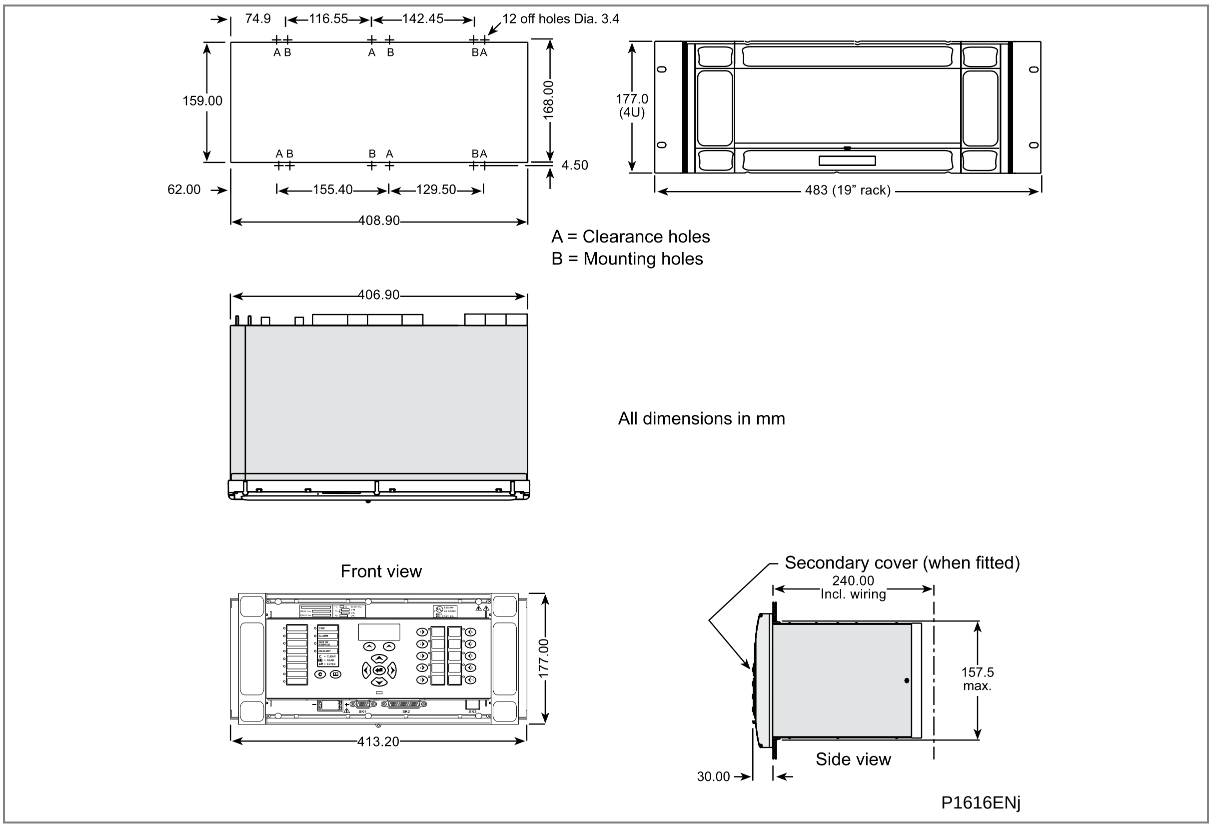


Figure 7: 80TE case dimensions

COMMISSIONING INSTRUCTIONS

CHAPTER 14

1 OVERVIEW

The Commissioning Instructions chapter describes in detail the commissioning process for the product.

It consists of the following sections:

2 GENERAL GUIDELINES

Px40 IEDs are self-checking and 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 IEDs, you do not need to test every IED 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 with appropriate setting software or by using the front panel interface (HMI panel).

The customer is usually responsible for determining the settings to be applied and for testing any scheme logic.

The menu language is user-selectable, so the Commissioning Engineer can change it for commissioning purposes if required.

Note: Restore the language setting to the customer's preferred language on completion.

Warning: Before carrying out any work on the equipment you should be familiar with the contents of the Safety Section or Safety Guide Pxxx-SG-4LM-2 as well as the ratings on the equipment's rating label.

Warning: Do not disassemble the IED in any way during commissioning, other than to test the CT shorting links.

3 COMMISSIONING TEST MENU

The IED provides several test facilities under the COMMISSION TESTS menu heading. There are menu cells that allow the status of the opto-isolated inputs, output relay contacts, internal Digital Data Bus (DDB) signals and user-programmable LEDs to be monitored. There are also cells to test the operation of the output contacts and user-programmable LEDs.

This section describes the commissioning tests available in the IEDs Commissioning test menu. Details of the setting ranges and default values can be found in the Settings and Records chapter.

3.1 Opto I/P Status

This cell can be used to monitor the status of the opto-isolated inputs while they are sequentially energized with a suitable DC voltage.

The cell displays the status of the opto-isolated inputs as a binary string, '1' meaning energized, '0' meaning de-energized. 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

This cell shows the status of the DDB signals, when the output relays are energized, as a binary string. A '1' indicates an operated state and '0' a non-operated state. If you move the cursor along the binary numbers the corresponding label text is displayed for each relay output.

The displayed information can be used to indicate the status of the output relays when the IED is in service. Also fault finding for output relay damage can be performed by comparing the status of the output contact under investigation with its associated bit.

> ***Note:*** *When the **Test Mode** cell is set to **Contacts Blocked**, this cell continues to indicate which contacts would operate if the IED was in-service. It does not show the actual status of the output relays.*

3.3 Test Port Status

This cell displays the status of the eight 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 the programmable scheme logic to be tested.

3.4 LED Status

The **Red LED Status** and **Green LED Status** cells are eighteen bit binary strings that show which of the user-programmable LEDs are ON when accessing from a remote location. **1** means a particular LED is ON and **0** means OFF. When the status of a particular LED in both cells is **1**, this means the LED is lit yellow.

3.5 Monitor Bits 1 to 8

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 25-pin front monitor/download 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.

Warning: The monitor/download port is not electrically isolated against induced voltages on the communications channel. It should therefore only be used for local communications.

3.6 Test Mode

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 select test mode, set the **Test Mode** menu cell to **Test Mode**. This takes the IED out of service and blocks the maintenance counters. It also causes an alarm condition to be recorded so the yellow **Out of Service LED** switches ON and an alarm message **Prot'n. Disabled** is displayed. This 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 so they can be tested, select **Contacts Blocked**. It also enables the test pattern and contact test functions, used to manually operate the output contacts.

Once testing is complete, set the cell to **Disabled** to restore the relay back to service.

Warning: When the cell is in Test mode, the scheme logic still drives the output relays, which could trip the circuit breakers. To avoid this, set the Test Mode cell to Contacts Blocked.

Notes: ***Test mode*** *and* ***Contacts Blocked*** *mode can also be selected by energizing an opto-input mapped to the Test Mode signal, and the Contact Block signal respectively.*

3.7 Test Pattern

Use the **Commission Tests** > **Test Pattern** cell 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.

3.8 Contact Test

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 changes to **No Operation**. The contacts remain in the Test state until reset by issuing the **Remove Test** command. The command text on the LCD shows **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 so can not be used to confirm operation of the output relays. Therefore it is necessary to monitor the state of each contact in turn.*

3.9 Test LEDs

When the **Apply Test** command in this cell is issued the user-programmable LEDs are ON for approximately 2 seconds before they switch OFF and the command text on the LCD reverts to **No Operation**.

3.10 Test Autoreclose

If the IED has an auto-reclose function, this cell is available for testing the sequence of circuit breaker trip and auto-reclose cycles.

The **All Pole Trip** command causes the device to perform the first all phase trip/reclose cycle so that associated output contacts can be checked for operation at the correct times during the cycle. Once the trip output has operated, the command text reverts to **No Operation** while the rest of the auto-reclose cycle is performed. To test subsequent all-phase autoreclose cycles, repeat the All Pole Trip command.

Similarly, where single pole auto-reclosing is available, the cycles for each single pole can be checked by sequentially issuing the **Pole Cat Test** or **Pole Fdr Test**, as appropriate.

> *Note: The default settings for the programmable scheme logic have the **AR Trip Test** signals mapped to the **Trip Input** signals. If the programmable scheme logic has been changed, it is essential that these signals retain this mapping for the Test Auto-Reclose facility to work.*

3.11 Static Test Mode

Static Test Mode can be set to **Enabled** or **Disabled**. When the Static Test mode is enabled it allows older injection test sets to be used to commission and test the device.

Modern dynamic secondary injection test sets are able to accurately mimic real power system faults. The test sets mimic an instantaneous fault “shot”, with the real rate of rise of current, and the decaying DC exponential component. Dynamic injection test sets are available, which cater for all phases, providing a six signal set of analogue inputs: Vcat, Vfdr, Vsch, Icat, Ifdr, Idef. Such injection test sets can be used with the device, with no special testing limitations.

Conversely, older test sets, also known as Static Simulators, may not properly provide or simulate:

- A healthy pre-fault voltage
- A real fault shot (instead a gradually varying current or voltage would be used)
- The rate of rise of current and DC components
- A complete set of three-phase analogue inputs
- Real dynamic step changes in current and voltage.

The IED relies on voltage memory and delta step changes in a real power system, therefore certain functions are disabled or bypassed to allow injection testing. Selecting the Static Mode test option bypasses the delta phase selectors, and power swing detection.

For the tests, the delta directional line is replaced by a conventional distance directional line. Extra filtering of distance comparators is used so the filtering slows to use a fixed one cycle window. Memory polarizing is replaced by cross-polarizing from unfaulted phases.

> *Note: Trip times may be up to ½ cycle longer when tested in the static mode, due to the nature of the test voltage and current, and the slower filtering. This is normal, and perfectly acceptable.*

3.12 Loopback Mode

Loopback Mode can be used to test InterMiCOM^{64} signalling.

> *Note: If the cell is set to **Internal**, only the IED software is checked. If the cell is set to **External**, both the software and hardware are checked.*

When the device is switched into Loopback Mode, it automatically uses generic addresses 0-0. It responds as if it is connected to a remote device. The sent and received IM64 signals continue to be routed to and from the signals defined in the programmable logic.

> *Note: Loopback mode can also be selected by energizing an opto-input mapped to the Loopback signal.*

3.13 IM64 Test Pattern

This cell is used with the **IM64 Test Mode** cell to set a 16-bit pattern (8 bits per channel), which is transmitted whenever the **IM64 Test Mode** cell is set to **Enabled**. The **IM64 Test Pattern** cell has a binary string with one bit for each user-defined Inter-MiCOM command. These can be set to **1** to operate the IM64 output under test conditions and **0** for no operation.

3.14 IM64 Test Mode

When the Enable command in this cell is issued, the InterMiCOM^{64} commands change to reflect the state of the values set in the **IM64 Test Pattern** cell. If the cell is set to **Disabled**, the InterMiCOM^{64} commands reflect the state of the signals generated by the protection and control functions.

3.15 Using a Monitor/Download 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 dynamic current and voltage injection test set.
- Multi-meter with suitable ac current range, and ac and dc voltage ranges of 0 - 440 V and 0 - 250 V respectively
- Continuity tester (if not included in multi-meter).
- Phase angle meter
- Phase rotation meter
- A portable PC, installed with appropriate software (MiCOM S1 Agile)
- Fibre optic power meter if using IM64
- Fibre optic test leads (type and number according to application if using IM64)

4.2 Optional equipment

- 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).

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, make a copy of the settings. This allows 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.
- Writing them down as you sequentially step through the options using the front panel HMI.

If the customer has changed the password that prevents unauthorized 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 General Electric.*

5.1 With the IED De-energized

DANGER: 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, 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.

DANGER: 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 using 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: The rating information given under the top access cover on the front of the IED should be checked. Check that the IED being tested is correct for the line or circuit. Ensure that the circuit reference and system details are entered onto the setting record sheet. 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.

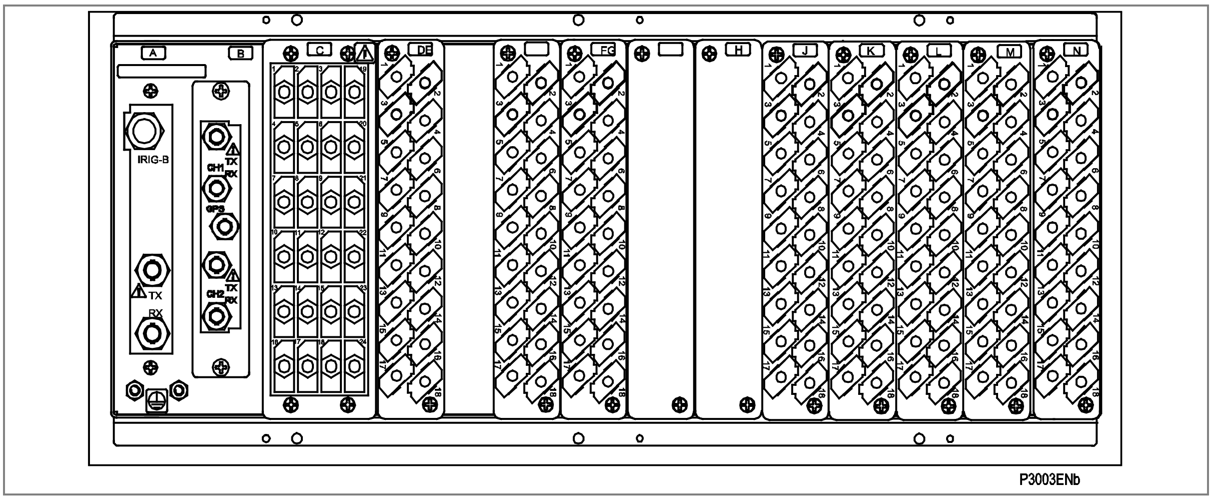


Figure 1: Rear terminal blocks on size 80TE case

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 minimize 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 main groups of IED terminals are:

- Voltage transformer circuits
- Current transformer circuits
- Auxiliary voltage supply
- Field voltage output and opto-isolated control inputs
- Relay contacts
- EIA(RS)485 communication port
- Ethernet communication port
- Case earth

The insulation resistance should be greater than 100 MΩ at 500 V.

On completion of the insulation resistance tests, ensure all external wiring is correctly reconnected to the IED.

5.1.4 External Wiring

Warning: Check that the external wiring is correct to the relevant IED diagram and scheme diagram. Ensure as far as practical that phasing/phase rotation appears to be as expected. The IED diagram number appears on the rating label under the top access cover on the front of the device.

If a P991 test block is provided, the connections should be checked against the scheme diagram. We recommend that you make the supply connections to the live side of the test block (coloured orange) and use the odd numbered terminals (1, 3, 5, 7 …).

The auxiliary supply normally uses terminals 13 (supply positive) and 15 (supply negative). Terminals 14 and 16 connected are connected to the IED's positive and negative auxiliary supply terminals respectively. However, you should check the wiring against the schematic diagram to ensure compliance with the customer's normal practice.

5.1.5 Test Watchdog Contacts (IED not Energized)

Using a continuity tester, check that the Watchdog contacts are in the following states:

Terminals	De-energized contact
N11 to N12	Closed
N13 to N14	Open

Table 1: Watchdog contacts – de-energized

5.1.6 Auxiliary 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 in Table 2.

Without energizing 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 - 48 V	N/A	19 to 65 V	N/A
48 - 110 V	30 - 100 V	37 to 150 V	32 - 110 V
125 - 250 V	100 - 240 V	87 to 300 V	80 to 265 V

Table 2: Operational range of auxiliary supply Vx

> ***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 energize the relay or interface unit using the battery charger with the battery disconnected as this can irreparably damage the relay's power supply circuitry.**

Energise the relay 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 relay.

5.2 With the IED Energized

> **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 auxiliary supply applied to the IED.

5.2.1 Test Watchdog Contacts (IED Energized)

Using a continuity tester, check that the Watchdog contacts are in the following states:

Terminals	De-energized contact
N11 to N12	Open
N13 to N14	Closed

Table 3: Watchdog contacts – energized

5.2.2 LCD

The Liquid Crystal Display (LCD) is designed to operate in a wide range of substation ambient temperatures and therefore has a contrast setting. This is factory preset but to adjust it use **CONFIGURATION** > **LCD Contrast.**

> **Warning: Before applying a contrast setting, make sure it does not make the display too light or dark so the menu text becomes unreadable. The display visibility can be restored by downloading a MiCOM S1 Studio setting file, with the LCD contrast set in the range of 7 to 11.**

5.2.3 Date and Time

The date and time are stored in memory, which is backed up by an auxiliary battery behind the front lower access cover. When delivered, this battery is isolated to prevent battery drain during transportation and storage.

Before setting the time and date:

1. Open the lower access cover on the front panel.
2. 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.

Now it is necessary to set the date and time to the correct values. The method of setting depends on whether accuracy is maintained by the IRIG-B port at the rear or by the IED's internal clock.

With an IRIG-B signal

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 energized and functioning.

1. In the **DATE AND TIME** column, set the **IRIG-B Sync** cell 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 needs to be set manually in this cell.
5. If the auxiliary supply fails, the time and date are 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-energized for approximately 30 seconds. On re energization, the time should be correct.
6. Reconnect the IRIG-B signal.

Without an IRIG-B signal

If the time and date is not being maintained by an IRIG-B signal, in the **DATE AND TIME** column, ensure that the **IRIG-B Sync** cell 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.
2. If the auxiliary supply fails, the time and date are 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 auxiliary supply. Leave the device de-energized for approximately 30 seconds. On re energization, the time should be correct.

5.2.4 LEDs

On power-up, all LEDs first flash yellow. Following this, the green "Healthy" LED switches ON, indicating that the device is healthy.

The IEDs non-volatile memory stores the states of the alarm, trip and user-programmable LEDs (if configured to latch). If the auxiliary supply is disconnected, then at some later time reconnected, the LEDS return to their previous states. If any LEDs were ON previously, they switch ON when the auxiliary supply is applied.

If any of these LEDs are ON, reset them before proceeding with further testing. If the LED switches OFF, this means it has reset successfully so it is operational and no testing is needed.

Note: In most cases, alarms related to the communications channels do not reset at this stage.

5.2.5 Testing the 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 is ON 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 is required for later tests.

5.2.6 Testing the trip LED

To test the trip LED, initiate a manual circuit breaker trip from the relay. However, the trip LED will operate during the setting checks performed later. Therefore no further testing of the trip LED is required at this stage.

5.2.7 Test user-programmable LEDs

To test these LEDs, set **COMMISSIONING TESTS** > **Test LEDs** to **Apply Test**. Check that all user-programmable LEDs switch on.

5.2.8 Test Input Opto-Isolators

This test checks that all the opto-isolated inputs on the IED are functioning correctly.

The opto-isolated inputs should be energized one at a time. For terminal numbers, please see the external connection diagrams in the "Wiring Diagrams" chapter. Ensuring correct polarity, connect the field supply voltage to the appropriate terminals for the input being tested.

Warning: The opto-isolated inputs may be energized from an external DC auxiliary supply such as the station battery in some installations. Check that this is not the case before connecting the field voltage otherwise damage to the IED may result.

The status of each opto-isolated 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 energized input and a '0' indicates a de-energized input. When each opto-input is energized, one of the characters on the bottom line of the display changes to indicate the new state of the input.

5.2.9 Test Output Relays

Caution: The high break output contacts, fitted to some models, are polarity sensitive. External wiring should be verified against polarity requirements described in the external connection diagram to ensure correct operation.

This test checks that all the output relays are functioning correctly.

3. Ensure that the IED is still in test mode by checking that **COMMISSION TESTS** > **Test Mode** is set to **Blocked**.
4. Energize the output relays one at a time. To select output relay 1 for testing, set the **Test Pattern** cell to 1.
5. Connect a continuity tester across the terminals corresponding to output relay 1 as shown in the external connection diagram.
6. To operate the output relay set the **Contact Test** cell to **Apply Test**.
7. Check the operation with a continuity tester.
8. Measure the resistance of the contacts in the closed state.
9. Reset the output relay by setting the **Contact Test** cell to **Remove Test**.
10. Repeat the test for the remaining output relays.
11. Return the IED to service by setting **COMMISSION TESTS** > **Test Mode** to **Disabled**.

Warning: Keep the time between application and removal of the contact test as short as possible to avoid excessive heating. Ensure the associated output relay does not exceed the thermal ratings of anything connected to the output relays during the contact test procedure.

5.2.10 Communication Port RP1

You need only perform this test if the IED is to be accessed from a remote location. The test varies depending on the communications protocol used.

This test is not intended to verify the complete communication link between the IED and the remote location. The test is intended to verify the IED's rear communications port and, if applicable, the protocol converter.

The rear communication port RP1 has the following physical layer implementations:

- K-Bus (copper connection)
- EIA(RS)485 (copper connection)
- Optical Fibre (fibre optic connection)

Copper connection

The copper rear communication port RP1 is presented on pins 16, 17 and 18 of the power supply terminal block. Screened twisted pair cable is used. Pin 16 is the earth connection for the screen and pins 17 and 18 are for the communication signal. The optional fibre connection is presented on a separate board, housed in the communications slot.

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 17 is positive, pin 18 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 or PAS&T) can be connected to the incoming side of the protocol converter, as shown in Figure 2.

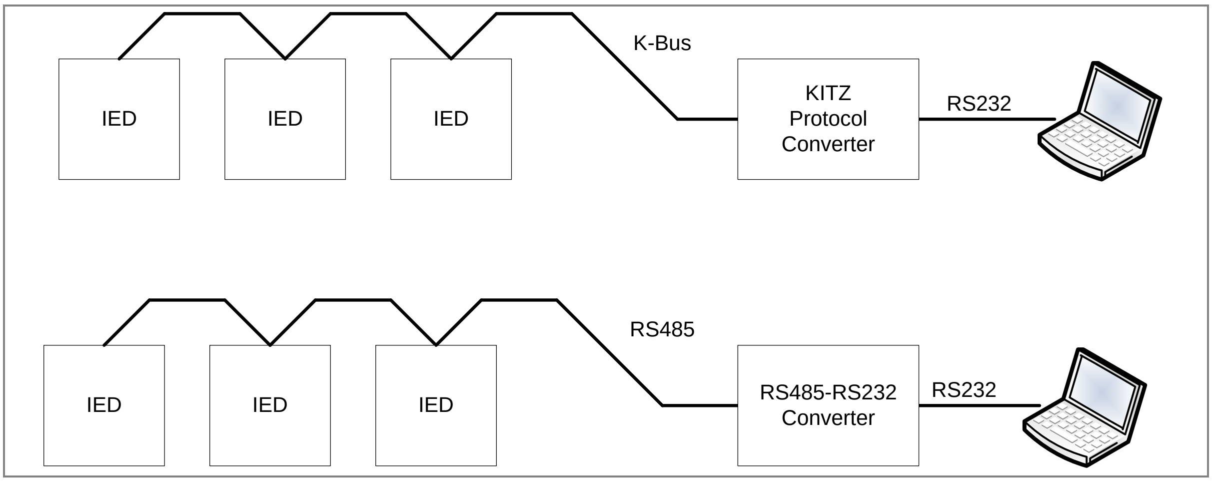


Figure 2: Connecting laptop to protocol converter

K-Bus can only be used with the Courier protocol, whereas RS485 and RS232 can be used for a variety of serial protocols as required by the device in question, so communication using the chosen data protocol also needs to be checked, as described in the following sections.

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.

5.2.10.1 Courier

K-Bus

1. Set **COMMUNICATIONS** > **Physical Link** to **K-Bus**
2. Ensure that the communications baud rate and parity settings in the application software are set the same as those on the protocol converter.
3. In **COMMUNICATIONS** > **Remote Address** set the IED's Courier address to a value between 1 and 254.
4. Check that communications can be established with this IED using the portable PC/Master Station.

Copper

1. Set **COMMUNICATIONS** > **Physical Link** to **copper**.
2. Ensure that the communications baud rate and parity settings in the application software are set the same as those of the IED.
3. In **COMMUNICATIONS** > **Remote Address** set the IED's Courier address to a value between 1 and 254.
4. Check that communications can be established with this IED using the portable PC/Master Station

Fibre

1. Set **COMMUNICATIONS** > **Physical Link** to **fibre-optic**.
2. Ensure that the address and baud rate settings in the application software are set the same as those of the IED.
3. Check that communications with the IED can be established using the Master Station.

5.2.10.2 IEC60870-5-103 (VDEW) communications

Copper

1. Set **COMMUNICATIONS** > **Physical Link** to **copper**.
2. IEC60870-5-103/VDEW communication systems are designed to have a local Master Station and this should be used to verify that the rear fibre optic or EIA(RS)485 port, as appropriate, is working. Ensure that the IED address and baud rate settings in the application software are set the same as those in the IED.
3. Check that communications with the IED can be established using the Master Station.

Fibre

1. Set **COMMUNICATIONS** > **Physical Link** to **fibre-optic**.
2. Ensure that the address and baud rate settings in the application software are set the same as those of the IED.
3. Check that communications with the IED can be established using the Master Station.

5.2.10.3 DNP3.0 communications

Copper

1. Set **COMMUNICATIONS** > **Physical Link** to **copper**.
2. Ensure that the IED address, baud rate and parity settings in the application software are set the same as those in the IED.
3. Check that communications with this IED can be established using the Master Station.

Fibre

1. Set **COMMUNICATIONS** > **Physical Link** to **fibre-optic**.
2. Ensure that the address and baud rate settings in the application software are set the same as those of the IED.
3. Check that communications with the IED can be established using the Master Station.

5.2.10.4 IEC 61850 communications

1. Connect a portable PC running the appropriate IEC 61850 Client Software or MMS browser to the IED's Ethernet port (RJ45 or ST fibre optic connection). Alternatively, you can use a simple Ethernet 'ping' to the configured IP address.
2. Configure the IP parameters (IP Address, Subnet Mask, Gateway) and SNTP time synchronization parameters (SNTP Server 1, SNTP Server 2) Configuration of the IP parameters can be imported from an SCL file or made manually by using the IED Configurator tool, which is installed as part of MiCOM S1 Studio. In either case, these parameters are sent to the IED using the IED Configurator via a serial connection to the IED’s front port - they cannot be configured via the IED’s HMI on the front panel.

> *Note:* *If the assigned IP address is duplicated elsewhere on the same network, the remote communications operates in an indeterminate way. However, the device checks for a conflict on every IP configuration change and at power up. An alarm is raised if an IP conflict is detected. The device can be configured to accept data from networks other than the local network using the ‘Gateway’ setting.*

3. Check that communications with this IED can be established.

5.2.11 Rear communications 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 the test to verify the operation of the complete system from the IED to the remote location, just the IED's rear communications port and any protocol converter necessary.

5.2.11.1 K-Bus configuration

1. If a K-Bus-to-RS232 KITZ protocol converter is installed, connect a portable PC running appropriate software (such as MiCOM S1 Agile or PAS&T) to the to the RS232 port of the KITZ protocol converter.
2. Ensure that the communications baud rate and parity settings in the application software are set the same as those on the protocol converter.
3. In **COMMUNICATIONS** > **Remote Address** set the IED's Courier address to a value between 1 and 254.
4. Set **COMMUNICATIONS** > **RP2 Port Config** to **K-Bus**
5. Check that communications can be established with this IED using the portable PC.

5.2.11.2 EIA(RS)485 configuration

1. If an EIA(RS)485 to EIA(RS)232 converter is installed, connect a portable PC running appropriate software (for example MiCOM S1 Agile) to the EIA(RS)232 side of the converter and the IED's RP2 port to the EIA(RS)485 side of the converter.
2. Ensure that the communications baud rate and parity settings in the application software are set the same as those in the IED.
3. In **COMMUNICATIONS** > **RP2 Address** set the IED's Courier address to a value between 1 and 254.
4. Set **COMMUNICATIONS** > **RP2 Port Config** to **EIA(RS)485**.
5. Check that communications can be established with this relay using the portable PC.

5.2.11.3 EIA(RS)232 configuration

1. Connect a portable PC running the appropriate software (for example MiCOM S1 Agile) to the rear EIA(RS)232 port (SK5)
2. Ensure that the communications baud rate and parity settings in the application software are set the same as those in the IED.
3. In **COMMUNICATIONS** > **RP2 Address** set the IED's Courier address to a value between 1 and 254.
4. Set **COMMUNICATIONS** > **RP2 Port Config** to **EIA(RS)232**.
5. Check that communications can be established with this IED using the portable PC.

5.2.12 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 current equal to the line current transformer secondary winding rating to each current transformer input in turn. See the external connection diagram for the terminal numbers.
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 are either in primary or secondary Amperes. If **MEASURE'T SETUP** > **Local Values** is set to **Primary**, the value displayed should be equal to the applied current multiplied by the corresponding current transformer ratio (set in the CT AND VT RATIOS column). See Table 4. If **Local Values** is set to **Secondary**, the value displayed should be equal to the applied current.

> ***Note:*** *If a PC is connected to the IED rear communications port to display the measured current, the process is similar. However, the **MEASURE'T SETUP** > **Remote Values** setting determines 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.

Cell in MEASUREMENTS 1	Corresponding CT ratio (in 'CT and VT RATIOS' column)
Icat magnitude Ifdrmagnitude Idef magnitude	Phase CT Primary / Phase CT Secondary

Table 4: CT Ratios settings

5.2.13 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 are either in primary or secondary Volts. If **MEASURE'T SETUP** > **Local Values** is set to **Primary**, the values displayed should be equal to the applied voltage multiplied by the corresponding voltage transformer ratio (set in the CT AND VT RATIOS column), as shown in Table 5. 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 is similar. However, setting **MEASURE'T SETUP** > **Remote Values** determines whether the displayed values are in primary or secondary Amperes.*

Cell in MEASUREMENTS 1	Corresponding CT ratio (in 'CT and VT RATIOS' column)
Vcat magnitude Vfdr magnitude	Main VT Primary / Main VT Secondary
Check Sync Voltage Magnitude	C/S VT Primary / C/S VT Secondary

Table 5: Voltage ratio settings

6 INTERMICOM COMMUNICATION LOOPBACK

If the IED is used in a scheme with InterMiCOM^{64} communications, it is necessary to configure a loopback to test the communication.

Several different fibre-optic interfaces are available. In general, 1300 nm fibres are used, either single-mode or multi-mode are used for direct connection. 850 nm multimode fibres are used with multiplexing telecommunications equipment. It is important that any fibres used for testing are correct for the specified interface(s).

Optical fibres should be terminated with BFOC2.5 (ST2.5) connectors. For multimode applications use 50/125 µm cored. Make sure fibre test leads used for measurements are long enough for mode stripping. A minimum length of 10 m (30ft) is recommended for this.

If IEDs communicate using multiplexed electrical communication channels, a P590 is used. This is a bidirectional optical-to-electrical signal convertor. It is situated near the multiplexer, between the fibre from the IED and the electrical interface of the multiplexer. Apply the loopback either at the P590 or the multiplexer to ensure as much of the circuit as possible is tested.

Set **CONFIGURATION** > **InterMiCOM64** to **Enable**.

The testing method is similar, irrespective of whether the communications between devices is with dedicated fibres or with direct fibre connection to a IEEE C37.94 multiplexer.

If using dedicated fibres, a P590 unit is used to interface the IED's fibre-optic communications channel to a multiplexer. The P590 interface units require additional tests (see P590 documentation).

If the IED is connected to a IEEE C37.94 multiplexer, the loopback testing is exactly the same as for a direct fibre connection.

Note: Two channels may have different implementations. The sections describing commissioning the interfaces and the loopback tests should be used as is relevant to each channel.

Warning: NEVER look directly into the transmit port or the end of an optical fibre, as this could severely damage your eyes

6.1 Communications Loopback Setting

The loopback test can be used to establish correct operation of the local communication interface.

In loopback mode the signals sent and received using the communications interface are routed to and from the signals defined in the programmable logic. If **CONFIGURATION** > **InterMiCOM64** is set to **Enable**, this still applies but if **COMMISSION TESTS** > **IM64 Test Mode** is set to Enabled, an IM64 test pattern is transmitted instead.

1. Set **INTERMICOM COMMS** > **Loopback Mode** to **External**.
2. Using an appropriate fibre-optic cable, connect the Channel 1 transmitter (TX1) to an optical power meter. Check that the average power transmitted is within the range given in the following table.
3. Record the transmit power level
4. Repeat for Channel 2 if applicable

Power	850 nm multi-mode	1300 nm multi-mode	1300 nm single-mode
Maximum transmitter power (average value)	-19.8 dBm	-3 dBm	-3 dBm
Minimum transmitter power (average value)	-22.8 dBm	-9 dBm	-9 dBm

Table 6: Transmit power levels

6.2 Loopback Communications Configuration

Make a communications loopback on the protection signalling communication paths. Either one or two channels are fitted depending on the product variant and application. A direct fibre connection or a multiplexed connection (using P59x units) can be used on each of the channels. Loopbacks should be made for each of the two channels.

Where direct fibre connections are used (or where multiplexer channels conforming to the IEEE C37.94 standard are used), connect an appropriate fibre-optic cable from the channel transmitter to the channel receiver port on the rear of the device.

If the communications use P59x interface devices, connect the appropriate optical fibre(s) between the channel transmitter(s) on the IED used to make connection to the P590 optical receiver(s). Then commission the relevant P59x devices as described in Appendix B Commissioning Instructions.

6.3 Loopback Test

1. Set **COMMISSION TESTS** > **IM64 Test Mode** to **Enabled**, and use **COMMISSION TESTS** > **Test Pattern** to set a bit pattern sent using the InterMiCOM^{64} loopback.
2. Check that **MEASUREMENTS 4** > **IM64 Rx Status** matches the test pattern set. The communication statistics show the number of valid and erroneous messages received.

Notes: *The propagation delay measurement is not valid in this mode of operation. The IED responds as if it is connected to a remote IED. It indicates a loopback alarm which can only be cleared by setting* ***COMMISSION TESTS*** *>* ***Loopback Mode*** *to* ***Disabled****.*

In loopback mode the signals sent and received through the protection communications interface continue to be routed to and from the signals defined in the programmable logic.

A test pattern can also be sent to the remote end to test the whole InterMiCOM communication path. To do this, set ***COMMISSION TESTS >IM64 Test Mode*** *to* ***Enable*** *and connect two ends. Take special care because the test pattern is executed using PSL at the remote end.*

7 INTERMICOM COMMUNICATION LOOPBACK

If the IED is used in a scheme with InterMiCOM communications it is necessary to configure a loopback on the InterMiCOM communications.

Make the loopback as close as possible to where the communication link leaves the substation. Therefore as much of the wiring as possible and all associated communication signal converters are included in the test.

This section only covers an electrical loopback connection using EIA(RS)232 Fibre loopback connections have already been covered in section 6.

7.1 EIA(RS)232 InterMiCOM communications

1. Set **CONFIGURATION** > **InterMiCOM** to **Enabled**.
2. Set **INTERMICOM COMMS** > **Ch Statistics** and **Ch Diagnostics** to **Visible**.
3. Check that **INTERMICOM COMMS** > **IM HW Status** displays **OK**. This means the InterMiCOM hardware is fitted and initialized.

7.1.1 MODEM InterMiCOM loopback testing & diagnostics

INTERMICOM COMMS > **Loopback Mode** allows you to test the InterMiCOM channel. In normal service it must be disabled. **INTERMICOM COMMS** > **Loopback Status** shows the status of the InterMiCOM loopback mode.

*Note: If **INTERMICOM COMMS** > **Loopback Mode** is set to **Internal**, only the internal software of the device is checked. This is useful for testing functionality if no communications connections are made. Use the **External** setting during commissioning because it checks both the software and hardware used by InterMiCOM. When the IED is switched into either Internal or External Loopback Mode it automatically uses generic addresses and inhibits the InterMiCOM messages to the PSL by setting all eight InterMiCOM message command states to zero.*

Set **INTERMICOM COMMS** > **Loopback Mode** to **External** and form a communications loopback by connecting the transmit signal (pin 2) to the receive signal (pin 3).

Note: The DCD signal must be held high (by connecting pin 1 to pin 4) if the connected equipment does not support DCD. A communications converter is probably used and the loopback is not at the InterMiCOM connector. Make the loopback as far into the communications channel as possible so that as much wiring, and as many ancillary communication components as possible are included in the test.

The loopback mode is shown on the front panel by an Alarm LED and the message **IM Loopback** on the LCD.

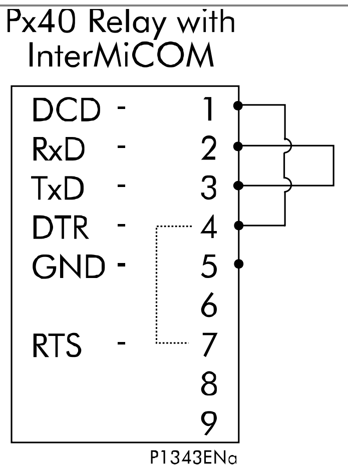


Figure 3: Connections for InterMiCOM communications loopback

Check that all connections are correct and the software is working correctly. Check that **INTERMICOM COMMS** > **Loopback Status** shows **OK**.

7.1.1.1 MODEM InterMiCOM command bits

To test the InterMiCOM command bits, go to the **INTERMICOM COMMS** column and do the following:

1. Enter any test pattern in the **Test Pattern** cell in the by scrolling through and changing selected bits between **1** and **0**. The entered pattern is transmitted through the loopback.
2. Check that the **IM Output Status** cell matches the applied Test Pattern.
3. Check that all 8 bits in the **IM Input Status** cell are zero.

7.1.1.2 MODEM InterMiCOM channel diagnostics

Check that the following cells in the **INTERMICOM COMMS** column all read **OK**.

- **Data CD Status**
- **FrameSync Status**
- **Message Status**
- **Channel Status**

7.1.1.3 MODEM InterMiCOM channel failure

1. Simulate a failure of the communications link by breaking a connection and checking that some of these cells show **Fail**.
2. Restore the communications loopback and ensure that the four diagnostic cells display **OK**

> *Note: Some or all of these cells show **Fail** depending on the communications configuration and the way the link has failed.*

.

8 SETTING CHECKS

The setting checks ensure that all of the application-specific settings have been correctly applied, both the IED's function and the programmable scheme logic settings.

> ***Note:*** *If applicable, the trip circuit remains isolated during these checks to prevent accidental operation of the associated circuit breaker.*

8.1 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

8.1.1 Transferring settings from a settings file

This method is preferred for transferring function settings as it is much faster, and there is a lower margin for error.

1. Connect a laptop/PC (that is running MiCOM S1 Agile) to the IED's front serial port, or any rear Courier communications port (with a KITZ protocol converter if necessary).
2. Power on the IED
3. Right-click on the appropriate device name in the Agile Explorer pane and select **Send**
4. In the **Send to** dialog select the setting files and click **Send**
5. Close the **Send to** dialog by clicking Close

> Notes: *If the device name does not already exist in the Agile Explorer system, first perform a QuickConnect to the IED. Then manually add the settings file to the device name in the Studio Explorer system. Refer to the MiCOM S1 Agile help for details of how to do this.*
>
> *If application-specific Programmable Logic Scheme (PSL) is used, this must be transferred to the IED from MiCOM S1 Agile. It is not possible to change the PSL using the IED's front panel HMI.*

8.1.2 Entering the settings using the IED's front panel HMI panel

> Note: *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 and hold the up cursor key, 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 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.

***Notes**: 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*

Warning: If the installation needs application-specific PSL, the relevant .psl files, must be transferred to the IED for each setting group that will be used.
If you do not do this, the factory default PSL is still resident. This may have severe operational and safety consequences.

*Note: If, as a result of applying the application settings, the communication mode (**Comms Mode** cell) has been changed, a **comms changed** alarm is raised on the user interface. This alarm can only be cleared by power cycling the relay. If the alarm appears, remove and then re-apply the auxiliary supply to the relay.*

8.1.3 Protection communications loopback

If InterMiCOM^{64} is being used for the signalling channel, the communication loopbacks that were tested earlier need to be maintained while scheme testing is performed.

Set **COMMISSIONING TEST** > **Test Loopback** to **External**

Check that **COMMISSIONING TEST** > **Test Pattern** has all bits set to **0** initially.

Set **COMMISSIONING TEST** > **IM64Test Mode** to **Enabled**.

8.1.4 Reset statistics

The protection communications / InterMiCOM^{64} communications statistics should be reset at this point. The **Clear Statistics** cell in the MEASUREMENTS 4 column is used for this.

8.2 Distance Protection

8.2.1 Distance Protection Single-ended Testing

If the distance protection function is being used, the reaches and time delays should be tested.

1. Check for any possible dependency conditions and simulate as appropriate.
2. In the **CONFIGUARATION** 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.

8.2.1.1 Connection and preliminaries

The IED should now be connected to equipment able to supply phase-phase and phase-neutral volts with current in the correct phase relation for a particular type of fault on the selected characteristic angle. The facility for altering the loop impedance (phase-to-ground fault or phase-phase) presented to the IED is essential.

We recommend that you use a three-phase digital/electronic injection test set to make the commissioning procedure easier.

1. If testing the distance elements using using test sets that do not provide a dynamic model to generate true fault delta conditions, set **COMMISSIONING TESTS** > **Static Test Mode** to **Enabled**. When set, this disables phase selector control and forces the device to use a conventional (non-delta) directional line.
2. For lower specification test equipment that cannot apply a full three phase set of healthy simulated pre-fault voltages, the VT supervision may need to be disabled to avoid spurious pickup. Set **CONFIGURATION** > **Supervision** to **Disabled**.
3. Connect the test equipment to the device using the test block(s), taking care not to open-circuit any CT secondary windings. If using MMLG type test blocks, the live side of the test plug must be provided with shorting links before it is inserted into the test block.
4. When the test is complete, make sure **COMMISSIONING TESTS** > **Static Test Mode** is set back to **Disabled**.

8.2.1.2 Zone 1 reach check

The zone 1 element is set to be directional forward.

1. Apply a dynamic Cat-phase-to-neutral fault, slightly in excess of the expected reach. The duration of the injection should be in excess of the tZ1 timer setting, but less than tZ2. These settings are in the DISTANCE column. No trip should occur, and the red Trip LED should remain OFF.
2. Reduce the impedance and reapply the simulated fault.
3. Repeat this procedure until a trip occurs. When this happens, the display shows **Alarms/Faults present** and the Alarm and Trip LEDs switch ON.
4. To view the alarm message, keep pressing the read key until the yellow alarm LED changes from flashing to being steadily on.
5. At the prompt **Press clear to reset alarms**, press the **C** key. This clears the fault record from the display.
6. Record the impedance at which the device trips. The measured impedance should be within +/- 10% of the expected reach.
7. Read and reset the alarms

Modern injection test sets usually calculate the expected fault loop impedance from the device settings.

8.2.1.3 Zone 2 reach check

The zone 2 element is set to be directional forward.

1. Apply a dynamic Cat-Fdr fault, slightly in excess of the expected reach. The duration of the injection should be in excess of the tZ2 timer setting, but less than tZ3. These settings are in the DISTANCE column. No trip should occur, and the red Trip LED should remain OFF.
2. Repeat the test described above to find the zone reach.
3. Record the impedance at which the device trips. The measured impedance should be within +/- 10% of the expected reach.
4. Read and reset the alarms.

Modern injection test sets usually calculate the expected fault loop impedance from the device settings. For those that do not, check the reach for phase-phase and confirm the operation of the appropriate contacts. The appropriate loop impedance is now given by:

$$2 \times Z2\ \Omega$$

8.2.1.4 Zone 3 reach check

The zone 3 element is set to forward, reverse or offset. The current injected must be in the appropriate direction to match the setting in the DISTANCE SETUP column.

1. Apply a dynamic Fdr-Cat fault, slightly in excess of the expected reach. The duration of the injection should be in excess of the tZ3 timer setting (typically tZ3 + 100 ms).
2. Repeat the test described above to find the zone reach.
3. Record the impedance at which the device trips. The measured impedance should be within +/- 10% of the expected reach.
4. Read and reset the alarms.
5. Check that the correct reverse offset (Z3') has been applied. The setting is in the **Z3' Ph Rev Reach** and **Z3' Gnd Rev Reach** cells.

8.2.1.5 Zone 4 reach check (if enabled)

The zone 4 element is set to be directional reverse.

1. Apply a dynamic Fdr-N fault, slightly in excess of the expected reach. The duration of the injection should be in excess of the tZ4 timer setting (typically tZ4 + 100 ms).
2. Repeat the test described above to find the zone reach.
3. Record the impedance at which the device trips. The measured impedance should be within +/- 10% of the expected reach.
4. Read and reset the alarms.

8.2.1.6 Zone P reach check (if enabled)

The zone P element can be set to forward or reverse directional or offset. The current injected must be in the appropriate direction to match the setting in the DISTANCE SETUP column.

1. Apply a dynamic Cat-N fault, slightly in excess of the expected reach. The duration of the injection should be in excess of the tZP timer setting (typically tZP + 100 ms).

2. Repeat the test described above to find the zone reach.
3. Record the impedance at which the relay trips. The measured impedance should be within +/-10% of the expected reach.
4. Read and reset the alarms.

8.2.1.7 Resistive reach (quadrilateral characteristics only)

Check that the correct settings for phase and ground element resistive reaches have been applied. The relevant settings are:

- R1Ph, R2Ph, R3Ph, R3Ph reverse, R4Ph and RP Ph for phase fault zones.
- R1Gnd, R2Gnd, R3Gnd, R3Gnd reverse, R4Gnd and RP Gnd for ground fault zones.

Note: Zone 3 has an independent setting for the forward resistance reach (right-hand resistive reach line), and the reverse resistance reach (left-hand resistive reach line).

8.2.1.8 Load blinder

Check that the correct settings for the load blinder have been applied. The settings are at the end of the DISTANCE SETUP column.

Verify that the **Load B/Angle** cell is set at least 10 degrees less than the **Line Angle** setting in the LINE PARAMETERS column.

8.2.2 Distance Protection Operation and Contact Assignment

8.2.2.1 Phase Cat

1. Prepare a dynamic Cat-phase-to-neutral fault, at half the Zone 1 reach.
2. Set a timer to start when the fault injection is applied and to stop when the trip occurs.
3. To verify correct output contact mapping use the trip contacts that would be expected to trip the circuit breaker(s), as shown below.

Tripping type	Single breaker
All Pole Tripping	Any Trip
Single Pole Tripping	Trip Cat

4. Record the phase Cat trip time.
5. Switch OFF the AC supply and reset the alarms.

8.2.2.2 Phase Fdr

1. Reconfigure to test a Fdr phase fault.
2. Repeat the test, this time ensuring that the breaker trip contacts relative to Fdr phase operation close correctly.
3. Record the phase Fdr trip time.
4. Switch OFF the AC supply and reset the alarms.

The average of the recorded operating times for the three phases should typically be less than 20 ms for 50 Hz, and less than 16.7 ms for 60 Hz when set for instantaneous operation.

> *Note• Where a non-zero tZ1 Gnd time delay is set in the DISTANCE menu column, the expected operating time is typically within +/- 5% of the tZ1 setting plus the "instantaneous" delay quoted above.*

8.2.2.3 Time delay settings tZ1 Ph, and tZ2 - tZ4

Check that the correct time delay settings have been applied. The relevant settings are in the SCHEME LOGIC column and are as follows:

- tZ1 Ph Time Delay and tZ1 Gnd Time Delay
- tZ2 Ph Time Delay and tZ2 Gnd Time Delay
- tZ3 Ph Time Delay and tZ3 Gnd Time Delay
- tZP Ph Time Delay and tZP Gnd Time Delay
- tZ4 Ph Time Delay and tZ4 Gnd Time Delay

> *Note: The P44T allows separate time delay settings for phase ("Ph") and ground ("Gnd") fault elements. BOTH must be checked to ensure that they have been set correctly.*

8.2.3 Distance Protection Scheme Testing

The device is tested for its response to internal and external fault simulations, but the response depends on the aided channel (pilot) scheme selected. Table 7 shows the expected response for various test situations for a conventional signalling scheme. The response to the **Reset Z1 Extension** opto-input is shown in the case of a Zone 1 Extension scheme.

We assume a conventional signalling scheme implementation.

If an InterMiCOM^{64} scheme is used to provide the signalling, the scheme logic may not use opto-inputs for the aided scheme implementation. In this case, internal logic signals (DDBs) need to be set or reset to test the operation of the protection scheme.

Use the IM64 Test Mode with the IM64 Test Pattern to assert or monitor the relevant signals.

Ensure that the injection test set timer is still connected to measure the time taken for the device to trip. A series of fault injections are applied, with a Zone 1, end-of-line, or Zone 4 fault simulated. At this stage, note the method in which each fault is applied, but do not inject yet:

- **Zone 1 fault**: A dynamic forward Cat-Fdr fault at half the Zone 1 reach is simulated.
- **End of line fault**: A dynamic forward Cat-Fdr fault at the remote end of the line is simulated. The fault impedance simulated should match the **Line Impedance** setting in the LINE PARAMETERS menu column.
- **Zone 4 fault**: A dynamic reverse Cat-Fdr fault at half the Zone 4 reach is simulated.

Fault type simulated	IED RESPONSE					
	Forward fault in zone 1		Forward fault at end of line (within Z1X/Z2)		Reverse fault in zone 4	
Signal receive opto	ON	OFF	ON	OFF	ON	OFF
Zone 1 extension	Trip	Trip	No Trip	Trip	No Trip	No Trip
Blocking scheme	Trip, No Signal Send	Trip, No Signal Send	No Trip, No Signal Send	Trip, No Signal Send	No Trip, Signal Send	No Trip, Signal Send
Permissive Scheme (PUR/PUTT)	Trip, Signal Send	Trip, Signal Send	Trip, No Signal Send	No Trip, No Signal Send	No Trip, No Signal Send	No Trip, No Signal Send
Permissive Scheme (POR/POTT)	Trip, Signal Send	Trip, Signal Send	Trip, Signal Send	No Trip, Signal Send	No Trip, No Signal Send	No Trip, No Signal Send

Table 7: Scheme test response

8.2.3.1 Scheme Trip Test for Zone 1 Extension Only

1. Energize the **Reset Z1X** (Reset Zone 1 Extension) opto-input. This is done by applying a continuous dc voltage onto the required opto-input, either from the test set, station battery, or IED field voltage. The commissioning engineer decides on the best method.
2. Inject an end of line fault. The duration of injection should be set to 100 ms. No trip should occur.
3. De-energize the **Reset Z1X** opto-input
4. Repeat the test injection and record the operating time. This should typically be less than 20 ms for 50 Hz, and less than 16.7 ms for 60 Hz when set for instantaneous operation.
5. Switch OFF the ac supply and reset the alarms.

Note: *Where a non-zero tZ1 Ph or tZ1 Gnd time delay is set in the DISTANCE column, the expected operating time is typically within +/- 5% of the tZ1 setting plus the "instantaneous" delay quoted above.*

8.2.3.2 Scheme trip tests for permissive schemes (PUR/POR only)

This test applies to both Permissive Underreach and Permissive Overreach aided scheme applications.

1. Energize the **Signal Receive** opto-input. This is done by applying a continuous dc voltage onto the required opto-input from the test set, station battery, or IED field voltage (it is up to commissioning engineer to decide on the best method).
2. Inject an end of line fault, and record the operating time. The measured operating time should typically be less than 20 ms for 50 Hz, and less than 16.7ms for 60 Hz when set for instantaneous operation.
3. Switch OFF the ac supply and reset the alarms.

Note: *Where a non-zero Aided Distance Dly time delay is set in the DISTANCE menu column, the expected operating time is typically within +/- 5% of the tZ1 setting plus the "instantaneous" delay quoted above.*

De-energize the **Signal Receive** opto-input (remove the temporary energization link, to turn it OFF).

8.2.3.3 Scheme trip tests for blocking scheme only

1. Energize the **Signal Receive** opto-input. This is done by applying a continuous DC voltage onto the required opto-input, either from the test set, station battery, or IED field voltage. The commissioning engineer decides on the best method.
2. Inject an end of line fault. The duration of injection should be set to 100 ms. No trip should occur.
3. De-energize the **channel received** opto-input.
4. Repeat the test injection, and record the operating time.
5. Switch OFF the ac supply and reset the alarms.

> *Note* *For blocking schemes, a non-zero Aided Distance Dly time delay is set, so the expected operating time is typically within +/- 5% of the delay setting plus the "instantaneous" operating delay. The trip time should thus be less than 20 ms for 50 Hz, and less than 16.7 ms for 60 Hz, plus 1.05 x Delay setting.*

8.2.3.4 Signal send test for permissive schemes (PUR/POR only)

This test applies to both Permissive Underreach and Permissive Overreach scheme applications.

1. Reconnect the test set so that the timer is no longer stopped by the Trip contact, but is now stopped by the Signal Send contact (the contact that would normally be connected to the pilot/signalling channel).
2. Inject a Zone 1 fault, and record the signal send contact operating time. The measured operating time should typically be less than 20 ms for 50 Hz, and less than 16.7 ms for 60 Hz applications.
3. Switch OFF the ac supply and reset the alarms.

8.2.3.5 Signal send test for blocking scheme only

1. Reconnect the test set so that the timer is no longer stopped by the Trip contact, but is now stopped by the Signal Send contact. This is the contact that would normally be connected to the pilot/signalling channel.
2. Inject a Zone 4 fault, and record the signal send contact operating time. The measured operating time should typically be less than 20 ms for 50 Hz, and less than 16.7 ms for 60 Hz applications.
3. Switch OFF the ac supply and reset the alarms.

8.2.4 Scheme Timer Settings

Check that the correct time delay settings have been applied. The relevant settings in the AIDED SCHEMES column are:

- **tRev. Guard** (if applicable/visible)
- **Unblocking Delay** (if applicable/visible)
- **WI Trip Delay** (if applicable/visible)

1. **When the tests are completed, restore all settings that were disabled for testing purposes.**
2. **Set the Static Test Mode to Disabled.**
3. **Remove any wires or leads temporarily fitted to energize the channel receive opto-input.**

.

8.3 Delta Directional Comparison

8.3.1 Delta Protection Single-ended Testing

If the delta directional comparison aided scheme is being used, test the operation.

1. In the CONFIGUARATION column, disable all protection elements other than the one being tested.
2. Make a note of which elements need to be re-enabled after testing

8.3.1.1 Connection and preliminaries

Use a three-phase digital/electronic injection test set to make the commissioning procedure easier.

Connect the test equipment to the device using the test block(s) taking care not to open-circuit any CT secondary. If MMLG type test blocks are used, the live side of the test plug must be provided with shorting links before it is inserted into the test block.

8.3.1.2 Single-ended Injection Test

This set of injection tests aims to determine correct operation of a single IED at one end of the scheme. The device is tested in isolation, with the communications channel to the remote line terminal disconnected.

First verify that the device cannot send or receive channel scheme signals to or from the remote line end.

The device is tested for its response to forward and reverse fault injections but the response depends on the aided channel (pilot) scheme that is selected. Table 8 shows the expected response for various test situations for a conventional signalling scheme.

We assume a conventional signalling scheme implementation.

If an InterMiCOM^{64} scheme is used to provide the signalling, the scheme logic may not use opto-inputs for the aided scheme implementation. In this case, internal logic signals (DDBs) need to be set or reset to test the operation of the protection scheme.

Use the IM64 Test Mode with the IM64 Test Pattern to assert or monitor the relevant signals.

	IED RESPONSE			
Direction of fault test injection	**Forward fault**		**Reverse fault**	
Signal receive opto	ON	OFF	ON	OFF
Blocking scheme	No Trip, No Signal Send	Trip, No Signal Send	No Trip, Signal Send	No Trip, Signal Send
Permissive scheme (POR/POTT)	Trip, Signal Send	No Trip, Signal Send	No Trip, No Signal Send	No Trip, No Signal Send

Table 8: Delta protection scheme response

8.3.1.3 Forward fault preparation

Configure the test set to inject a dynamic sequence of injection, as follows:

1. Simulate a healthy all-phase set of balanced voltages, each of magnitude Vn. No load current should be simulated. The duration of injection should be set to 1 second. Step 1 therefore mimics a healthy unloaded line before the onset of a fault.
2. Simulate a forward fault on the Cat-phase. The Cat-phase voltage must be simulated to drop by 3 times the **Dir. V Fwd** setting,

$$Vcat = Vn - 3(Dir.\ V\ Fwd)$$

The fault current on the Cat-phase should be set to 3 times the **Dir. I Fwd** setting, lagging Vcat by a phase angle equal to the line angle,

$$Icat = 3\ (Dir.\ I\ Fwd)\angle -\theta\ \ Line$$

Phases B and C should retain their healthy pre-fault voltage, and no current. The duration of injection should be set to 100 ms longer than the **Delta Dly** time setting.

8.3.2 Delta Directional Comparison Operation and Contact Assignment

A forward fault should be injected with the intention of causing a scheme trip. For a Permissive scheme, the **Signal Receive** opto-input needs to be energized. This is done by applying a continuous DC voltage onto the required opto-input, either from the test set, station battery, or IED field voltage. The commissioning engineer decides on the best method.

For a Blocking scheme, the opto-input should remain de-energized.

Phase Cat

1. Prepare a dynamic Cat-phase-to-neutral fault, as detailed above.
2. Set a timer to start when the fault injection is applied, and to stop when the trip occurs.
3. To verify the correct output contact mapping use the trip contacts that would be expected to trip the circuit breaker(s), as shown in the following table.

Tripping type	Single breaker
All Pole Tripping	Any Trip
Single Pole Tripping	Trip Cat

4. Record the phase Cat trip time
5. Switch OFF the ac supply and reset the alarms

Phase Fdr

1. Reconfigure to test a Fdr phase fault.
2. Repeat the test, this time ensuring that the breaker trip contacts relative to Fdr phase operation close correctly.
3. Record the phase Fdr trip time.
4. Switch OFF the ac supply and reset the alarms.

The average of the recorded operating times for the three phases should typically be less than 20 ms for 50 Hz, and less than 16.7 ms for 60 Hz when set for instantaneous operation.

> *Note; For Blocking schemes, where a non-zero Delta Dly time delay is set, the expected operating time is typically within +/- 5% of the delay setting plus the "instantaneous" delay quoted above.*

8.3.3 Delta Directional Comparison Scheme Testing

Signal send test for permissive schemes

1. Reconnect the test set so that the timer is no longer stopped by the Trip contact, but is now stopped by the **Signal Send** contact. This is the contact that would normally be connected to the pilot/signalling channel.
2. Repeat the forward fault injection, and record the **Signal Send** contact operating time. The measured operating time should typically be less than 20 ms for 50 Hz, and less than 16.7 ms for 60 Hz applications.
3. Switch OFF the ac supply and reset the alarms.

Signal send test for blocking schemes only

Configure the test set to inject a dynamic sequence of injection, as follows:

1. Simulate a healthy all-phase set of balanced voltages, each of magnitude Vn. No load current should be simulated. The duration of injection should be set to 1 second. Step 1 therefore mimics a healthy unloaded line, prior to the onset of a fault.
2. Simulate a reverse fault on the Cat-phase. The Cat-phase voltage must be simulated to drop by 3 times the **Dir. V Rev** setting,

$$Vcat = Vn - 3(Dir.\ V\ Rev)$$

The fault current on the A-phase should be set to 3 times the **DI Rev** setting, and in antiphase to the forward injections,

$$Icat = 3\ (Dir.\ I\ Rev)\angle\ 180° - \theta\ \ Line$$

1. Prepare the dynamic Cat phase reverse fault, as detailed above. Ensure that the test set is simulating Steps 1 and 2 as one continuous transition.
2. Set a timer to start when the fault injection is applied, and to stop when the Delta scheme Signal Send contact closes.
3. Apply the test, and record the signal send contact response time. The recorded operating time should typically be less than 20 ms for 50 Hz, and less than 16.7 ms for 60 Hz applications.
4. Switch OFF the ac supply and reset the alarms.

1. When the tests are completed, restore all settings that were disabled for testing purposes.
2. Remove any wires or leads temporarily fitted to energize the channel receive opto-input.

8.4 Overcurrent Protection

If the overcurrent protection function is being used, the I>1 element should be tested.

1. Check for any possible dependency conditions and simulate as appropriate.
2. In the CONFIGUARATION 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.

8.4.1 Connecting the test circuit

1. Determine which output relay has been selected to operate when an I>1 trip occurs by viewing the programmable scheme logic. The output relay assigned for Trip Output Cat (DDB 523) faults should be used. Stage 1 should be mapped directly to an output relay in the programmable scheme logic.

> *Note: If the default PSL is used, output relay 3 can be used as I1> is mapped to **Trip inputs All Ph** (DDB 529), which in turn is mapped internally to **Any Trip** (DDB 522), which is mapped to output relay 3.*

2. Connect the output relay so that its operation trips the test set and stops the timer.
3. Connect the current output of the test set to the A-phase current transformer input.

   If the I**>1 Directional** cell in the GROUP 1 OVERCURRENT column is set to 'Directional Fwd', the current should flow out of terminal C2. If set to 'Directional Rev', it should flow into terminal 2.

   If the I**>1 Directional** cell in the GROUP 1 OVERCURRENT column has been set to 'Directional Fwd' or 'Directional Rev', the rated voltage should be applied to terminals 20 and 21.
4. Ensure that the timer starts when the current is applied to the relay.

> *Note: If the timer does not stop when the current is applied and stage 1 has been set for directional operation, the connections may be incorrect for the direction of operation set. Try again with the current connections reversed.*

8.4.2 Perform the test

1. Ensure that the timer is reset.
2. Apply a current of twice the setting shown in the **I>1 Current Set** cell in the GROUP 1 OVERCURRENT column.
3. Note the time displayed when the timer stops.
4. Check that the red trip LED is ON.

8.4.3 Check the operating time

Check that the operating time recorded by the timer is within the range shown in Table 9.

For all characteristics, allowance must be made for the accuracy of the test equipment being used.

Characteristic	Operating time at twice current setting and time multiplier/ time dial setting of 1.0	
	Nominal (seconds)	Range (seconds)
DT	I>1 Time Delay] setting	Setting ±2%
IEC S Inverse	10.03	9.53 - 10.53
IEC V Inverse	13.50	12.83 - 14.18
IEC E Inverse	26.67	24.67 - 28.67
UK LT Inverse	120.00	114.00 - 126.00
IEEE M Inverse	3.8	3.61 - 4.0
IEEE V Inverse	7.03	6.68 - 7.38
IEEE E Inverse	9.50	9.02 - 9.97
US Inverse	2.16	2.05 - 2.27
US ST Inverse	12.12	11.51 - 12.73

Table 9: Characteristic operating times for I>1

Notes: with the exception of the definite time characteristic, the operating times given in Table 9 are for a Time Multiplier Setting (TMS) or Time Dial Setting (TDS) of 1. For other values of TMS or TDS, the values need to be modified accordingly.

For definite time and inverse characteristics there is an additional delay of up to 0.02 second and 0.08 second respectively. You may need to add this the IED's acceptable range of operating times.

Caution: When the tests are completed, restore all settings that were disabled for testing purposes.

8.5 Restoration of communications and clearing VTS

If, during the testing described above, it was necessary to create communication failure conditions or VTS alarm conditions, these should now be cleared now. If communications failure was achieved by setting the **Test Loopback** cell to **Disabled**, this should be reset to **Enabled**.

The protection communications statistics also need to be reset.

8.6 System Check and Check Synchronization

This function performs a comparison between the line voltage and the bus voltage.

For a single circuit breaker application, there are two voltage inputs to compare:

- one from the voltage transformer input from the line side of the circuit breaker (Main VT)
- one from the VT on the bus side of the circuit breaker (CS VT).

In most cases the line VT input is all phase, whereas the bus VTs are single phase.

The bus VT inputs are normally single phase so the system voltage checks are made on single phases and the VT may be connected to either a phase-to-phase or phase to neutral voltage.

For these reasons, the IED has to be programmed with the appropriate connection. The **CS Input** setting in the CT AND VT RATIOS column can be set to Cat-N, Fdr-N, Cat-Fdr or Fdr-Cat according to the application.

Any voltage measurements or comparisons using bus VT inputs are made using the compensated values.

Each circuit breaker controlled can have two stages of check synchronism enabled according to the settings:

- **System Checks**, **CS1 Status** and **CS2 Status** for single CB models

When the system voltage check conditions are satisfied, the relevant DDB signals are asserted high as follows:

- DDB (883): Check Sync 1 OK (single CB models)
- DDB (884): Check Sync 2 OK (single CB models)

These DDB signals should be mapped to the monitor/download port and used to indicate that the system check synchronizing condition has been satisfied.

8.6.1 Check sync ok

1. Taking note of the check synchronism settings, identify the appropriate VT input terminals and inject voltage signals that should satisfy the system voltage check synchronism criteria.
2. Check that the DDB signals are asserted high.

8.6.2 Check sync fail

1. Change the voltage signals so that the criteria are not satisfied
2. Check that the appropriate DDB signals are driven low.

8.7 Check trip and auto-reclose cycle

If the auto-reclose function is being used, the circuit breaker trip and auto reclose cycle can be tested automatically by using the application-specific settings.

To test the trip and close operation without operating the breaker, the following conditions must be satisfied:

- The **CB Healthy** DDB should either not be mapped, or if it is mapped it must be asserted high.
- The **CB status** inputs (52A, etc.) should either not be mapped, or if they are mapped they should be activated to mimic the circuit breaker operation.
- If configured for single pole tripping, either the **VTs Connected** setting in the CT/VT RATIO column should be set to **No**, or appropriate voltage signals need to be applied to prevent the pole dead logic from converting to all-pole tripping.

1. To test the first all-phase auto-reclose cycle, set **COMMISSION TESTS** > **Test Auto-reclose** to **Trip All Pole**. The IED performs a trip/reclose cycle.
2. Repeat this operation to test the subsequent all-phase auto-reclose cycles.
3. Check all output relays (used for such as circuit breaker tripping and closing, or blocking other devices) operate at the correct times during the trip/close cycle.

Check the auto-reclose cycles for single phase trip conditions one at a time by sequentially setting **COMMISSION TESTS** > **Test Auto-reclose** to **Trip Pole Cat** and **Trip Pole Fdr**.

9 END-TO-END PROTECTION COMMUNICATION TESTS

If the IED is being used in a scheme with InterMiCOM^{64} communications you must perform end-to-end testing of the protection communications channels.

In this section all loopbacks are removed and satisfactory communications between line ends of the IEDs in the scheme are confirmed.

> *Note 1:* *End-to-end communication requires a working telecommunication channel between line ends (which may be a multiplexed link or may be a direct connection). If the telecommunication channel is not available, it is not possible to establish end-to end communication. Unless otherwise directed by local operational practice, follow the instructions in this section so the scheme is ready for full operation when the telecommunications channels become available.*
>
> *Note 2:* *The trip circuit should remain isolated during these checks to prevent accidental operation of the associated circuit breaker.*

9.1 Remove local loopbacks

As well as removing the loopback, this section checks that all wiring and optical fibre are reconnected. If P592 or P593 interface units are installed the application-specific settings are also applied.

1. Check the alarm records to ensure that no communications failure alarms have occurred while the loopback test was in progress. If it was necessary to ‘fail’ the communications while testing the non-current differential elements, observe the communications behaviour for a few minutes before removing the loopbacks.
2. After you are satisfied with the communications behaviour in loopback, set **COMMISSION TESTS** > **Test Mode** and **Loopback Mode** to **Disabled**.

> *Note:* *Most of the required optical signal power levels have already been measured and recorded. If all signalling uses P59x interface units, no further measurements are required. If, however, direct fibre or C37.94 communications are used, further measurements are needed.*

9.1.1 Restoration of direct fibre connections

When restoring direct fibre connections, check the optical power level received from the remote IED(s).

1. Remove the loopback test fibres and at both ends of each channel used, reconnect the fibre optic cables for communications between IEDs.
2. For each channel fitted, remove the fibre connecting to the optical receiver (RX).
3. Using an optical power meter measure the strength of the signal received from the remote IED. The measurements should be within -25.4dBm and -16.8dBm for 850 nm fibre connections and between -37dBm and -7dBm for 1300nm fibre connections
4. Record the received power level(s).
5. Reconnect the fibre(s) to the IED receiver(s).

> **Warning:** **NEVER look directly into the transmit port or the end of an optical fibre, as this could severely damage your eyes**

9.2 Restoration of C37.94 fibre connections

1. When restoring C37.94 fibre connections, it is necessary to check the optical power level received from the IED at the C37.94 multiplexer, as well as that received by the IED from the C37.94 multiplexer.
2. Remove the loopback test fibres and at both ends of each channel used.
3. Reconnect the fibre optic cables for communications between IEDs and the C37.94 compatible multiplexer.
4. Check that the value received from the IED at the C37.94 multiplexer, as well as that received by the IED from the C37.94 multiplexer are between -25.4 dBm (min) and -16.8 dBm (max).
5. Record the received power level(s).
6. Reconnect the fibre(s) to the IED receiver(s).

9.2.1 Communications using P59x interface units

If external wiring has been removed to facilitate testing, ensure that it is replaced in accordance with the relevant connection diagram or scheme diagram.

For the P592:

1. Set the **V.35 LOOPBACK** switch to the **0** position.
2. Set the **CLOCK SWITCH**, **DSR**, **CTS** and **DATA RATE** switches on each unit to the positions required for the specific application
3. Ensure the **OPTO LOOPBACK** switch is in the **0** position.
4. If applicable, replace the secondary front cover

For the P593:

1. Set the **X.21 LOOPBACK** switch to the **OFF** position
2. Ensure the **OPTO LOOPBACK** switch is also in the **OFF** position.
3. If applicable, replace the secondary front cover.

9.3 Remote Loopback removal

Remove loopbacks at remote terminal connected to channel 1 and channel 2 by repeating the instructions for local loopback removal.

9.4 Verify communications between IEDs

Communications statistics and status

1. Reset any alarm indications and check that no further communications failure alarms are raised.
2. Check channel status and propagation delays in MEASUREMENTS 4 column for channel 1 (and channel 2 where fitted).
3. Clear the statistics and record the number of valid messages and the number of errored messages after a minimum period of 1 hour.
4. Check that the ratio of errored/good messages is better than 10^{-4}.
5. Record the measured message propagation delays for channel 1, and channel 2 (if fitted).

10 END TO END SCHEME TESTS

If an external signalling channel is being used to provide aided scheme signalling, and if an aided protection scheme is being used without InterMiCOM^{64} protection signalling, it should be tested.

This section aims to check that the signalling channel is able to transmit the ON/OFF signals used in aided schemes between the remote line ends.

Before testing, check that the channel is healthy. For example, if a power line carrier link is being used, it may not be possible to perform the tests until the protected circuit is in service.

10.1 Aided scheme 1

Aided Scheme 1 can be tested by operating output contacts to mimic the transmission of an aided channel signal.

For these tests, an engineer needs to be present at both ends of the line - at the local end to send aided signals, and at the remote end to observe that the signals are received. A telephone link between the two commissioning engineers is also necessary, to allow conversation.

1. Put the IED in test mode by setting **COMMISSION TESTS** > **Test Mode** to **Blocked**.
2. Record which contact is assigned as the **Signal Send 1** output
3. Select this output contact as the one to test and advise the engineer at the remote end that the contact is about to be tested.

10.1.1 Remote end preparation to observe channel arrival

At the remote end, the engineer must confirm the assignment of the Monitor Bits in the COMMISSION TESTS column in the menu, to be able to see the aided channel on arrival.

Scroll down and ensure that the **Monitor Bit 1** cell is set to DDB493 and that the **Monitor Bit 5** cell is set to 507. The **Test Port Status** cell appropriately sets or resets the bits that now represent Aided 1 Scheme Receive (DDB #493), and Aided 2 Scheme Receive (DDB #507), with the rightmost bit representing Aided Channel 1. From now on the remote end engineer should monitor the indication of the **Test Port Status** cell.

10.1.2 Application of the test

1. At the local end, set the **COMMISSION TESTS** > **Contact Test** to **Apply Test**.
2. Reset the output relay by setting **COMMISSION TESTS** > **Contact Test** to **Remove Test**.

Note: Ensure that thermal ratings of anything connected to the output relays during the contact test procedure are not exceeded by being operated for too long. We therefore advise that the time between application and removal of the contact test is kept short.

3. Check with the engineer at the remote end that the Aided Channel 1 signal did change state as expected. The **Test Port Status** cell should have responded as in the table below:

DDB No.				507				493
Monitor Bit	8	7	6	5	4	3	2	1
Contact Test OFF	X	X	X	X	X	X	X	0
Contact Test Applied (ON)	X	X	X	X	X	X	X	1
Test OFF	X	X	X	X	X	X	X	0

Note: “x” = Wildcard/denotes don’t care.

4. Return the IED to service by setting **COMMISSION TESTS** > **Test Mode** to **Disabled**.

10.1.3 Channel check in the opposite direction

Repeat the aided scheme 1 test procedure, but this time to check that the channel responds correctly when keyed from the remote end. The remote end commissioning engineer should perform the contact test, with the Monitor Option observed at the local end.

10.2 Aided scheme 2

1. If applicable, repeat the test for Aided Channel 2.
2. Return the device to service by setting **COMMISSION TESTS** > **Test Mode** to **Disabled**.

11 ON-LOAD CHECKS

The objectives of the on-load checks are to:

- Confirm the external wiring to the current and voltage inputs is correct
- Measure the magnitude of capacitive current
- Directionality check for distance elements

These checks can only be carried out if there are no restrictions preventing the energization of the plant, and the other devices in the group have already been commissioned.

Remove all test leads and temporary shorting leads, and 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.

11.1 Confirm Voltage Connections

1. Using a multimeter, measure the voltage transformer secondary voltages to ensure they are correctly rated. Check that the system phase rotation is correct using a phase rotation meter.
2. Compare the values of the secondary phase voltages with the measured values in the MEASUREMENTS 1 menu column.

Voltage	Cell in MEASUREMENTS 1 Column (02)	Corresponding VT ratio in 'VT and CT RATIO' column (0A) of menu)
Vcat-fdr Vcat Vfdr	Vcat-fdr Magnitude Vcat Magnitude Vfdr Magnitude	Main VT Primary / Main VT Secondary
VCHECKSYNC.	CS Voltage Mag.]	CS VT Primary / CS VT Secondary

Table 10: Measured voltages and VT ratio settings

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.

11.2 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.

11.3 On load directional test

This test ensures that distance directionalized overcurrent and fault locator functions have the correct forward/reverse response to fault and load conditions. For this test you must first know the actual direction of power flow on the system. If not known already, this must be determined using adjacent instrumentation or protection already in-service.

- For load current flowing in the Forward direction (power export to the remote line end), the **Cat Phase Watts cell** in the MEASUREMENTS 2 column should show **positive** power signing.
- For load current flowing in the Reverse direction (power import from the remote line end), the **Cat Phase Watts cell** in the MEASUREMENTS 2 column should show **negative** power signing.

*Note: This check applies only for Measurement Modes 0 (default), and 2. This should be checked in the MEASURE'T. SETUP column (**Measurement Mode** = 0 or 2). If measurement modes 1 or 3 are used, the expected power flow signing would be opposite to that shown above.*

In the event of any uncertainty, check the phase angle of the phase currents with respect to their phase voltage.

11.4 Signalling channel check (if not already completed)

If the aided scheme signalling channel(s) have not already been tested, they should be tested now. This test may be avoided only with the agreement of the customer, or if the basic scheme is used.

Follow the tests in section 11.

12 FINAL CHECKS

The tests are now complete.

1. Remove all test leads and temporary shorting leads.
2. If you have had to disconnect any of the external wiring, to perform the wiring verification tests, replace all wiring, fuses and links in accordance with the relevant external connection or scheme diagram.
3. Ensure that the IED has been restored to service by checking that the **Test Mode** and **Static Test** cells in the COMMISSION TESTS column are set to ‘Disabled’.
4. 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.

There are two methods of checking the settings;

- Extracting them from the IED to a laptop
- Step through the settings using the HMI panel

In either case, compare the settings with the original application-specific setting records

Finally, ensure that all protection elements required have been set to **Enabled** in the CONFIGURATION column

5. 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 requests a password so the setting change can be made.
6. If the menu language has been changed to allow accurate testing it should be restored to the customer’s preferred language.
7. 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.
8. Ensure that all alarms and LEDs and communications statistics have been reset.
9. If applicable, replace the secondary front cover of the unit.

MAINTENANCE & TROUBLESHOOTING

CHAPTER 15

1 CHAPTER OVERVIEW

The Maintenance and Troubleshooting chapter provides details of how to maintain and troubleshoot products based on the Px40 platform. It is important to heed the warning signs in this chapter as this 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 Pxxx-SG-4LM-2 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 IED 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 consists of the following sections:

2 MAINTENANCE

2.1 Maintenance Checks

We recommend that General Electric products receive periodic monitoring after installation. In view of the critical nature of the application, they should be checked at regular intervals to confirm they are operating correctly.

General Electric IEDs 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.

If the customer's organization has a Preventative Maintenance Policy, the recommended product checks should be included in the regular program. Maintenance periods depend on many factors, such as:

- The operating environment
- The accessibility of the site
- The amount of available manpower
- The importance of the installation in the power system
- The consequences of failure

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 Pxxx-SG-4LM-2 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 energized, 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 IED'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 unit

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.

If possible you should replace the complete unit, 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 ease removal of the complete unit, 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 Pxxx-SG-4LM-2, 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 unit, isolate all voltage and current supplying it.**

Note: The MiCOM products have integral current transformer shorting switches which will close, for safety reasons, when the heavy duty and/or MiDOS terminal block is removed

To replace the complete unit:

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 unit.
2. Remove the terminal block screws using a magnetic bladed screwdriver to minimize the risk of losing the screws or leaving them in the terminal block.

Note: There are four types of terminal block: RTD/CLIO input, heavy duty, medium duty, and MiDOS. The terminal blocks are fastened to the rear panel using slotted screws on the RTD/CLIO input blocks and crosshead screws on the heavy and medium duty blocks. See Figure 1.

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 unit 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 unit.

5. Withdraw the unit from the panel and rack. Take care, as the unit will be heavy due to the internal transformers.
6. To reinstall the unit, 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 unit has been reinstalled, it should be re-commissioned as set out in the Commissioning chapter.

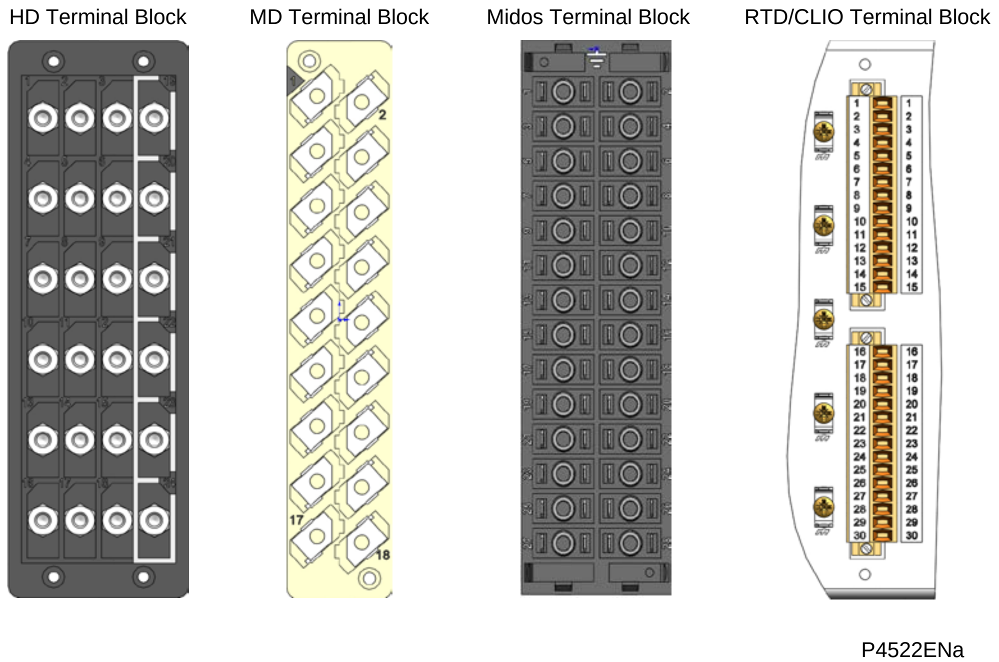


Figure 1: Terminal block types

2.3 Repairing the unit

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 General Electric-approved Service Centres. Failure to obtain the authorization of General Electric after-sales engineers prior to commencing work may invalidate the product warranty.

We recommend that you entrust any repairs to General Electric 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 Pxxx-SG-4LM-2, 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 crosshead 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 Figure 2. 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.*

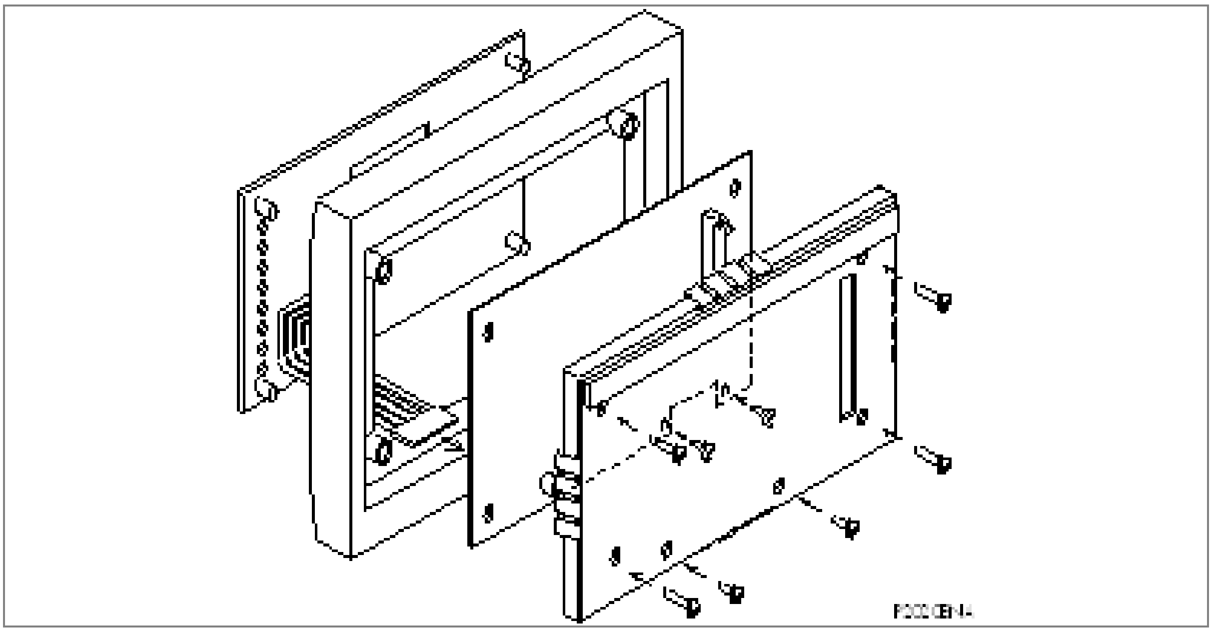


Figure 2: Front panel assembly

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 processsing 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 (adapt the procedure described in Section 2.4).
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 Pxxx-SG-4LM-2, 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-energized.

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 IED, ensure that all AC and DC supplies and current 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 Problem Identification

Use Table 1 to find the description that best matches the problem, and then consult the referenced section for a more detailed analysis of the problem.

Symptom	Refer to
IED fails to power up	Section 3.2
IED powers up but indicates an error and halts during the power-up sequence	Section 3.3
IED Powers up but the Out of Service LED is ON	Section 3.4
Error during normal operation	Section 3.5
Mal-operation of the IED during testing	Section 3.6

Table 1: Problem Identification

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.

Table 2: Power-up errors Identification

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 General Electric 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. 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 General Electric.

Table 3: Power on self test up error

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

Test	Check	Action	
		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)
		8	The VT type field in the model number is incorrect (no VTs fitted)

Table 4: Out of service LED illuminated

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.

If the IED's self-check detects a failure of the field voltage or the lithium battery, the IED displays an alarm message and logs a maintenance record but the IED does not reset.

If the IED detects the field voltage has dropped below threshold, a scheme logic signal is set. This allows the scheme logic to be adapted specifically for this failure (for example if a blocking scheme is being used).

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 (see Table 4).
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.

Test	Check	Action
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.

Table 5: Failure of output contacts

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 recognized 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 battery 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 (in particular the dual-rated CT inputs)
3. Check the CT and VT ratios set on the relay are correct.
4. Check the phase displacement to confirm the inputs are correctly connected

3.7 Coprocessor board failures

If a coprocessor board is used, this may cause the IED to report one or more of the following alarms:

- Signalling failure alarm (on its own)
- C diff failure (on its own)
- Signalling failure and C diff failure together
- Incompatible IED
- Comms changed
- IEEE C37.94 fail

Signalling failure alarm (on its own)

This indicates that there is a problem with one of the fibre-optic signalling channels. This alarm can occur in dual redundant or three terminal schemes. The fibre may have been disconnected, the device may have been incorrectly configured at one of the ends, or there is a problem with the communications equipment. Further information about the status of the signalling channels can be found in MEASUREMENTS 4 column.

C diff failure alarm (on its own)

This indicates there is a problem with the Coprocessor board. As a result the current differential/distance protection is not available and backup protection will operate, if configured to do so. Further information can be found in the maintenance records.

Signaling failure and C diff failure alarms together

This indicates that there is a problem with one or both fibre-optic signalling channels. The fibre may have been disconnected, the device may have been incorrectly configured at one of the ends, or there is a problem with the communications equipment. As a result the current differential protection is not available and backup protection will operate, if configured to do so. Further information about the status of the signalling channels can be found in MEASUREMENTS 4 column.

Incompatible IED

This occurs if the IEDs trying to communicate with each other are of incompatible types.

Comms changed

This indicates that the **Comms Mode** setting has been changed without a subsequent power off and on.

IEEE C37.94 fail

This indicates a Signal Lost, a Path Yellow (indicating a fault on the communications channel) or a mismatch in the number ofN*64 channels used on either channel 1 or channel 2. Further information can be found in the MEASURMENTS 4 column.

3.8 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. See MiCOM S1 Agile connection configurations
- The option switches on any KITZ101/102 in use may be incorrectly set

3.8.1 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.

3.8.2 PSL Version Check

The PSL is saved with a version reference, time stamp and CRC check. This gives a visual check whether the default PSL is in place or whether a new application has been downloaded.

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

   https://www.gegridsolutions.com
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
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 center 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

The Technical Specifications chapter consists of the following sections:

2 INTERFACES

2.1 Front Serial Port

Front parallel port	
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 parallel port	
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

Rear serial port	
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-870-5-103, DNP3.0
Isolation	Isolation to SELV level
Constraints	Maximum cable length 1000 m

2.4 Optional Second Rear Serial Port SK4

Rear serial port	
Use	For SCADA communications (multi-drop)
Standard	EIA(RS)485, K-bus, EIA(RS)232
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

2.5 Optional Second Rear Serial Port SK5

Rear serial port	
Use	For SCADA communications (multi-drop)
Standard	EIA(RS)232
Connector	9 pin D-type female connector
Cable	Screened twisted pair (STP)
Supported Protocols	InterMiCOM (IM)
Isolation	Isolation to SELV level
Constraints	Maximum cable length 15 m

2.6 Optional Rear Serial Fiber Port

Rear Ethernet port (fiber)	
Main Use	Serial SCADA communications over fiber
Connector	IEC 874-10 BFOC 2.5 –(ST®) (1 each for Tx and Rx)
Fiber type	Multimode 50/125 µm or 62.5/125 µm
Supported Protocols	Courier, IEC870-5-103, DNP 3.0
Wavelength	850 nm MM

2.7 Optional IRIG-B (Demodulated)

IRIG-B Interface (De-modulated)	
Use	External clock synchronization signal
Standard	IRIG 200-98 format B00X
Connector	BNC
Cable type	50 Ohm coaxial
Isolation	Isolation to SELV level
Constrains	Maximum cable lengh 10 m
Input signal	TTL level
Input impedance dc	10k ohms at dc
Accuracy	< +/- 1 s per day

2.8 Optional IRIG-B (Modulated)

IRIG-B Interface (Modulated)	
Use	External clock synchronization signal
Standard	IRIG 200-98 format B12X
Connector	BNC
Cable type	50 Ohm coaxial
Isolation	Isolation to SELV level
Input signal	200 mV to 20 V peak-to-peak
Input impedance ac	6 k ohms at 1 kHz
Accuracy	< +/- 1 s per day

2.9 Rear Ethernet Port (copper)

Rear Ethernet port (copper)	
Main Use	IEC 61850 or DNP3 SCADA communications
Standard	IEEE 802.3 10BaseT/100BaseTX
Connector	RJ45
Cable type	Screened twisted pair (STP)
Isolation	1 kV
Supported Protocols	IEC 61850, DNP3.0
Constraints	Maximum cable length 10 m

2.10 Rear Ethernet Port (fiber including redundancy option)

Rear Ethernet port (fiber)	
Main Use	IEC 61850 or DNP3 SCADA communications
Connector	IEC 874-10 BFOC 2.5 –(ST®) (1 each for Tx and Rx)
Standard	IEEE 802.3 100 BaseFX
Fiber 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

100 Base FX Transmitter characteristics

Parameter	Sym	Min.	Typ.	Max.	Unit
Output Optical Power BOL 62.5/125 µm NA = 0.275 Fiber EOL	PO	-19 -20	-16.8	-14	dBm avg.
Output Optical Power BOL 50/125 µm NA = 0.20 Fiber 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 (“0”)			-45	dBm avg.

Conditions: T_A = 0°C to 70°C, VCC = 4.75 V to 5.25 V

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: T_A = 0°C to 70°C, VCC = 4.75 V to 5.25 V

2.11 InterMiCOM Fibre Interface

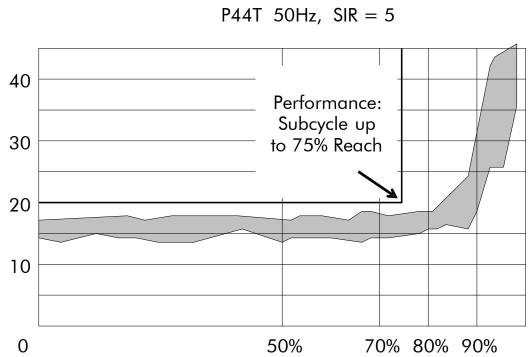
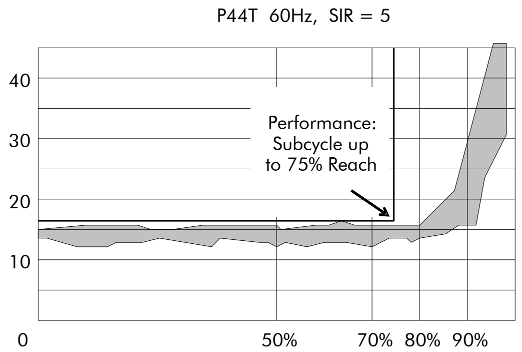
InterMiCOM (fiber)	
Main Use	Inter relay communications
Connector	IEC 874-10 BFOC 2.5 –(ST®) (1 each for Tx and Rx) 1 or 2 channels
Fiber type	Multimode 50/125 µm or 62.5/125 µm or Single mode 9/125 µm
Wavelength	850 nm MM, 1300 nm MM, 1300 nm SM, 1550 nm SM

Optical budget

	850 nm Multi mode	1300 nm Multi mode	1300 nm Single mode	1550 nm Single mode
Min. transmit output level (average power)	-19.8 dBm	-6 dBm	-6 dBm	-6 dBm
Receiver sensitivity (average power)	-25.4 dBm	-49 dBm	-49 dBm	-49 dBm
Optical budget	5.6 dB	43.0 dB	43.0 dB	43.0 dB
Less safety margin (3 dB)	2.6 dB	40.0 dB	40.0 dB	40.0 dB
Typical cable loss	2.6 dB/km	0.8 dB/km	0.4 dB/km	0.3 dB/km
Max. transmission distance	1 km	50.0 km	100.0 km	130 km

3 PROTECTION FUNCTIONS

3.1 Distance Protection

Operating time versus reach percentage, for faults close to line angle. 50 Hz, SIR = 5 All quoted operating times include closure of the trip output contact	
Operating time versus reach percentage, for faults close to line angle. 60 Hz, SIR = 5 All quoted operating times include closure of the trip output contact	
Operating time for resistive faults > 20% inside the characteristic	50 Hz, up to SIR = 30 < 30 ms 60 Hz, up to SIR = 30 < 25 ms

Accuracy	
Characteristic shape, up to SIR = 30	+/- 5% for on-angle fault (on the set line angle) +/- 10% for off-angle fault Example: For a 70 degree set line angle, injection testing at 40 degrees would be referred to as “off-angle”.
Zone time delay deviations	+/- 20 ms or 2%, whichever is greater

3.2 InterMiCOM^{64} Fibre Optic Teleprotection

The table below shows the minimum and maximum transfer time for InterMiCOM^{6}4 (IM64). The times are measured from opto initialization (with no opto filtering) to relay standard output and include a small propagation delay for back-back test (2.7 ms for 64 kbits/s and 3.2 ms for 56 kbits/s).

IDiff IM64 indicates InterMiCOM^{64} signals working in conjunction with the differential protection fiber optic communications channel. IM64 indicates InterMiCOM^{64} signals working as a standalone feature.

Configuration	Permissive op times (ms)	Direct op times (ms)
IM64 at 64 k	4 - 9	6 - 10
IM64 at 56 k	4 - 10	6 - 12

3.3 Phase Overcurrent Protection

Accuracy	
IDMT Pick-up	1.05 x Setting +/- 5%
DT Pick-up	Setting +/- 5%
Drop-off	0.95 x setting +/- 5%
Inverse time stages	+/-40 ms or 5%, whichever is greater
Definite time stages I = 1.05 to 1.8 Setting I > 1.8 Setting	 +/-50 ms or 2%, whichever is greater +/-40 ms or 2%, whichever is greater
Repeatability	5%
Directional boundary accuracy	+/-2° with hysteresis <3°
Additional tolerance due to increasing X/R ratios	+/- 5% over the X/R ratio from 1 to 90
Overshoot of overcurrent elements	<30 ms

3.4 Defrost Protection

Accuracy	
Pick-up	Setting +/- 5% or 20mA, whichever is greater
Drop-off	0.95 x setting +/- 5% or 20mA, whichever is greater
DT operation	+/-40 ms or 2%, whichever is greater
Typical instantaneous operation with default settings and Defrost > 50% above threshold 50 Hz 60 Hz	 30-50 ms 25-42 ms
Repeatability	+/- 2.5%

3.5 High Impedance Delta

Accuracy	
HZ Delta I magnitude	+/- 2% or 10mA, whichever is greater than 100mA
HZ Delta I angle	+/- 3°
HZ Delta I reactance	+/- 2% or 10m Ω,whichever is greater
2nd harmonics ratio	+/- 2%
3rd harmonics ratio	+/- 2%
5th harmonics ratio	+/- 2%

3.6 Undervoltage

Accuracy	
DT Pick-up	Setting +/- 5%
IDMT Pick-up	0.98 x Setting +/- 2%
Drop-off	1.02 x Setting +/-2%
DT operation	+/- 40 ms or 2%, whichever is greater
Reset	< 35 ms
IDMT shape	+/- 40 ms or 2%, whichever is greater
Repeatability	+/- 1%

3.7 Overvoltage

Accuracy	
DT Pick-up	Setting +/- 1%
IDMT Pick-up	1.02 x Setting +/- 2%
Drop-off	0.98 x Setting +/-2%
DT operation	+/- 40 ms or 2%, whichever is greater
Reset	< 75 ms
IDMT shape	+/- 45 ms or 2%, whichever is greater
Repeatability	+/- 1%

3.8 Circuit Breaker Fail and Undercurrent

Accuracy	
Pick-up	+/- 10% or 0.025 In, whichever is greater
Operating time	< 12 ms
Timers	+/- 40 ms or 2%, whichever is greater
Reset	< 15 ms

3.9 Panto Flash Over

Accuracy	
Alarm DT Pick-up	Setting +/- 5%
Drop-off	1.02 x Setting +/-2%
Alarm DT operation	+/- 45 ms or 2%, whichever is greater
Reset	< 35 ms
Trip DT Pick-up	Setting +/- 1%
Drop-off	0.98 x Setting +/-2%
DT operation	+/- 45 ms or 2%, whichever is greater
Reset	< 75 ms
Repeatability	+/- 1%

3.10 Thermal Overload

Accuracy	
Thermal alarm pick-up	Calculated trip time +/- 10%
Thermal overload pick-up	Calculated trip time +/- 10% Cooling time accuracy +/- 15% of theoretical
Repeatability	<5%

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

3.11 Voltage Transformer Supervision (VTS)

Accuracy	
Fast block operation	< 1 cycle
Fast block reset	<1.5 cycles
Time delay	+/- 35 ms or 2%, whichever is greater

3.12 CB State Monitoring and Condition Monitoring

Accuracy	
Timers	+/- 20 ms or 2%, whichever is greater
Broken current accuracy	< 5%

3.13 Programmable Scheme Logic

Accuracy	
Output conditioner timer	Setting +/- 20 ms or 2%, whichever is greater
Dwell conditioner timer	Setting +/- 20 ms or 2%, whichever is greater
Pulse conditioner timer	Setting +/- 20 ms or 2%, whichever is greater

3.14 Auto-reclose and Check Synchronism

Accuracy	
Timers	+/- 40 ms or 2%, whichever is greater

4 MEASUREMENTS AND RECORDING

4.1 General

General Measurement Accuracy	
General measurement accuracy	Typically +/- 1%, but +/- 0.5% between 0.2 - 2 In/Vn
Current	0.05 to 2 In +/- 1.0% of reading
Voltage	0.05 to 2 Vn +/- 1.0% of reading
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 2 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
Phase	0° to 360° +/- 0.5%
Frequency	45 to 65 Hz +/- 0.025 Hz

4.2 Disturbance Records

Disturbance Records Measurement Accuracy	
Maximum record duration	50 s
No of records	Minimum 5 at 10 seconds each Maximum 50 at 1 second each (8 records at 3 seconds, each via IEC60870-5-103 protocol)
Magnitude and relative phases accuracy	±5% of applied quantities
Duration accuracy	±2%
Trigger position accuracy	±2% (minimum Trigger 100 ms)

4.3 Event, Fault & Maintenance Records

Event, Fault & Maintenance Records	
Record location	The most recent records are stored in battery-backed memory
Viewing method	Front panel display or S1 Agile
Extraction method	Extracted via the communication port
Number of Event records	Up to 1024 time tagged event records
Number of Fault Records	Up to 15
Number of Maintenance Records	Up to 10

4.4 Fault Locator

Accuracy	
Fault Location	+/- 2% of line length up to SIR 30 for Single Mode Reference conditions: solid fault applied on line +/- 5% of line length up to SIR 30 for Autotransformer

4.5 Plant Supervision

Accuracy	
Timers	+/- 2% or 40 ms, whichever is greater
Broken current accuracy	+/- 5%
Reset time	<30 ms

Undercurrent Accuracy	
Pick-up	+/- 10% or 25 mA, whichever is greater
Operating time	< 20 ms
Reset time	< 25 ms

5 STANDARDS COMPLIANCE

5.1 EMC Compliance: 2004/108/EC

Compliance with the European Commission Directive on EMC is demonstrated using a Technical File.

Compliance with EN50263:2000 was used to establish conformity.

5.2 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:

5.3 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.

5.4 UL/CUL Compliance

Canadian and USA Underwriters Laboratory

File Number E202519

6 MECHANICAL SPECIFICATIONS

6.1 Physical Parameters

Physical Measurements	
Case Types	60TE and 80TE
Weight (80TE case)	11kg – 13.1kg (depending on chosen options)
Dimensions in mm (w x h x l) (80TE case)	413.2 x 177 x 270 (with secondary cover fitted)
Mounting	Front of panel flush mounting

6.2 Enclosure Protection: IEC 60529:1999

Enclosure Protection	
Against dust and dripping water (front face)	IP52 as per IEC 60529:1999
Protection for sides of the case	IP30 as per IEC 60529:1999
Protection for rear of the case	IP10 as per IEC 60529:1999

6.3 Mechanical Robustness

Mechanical Robustness	
Vibration test per IEC 60255-21-1:1996	Response: class 2, Endurance: class 2
Shock and bump immunity per IEC 60255-21-2:1995	Shock response: class 2, Shock withstand: class 1, Bump withstand: class 1
Seismic test per IEC 60255-21-3: 1995	Class 2
Transit Packaging Performance Vibration and Drop Release Tests	Product testing to simulate protection offered by primary packaging carton, to ISTA 1C specification Vibration tests in 3 orientations, vibratory movement 7 Hz, amplitude 5.3 mm, acceleration 1.05g Drop tests - 10 drops from 61 cm height on multiple carton faces, edges and corners

7 TERMINALS

7.1 AC Current and Voltage Measuring Inputs

AC Current and Voltage Measuring Inputs	
Terminal Block Type	Heavy Duty (HD)
Use	For CT and VT inputs
Terminal Location	Located on heavy duty (black) terminal block, at rear
Connection type	Threaded female M4 terminals, for ring lug connection
Protection	CT inputs have integral safety shorting, upon removal of the terminal block

7.2 General Input/Output Terminals

General Input/Output Terminals	
Terminal Block Type	Medium Duty (MD)
Use	For power supply, opto-inputs, output contacts and RP1 rear communications
Terminal Location	Located on general purpose (grey) blocks, at rear
Connection type	Threaded female M4 terminals, for ring lug connection

7.3 Case Protective Ground Connection

Case Protective Ground Connection	
Use	For case protective ground only
Terminal Location	Two stud connections at rear
Connection type	Threaded M4 studs. Suitable for ring tags
Special conditions	Must be grounded for safety. Minimum earth wire size 2.5 mm^2

8 RATINGS

8.1 AC Measuring Inputs

AC Measuring Inputs	
Nominal frequency	50 and 60 Hz (settable)
Operating range	45 to 65 Hz

8.2 AC Current

AC Current	
Nominal current (In)	1 A and 5 A dual rated*
Nominal burden per phase	< 0.05 VA at In
AC current thermal withstand	Continuous: 4*In 10 s: 30 x In 1 s: 100 x In Linear to 64 x In (non-offset ac current)

Note: 1A and 5A inputs use different transformer tap connections, check correct terminals are wired.

8.3 AC Voltage

AC Voltage	
Nominal voltage	100 to 120 V phase-phase
Nominal burden per phase	< 0.1 VA at Vn
Thermal withstand	Continuous: 2*Vn, 10 s: 2.6*Vn

8.4 Auxiliary Voltage (Vx)

Auxiliary voltage (Vx)	
Ordering options	Type 1: 24-48 V dc, Type 2: 48-110 V dc + 40-100 V ac Type 3: 110-250 V dc + 100-240 V ac
Operating range, type 1	19 to 65 V dc
Operating range, type 2	48 to 110 V dc 40 to 100 V ac
Operating range, type 3	110 to 250 V dc 100 to 240 V ac
Ripple	<15% for a dc supply (compliant with IEC 60255-11:2008)

8.5 Nominal Burden

Nominal burden	
Quiescent burden	< 10 W
Additions for second rear comms board	1.25W
Additions for energized binary inputs	Per opto input: 0.09 W (24 to 54 V) 0.12 W (110/125 V) 0.19 W (120/220 V)
Additions for energized binary outputs	Per energized output relay: 0.13 W

8.6 Power-up

Power-up	
Time to power up	< 11 s
Battery Backup	Mounting: Front panel, Type: ½ AA, 3.6 V Lithium Thionyl Chloride Battery
Battery Type	Type: ½ AA, 3.6 V Lithium Thionyl Chloride Battery (SAFT advanced: LS14250)
Battery Life	>10 years (based on 90% energization time)

8.7 Power Supply Interruption

Power Supply Interruption	
Standard	IEC60255-11:2008 (dc) IEC61000-4-11:2004 (ac)
Vx = 24 – 48V dc Quiescent / half load	20 ms at 24 V 50 ms at 36 V 100 ms at 48 V
Vx = 24 – 48V dc Full load	20 ms at 24 V 50 ms at 36 V 100 ms at 48 V
Vx = 48 – 100V dc Quiescent / half load	20 ms at 36 V 50 ms at 60 V 100 ms at 72 V 200 ms at 110 V
Vx = 48 – 100V dc Full load	20 ms at 36 V 50 ms at 60 V 100 ms at 85 V 200 ms at 110 V
Vx = 110 – 250V dc Quiescent / half load	50 ms at 110 V 100 ms at 160 V 200 ms at 210 V
Vx = 110 – 250V dc Full load	20 ms at 85 V 50 ms at 98 V 100 ms at 135 V 200 ms at 174 V

Power Supply Interruption	
Vx = 40 – 100V ac Quiescent / half load	50 ms at 27 V for 100% voltage dip
Vx = 40 – 100V ac Full load	10 ms at 27 V for 100% voltage dip
Vx = 100 – 240V ac Quiescent / half load	50 ms at 80 V for 100% voltage dip
Vx = 100 – 240V ac Full load	50 ms at 80 V for 100% voltage dip

Maximum loading = all digital inputs/outputs energized
Quiescent or 1/2 loading = 1/2 of all digital inputs/outputs energized

8.8 Output Contacts

Standard Contacts	
Compliance	In accordance with IEC 60255-1:2009
Use	General purpose relay outputs for signaling, 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 ϕ = unity)
Make and break, ac inductive	2500 VA inductive (cos ϕ = 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	10,000 operations min.
Operate time	< 5 ms
Reset time	< 10 ms

8.9 High Break Contacts (Optional)

High Break Contacts	
Use	High Break relays used for tripping purposes
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	7500 W
Make and break, dc inductive	2500 W (L/R = 50 ms)
Make and carry, dc resistive	30 A for 3 s, 10000 operations (subject to the above limits)

High Break Contacts	
Make, carry and break, dc resistive	30 A for 3 s, 5000 operations (subject to the above limits)
Make, carry and break, dc resistive	30 A for 200 ms, 10000 operations (subject to the above limits)
Make, carry and break, dc inductive	10 A, 10000 operations (subject to the above limits) See table below for test details
MOV protection	Maximum voltage 330 V dc
Durability - Loaded contact	1000 operations min.
Durability - Unloaded contact	10,000 operations min.
Operate time	< 0.2 ms
Reset time	< 8 ms

Make, carry and break, dc inductive			
Voltage	**Current**	**L/R**	**No. of shots per second**
65 V	10 A	40 ms	5
150 V	10 A	40 ms	4
250 V	10 A	40 ms	2
250 V	10 A	20 ms	4

Note: Typical for repetitive shots with 2 minutes idle for thermal dissipation

8.10 Watchdog Contacts

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 ϕ = 0.7)

8.11 Fiber Defect Contacts (watchdog relay – redundant Ethernet version)

Fiber Defect Contacts	
Use	Non-programmable contacts for Ethernet fiber healthy/fail indication
Connection method	Phoenix cage type retention
Rated voltage	250 Vac
Rated continuous current	5 A
Make current	Max. 30 A and carry for 3 s
Breaking capacity AC	1500 VA resistive (cos ϕ = unity) 1500 VA inductive (cos ϕ = 0.5)
Breaking capacity, DC	50 W, 250 Vdc resistive 25 W, inductive (L/R = 40 ms)

8.12 Opto-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

Nominal pick-up 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: Opto-inputs operated with filtering removed are more susceptible to EM interference and precautions should be taken to minimize pickup on the external wiring.

9 ENVIRONMENTAL CONDITIONS

9.1 Ambient Temperature Range

Ambient Temperature Range	
Compliance	IEC 60068-2-1: 2007 and 60068-2-2: 2007
Operating temperature range	-25°C to +55°C (-13°F to +131°F)
Storage and transit temperature range	-25°C to +70°C (-13°F to +158°F)
Tested as per IEC 60068-2-1: 2007 IEC 60068-2-2: 2007	 -25°C storage (96 hours) -40°C operation (96 hours) +85°C storage (96 hours) +85°C operation (96 hours)

9.2 Ambient Humidity Range

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 (for relays with harsh environment coating of PCBs)

Corrosive Environments	
Compliance	IEC 60068-2-60: 1995, Part 2, Test Ke, Method (class) 3
Industrial corrosive environment/poor environmental control, mixed gas flow test	21 days at 75% relative humidity and +30ºC exposure to elevated concentrations of H_2S, (100 ppb) NO_2, (200 ppb) Cl_2 (20 ppb).
Tested as per IEC 60068-2-52 IEC 60068-2-43 IEC 60068-2-42	 Salt mist (7 days) H_2S (21 days), 15 ppm SO_2 (21 days), 25 ppm

10 TYPE TESTS

10.1 Insulation

Insulation	
Compliance	IEC 60255-27: 2005
Insulation resistance	> 100 MΩ at 500 V dc (Using only electronic/brushless insulation tester)

10.2 Creepage Distances and Clearances

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

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 D-type EIA(RS)232 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

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

Exceptions: *EIA(RS)232 ports and EIA(RS485) ports and normally-open output contacts*

.

11 ELECTROMAGNETIC COMPATIBILITY (EMC)

11.1 1 MHz Burst High Frequency Disturbance Test

1 MHz Burst High Frequency Disturbance Test	
Compliance	IEC 60255-22-1: 2007 2008, Class III
Common-mode test voltage	2.5 kV
Differential test voltage	1.0 kV

Exception: EIA(RS)232 ports

11.2 100 kHz Damped Oscillatory Test

100 kHz Damped Oscillatory Test	
Compliance	EN61000-4-18: 2006: Level 3, 100 kHz and 1 MHz
Common-mode test voltage	2.5 kV
Differential mode test voltage	1.0 kV

11.3 Immunity to Electrostatic Discharge

Immunity to Electrostatic Discharge	
Compliance	IEC 60255-22-2: 2008 Class 4,
Class 4 Condition	15 kV discharge in air to user interface, display, and exposed metalwork

11.4 Electrical Fast Transient or Burst Requirements

Electrical Fast Transient or Burst Requirements	
Compliance	IEC 60255-22-4: 2008. Test severity Class IV
Applied to auxiliary supply and all other inputs except for EIA(RS)232)	Amplitude: 2 kV, burst frequency 5 kHz (class IV)
Applied to auxiliary supply and all other inputs except for EIA(RS)232)	Amplitude: 4 kV, burst frequency 5 kHz (class IV)
Applied directly to auxiliary	Amplitude: 2 kV, burst frequency 100 kHz (class IV)
Applied directly to auxiliary	Amplitude: 4 kV, burst frequency 100 kHz (class IV)

11.5 Surge Withstand Capability

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 (filtered), output relays, CTs, VTs, power supply, field voltage
Condition 2	4 kV fast transient and 2.5 kV oscillatory applied common mode to communications, IRIG-B

11.6 Surge Immunity Test

Surge Immunity Test	
Compliance	IEC 60255-22-5: 2001 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	Amplitude 2 kV

Exception: EIA(RS)232 ports

11.7 Immunity to Radiated Electromagnetic Energy

Immunity to Radiated Electromagnetic Energy	
Compliance	IEC 60255-22-3: 2008, Class III
Frequency band	80 MHz to 3 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, 450, 900 MHz
Waveform	1 kHz 80% am and am pulse modulated
Field strength	35 V/m

11.8 Radiated Immunity from Digital Communications

Radiated Immunity from Digital Communications	
Compliance	EN61000-4-3: 2006+A2:2010, Level 4
Frequency bands	800 to 960 MHz, 1.4 to 2.0 GHz
Test field strength	35 V/m
Test using AM	1 kHz / 80%

11.9 Radiated Immunity from Digital Radio Telephones

Immunity to Conducted Disturbances Induced by Radio Frequency Fields	
Compliance	IEC 61000-4-3: 2002
Frequency bands	900 MHz and 1.89 GHz
Test disturbance voltage	10 V/m

11.10 Immunity to Conducted Disturbances Induced by Radio Frequency Fields

Immunity to Conducted Disturbances Induced by Radio Frequency Fields	
Compliance	IEC 61000-4-6: 2009, Level 3
Frequency bands	150 kHz to 80 MHz
Test disturbance voltage	10 V
Test using AM	1 kHz @ 80%
Spot tests	27 MHz and 68 MHz

11.11 Magnetic Field Immunity

Magnetic Field Immunity	
Compliance	IEC 61000-4-8: 2010 Level 5 IEC 61000-4-9/10: 1993 Level 5
IEC 61000-4-8 test	100 A/m applied for 60 s, 1000 A/m applied for 3 s
IEC 61000-4-9 test	1050 A/m applied for 3 s
IEC 61000-4-10 test	110 A/m applied at 100 kHz/1 MHz with a burst duration of 2 s

11.12 Conducted Emissions

Conducted Emissions	
Compliance	EN 55022: 2006
Test 1	0.15 - 0.5 MHz, 79 dBμV (quasi peak) 66 dBμV (average)
Test 2	0.5 – 30 MHz, 73 dBμV (quasi peak) 60 dBμV (average)

11.13 Radiated Emissions

Radiated Emissions	
Compliance	EN 55022: 1998
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

Radiated Emissions	
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)

Compliance is achieved using the opto-input filter.

SYMBOLS AND GLOSSARY

CHAPTER 17

1 CHAPTER OVERVIEW

This chapter consists of 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.
CAT	Catenary
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
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
CRP	Cross-network Redundancy Protocol
CRV	Curve (file format for curve information)

Term	Description
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	Defrost protection.
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
ER	Engineering Recommendation
FCB	Frame Count Bit
FDR	Feeder

Term	Description
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
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
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

Term	Description
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	An Optically coupled logic input. Alternative terminology: binary input.
OSI	Open Systems Interconnection
PCB	Printed Circuit Board
PCT	Protective Conductor Terminal (Ground)
PDC	Phasor Data Concentrator
PFO	Panto Flash Over
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
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).

Term	Description
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
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.
SPS	Single Point Status
SQRT	Square Root
STP	Spanning Tree Protocol
SV	Sampled Values
SVM	Sampled Value Model
TAF	Turbine Abnormal Frequency

Term	Description
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
TSU	Train Start Up
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
WPC	Wrong Phase Coupling
XML	Extensible Markup Language
XSD	XML Schema Definition
Z_S / Z_L	Source to Line Impedance Ratio

Table 1: Acronyms and abbreviations

3 COMPANY PROPRIETARY TERMS

Symbol	Description
Courier	General Electric's proprietary SCADA communications protocol
Metrosil	Brand of non-linear resistor produced by M&I Materials Ltd.
MiCOM	General Electric's brand of protection relays

Table 2: Company-proprietary terms

4 ANSI AND IEC 61850 TERMS

ANSI no.	IEC 61850	Description
	PTRC	Tripping Mode (1 & 3 pole)
	FnkGGIO	Function keys
	LedGGIO	Programmable LEDs
	PloGGIO1	Control inputs
∆I/∆V		Delta directional comparison
16E		Ethernet communication
16S		Serial communication
21/21N	DisPDIS	Distance zones, full-scheme protection
25	AscRSYN	Check synchronism
27	VtpPhsPTUV	Undervoltage protection
3PAR		Three pole auto-reclose.
3PDT		Three pole dead time (the dead time used in three pole auto-reclose cycles)
46		Current Transformer supervision
46BC		Broken conductor protection
47		Voltage Transformer supervision
49	ThmPTTR	Thermal overload protection
50/51/67	OcpPTOC/RDIR	Phase overcurrent protection with optional directionality
50BF	CbfRBRF	Breaker fail protection
50N/51N/ 67N	EfdPTOC/RDIR	Earth/ground overcurrent with optional directionality
50SOTF/27SOTF	SotfPSOF/ TorPSOF	Switch-On-To-Fault and trip on reclose
51N/67N/SEF	SenPTOC/RDIR	Sensitive earth fault (SEF)
52a		Circuit breaker control - Normally Open (NO): The contact is in the same state as the breaker primary contacts.
52b		Circuit breaker control - Normally Closed (NC): The contact is in the opposite state as the breaker primary contacts
59	VtpPhsPTOV	Overvoltage protection
59N	VtpResPTOV	Residual voltage protection (also known as Neutral Displacement)
59R	VtpCmpPTOV	Remote overvoltage protection
64	SenRefPDIF	High Impedance Restricted earth fault (REF)
67/46	NgcPTOC/RDIR	Negative sequence overcurrent protection, with optional directionality
67N		Directional earth fault (DEF) unit protection
68	PsbRPSB	Power swing blocking
78	OstRPSB	Out of step
78DCB/78DCUB		Delta directional comparison - fast channel schemes operating on fault generated superimposed quantities
79	ArcRREC1	Auto-reclose
81O	FrqPTOF	Overfrequency protection
81R	DfpPFRC	Rate of change of frequency protection
81U	FrqPTUF	Underfrequency protection
85	DisPSCH	Communication-aided schemes, PUTT, POTT, Blocking, Weak Infeed
87L	DifPDIF1	Phase segregated current differential protection
87N	DifPDIF2	Neutral current differential protection

ANSI no.	IEC 61850	Description
87T		Feeders with in-zone transformers
CLK		IRIG-B time synchronization
CTS		Current Transformer supervision (including differential CTS)
DFR	RDRE	Disturbance Recorder
FL	RFLO	Fault Locator
MET		Measurement of instantaneous values
VTS		Voltage transformer supervision
WPC		Wrong phase coupling

Table 3: ANSI terms

5 UNITS FOR DIGITAL COMMUNICATIONS

Unit	Description
b	bit
B	Byte
kb	Kilobit(s)
kbps	Kilobits per second
kB	Kilobyte(s)
Mb	Megabit(s)
Mbps	Megabits per second
MB	Megabyte(s)
Gb	Gigabit(s)
Gbps	Gigabits per second
GB	Gigabyte(s)
Tb	Terabit(s)
Tbps	Terabits per second
TB	Terabyte(s)

Table 4: Units for digital communications

6 AMERICAN VS BRITISH ENGLISH TERMINOLOGY

British English	American English
…ae…	…e…
…ence	…ense
…ise	…ize
…oe…	…e…
…ogue	…og
…our	…or
…ourite	…orite
…que	…ck
…re	…er
…yse	…yze
Aluminium	Aluminum
Centre	Center
Earth	Ground
Fibre	Fiber
Ground	Earth
Speciality	Specialty

Table 5: American vs British English terminology

7 LOGIC SYMBOLS AND TERMS

Symbol	Description	Units
&	Logical “AND”: Used in logic diagrams to show an AND-gate function.	
Σ	“Sigma”: Used to indicate a summation, such as cumulative current interrupted.	
τ	“Tau”: Used to indicate a time constant, often associated with thermal characteristics.	
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
di/dt	Rate of Change of Current protection	*A*
dphi/dt	Rate of Change of Phase angle protection	rad
dv/dt	Rate of Change of Voltage protection	V
F<1	First stage of underfrequency protection: Could be labelled 81-U in ANSI terminology.	Hz
F>1	First stage of overfrequency protection: Could be labelled 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
I∧	Current raised to a power: Such as when breaker statistics monitor the square of ruptured current squared (∧ power = 2).	An
I'f	Maximum internal secondary fault current (may also be expressed as a multiple of In)	A
I<	An undercurrent element: Responds to current dropout.	A
I>>	Current setting of short circuit element	In
I>1	First stage of phase overcurrent protection: Could be labelled 51-1 in ANSI terminology.	A
I>2	Second stage of phase overcurrent protection: Could be labelled 51-2 in ANSI terminology.	A
I>3	Third stage of phase overcurrent protection: Could be labelled 51-3 in ANSI terminology.	A
I>4	Fourth stage of phase overcurrent protection: Could be labelled 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

Symbol	Description	Units
I2	Negative sequence current.	A
I2>	Negative sequence overcurrent protection (NPS element).	A
I2pol	Negative sequence polarizing current.	A
Icat	Phase Cat current: Might be phase L1, red phase.. or other, in customer terminology.	A
Ifdr	Phase Fdr current: Might be phase L2, yellow phase.. or other, in customer terminology.	A
Idef	Defrost current.	A
Idiff	Current setting of biased differential element	A
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	InterMiCOM64.	
IMx	InterMiCOM64 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 labelled 51N-1 in ANSI terminology.	A
IN>2	Second stage of ground overcurrent protection: Could be labelled 51N-2 in ANSI terminology.	A
Iref	Reference current of P63x calculated from the reference power and nominal voltage	A
IRm2	Second knee-point bias current threshold setting of P63x biased differential element	A
Is	Value of stabilizing current	A
IS1	Differential current pick-up setting of biased differential element	A
IS2	Bias current threshold setting of biased differential element	A
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 kilometres	

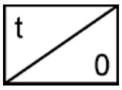
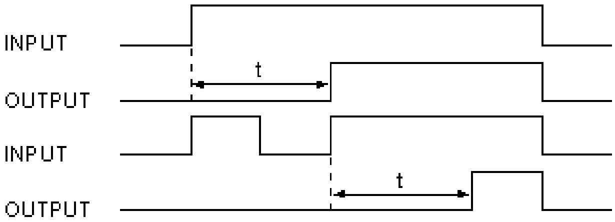
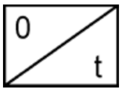
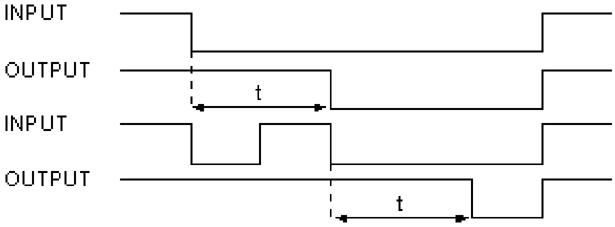
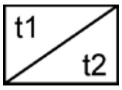
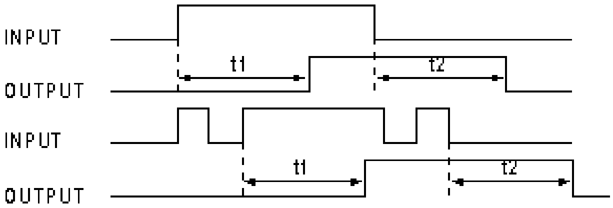
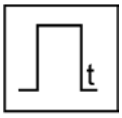
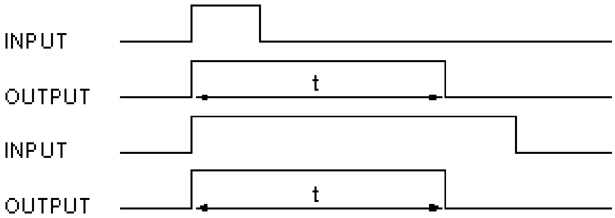
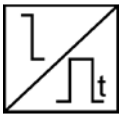
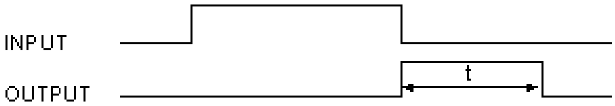
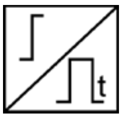
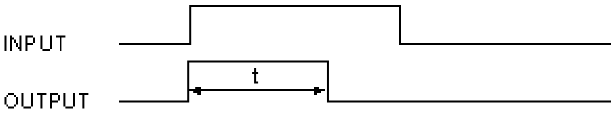
Symbol	Description	Units
Kmax	Maximum dimensioning factor	
Krpa	Dimensioning factor for reach point accuracy	
Ks	Dimensioning factor dependent upon through fault current	
Kssc	Short circuit current coefficient or ALF	
Kt	Dimensioning factor dependent upon operating time	
kZm	The mutual compensation factor (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
m1	Lower bias slope setting of P63x biased differential element	None
m2	Higher bias slope setting of P63x biased differential element	None
mi	Distance in miles.	
N	Indication of “Neutral” involvement in a fault: i.e. a ground (earth) fault.	
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.	
R	Resistance	Ω
R Gnd.	A distance zone resistive reach setting: Used for ground (earth) faults.	
R Ph	A distance zone resistive reach setting used for Phase-Phase faults.	
Rct	Secondary winding resistance	Ω
Rl	Resistance of single lead from relay to current transformer	Ω
Rr	Resistance of any other protective relays sharing the current transformer	Ω
Rrn	Resistance of relay neutral current input	Ω
Rrp	Resistance of relay phase current input	Ω
Rs	Value of stabilizing resistor	Ω
Rx	Receive: typically used to indicate a communication receive line/pin.	
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

Symbol	Description	Units
V<1	First stage of undervoltage protection: Could be labelled 27-1 in ANSI terminology.	V
V<2	Second stage of undervoltage protection: Could be labelled 27-2 in ANSI terminology.	V
V>	An overvoltage element.	V
V>1	First stage of overvoltage protection: Could be labelled 59-1 in ANSI terminology.	V
V>2	Second stage of overvoltage protection: Could be labelled 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
Vcat	Phase Cat voltage: Might be phase L1, red phase.. or other, in customer terminology.	V
Vfdr	Phase Fdr voltage: Might be phase L2, yellow 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
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

Symbol	Description	Units
Ψr	Remanent flux	Wb
Ψs	Saturation flux	Wb

Table 6: Logic Symbols and Terms

8 LOGIC TIMERS

Logic symbols	Explanation	Time chart
	Delay on pick-up timer, t	
	Delay on drop-off timer, t	
	Delay on pick-up/drop-off timer	
	Pulse timer	
	Pulse pick-up falling edge	
	Pulse pick-up raising edge	

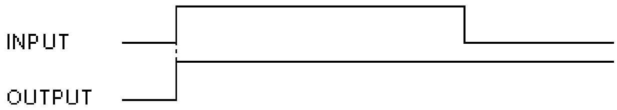
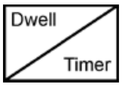
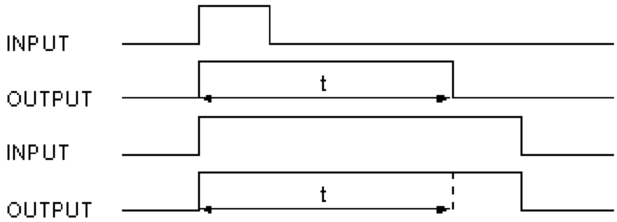
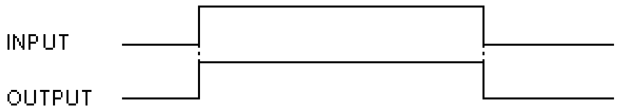
Logic symbols	Explanation	Time chart
	Latch	
	Dwell timer	
	**Straight (non latching):** Hold value until input reset signal	

Table 7: Logic Timers

9 LOGIC GATES

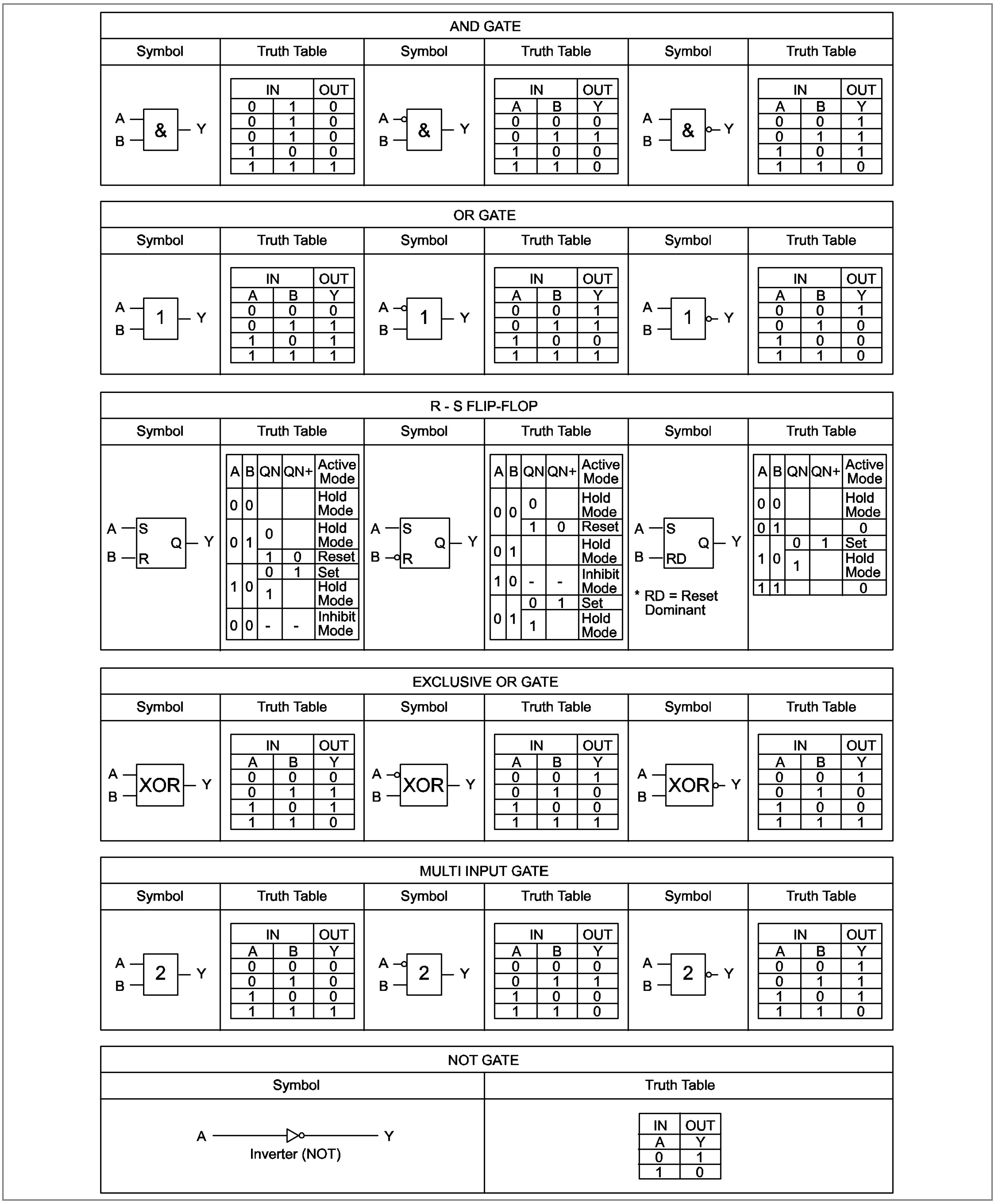


Figure 1: Logic Gates

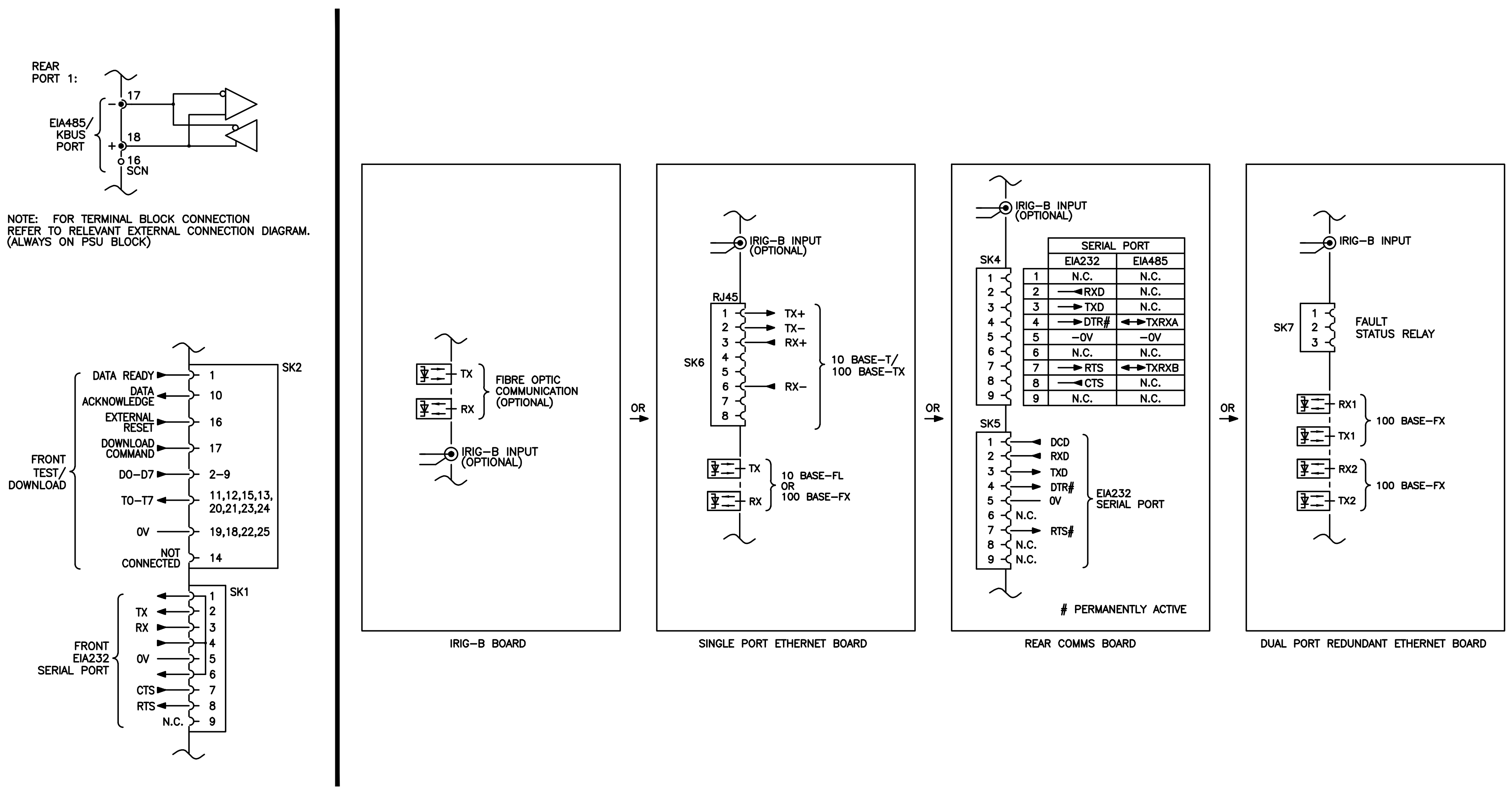
WIRING DIAGRAMS

CHAPTER 18

The following diagrams are for indication only. Please refer to the wiring diagrams supplied with the IED.

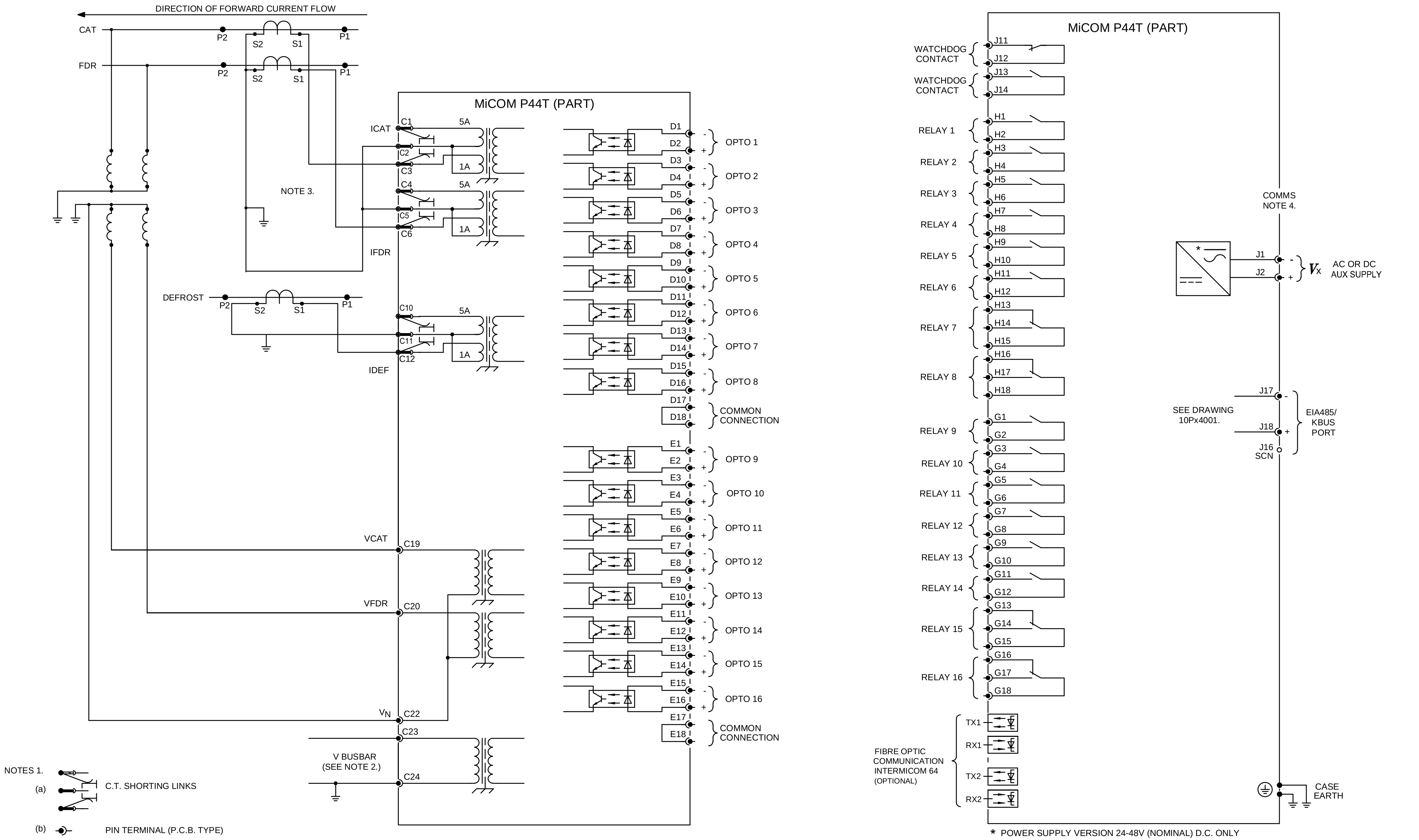
MODEL	CORTEC OPTION*	EXTERNAL CONNECTION DIAGRAM TITLE	DRAWING-SHEET	ISSUE
-	-	COMMS OPTIONS MICOM Px40 PLATFORM	10Px4001-1	J
P44T	Option A	EXT. CONNECTION DIAGRAM P44T 16I/16O	10P44T01-1, 10P44T01-2	B, B
	Option B	EXT. CONNECTION DIAGRAM P44T 16I/12O 4HB	10P44T03-1, 10P44T03-2	B, B
	Option C	EXT. CONNECTION DIAGRAM P44T 24I/32O	10P44T02-1, 10P44T02-2	B, B
	Option D	EXT. CONNECTION DIAGRAM P44T 24I/24O 8HB	10P44T04-1, 10P44T04-2	E, B

* When selecting the applicable wiring diagram(s), refer to appropriate model's CORTEC.



Issue: J	Revision: DRAWING OUTLINE UPDATED. CID BLIN-8BHLDT			Title: EXTERNAL CONNECTION DIAGRAM: COMMS OPTIONS MICOM Px40 PLATFORM	
Date: 30/11/2010	Name: W.LINTERN	CAD DATA 1:1 DIMENSIONS: mm DO NOT SCALE	ALSTOM GRID UK LTD Substation Automation Solutions (STAFFORD)	Drg No: 10Px4001	Sht: 1
Date:	Chkd: S KELSALL				Next Sht: -

ALSTOM



NOTES 1.

(a) C.T. SHORTING LINKS

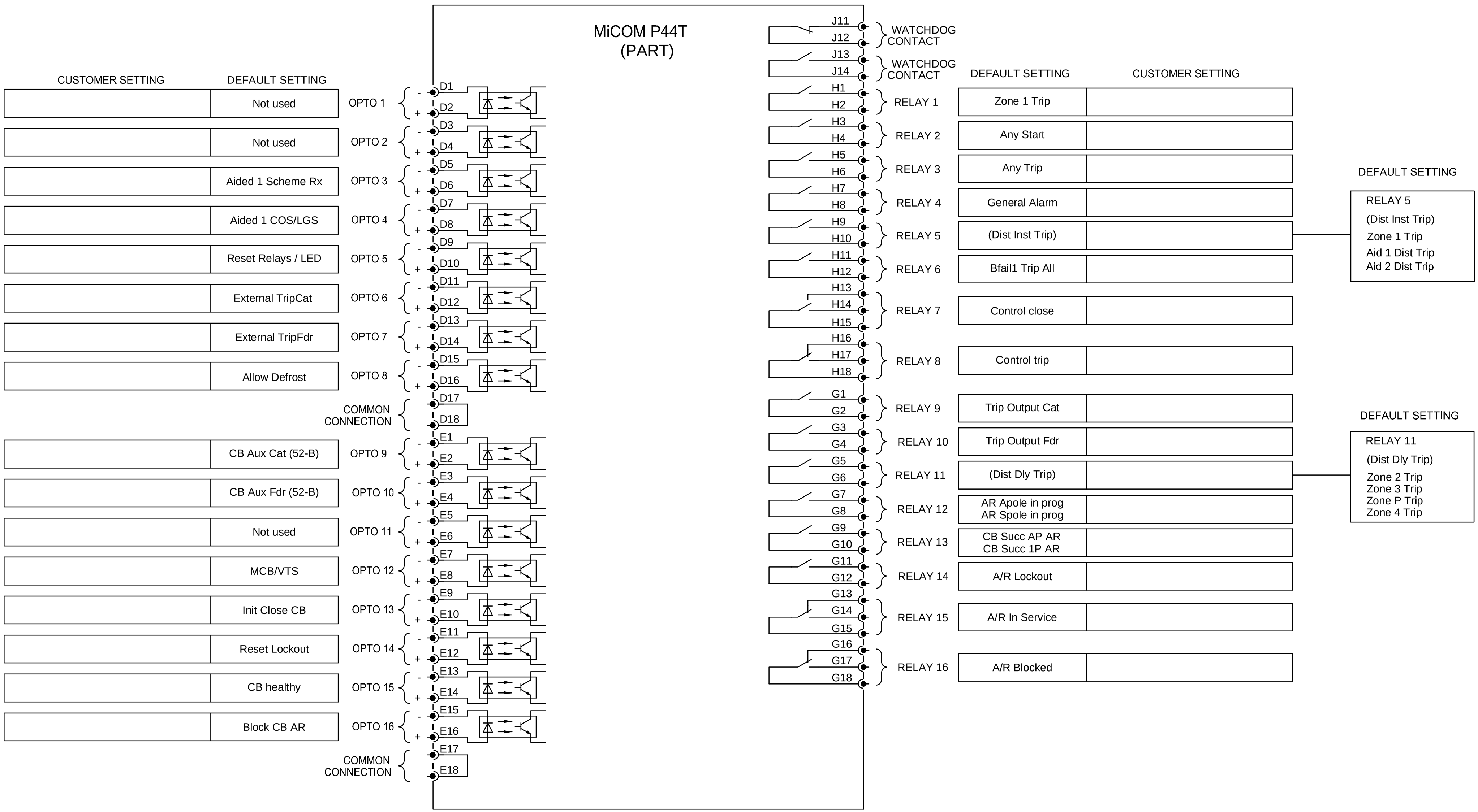
(b) PIN TERMINAL (P.C.B. TYPE)

2. V BUSBAR ONLY REQUIRED IF CHECK SYNCHRONISM FUNCTION ENABLED.

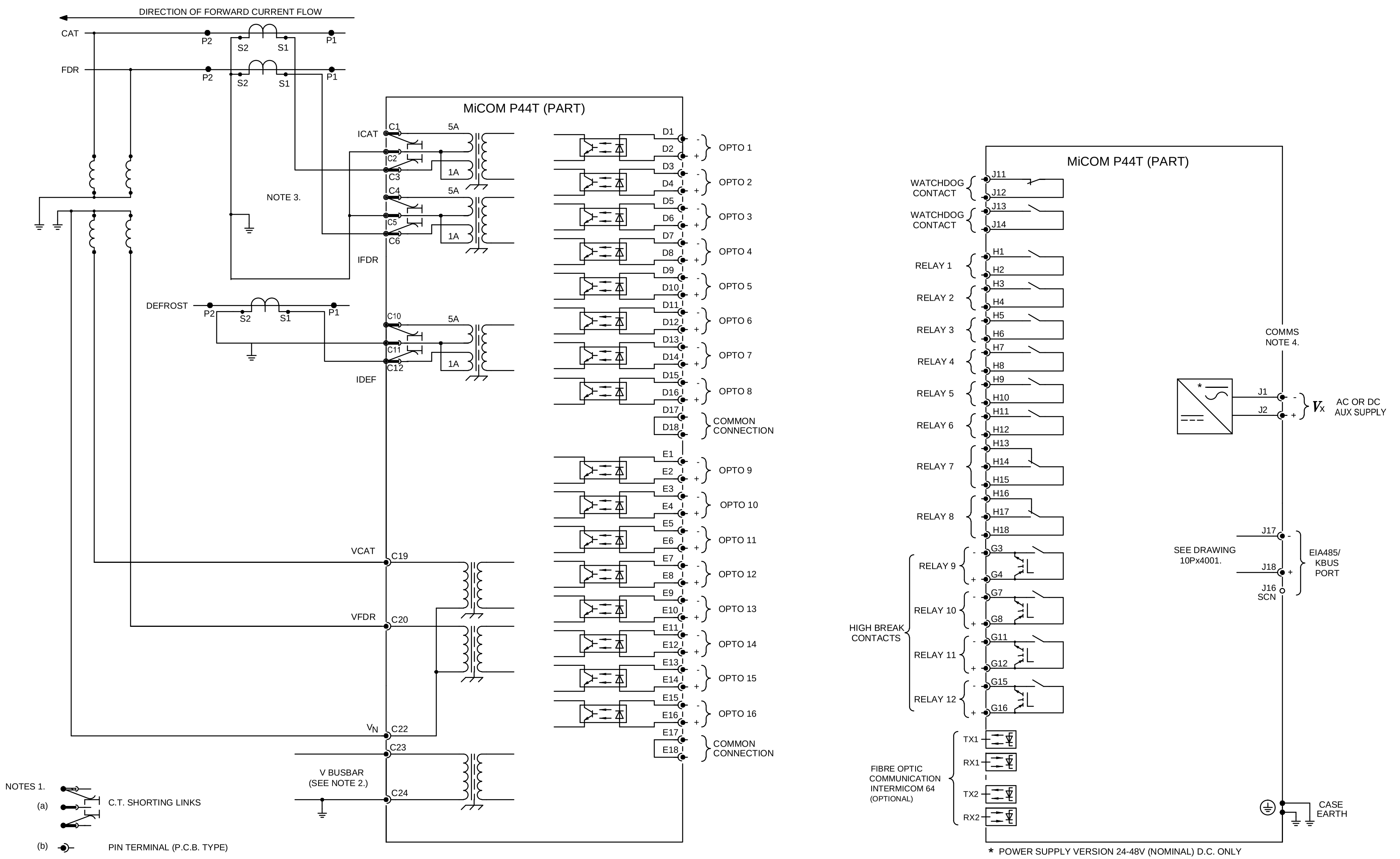
3. C.T. CONNECTIONS ARE SHOWN 1A CONNECTED AND ARE TYPICAL ONLY.

4. FOR COMMS OPTIONS SEE DRAWING 10PX4001

Issue: B	Revision: PWIG-94NQ2J			Title: EXT. CONNECTION DIAGRAM P44T 16I/16O
Date: 09/02/2013	Name: P.WIGGIN	CAD DATA 1:1 DIMENSIONS: mm DO NOT SCALE	ALSTOM GRID UK LTD Substation Automation Solutions (STAFFORD)	Drg No: 10P44T01 — Sht: 1 — Next Sht: 2 — ALSTOM
Date: 09/02/2013	Chkd: J.JESUS			



Issue: B	Revision: PWIG-94NQ2J			Title: EXT. CONNECTION DIAGRAM P44T 16I/16O
Date: 09/02/2013	Name: P.WIGGIN	CAD DATA 1:1 DIMENSIONS: mm DO NOT SCALE	ALSTOM GRID UK LTD Substation Automation Solutions (STAFFORD)	Drg No: 10P44T01 — Sht: 2 — Next Sht: - — ALSTOM
Date: 09/02/2013	Chkd: J.JESUS			



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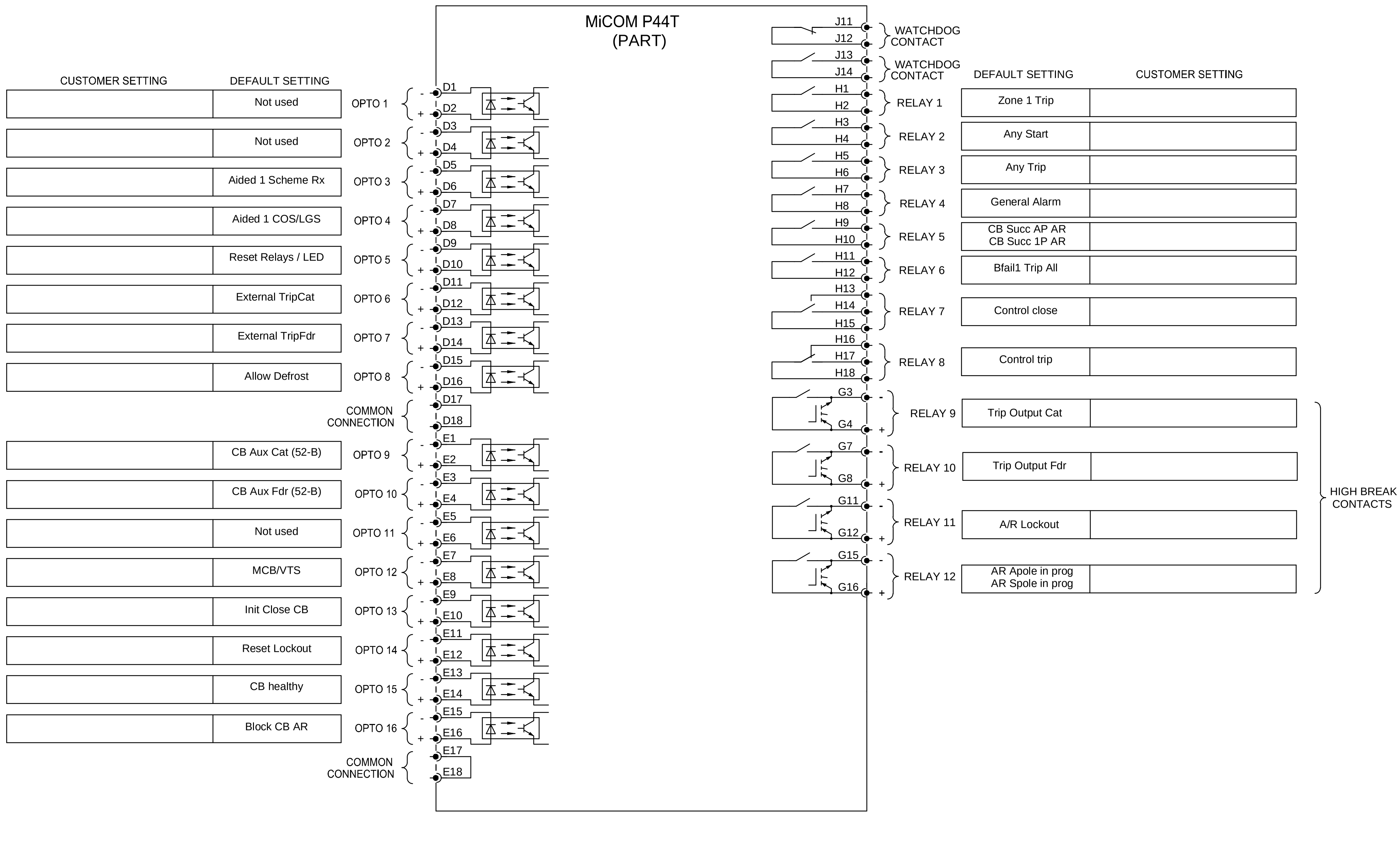
Issue: B	Revision: PWIG-94NQ2J				Title: EXT. CONNECTION DIAGRAM P44T 16I/12O 4HB	
Date: 09/02/2013	Name: P.WIGGIN	CAD DATA 1:1 DIMENSIONS: mm		ALSTOM GRID UK LTD Substation Automation Solutions (STAFFORD)	Drg No: 10P44T03	Sht: 1
Date: 09/02/2013	Chkd: J.JESUS	DO NOT SCALE				Next Sht: 2

ALSTOM



Issue:	Revision:	Title:
B	PWIG-94NQ2J	EXT. CONNECTION DIAGRAM P44T 16I/12O 4HB

Date: 09/02/2013 Name: P.WIGGIN

Date: 09/02/2013 Chkd: J.JESUS

CAD DATA 1:1 DIMENSIONS: mm
DO NOT SCALE

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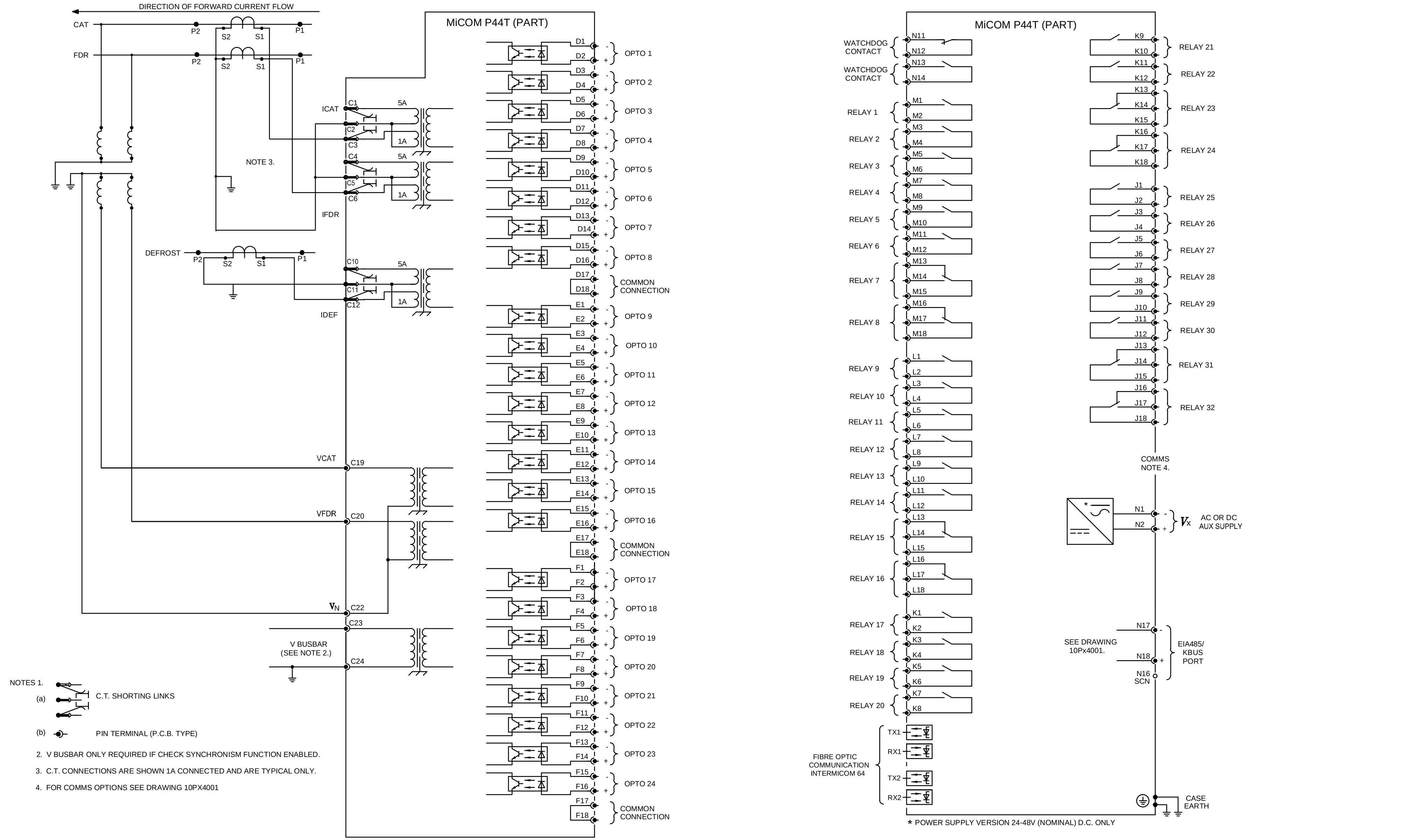
Substation Automation Solutions
(STAFFORD)

Drg No: **10P44T03**

Sht: 2
Next Sht: -

ALSTOM



NOTES 1.

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Issue: B	Revision: PWIG-94NQ2J	Title: EXT. CONNECTION DIAGRAM P44T 24I/32O
Date: 09/02/2013	Name: P.WIGGIN	CAD DATA 1:1 DIMENSIONS: mm
Date: 09/02/2013	Chkd: J.JESUS	DO NOT SCALE

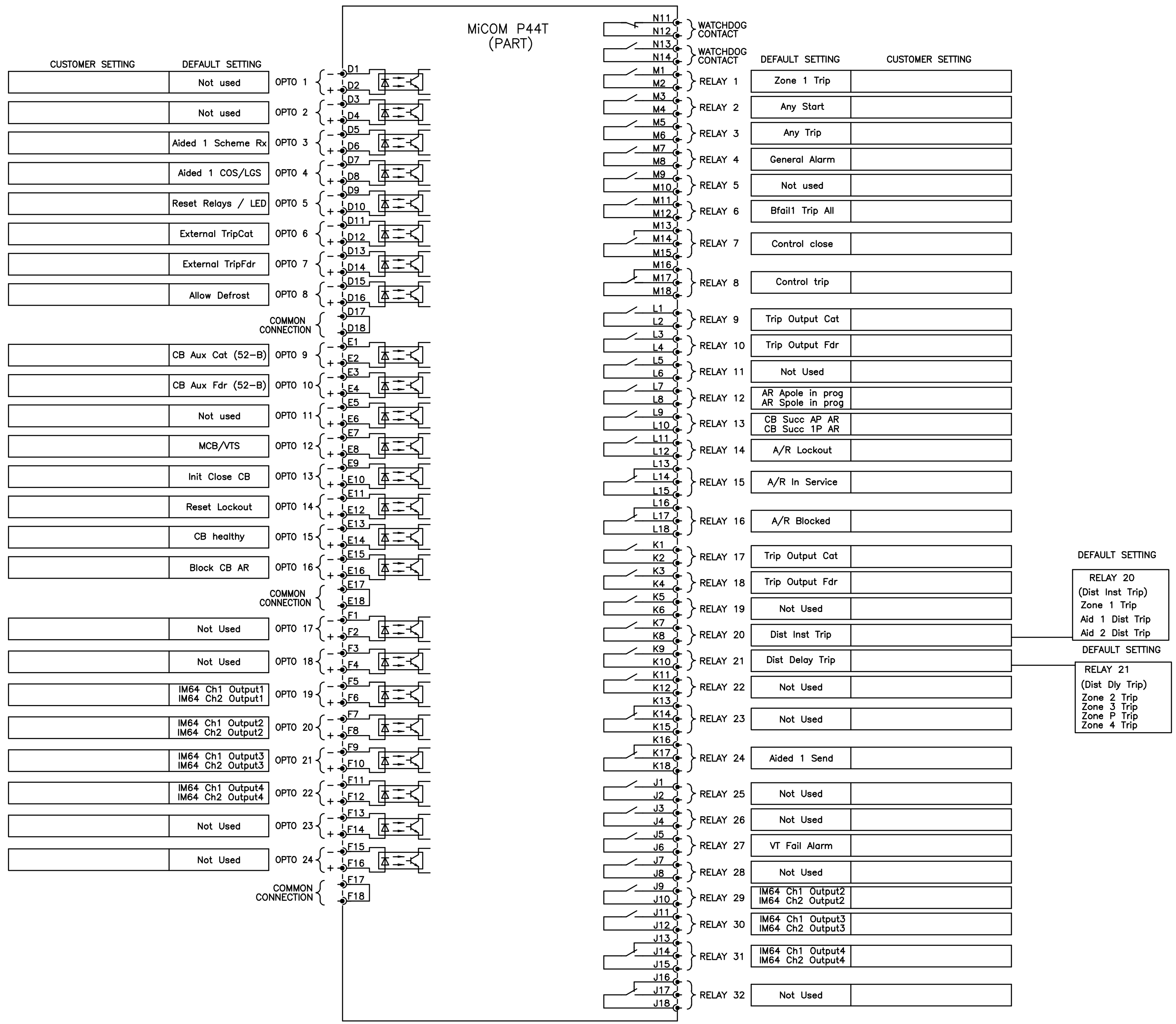
ALSTOM GRID UK LTD
Substation Automation Solutions
(STAFFORD)

Drg No: 10P44T02

Sht: 1

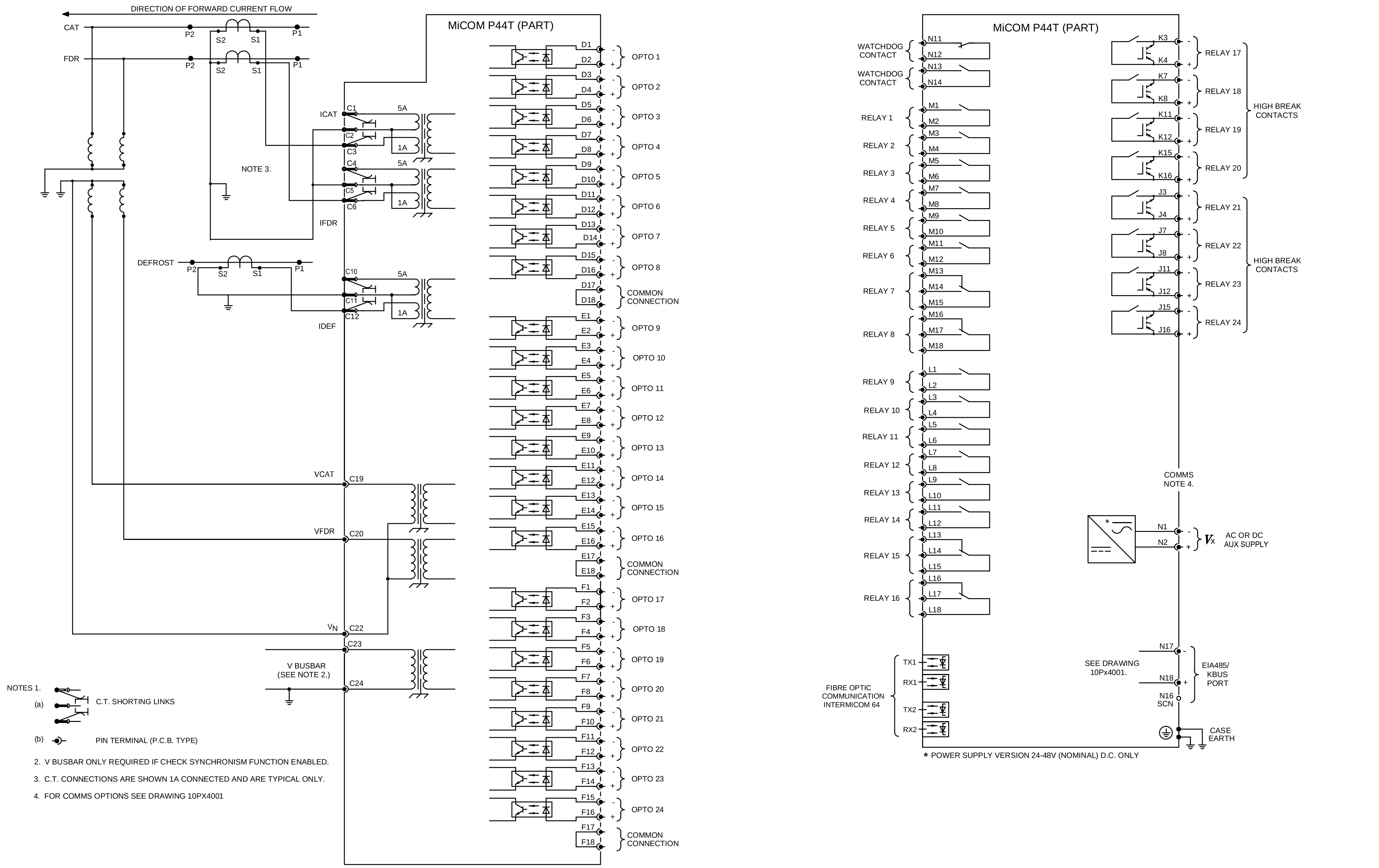
Next Sht: 2

ALSTOM



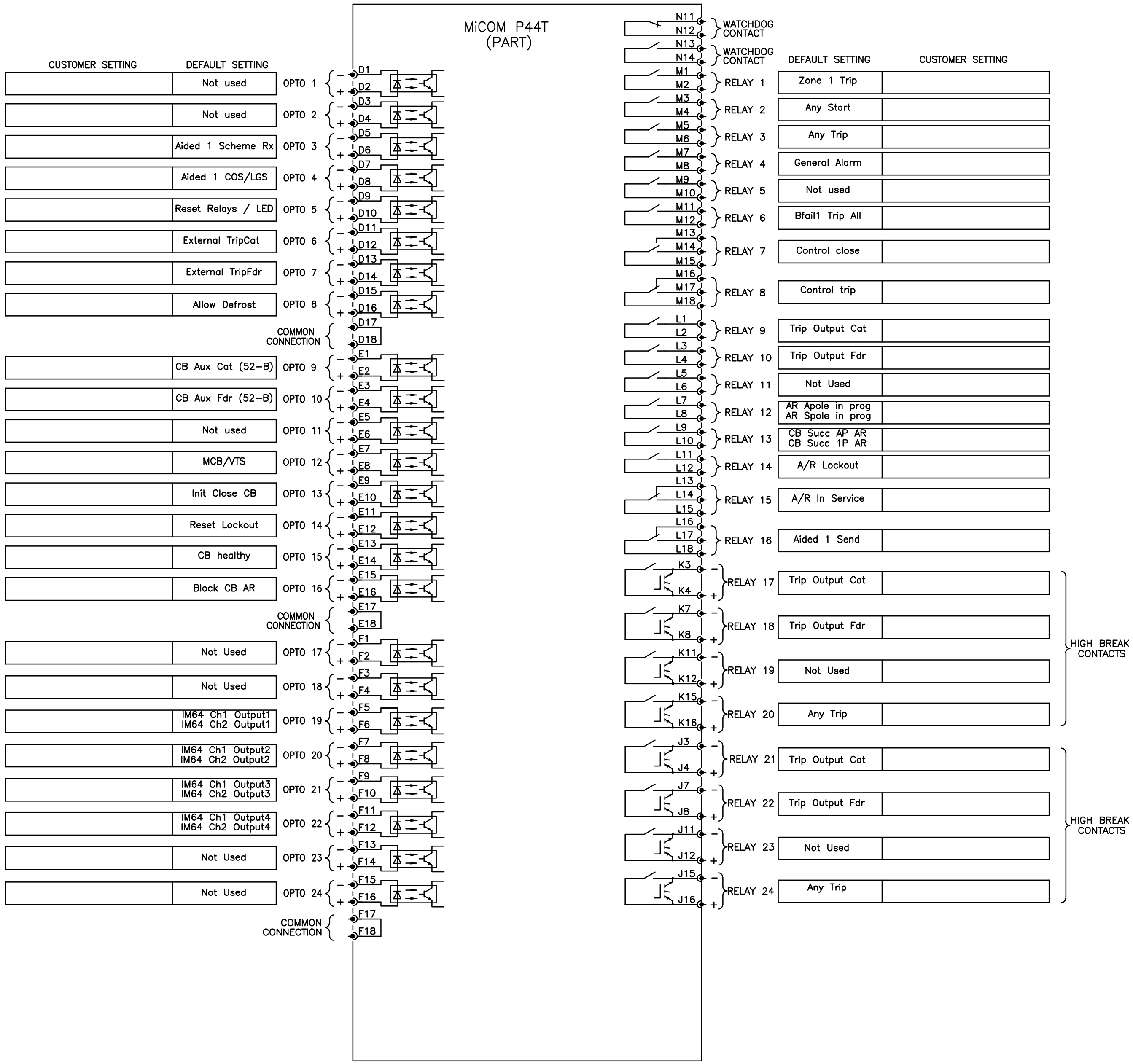
Issue: B	Revision: PWIG-94NQ2J			Title: EXT. CONNECTION DIAGRAM P44T 24I/32O	
Date: 09/02/2013	Name: P.WIGGIN	CAD DATA 1:1 DIMENSIONS: mm DO NOT SCALE	ALSTOM GRID UK LTD Substation Automation Solutions (STAFFORD)	Drg No: 10P44T02	Sht: 2
Date: 09/02/2013	Chkd: J. JESUS				Next Sht: -

ALSTOM



Issue: B	Revision: PWIG-94NQ2J			Title: EXT. CONNECTION DIAGRAM P44T 24I/24O 8HB	
Date: 09/02/2013	Name: P.WIGGIN	CAD DATA 1:1 DIMENSIONS: mm	ALSTOM GRID UK LTD Substation Automation Solutions (STAFFORD)	Drg No: 10P44T04	Sht: 1
Date: 09/02/2013	Chkd: J.JESUS	DO NOT SCALE			Next Sht: 2

ALSTOM



Issue: B	Revision: PWIG-94NQ2J			Title: EXT. CONNECTION DIAGRAM P44T 24I/24O 8HB
Date: 09/02/2013	Name: P.WIGGIN	CAD DATA 1:1 DIMENSIONS: mm DO NOT SCALE	ALSTOM GRID UK LTD Substation Automation Solutions (STAFFORD)	Drg No: 10P44T04
Date: 09/02/2013	Chkd: J.JESUS			Sht: 2 / Next Sht: -

ALSTOM

COMMISSIONING RECORD

APPENDIX A

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

This section should be completed to allow future identification of protective devices that have been commissioned using equipment that is later found to be defective or incompatible, but may not be detected during the commissioning procedure.

Test Equipment	Model	Serial Number
Injection test set		
Phase angle meter		
Optical power meter		
Phase rotation meter		
Insulation tester		
Setting software:		
IED configurator software		

1.4 Tests

The following tests are to be carried out with the product de-energized

Test	Result
Was the IED damaged on visual inspection?	Yes ☐ No ☐
Is the rating information correct for installation?	Yes ☐ No ☐

Test	Result
Is the case earth installed?	Yes ☐ No ☐
Are the current transformers shorting contacts closed?	Yes ☐ No ☐ Not checked ☐
Is the insulation resistance >100 MΩ at 500 V DC?	Yes ☐ No ☐ Not tested ☐
Wiring checked against diagram?	Yes ☐ No ☐
Test block connections checked?	Yes ☐ No ☐ N/A ☐
Watchdog terminals 11 and 12 contacts closed?	Yes ☐ No ☐
Watchdog terminals 13 and 14 contacts open?	Yes ☐ No ☐
Measured auxiliary supply	V AC ☐ DC ☐

The following tests are to be carried out with the product energized

General Tests	Result
Watchdog terminals 11 and 12 contact open?	Yes ☐ No ☐
Watchdog terminals 13 and 14 contact 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 ☐
All 18 programmable LEDs working?	Yes ☐ No ☐
Field supply voltage measured between terminals 8 and 9	V DC
All opto-inputs working?	Yes ☐ No ☐
All output relays working?	Yes ☐ No ☐

Communications	Result
SCADA Communication standard	Courier ☐ DNP3.0 ☐ IEC61850 ☐ IEC60870-5-103 ☐
Communications established?	Yes ☐ No ☐
Protocol converter tested?	Yes ☐ No ☐ N/A ☐

Current Inputs		Result
Displayed current		Primary ☐ Secondary ☐
Phase CT ratio		N/A ☐
Input CT	**Applied Value**	**Displayed Value**
Icat	A	A
Ifdr	A	A
Idef	A	A

Voltage Inputs	Result
Voltage inputs	
Displayed voltage	Primary* ☐ Secondary* ☐

Voltage Inputs		Result
Main VT ratio		N/A ☐
Input VT	**Applied Value**	**Displayed value**
Vcat	V	V
Vfdr	V	V

Overcurrent Checks	Result
Overcurrent type (set in cell [I>1 Direction])	Directional ☐ Non-directional ☐
Applied voltage	V N/A ☐
Applied current	A
Expected operating time	s
Measured operating time	s

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) …	
Relay IED is correctly directionalised?	Yes ☐ No ☐ N/A ☐

Final Checks	Result
All test equipment, leads, shorts and test blocks removed safely?	Yes ☐ No ☐
Ethernet connected?	Yes ☐ No ☐ N/A ☐
Disturbed customer wiring re-checked?	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 ☐
LEDs reset?	Yes ☐ No ☐
Secondary front cover replaced?	Yes ☐ No ☐ N/A ☐

P59X COMMISSIONING INSTRUCTIONS

APPENDIX B

1 OVERVIEW

Read all relevant safety instructions before starting commissioning process

This Appendix provides instructions on how to commission the P59x devices (P591, P592, P593)

It consists of the following sections:

1 Overview

2 Commissioning the P59x unit

2.1 P59x visual Inspection
2.2 P59x Insulation Tests
2.3 P59x External Wiring
2.4 P59x Auxiliary Supply
2.5 P59x LEDs
2.6 Optical Received Signal Level
2.7 Loopback
2.8 Optical Transmitter Signal Level
2.9 Optical Signal Optical Received from P59x

2 COMMISSIONING THE P59X UNIT

2.1 P59x visual Inspection

1. Carefully examine the unit to see that no physical damage has occurred since installation.
2. Check the rating information given under the top access cover on the front of the unit to ensure it is correct for the particular installation.
3. Ensure that the case earthing connection, top left-hand corner at the rear of the case, is used to connect the unit to a local earth bar using an adequate conductor.

2.2 P59x Insulation Tests

Insulation resistance tests are only necessary during commissioning if it is required for them to be done and they haven't been performed during installation.

1. 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.
2. The auxiliary DC supply terminals should be temporarily connected together.
3. Measure the insulation resistance. It 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 P59x.

Note: The V.35 circuits and the X.21 circuits of the P592 and P593 respectively are isolated from all other circuits but are electrically connected to the outer case. The circuits must therefore not be insulation or impulse tested to the case.

2.3 P59x External Wiring

Check that the external wiring accords with the connection diagram or scheme diagram. The connection diagram number appears on the rating label under the top access cover on the front of the P59x. The connection diagram should have been included in the P59x documentation.

Warning: Ensure that the DC supplies are wired with the correct polarity.

2.4 P59x Auxiliary Supply

P591 units operate from a DC auxiliary supply within the range of 19 V to 65 V for a 24 - 48 V version and 87.5 V to 300 V for a 110 - 250 V version.

P592 and P593 units operate from a DC auxiliary supply within the range of 19 V to 300 V.

Without energizing the unit measure the auxiliary supply to ensure it is within the operating range.

The units are designed to withstand an AC ripple component of up to 12% of the normal DC auxiliary supply. However, in all cases the peak value of the DC supply must not exceed the maximum specified operating limit.

Warning: Do not energize the unit using the battery charger with the battery disconnected as this can irreparably damage the unit's power supply circuitry.

2.5 P59x LEDs

On power up the green 'SUPPLY HEALTHY' LED should have illuminated and stayed on, indicating that the unit is healthy.

P592 only

The four red LED's can be tested by appropriate setting of the DIL switches on the unit's front plate. Set the data rate switch according to the communication channel bandwidth available. Set all other switches to 0. To illuminate the 'DSR OFF' and 'CTS OFF' LED's, disconnect the V.35 connector from the rear of the P592 and set the 'DSR' and 'CTS' switches to '0'. The 'OPTO LOOPBACK' and 'V.35 LOOPBACK' LEDs can be illuminated by setting their corresponding switches to '1'.

Once operation of the LED's has been established set all DIL switches, except for the 'OPTO LOOPBACK' switch, to '0' and reconnect the V.35 connector.

P593 only

Set the 'X.21 LOOPBACK' switch to 'ON'. The green 'CLOCK' and red 'X.21 LOOPBACK' LED's should illuminate. Reset the 'X.21 LOOPBACK' switch to the 'OFF' position.

Set the 'OPTO LOOPBACK' switch to 'ON'. The red 'OPTO LOOPBACK' LED should illuminate. Do not reset the "OPTO LOOPBACK' switch as it is required in this position for the next test.

2.6 Optical Received Signal Level

1. With an optical cable connected to the P54x optical transmitter, disconnect the other end of the cable from the P59x receiver (Rx) and use an optical power meter to measure the received signal strength. The value should be in the range -16.8 dBm to -25.4 dBm.
2. Record the measured value and replace the connector to the P59x receiver.

2.7 Loopback

P591

It is necessary to loop the transmitted electrical G.703 signal presented on terminals 3 and 4 of the P591 to the received signal presented on terminals 7 and 8.

If test links have been designed into the scheme to facilitate this they should be used. Alternatively, remove any external wiring from terminals 3, 4, 7 and 8 at the rear of each P591 unit. Loopback the G.703 signals on each unit by connecting a wire link between terminals 3 and 7, and a second wire between terminals 4 and 8.

P592

With the 'OPTO LOOPBACK' switch in the '1' position, the receive and transmit optical ports are connected together. This allows the optical fibre communications between the IED and the P592 to be tested, but not the internal circuitry of the P592 itself.

P593

With the 'OPTO LOOPBACK' switch in the '1' position, the receive and transmit optical ports are connected together. This allows the optical fibre communications between the IED and the P592 to be tested, but not the internal circuitry of the P592 itself.

Set the ‘OPTO LOOPBACK’ switch to ‘OFF’ and ‘X.21 LOOPBACK’ switch to ‘ON’ respectively. With the ‘X.21 LOOPBACK’ switch in this position the ‘Receive Data’ and ‘Transmit Data’ lines of the X.21 communication interface are connected together. This allows the optical fibre communications between the IED and the P593, and the internal circuitry of the P593 itself to be tested.

2.8 Optical Transmitter Signal Level

1. Using an appropriate fibre-optic cable, connect the optical transmitter (Tx) to an optical power meter.
2. Check that the average power transmitted is within the range -16.8 dBm to -22.8 dBm.
3. Record the transmit power level.
4. Connect the appropriate optical fibre to connect the P591 transmitter to the IED's optical receiver
5. Return to the IED

2.9 Optical Signal Optical Received from P59x

1. Disconnect the fibre from the IED's optical receiver that connects to the optical transmitter of the P59x and measure the received signal level. The value should be in the range -16.8 dBm to -25.4 dBm.
2. Record the measurement and then reconnect the fibre to the optical receiver.

DDB SIGNALS

APPENDIX C

DDB No	Text	Source	Description
0	Relay 1	Output conditioner	Assignment of signal to drive output Relay 1
1	Relay 2	Output conditioner	Assignment of signal to drive output Relay 2
2	Relay 3	Output conditioner	Assignment of signal to drive output Relay 3
3	Relay 4	Output conditioner	Assignment of signal to drive output Relay 4
4	Relay 5	Output conditioner	Assignment of signal to drive output Relay 5
5	Relay 6	Output conditioner	Assignment of signal to drive output Relay 6
6	Relay 7	Output conditioner	Assignment of signal to drive output Relay 7
7	Relay 8	Output conditioner	Assignment of signal to drive output Relay 8
8	Relay 9	Output conditioner	Assignment of signal to drive output Relay 9
9	Relay 10	Output conditioner	Assignment of signal to drive output Relay 10
10	Relay 11	Output conditioner	Assignment of signal to drive output Relay 11
11	Relay 12	Output conditioner	Assignment of signal to drive output Relay 12
12	Relay 13	Output conditioner	Assignment of signal to drive output Relay 13
13	Relay 14	Output conditioner	Assignment of signal to drive output Relay 14
14	Relay 15	Output conditioner	Assignment of signal to drive output Relay 15
15	Relay 16	Output conditioner	Assignment of signal to drive output Relay 16
16	Relay 17	Output conditioner	Assignment of signal to drive output Relay 17
17	Relay 18	Output conditioner	Assignment of signal to drive output Relay 18
18	Relay 19	Output conditioner	Assignment of signal to drive output Relay 19
19	Relay 20	Output conditioner	Assignment of signal to drive output Relay 20
20	Relay 21	Output conditioner	Assignment of signal to drive output Relay 21
21	Relay 22	Output conditioner	Assignment of signal to drive output Relay 22
22	Relay 23	Output conditioner	Assignment of signal to drive output Relay 23
23	Relay 24	Output conditioner	Assignment of signal to drive output Relay 24
24	Relay 25	Output conditioner	Assignment of signal to drive output Relay 25
25	Relay 26	Output conditioner	Assignment of signal to drive output Relay 26
26	Relay 27	Output conditioner	Assignment of signal to drive output Relay 27
27	Relay 28	Output conditioner	Assignment of signal to drive output Relay 28
28	Relay 29	Output conditioner	Assignment of signal to drive output Relay 29
29	Relay 30	Output conditioner	Assignment of signal to drive output Relay 30
30	Relay 31	Output conditioner	Assignment of signal to drive output Relay 31
31	Relay 32	Output conditioner	Assignment of signal to drive output Relay 32
32	Opto 1	Opto Input	From opto input 1 - when opto energized
33	Opto 2	Opto Input	From opto input 2 - when opto energized
34	Opto 3	Opto Input	From opto input 3 - when opto energized
35	Opto 4	Opto Input	From opto input 4 - when opto energized
36	Opto 5	Opto Input	From opto input 5 - when opto energized
37	Opto 6	Opto Input	From opto input 6 - when opto energized
38	Opto 7	Opto Input	From opto input 7 - when opto energized
39	Opto 8	Opto Input	From opto input 8 - when opto energized
40	Opto 9	Opto Input	From opto input 9 - when opto energized
41	Opto 10	Opto Input	From opto input 10 - when opto energized
42	Opto 11	Opto Input	From opto input 11 - when opto energized
43	Opto 12	Opto Input	From opto input 12 - when opto energized

DDB No	Text	Source	Description
44	Opto 13	Opto Input	From opto input 13 - when opto energized
45	Opto 14	Opto Input	From opto input 14 - when opto energized
46	Opto 15	Opto Input	From opto input 15 - when opto energized
47	Opto 16	Opto Input	From opto input 16 - when opto energized
48	Opto 17	Opto Input	From opto input 17 - when opto energized
49	Opto 18	Opto Input	From opto input 18 - when opto energized
50	Opto 19	Opto Input	From opto input 19 - when opto energized
51	Opto 20	Opto Input	From opto input 20 - when opto energized
52	Opto 21	Opto Input	From opto input 21 - when opto energized
53	Opto 22	Opto Input	From opto input 22 - when opto energized
54	Opto 23	Opto Input	From opto input 23 - when opto energized
55	Opto 24	Opto Input	From opto input 24 - when opto energized
56	Opto 25	Opto Input	From opto input 25 - when opto energized
57	Opto 26	Opto Input	From opto input 26 - when opto energized
58	Opto 27	Opto Input	From opto input 27 - when opto energized
59	Opto 28	Opto Input	From opto input 28 - when opto energized
60	Opto 29	Opto Input	From opto input 29 - when opto energized
61	Opto 30	Opto Input	From opto input 30 - when opto energized
62	Opto 31	Opto Input	From opto input 31 - when opto energized
63	Opto 32	Opto Input	From opto input 32 - when opto energized
64 to 79	Unused		Unused
80	IM Input 1	InterMiCOM	InterMiCOM Input 1 - is driven by a message from the remote line end
81	IM Input 2	InterMiCOM	InterMiCOM Input 2 - is driven by a message from the remote line end
82	IM Input 3	InterMiCOM	InterMiCOM Input 3 - is driven by a message from the remote line end
83	IM Input 4	InterMiCOM	InterMiCOM Input 4 - is driven by a message from the remote line end
84	IM Input 5	InterMiCOM	InterMiCOM Input 5 - is driven by a message from the remote line end
85	IM Input 6	InterMiCOM	InterMiCOM Input 6 - is driven by a message from the remote line end
86	IM Input 7	InterMiCOM	InterMiCOM Input 7 - is driven by a message from the remote line end
87	IM Input 8	InterMiCOM	InterMiCOM Input 8 - is driven by a message from the remote line end
88	IM Output 1	PSL	InterMiCOM Output 1 - is an output to the remote line end
89	IM Output 2	PSL	InterMiCOM Output 2 - is an output to the remote line end
90	IM Output 3	PSL	InterMiCOM Output 3 - is an output to the remote line end
91	IM Output 4	PSL	InterMiCOM Output 4 - is an output to the remote line end
92	IM Output 5	PSL	InterMiCOM Output 5 - is an output to the remote line end
93	IM Output 6	PSL	InterMiCOM Output 6 - is an output to the remote line end
94	IM Output 7	PSL	InterMiCOM Output 7 - is an output to the remote line end
95	IM Output 8	PSL	InterMiCOM Output 8 - is an output to the remote line end
96	IM64 Ch1 Input 1	IM64	IM64 Ch1 input 1 - is driven by a message from the remote line end

DDB No	Text	Source	Description
97	IM64 Ch1 Input 2	IM64	IM64 Ch1 input 2 - is driven by a message from the remote line end
98	IM64 Ch1 Input 3	IM64	IM64 Ch1 input 3 - is driven by a message from the remote line end
99	IM64 Ch1 Input 4	IM64	IM64 Ch1 input 4 - is driven by a message from the remote line end
100	IM64 Ch1 Input 5	IM64	IM64 Ch1 input 5 - is driven by a message from the remote line end
101	IM64 Ch1 Input 6	IM64	IM64 Ch1 input 6 - is driven by a message from the remote line end
102	IM64 Ch1 Input 7	IM64	IM64 Ch1 input 7 - is driven by a message from the remote line end
103	IM64 Ch1 Input 8	IM64	IM64 Ch1 input 8 - is driven by a message from the remote line end
104	IM64 Ch2 Input 1	IM64	IM64 Ch2 input 1 - is driven by a message from the remote line end
105	IM64 Ch2 Input 2	IM64	IM64 Ch2 input 2 - is driven by a message from the remote line end
106	IM64 Ch2 Input 3	IM64	IM64 Ch2 input 3 - is driven by a message from the remote line end
107	IM64 Ch2 Input 4	IM64	IM64 Ch2 input 4 - is driven by a message from the remote line end
108	IM64 Ch2 Input 5	IM64	IM64 Ch2 input 5 - is driven by a message from the remote line end
109	IM64 Ch2 Input 6	IM64	IM64 Ch2 input 6 - is driven by a message from the remote line end
110	IM64 Ch2 Input 7	IM64	IM64 Ch2 input 7 - is driven by a message from the remote line end
111	IM64 Ch2 Input 8	IM64	IM64 Ch2 input 8 - is driven by a message from the remote line end
112	IM64 Ch1 Output1	PSL	IM64 Ch1 output 1 - mapping what will be sent to the remote line end
113	IM64 Ch1 Output2	PSL	IM64 Ch1 output 2 - mapping what will be sent to the remote line end
114	IM64 Ch1 Output3	PSL	IM64 Ch1 output 3 - mapping what will be sent to the remote line end
115	IM64 Ch1 Output4	PSL	IM64 Ch1 output 4 - mapping what will be sent to the remote line end
116	IM64 Ch1 Output5	PSL	IM64 Ch1 output 5 - mapping what will be sent to the remote line end
117	IM64 Ch1 Output6	PSL	IM64 Ch1 output 6 - mapping what will be sent to the remote line end
118	IM64 Ch1 Output7	PSL	IM64 Ch1 output 7 - mapping what will be sent to the remote line end
119	IM64 Ch1 Output8	PSL	IM64 Ch1 output 8 - mapping what will be sent to the remote line end
120	IM64 Ch2 Output1	PSL	IM64 Ch2 output 1 - mapping what will be sent to the remote line end
121	IM64 Ch2 Output2	PSL	IM64 Ch2 output 2 - mapping what will be sent to the remote line end
122	IM64 Ch2 Output3	PSL	IM64 Ch2 output 3 - mapping what will be sent to the remote line end

DDB No	Text	Source	Description
123	IM64 Ch2 Output4	PSL	IM64 Ch2 output 4 - mapping what will be sent to the remote line end
124	IM64 Ch2 Output5	PSL	IM64 Ch2 output 5 - mapping what will be sent to the remote line end
125	IM64 Ch2 Output6	PSL	IM64 Ch2 output 6 - mapping what will be sent to the remote line end
126	IM64 Ch2 Output7	PSL	IM64 Ch2 output 7 - mapping what will be sent to the remote line end
127	IM64 Ch2 Output8	PSL	IM64 Ch2 output 8 - mapping what will be sent to the remote line end
128	Relay Cond 1	PSL	Input to relay 1 output conditioner
129	Relay Cond 2	PSL	Input to relay 2 output conditioner
130	Relay Cond 3	PSL	Input to relay 3 output conditioner
131	Relay Cond 4	PSL	Input to relay 4 output conditioner
132	Relay Cond 5	PSL	Input to relay 5 output conditioner
133	Relay Cond 6	PSL	Input to relay 6 output conditioner
134	Relay Cond 7	PSL	Input to relay 7 output conditioner
135	Relay Cond 8	PSL	Input to relay 8 output conditioner
136	Relay Cond 9	PSL	Input to relay 9 output conditioner
137	Relay Cond 10	PSL	Input to relay 10 output conditioner
138	Relay Cond 11	PSL	Input to relay 11 output conditioner
139	Relay Cond 12	PSL	Input to relay 12 output conditioner
140	Relay Cond 13	PSL	Input to relay 13 output conditioner
141	Relay Cond 14	PSL	Input to relay 14 output conditioner
142	Relay Cond 15	PSL	Input to relay 15 output conditioner
143	Relay Cond 16	PSL	Input to relay 16 output conditioner
144	Relay Cond 17	PSL	Input to relay 17 output conditioner
145	Relay Cond 18	PSL	Input to relay 18 output conditioner
146	Relay Cond 19	PSL	Input to relay 19 output conditioner
147	Relay Cond 20	PSL	Input to relay 20 output conditioner
148	Relay Cond 21	PSL	Input to relay 21 output conditioner
149	Relay Cond 22	PSL	Input to relay 22 output conditioner
150	Relay Cond 23	PSL	Input to relay 23 output conditioner
151	Relay Cond 24	PSL	Input to relay 24 output conditioner
152	Relay Cond 25	PSL	Input to relay 25 output conditioner
153	Relay Cond 26	PSL	Input to relay 26 output conditioner
154	Relay Cond 27	PSL	Input to relay 27 output conditioner
155	Relay Cond 28	PSL	Input to relay 28 output conditioner
156	Relay Cond 29	PSL	Input to relay 29 output conditioner
157	Relay Cond 30	PSL	Input to relay 30 output conditioner
158	Relay Cond 31	PSL	Input to relay 31 output conditioner
159	Relay Cond 32	PSL	Input to relay 32 output conditioner
160	Timer in 1	PSL	Input to auxiliary timer 1
161	Timer in 2	PSL	Input to auxiliary timer 2
162	Timer in 3	PSL	Input to auxiliary timer 3
163	Timer in 4	PSL	Input to auxiliary timer 4

DDB No	Text	Source	Description
164	Timer in 5	PSL	Input to auxiliary timer 5
165	Timer in 6	PSL	Input to auxiliary timer 6
166	Timer in 7	PSL	Input to auxiliary timer 7
167	Timer in 8	PSL	Input to auxiliary timer 8
168	Timer in 9	PSL	Input to auxiliary timer 9
169	Timer in 10	PSL	Input to auxiliary timer 10
170	Timer in 11	PSL	Input to auxiliary timer 11
171	Timer in 12	PSL	Input to auxiliary timer 12
172	Timer in 13	PSL	Input to auxiliary timer 13
173	Timer in 14	PSL	Input to auxiliary timer 14
174	Timer in 15	PSL	Input to auxiliary timer 15
175	Timer in 16	PSL	Input to auxiliary timer 16
176	Timer out 1	Auxiliary Timer	Output from auxiliary timer 1
177	Timer out 2	Auxiliary Timer	Output from auxiliary timer 2
178	Timer out 3	Auxiliary Timer	Output from auxiliary timer 3
179	Timer out 4	Auxiliary Timer	Output from auxiliary timer 4
180	Timer out 5	Auxiliary Timer	Output from auxiliary timer 5
181	Timer out 6	Auxiliary Timer	Output from auxiliary timer 6
182	Timer out 7	Auxiliary Timer	Output from auxiliary timer 7
183	Timer out 8	Auxiliary Timer	Output from auxiliary timer 8
184	Timer out 9	Auxiliary Timer	Output from auxiliary timer 9
185	Timer out 10	Auxiliary Timer	Output from auxiliary timer 10
186	Timer out 11	Auxiliary Timer	Output from auxiliary timer 11
187	Timer out 12	Auxiliary Timer	Output from auxiliary timer 12
188	Timer out 13	Auxiliary Timer	Output from auxiliary timer 13
189	Timer out 14	Auxiliary Timer	Output from auxiliary timer 14
190	Timer out 15	Auxiliary Timer	Output from auxiliary timer 15
191	Timer out 16	Auxiliary Timer	Output from auxiliary timer 16
192	Control Input 1	Virtual Input Command	Control input 1 - for SCADA and menu commands into PSL
193	Control Input 2	Virtual Input Command	Control input 2 - for SCADA and menu commands into PSL
194	Control Input 3	Virtual Input Command	Control input 3 - for SCADA and menu commands into PSL
195	Control Input 4	Virtual Input Command	Control input 4 - for SCADA and menu commands into PSL
196	Control Input 5	Virtual Input Command	Control input 5 - for SCADA and menu commands into PSL
197	Control Input 6	Virtual Input Command	Control input 6 - for SCADA and menu commands into PSL
198	Control Input 7	Virtual Input Command	Control input 7 - for SCADA and menu commands into PSL
199	Control Input 8	Virtual Input Command	Control input 8 - for SCADA and menu commands into PSL
200	Control Input 9	Virtual Input Command	Control input 9 - for SCADA and menu commands into PSL
201	Control Input 10	Virtual Input Command	Control input 10 - for SCADA and menu commands into PSL
202	Control Input 11	Virtual Input Command	Control input 11 - for SCADA and menu commands into PSL
203	Control Input 12	Virtual Input Command	Control input 12 - for SCADA and menu commands into PSL
204	Control Input 13	Virtual Input Command	Control input 13 - for SCADA and menu commands into PSL
205	Control Input 14	Virtual Input Command	Control input 14 - for SCADA and menu commands into PSL
206	Control Input 15	Virtual Input Command	Control input 15 - for SCADA and menu commands into PSL
207	Control Input 16	Virtual Input Command	Control input 16 - for SCADA and menu commands into PSL

DDB No	Text	Source	Description
208	Control Input 17	Virtual Input Command	Control input 17 - for SCADA and menu commands into PSL
209	Control Input 18	Virtual Input Command	Control input 18 - for SCADA and menu commands into PSL
210	Control Input 19	Virtual Input Command	Control input 19 - for SCADA and menu commands into PSL
211	Control Input 20	Virtual Input Command	Control input 20 - for SCADA and menu commands into PSL
212	Control Input 21	Virtual Input Command	Control input 21 - for SCADA and menu commands into PSL
213	Control Input 22	Virtual Input Command	Control input 22 - for SCADA and menu commands into PSL
214	Control Input 23	Virtual Input Command	Control input 23 - for SCADA and menu commands into PSL
215	Control Input 24	Virtual Input Command	Control input 24 - for SCADA and menu commands into PSL
216	Control Input 25	Virtual Input Command	Control input 25 - for SCADA and menu commands into PSL
217	Control Input 26	Virtual Input Command	Control input 26 - for SCADA and menu commands into PSL
218	Control Input 27	Virtual Input Command	Control input 27 - for SCADA and menu commands into PSL
219	Control Input 28	Virtual Input Command	Control input 28 - for SCADA and menu commands into PSL
220	Control Input 29	Virtual Input Command	Control input 29- for SCADA and menu commands into PSL
221	Control Input 30	Virtual Input Command	Control input 30 - for SCADA and menu commands into PSL
222	Control Input 31	Virtual Input Command	Control input 31 - for SCADA and menu commands into PSL
223	Control Input 32	Virtual Input Command	Control input 32 - for SCADA and menu commands into PSL
224	Virtual Input 1	GOOSE Input Command	Virtual Input 1 - received from GOOSE message
225	Virtual Input 2	GOOSE Input Command	Virtual Input 2 - received from GOOSE message
226	Virtual Input 3	GOOSE Input Command	Virtual Input 3 - received from GOOSE message
227	Virtual Input 4	GOOSE Input Command	Virtual Input 4 - received from GOOSE message
228	Virtual Input 5	GOOSE Input Command	Virtual Input 5 - received from GOOSE message
229	Virtual Input 6	GOOSE Input Command	Virtual Input 6 - received from GOOSE message
230	Virtual Input 7	GOOSE Input Command	Virtual Input 7 - received from GOOSE message
231	Virtual Input 8	GOOSE Input Command	Virtual Input 8 - received from GOOSE message
232	Virtual Input 9	GOOSE Input Command	Virtual Input 9 - received from GOOSE message
233	Virtual Input 10	GOOSE Input Command	Virtual Input 10 - received from GOOSE message
234	Virtual Input 11	GOOSE Input Command	Virtual Input 11 - received from GOOSE message
235	Virtual Input 12	GOOSE Input Command	Virtual Input 12 - received from GOOSE message
236	Virtual Input 13	GOOSE Input Command	Virtual Input 13 - received from GOOSE message
237	Virtual Input 14	GOOSE Input Command	Virtual Input 14 - received from GOOSE message
238	Virtual Input 15	GOOSE Input Command	Virtual Input 15 - received from GOOSE message
239	Virtual Input 16	GOOSE Input Command	Virtual Input 16 - received from GOOSE message
240	Virtual Input 17	GOOSE Input Command	Virtual Input 17 - received from GOOSE message
241	Virtual Input 18	GOOSE Input Command	Virtual Input 18 - received from GOOSE message
242	Virtual Input 19	GOOSE Input Command	Virtual Input 19 - received from GOOSE message
243	Virtual Input 20	GOOSE Input Command	Virtual Input 20 - received from GOOSE message
244	Virtual Input 21	GOOSE Input Command	Virtual Input 21 - received from GOOSE message
245	Virtual Input 22	GOOSE Input Command	Virtual Input 22 - received from GOOSE message
246	Virtual Input 23	GOOSE Input Command	Virtual Input 23 - received from GOOSE message
247	Virtual Input 24	GOOSE Input Command	Virtual Input 24 - received from GOOSE message
248	Virtual Input 25	GOOSE Input Command	Virtual Input 25 - received from GOOSE message
249	Virtual Input 26	GOOSE Input Command	Virtual Input 26 - received from GOOSE message
250	Virtual Input 27	GOOSE Input Command	Virtual Input 27 - received from GOOSE message
251	Virtual Input 28	GOOSE Input Command	Virtual Input 28 - received from GOOSE message

DDB No	Text	Source	Description
252	Virtual Input 29	GOOSE Input Command	Virtual Input 29 - received from GOOSE message
253	Virtual Input 30	GOOSE Input Command	Virtual Input 30 - received from GOOSE message
254	Virtual Input 31	GOOSE Input Command	Virtual Input 31 - received from GOOSE message
255	Virtual Input 32	GOOSE Input Command	Virtual Input 32 - received from GOOSE message
256	Virtual Output 1	PSL	Virtual output 1 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
257	Virtual Output 2	PSL	Virtual output 2 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
258	Virtual Output 3	PSL	Virtual output 3 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
259	Virtual Output 4	PSL	Virtual output 4 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
260	Virtual Output 5	PSL	Virtual output 5 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
261	Virtual Output 6	PSL	Virtual output 6 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
262	Virtual Output 7	PSL	Virtual output 7 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
263	Virtual Output 8	PSL	Virtual output 8 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
264	Virtual Output 9	PSL	Virtual output 9 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
265	Virtual Output10	PSL	Virtual output 10 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
266	Virtual Output11	PSL	Virtual output 11 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
267	Virtual Output12	PSL	Virtual output 12 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
268	Virtual Output13	PSL	Virtual output 13 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
269	Virtual Output14	PSL	Virtual output 14 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
270	Virtual Output15	PSL	Virtual output 15 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
271	Virtual Output16	PSL	Virtual output 16 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
272	Virtual Output17	PSL	Virtual output 17 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
273	Virtual Output18	PSL	Virtual output 18 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
274	Virtual Output19	PSL	Virtual output 19 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
275	Virtual Output20	PSL	Virtual output 20 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
276	Virtual Output21	PSL	Virtual output 21 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
277	Virtual Output22	PSL	Virtual output 22 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
278	Virtual Output23	PSL	Virtual output 23 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
279	Virtual Output24	PSL	Virtual output 24 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices

DDB No	Text	Source	Description
280	Virtual Output25	PSL	Virtual output 25 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
281	Virtual Output26	PSL	Virtual output 26 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
282	Virtual Output27	PSL	Virtual output 27 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
283	Virtual Output28	PSL	Virtual output 28 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
284	Virtual Output29	PSL	Virtual output 29 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
285	Virtual Output30	PSL	Virtual output 30 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
286	Virtual Output31	PSL	Virtual output 31 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
287	Virtual Output32	PSL	Virtual output 32 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
288	SG-opto Invalid	Group Selection	Setting group selection opto inputs have detected an invalid (disabled) settings group
289	Prot'n Disabled	Commissioning Test	Protection disabled - typically out of service due to test mode
290	Static Test Mode	Commissioning Test	Static test mode option bypasses the delta phase selectors, power swing detection and reverts to conventional directional line and cross polarization to allow testing with test sets that can not simulate a real fault
291	Reserved	C Diff	Unused
292	Reserved	C Diff	Unused
293	VT Fail Alarm	VT Supervision	VTS indication alarm- failed VT (fuse blow) detected by VT supervision
294	MF out of Range	Defrost Protection	Matching factor out of range alarm
295	Unused	WPC	Wrong configure setting for WPC mode
296	Unused	Train Startup	Wrong configure Timer setting for train start-up
297	Unused	Panto Flash Over	Trigger the panto flash over under voltage element alarm
298	CB Fail Alarm	CB Fail	Circuit breaker fail alarm
299	CB Monitor Alarm	CB Monitoring	This alarm indicates that DDB CB I^ Maint (1106) or DDB CB OPs Maint. (1108) or DDB CB Time Maint. (1110)
300	CB Mon LO Alarm	CB Monitoring	This alarm indicates that DDB CB I^ Lockout (1107) or DDB CB Ops Lock (1109) or DDB CB Time lockout (1111)
301	CB Status Alarm	CB Status	CB Status Alarm - set when CB status is determined by inputs from BOTH 52A and 52B type auxiliary contacts (setting "CB Status Input = 52A&52B-xPole), and both inputs are in the same state (both = 0 or both = 1) for time period => 5sec, indicating a probl
302	CB Trip Fail	CB Control	CB Failed to Trip - alarm set if CB does not trip within set Trip Pulse Time when CB trip command is issued.
303	CB Close Fail	CB Control	CB Failed to Close - alarm set if CB fails to close within set Close Pulse Time when CB close command is issued
304	Man CB Unhealthy	CB Control	ManCB1 Unhealthy - alarm set if CB1 remains "unhealthy" for CB Control set time "CB Healthy Time" when operator controlled CB1 close sequence is initiated. (Please see description for CB Control setting "CB Healthy Time").

DDB No	Text	Source	Description
305	No C/S Man Close	CB Control	No C/S Man Close - alarm set if selected system check conditions for manual closing CB1 remain unsatisfied for CB Control set time "Check Sync Time" when operator controlled CB1 close sequence is initiated. (Please see description for CB Control setting "
306	A/R Lockout	Autoreclose	A/R Lockout - alarm set when CB autoreclose is locked out.
307	A/R CB Unhealthy	Autoreclose	A/R CB Unhealthy - alarm set if CB remains "unhealthy" for Autoreclose set time "CB Healthy Time" when CB close sequence is initiated by autoreclose function. (Please see description for Autoreclose setting "CB Healthy Time").
308	A/R No Checksync	Autoreclose	A/R No Checksync - alarm set if selected system check conditions for autoreclosing CB remain unsatisfied for Autoreclose set time "Check Sync Time" when CB close sequence is initiated by autoreclose function. (Please see description for Autoreclose settin
309	Reserved	Check sync	Unused
310	Reserved	C Diff	Unused
311	Reserved	C Diff	Unused
312	Reserved	C Diff	Unused
313	Reserved	C Diff	Unused
314	IM64 SchemeFail	PSL	It indicates that communications between relays are completely lost and therefore IM64 does not work
315	Reserved	C Diff	Unused
316	Reserved	C Diff	Unused
317	Aid 1 Chan Fail	PSL	Aided channel scheme 1 - channel out of service indication, indicating channel failure
318	Aid 2 Chan Fail	PSL	Aided channel scheme 2 - channel out of service indication, indicating channel failure
319	F out of Range	Frequency Tracking	Frequency out of range alarm
320 to 332	Reserved	CB2 Fail	Unused
333	Reserved	C Diff	Unused
334	Main Prot. Fail	Co-processor interface	Indicates a failure with the Co-Processor, this will affect the protections that run on this board, eg. current differential, phase comparision, distance and DEF Protections.
335	Reserved	C Diff	Unused
336	Reserved	C Diff	Unused
337	Reserved	C Diff	Unused
338	Reserved	C Diff	Unused
339 to 343	Reserved	PSL	Unused
344	SR User Alarm 1	PSL	Triggers user alarm 1 message to be alarmed on LCD display (self-resetting)
345	SR User Alarm 2	PSL	Triggers user alarm 2 message to be alarmed on LCD display (self-resetting)
346	SR User Alarm 3	PSL	Triggers user alarm 3 message to be alarmed on LCD display (self-resetting)
347	SR User Alarm 4	PSL	Triggers user alarm 4 message to be alarmed on LCD display (self-resetting)
348	MR User Alarm 5	PSL	Triggers user alarm 5 message to be alarmed on LCD display (manual-resetting)
349	MR User Alarm 6	PSL	Triggers user alarm 6 message to be alarmed on LCD display (manual-resetting)

DDB No	Text	Source	Description
350	MR User Alarm 7	PSL	Triggers user alarm 7 message to be alarmed on LCD display (manual-resetting)
351	MR User Alarm 8	PSL	Triggers user alarm 8 message to be alarmed on LCD display (manual-resetting)
352	Battery Fail	Self monitoring	Front panel miniature battery failure - either battery removed from slot, or low voltage
353	Reserved	Self monitoring	Unused
354	Rear Comm 2 Fail	Self monitoring	Comm2 hardware failure - second rear communications board
355	GOOSE IED Absent	Ethernet Interface	The IED is not subscribed to a publishing IED in the current scheme
356	NIC Not Fitted	Ethernet Interface	Ethernet board not fitted
357	NIC No Response	Ethernet Interface	Ethernet board not responding
358	NIC Fatal Error	Ethernet Interface	Ethernet board unrecoverable error
359	NIC Soft. Reload	Ethernet Interface	Ethernet problem
360	Bad TCP/IP Cfg.	Ethernet Interface	Ethernet problem
361	Bad OSI Config.	Ethernet Interface	Ethernet problem
362	NIC Link Fail	Ethernet Interface	Ethernet link lost
363	NIC SW Mis-Match	Ethernet Interface	Ethernet board software not compatible with main CPU
364	IP Addr Conflict	Ethernet Interface	The IP address of the IED is already used by another IED
365	IM Loopback	InterMiCOM	EIA(RS)232 InterMiCOM indication that Loopback testing is in progress
366	IM Message Fail	InterMiCOM	EIA(RS)232 InterMiCOM Message Failure alarm. Setting that is used to alarm for poor channel quality. If during the fixed 1.6 s rolling window the ratio of invalid messages to the total number of messages that should be received (based upon the ‘Baud Rate’
367	IM Data CD Fail	InterMiCOM	EIA(RS)232 InterMiCOM Data Channel Detect Fail i.e. modem failure
368	IM Channel Fail	InterMiCOM	EIA(RS)232 InterMiCOM Channel Failure alarm. No messages were received during the alarm time setting
369	Backup Setting	Self monitoring	This is an alarm that is ON if any setting fail during the setting changing process. If this happens, the relay will use the last known good setting
370	Reserved	Self monitoring	Bad DNP Settings
371	Backup Usr Curve	Self monitoring	Backup Curve
372	SNTP Failure		Platform Alarm 21
373	NIC MemAllocFail		Platform Alarm 22
374	Reserved		Platform Alarm 23
375	Reserved		Platform Alarm 24
376	Reserved		Platform Alarm 25
377	Reserved		Platform Alarm 26
378	Reserved		Platform Alarm 27
379	Reserved		Platform Alarm 28
380	Reserved		Platform Alarm 29
381	Reserved		Platform Alarm 30
382	Reserved		Platform Alarm 31
383	Reserved		Platform Alarm 32
384	Block Zone 1 Gnd	PSL	Zone 1 ground basic scheme blocking
385	Block Zone 1 Phs	PSL	Zone 1 phase basic scheme blocking

DDB No	Text	Source	Description
386	Block Zone 2 Gnd	PSL	Zone 2 ground basic scheme blocking
387	Block Zone 2 Phs	PSL	Zone 2 phase basic scheme blocking
388	Block Zone 3 Gnd	PSL	Zone 3 ground basic scheme blocking
389	Block Zone 3 Phs	PSL	Zone 3 phase basic scheme blocking
390	Block Zone P Gnd	PSL	Zone P ground basic scheme blocking
391	Block Zone P Phs	PSL	Zone P phase basic scheme blocking
392	Block Zone 4 Gnd	PSL	Zone 4 ground basic scheme blocking
393	Block Zone 4 Phs	PSL	Zone 4 phase basic scheme blocking
394	Aid1 InhibitDist	PSL	Block distance aided scheme 1 tripping
395	Bloc Z2 Train st	Train Startup	Block train start-up in zone 2
396	Bloc Z3 Train st	Train Startup	Block train start-up in zone 3
397	Aid2 InhibitDist	PSL	Block distance aided scheme 2 tripping
398	Inhi.P.F.Alarm	Panto Flash Over	Inhibit Panto Flash over alarm protection function
399	Inhi.P.F.Trip	Panto Flash Over	Inhibit Panto Flash over Trip protection function
400	Time Synch	PSL	Time synchronism by opto pulse
401	I>1 Timer Block	PSL	Block phase overcurrent stage 1 time delayed trip
402	I>2 Timer Block	PSL	Block phase overcurrent stage 2 time delayed trip
403	I>3 Timer Block	PSL	Block phase overcurrent stage 3 time delayed trip
404	I>4 Timer Block	PSL	Block phase overcurrent stage 4 time delayed trip
405	HZDeltIBlock	PSL	Block Delta I function from trigering trip signal
406	HZDeltI CatMag	PSL	Catenary delta I magnitude detection signal
407	HZDeltI FdrMag	PSL	Feeder delta I magnitude detection signal
408	HZDIISensitCat	PSL	Signal to indicate that catenary current is below the set minimum threshold
409	HZDIVSensitCat	PSL	Signal to indicate that catenary voltage is below the set minimum threshold
410	HZDeltI CatAng	PSL	Caternary delta I angle detection signal
411	HZDeltI FdrAng	PSL	Feeder delta I angle detection signal
412	HZDeltI StartCat	PSL	Catenary HZ delta I Start signal
413	HZDeltI StartFdr	PSL	Feeder HZ delta I Start signal
414	V<1 Timer Block	PSL	Block phase undervoltage stage 1 time delayed trip
415	V<2 Timer Block	PSL	Block phase undervoltage stage 2 time delayed trip
416	V>1 Timer Block	PSL	Block phase overvoltage stage 1 time delayed trip
417	V>2 Timer Block	PSL	Block phase overvoltage stage 2 time delayed trip
418	Unused	PSL	Unused
419	Def Timer Blk	PSL	Defrost Timer Block
420	CB Aux All(52-A)	PSL	52-A (CB closed) CB auxiliary input (All phases)
421	CB Aux Cat(52-A)	PSL	52-A (CB Cat phase closed) CB auxiliary
422	CB Aux Fdr(52-A)	PSL	52-A (CB Fdr phase closed) CB auxiliary
423	Unused	PSL	Unused
424	CB Aux All(52-B)	PSL	52-B (CB open) CB auxiliary input (All phases)
425	CB Aux Cat(52-B)	PSL	52-B (CB Cat phase open) CB auxiliary input
426	CB Aux Fdr(52-B)	PSL	52-B (CB Fdr phase open) CB auxiliary input
427	Unused	PSL	Unused
428 to 435	Unused	PSL	Unused

DDB No	Text	Source	Description
436	CB Healthy	PSL	Circuit breaker healthy (input to auto-recloser - that the CB has enough energy to allow re-closing)
437	Unused	PSL	Unused
438	MCB/VTS	PSL	VT supervision input - signal from external miniature circuit breaker showing MCB tripped
439	Init Trip CB	PSL	Initiate tripping of circuit breaker from a manual command
440	Init Close CB	PSL	Initiate closing of circuit breaker from a manual command
441 to 442	Unused	PSL	Unused
443	Reset Close Dly	PSL	Reset Manual CB Close Timer Delay (stop & reset Manual Close Delay time for closing CB).
444	Reset Relays/LED	PSL	Reset latched relays & LEDs
445	Reset Thermal	PSL	Reset thermal state to 0%
446	Reset Lockout	PSL	Manual control to reset auto-recloser from lockout
447	Reset CB Data	PSL	Reset CB Maintenance values
448	Block CB AR	PSL	DDB mapped in PSL from opto or comms input. External signal to force CB autoreclose to lockout.
449 to 450	Unused	PSL	Unused
451	Pole Discrepancy	PSL	Pole discrepancy (from external detector) - input used to force a 3 pole trip on CB.
452	Loopback Mode	PSL	To enable loopback mode via opto input
453 to 457	Unused		Unused
458	Inhibit WI	PSL	Inhibit weak infeed aided scheme logic
459	Test Mode	PSL	Commissioning tests - automatically places relay in test mode
460	103 CommandBlock	PSL	For IEC-870-5-103 protocol only, used for "Command Blocking" (relay ignores SCADA commands)
461	103 MonitorBlock	PSL	For IEC-870-5-103 protocol only, used for "Monitor Blocking" (relay is quiet - issues no messages via SCADA port)
462	Unused		Unused
463	Inhibit I>1	PSL	Inhibit stage 1 overcurrent protection
464	Inhibit I>2	PSL	Inhibit stage 2 overcurrent protection
465	Inhibit I>3	PSL	Inhibit stage 3 overcurrent protection
466	Inhibit I>4	PSL	Inhibit stage 4 overcurrent protection
467	Unused		Unused
468	Unused		Unused
469	Unused		Unused
470	Unused		Unused
471	Inhibit V<1	PSL	Inhibit stage 1 undervoltage protection
472	Inhibit V<2	PSL	Inhibit stage 2 undervoltage protection
473	Inhibit V>1	PSL	Inhibit stage 1 overvoltage protection
474	Inhibit V>2	PSL	Inhibit stage 2 overvoltage protection
475	Unused		Unused
476	Unused		Unused
477	Unused	PSL	Unused
478	Inhibit Thermal	PSL	Inhibit thermal overload protection
479	InhibitCB Status	PSL	Inhibit circuit breaker state monitoring (no alarm for defective/stuck auxiliary contact)
480	Inhibit CB Fail	PSL	Inhibit circuit breaker fail protection

DDB No	Text	Source	Description
481	Unused		Unused
482	Inhibit VTS	PSL	Inhibit VT supervision (including turn OF MCB's) via PSL
483	Unused		Unused
484	InhibitChecksync	PSL	Inhibit checksync. (Both stages and for each CB)
485	Inhibit TOR	PSL	Inhibit trip on reclose (TOR)
486	Inhibit SOTF	PSL	Inhibit switch onto fault (SOTF)
487	Unused	PSL	Unused
488	Set SOTF	PSL	To enable SOTF logic by an external pulse. When this input is energized by en external pulse, SOTF becomes enabled during "SOTF Pulse" time setting
489	AR Reset Z1 EXT	Zone 1 Extension Scheme	This signal is to reset the Z1X reach back to Z1 reach in Z1 extension scheme. DDB to be mapped in PSL from either internal or external AR
490	Reset Zone 1 Ext	PSL	Reset zone Z1X back to Z1 reach using logic input (i.e. case when external AR and Z1 extension scheme are used)
491	Unused		Unused
492	Aided 1 COS/LGS	PSL	Aided 1 channel out of service signal (COS) or Loss of Guard Signal (LGS) in distance unblocking schemes. This signal is normally driven from an opto input on conventional channels or from InterMiCOM
493	Aided1 Scheme Rx	PSL	Aided channel 1 - external signal received, for input to distance fixed scheme logic
494	Aided 1 Receive	Aided Scheme Logic	Aided channel 1 - internal signal received generated in the signal receive logic
495	Unused		Unused
496	Aid1 Block Send	PSL	Prevent sending by customized logic - aided scheme 1
497	Aid1 Custom Send	PSL	Programmable send logic for special customized scheme (aided channel 1)
498	Aided 1 Send	Aided Scheme Logic	Aided channel 1 send - internal send signal generated in signal send logic
499	Aid1 Custom T In	PSL	When using a custom programmable aided scheme 1, the user is able to include a current reversal guard timer. Energizing this DDB will additionally start this timer, from PSL
500	Aid1 CustomT Out	Aided Scheme Logic	When using customized aided scheme 1, this signal is used to indicate any additional condition that should be treated as permission for an aided trip (for example a permissive signal received could be connected, or a blocking signal could be inverted and
501	Aid1 Trip Enable	Aided Scheme Logic	Aided scheme 1 trip enable - this is a permissive signal used to accelerate zone 2, or a blocking signal which has been inverted. It is a signal output, part-way through the internal fixed logic of aided schemes
502	Aid1 Custom Trip	PSL	Aid1 custom trip enable
503	Aid 1 Dist Trip	Aided Scheme Logic	Aided scheme 1 distance trip command (output from aided tripping logic)
504	Unused		Unused
505	Unused		Unused
506	Aided 2 COS/LGS	PSL	Aided 2 channel out of service signal (COS) or Loss of Guard Signal (LGS) in distance unblocking schemes. This signal is normally driven from an opto input on conventional channels or from InterMiCOM

DDB No	Text	Source	Description
507	Aided2 Scheme Rx	PSL	Aided channel 2 - external signal received, for input to distance fixed scheme logic
508	Aided 2 Receive	Aided Scheme Logic	Aided channel 2 - internal signal received generated in the signal receive logic
509	RP1 Read Only	RP1 Read Only	Enables RP1 Read Only
510	RP2 Read Only	RP2 Read Only	Enables RP2 Read Only
511	NIC Read Only	NIC Read Only	Enables NIC Read Only
512	Aid2 Block Send	PSL	Prevent sending by customized logic - aided scheme 2
513	Aid2 Custom Send	PSL	Programmable send logic for special customized scheme (aided channel 2)
514	Aided 2 Send	Aided Scheme Logic	Aided channel 2 send - internal send signal generated in signal send logic
515	Aid2 Custom T In	PSL	When using a custom programmable aided scheme 2, the user is able to include a current reversal guard timer. Energizing this DDB will additionally start this timer, from PSL
516	Aid2 CustomT Out	Aided Scheme Logic	When using customized aided scheme 2, this signal is used to indicate any additional condition that should be treated as permission for an aided trip (for example a permissive signal received could be connected, or a blocking signal could be inverted and
517	Aid2 Trip Enable	Aided Scheme Logic	Aided scheme 2 trip enable - this is a permissive signal used to accelerate zone 2, or a blocking signal which has been inverted. It is a signal output, part-way through the internal fixed logic of aided schemes
518	Aid2 Custom Trip	PSL	Aid2 custom trip enable
519	Aid 2 Dist Trip	Aided Scheme Logic	Aided scheme 2 distance trip command (output from aided tripping logic)
520	Unused		Unused
521	Unused		Unused
522	Any Trip	Trip Conversion Logic	Any trip signal - can be used as the trip command in three-pole tripping applications
523	Trip Output Cat	Trip Conversion Logic	Trip signal for phase Cat - used as a command to drive trip Cat output contact(s). Takes the output from the internal trip conversion logic
524	Trip Output Fdr	Trip Conversion Logic	Trip signal for phase Fdr - used as a command to drive trip Fdr output contact(s). Takes the output from the internal trip conversion logic
525	Unused		Unused
526	Trip All	Trip Conversion Logic	Trip signal for All ph - used as a command to drive trip All ph output contact(s). Takes the output from the internal trip conversion logic
527	All Ph Fault	Trip Conversion Logic	All phase fault indication - used to flag whether the fault is polyphase. Typically used to control auto-reclose logic, where auto-reclosing is allowed only for single phase faults
528	Unused		Unused
529	Trip Inputs All	PSL	Trip All phase - input to trip latching logic
530	Trip Inputs Cat	PSL	Cat phase trip - input to trip conversion logic. Essential to ensure correct single or all pole trip command results.
531	Trip Inputs Fdr	PSL	Fdr phase trip - input to trip conversion logic. Essential to ensure correct single or all pole trip command results.
532	Unused		Unused

DDB No	Text	Source	Description
533	Force APole Trip	PSL	External DDB input to host protection trip conversion logic to force All Pole tripping of CB for all faults
534	External TripAll	PSL	External trip All phase - allows external protection to initiate breaker fail, circuit breaker condition monitoring statistics, and internal auto-reclose (if enabled)
535	External TripCat	PSL	External trip Cat phase - allows external protection to initiate breaker fail, circuit breaker condition monitoring statistics, and internal auto-reclose (if enabled)
536	External TripFdr	PSL	External trip Fdr phase - allows external protection to initiate breaker fail, circuit breaker condition monitoring statistics, and internal auto-reclose (if enabled)
537	Unused		Unused
538 to 541	Unused		Unused
542	SG Select x1		Setting group selector X1 (low bit)-selects SG2 if only DDB 542 signal is active. SG1 is active if both DDB 542 & DDB 543=0 SG4 is active if both DDB 542 & DDB 543=1
543	SG Select 1x		Setting group selector 1X (high bit)-selects SG3 if only DDB 543 is active. SG1 is active if both DDB 542 & DDB 543=0 SG4 is active if both DDB 542 & DDB 543=1
544	Clear Statistics	PSL	To reset all statistics values cumulated on the relay. If mapped, the input for this signal could come from a command of the remote end (DDB 1020 - clear stats cmd -) via IM64
545	Unused		Unused
546	Unused		Unused
547	Unused		Unused
548	Unused		Unused
549	Unused		Unused
550	Unused		Unused
551	Unused		Unused
552	Unused		Unused
553	Unused		Unused
554	Unused		Unused
555	Unused		Unused
556	CNV ACTIVE	Distance Basic Scheme	Level detector Current No Volts (CNV) exceeded
557	TOR Trip CNV	Distance Basic Scheme	Trip on Reclose trip due to Current No Volts (CNV) level detectors
558	SOTF Trip CNV	Distance Basic Scheme	Switch on to Fault trip due to Current No Volts (CNV) level detectors
559	Fast OV Cat	Distance Basic Scheme	Phase Cat Fast Overvoltage level detector used by Current No Volts (CNV)
560	Fast OV Fdr	Distance Basic Scheme	Phase Fdr Fast Overvoltage level detector used by Current No Volts (CNV)
561	Unused		Unused
562	Unused		Unused
563	Unused		Unused
564	Unused		Unused
565	Unused		Unused
566	Unused		Unused

DDB No	Text	Source	Description
567	Unused		Unused
568	Unused		Unused
569	Unused		Unused
570	Unused		Unused
571	Unused		Unused
572	Unused		Unused
573	Unused		Unused
574	Unused		Unused
575	Unused		Unused
576	AR Trip Test All	Commissioning Test	Auto-reclose trip test all phase. Indication that a manually-initiated test cycle is in progress
577	AR Trip Test Cat	Commissioning Test	Auto-reclose trip test Cat phase. Indication that a manually-initiated test cycle is in progress
578	AR Trip Test Fdr	Commissioning Test	Auto-reclose trip test Fdr phase. Indication that a manually-initiated test cycle is in progress
579	Unused		Unused
580 to 581	Unused	Autoreclose	Unused
582	Defrost Trip	PSL	Defrost protection Trip signal
583	HZDeltI TripCat	HZ Delta I	Catenary HZ delta I Trip signal
584	HZDeltI TripFdr	HZ Delta I	Feeder HZ delta I Trip signal
585	HZDIISensitFdr	HZ Delta I	Signal to indicate that feeder current is below the set minimum threshold
586	HZDIVSensitFdr	HZ Delta I	Signal to indicate that feeder voltage is below the set minimum threshold
587	HZD ZGND Fw Cat	HZ Delta I	HZ delta forward reactance reach for catenary (Phase to ground)
588	HZD ZGND Rv Cat	HZ Delta I	HZ delta reverse reactance reach for catenary or feeder (Phase to ground)
589	HZD ZGND Fw Fdr	HZ Delta I	HZ delta reverse reactance reach for catenary or feeder (Phase to ground)
590	HZD ZGND Rv Fdr	HZ Delta I	HZ delta reverse reactance reach for catenary or feeder (Phase to ground)
591	Unused		Unused
592	VirtualOutput113	PSL	Virtual output 113 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
593	VirtualOutput114	PSL	Virtual output 114 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
594	VirtualOutput115	PSL	Virtual output 115 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
595	VirtualOutput116	PSL	Virtual output 116 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
596	VirtualOutput117	PSL	Virtual output 117 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
597	VirtualOutput118	PSL	Virtual output 118 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
598	VirtualOutput119	PSL	Virtual output 119 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
599	VirtualOutput120	PSL	Virtual output 120 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
600	VirtualOutput121	PSL	Virtual output 121 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices

DDB No	Text	Source	Description
601	VirtualOutput122	PSL	Virtual output 122 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
602	VirtualOutput123	PSL	Virtual output 123 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
603	VirtualOutput124	PSL	Virtual output 124 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
604	VirtualOutput125	PSL	Virtual output 125 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
605	VirtualOutput126	PSL	Virtual output 126 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
606	VirtualOutput127	PSL	Virtual output 127 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
607	VirtualOutput128	PSL	Virtual output 128 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
608	Zone 1 Trip	Distance Basic Scheme	Zone 1 Trip
609	Zone 1 Cat Trip	Distance Basic Scheme	Zone 1 Cat Phase Trip
610	Zone 1 Fdr Trip	Distance Basic Scheme	Zone 1 Fdr Phase Trip
611	Unused		Unused
612	Zone 1 GND Trip	Distance Basic Scheme	Zone 1 GND Trip
613	Zone 2 Trip	Distance Basic Scheme	Zone 2 Trip
614	Zone 2 Cat Trip	Distance Basic Scheme	Zone 2 Cat Phase Trip
615	Zone 2 Fdr Trip	Distance Basic Scheme	Zone 2 Fdr Phase Trip
616	Unused		Unused
617	Zone 2 GND Trip	Distance Basic Scheme	Zone 2 GND Trip
618	Zone 3 Trip	Distance Basic Scheme	Zone 3 Trip
619	Zone 3 Cat Trip	Distance Basic Scheme	Zone 3 Cat Phase Trip
620	Zone 3 Fdr Trip	Distance Basic Scheme	Zone 3 Fdr Phase Trip
621	Unused		Unused
622	Zone 3 GND Trip	Distance Basic Scheme	Zone 3 GND Trip
623	Zone P Trip	Distance Basic Scheme	Zone P Trip
624	Zone P Cat Trip	Distance Basic Scheme	Zone P Cat Phase Trip
625	Zone P Fdr Trip	Distance Basic Scheme	Zone P Fdr Phase Trip
626	Unused		Unused
627	Zone P GND Trip	Distance Basic Scheme	Zone P GND Trip
628	Zone 4 Trip	Distance Basic Scheme	Zone 4 Trip
629	Zone 4 Cat Trip	Distance Basic Scheme	Zone 4 Cat Phase Trip
630	Zone 4 Fdr Trip	Distance Basic Scheme	Zone 4 Fdr Phase Trip
631	Unused		Unused
632	Zone 4 GND Trip	Distance Basic Scheme	Zone 4 GND Phase Trip
633	Aided 1 Trip Cat	Aided Scheme Logic	Aided scheme 1 trip Cat phase
634	Aided 1 Trip Fdr	Aided Scheme Logic	Aided scheme 1 trip Fdr phase
635	Unused		Unused
636	Aided 1 Trip GND	Aided Scheme Logic	Aided scheme 1 trip involving ground (GND)
637	Aid 1 WI Trip Cat	Aided Scheme Logic	Aided scheme 1 Weak Infeed trip phase Cat
638	Aid 1 WI Trip Fdr	Aided Scheme Logic	Aided scheme 1 Weak Infeed trip phase Fdr
639	Unused		Unused

DDB No	Text	Source	Description
640	Unused		Unused
641	Unused		Unused
642	Aid1 WI Trip All Ph	Aided Scheme Logic	Aided scheme 1 Weak Infeed logic trip All phase
643	Aided 2 Trip Cat	Aided Scheme Logic	Aided scheme 2 trip Cat phase
644	Aided 2 Trip Fdr	Aided Scheme Logic	Aided scheme 2 trip Fdr phase
645	Unused		Unused
646	Aided 2 Trip GND	Aided Scheme Logic	Aided scheme 2 trip involving ground (GND)
647	Aid 2 WI Trip Cat	Aided Scheme Logic	Aided scheme 2 Weak Infeed trip phase Cat
648	Aid 2 WI Trip Fdr	Aided Scheme Logic	Aided scheme 2 Weak Infeed trip phase Fdr
649	Unused		Unused
650	Unused		Unused
651	Unused		Unused
652	Aid2 WI Trip All	Aided Scheme Logic	Aided scheme 2 Weak Infeed logic trip All phase
653	Unused		Unused
654	Unused		Unused
655	I>1 Trip	Overcurrent	1st stage phase overcurrent trip All phase
656	I>1 Trip Cat	Overcurrent	1st stage phase overcurrent trip phase Cat
657	I>1 Trip Fdr	Overcurrent	1st stage phase overcurrent trip phase Fdr
658	Unused		Unused
659	I>2 Trip	Overcurrent	2nd stage phase overcurrent trip All phase
660	I>2 Trip Cat	Overcurrent	2nd stage phase overcurrent trip phase Cat
661	I>2 Trip Fdr	Overcurrent	2nd stage phase overcurrent trip phase Fdr
662	Unused		Unused
663	I>3 Trip	Overcurrent	3rd stage phase overcurrent trip All phase
664	I>3 Trip Cat	Overcurrent	3rd stage phase overcurrent trip phase Cat
665	I>3 Trip Fdr	Overcurrent	3rd stage phase overcurrent trip phase Fdr
666	Unused		Unused
667	I>4 Trip	Overcurrent	4th stage phase overcurrent trip All phase
668	I>4 Trip Cat	Overcurrent	4th stage phase overcurrent trip phase Cat
669	I>4 Trip Fdr	Overcurrent	4th stage phase overcurrent trip phase Fdr
670	Unused		Unused
671	Unused		Unused
672	Unused		Unused
673	Unused		Unused
674	Unused		Unused
675	Unused		Unused
676	Unused		Unused
677	Unused		Unused
678	Unused		Unused
679	Unused		Unused
680	Thermal Trip	Thermal overload	Thermal Overload Trip
681	Unused		Unused
682	Unused		Unused
683	V<1 Trip	Undervoltage	Undervoltage stage 1, all phase trip

DDB No	Text	Source	Description
684	V<1 Trip Cat	Undervoltage	Undervoltage stage 1 Cat phase trip
685	V<1 Trip Fdr	Undervoltage	Undervoltage stage 1 Fdr phase trip
686	Unused		Unused
687	V<2 Trip	Undervoltage	Undervoltage stage 2, all phase trip
688	V<2 Trip Cat	Undervoltage	Undervoltage stage 2 Cat phase trip
689	V<2 Trip Fdr	Undervoltage	Undervoltage stage 2 Fdr phase trip
690	Unused		Unused
691	V>1 Trip	Overvoltage	Overvoltage stage 1, all phase trip
692	V>1 Trip Cat	Overvoltage	Overvoltage stage 1 Cat phase trip
693	V>1 Trip Fdr	Overvoltage	Overvoltage stage 1 FdrC phase trip
694	Unused		Unused
695	V>2 Trip	Overvoltage	Overvoltage stage 2, all phase trip
696	V>2 Trip Cat	Overvoltage	Overvoltage stage 2 Cat phase trip
697	V>2 Trip Fdr	Overvoltage	Overvoltage stage 2 Fdr phase trip
698	Unused		Unused
699	Pole Discrepancy	Pole discrepency	Pole Discrepancy (signal raised when a pole discrepancy state is detected on CB)
700	Unused		Unused
701	Unused		Unused
702	Fault REC TRIG	PSL	Trigger for Fault Recorder
703	Unused	Neg Sequence overcurrent	Unused
704	TOR Trip Zone 1	Trip on Close	TOR trip zone 1 (trip on reclose)
705	TOR Trip Zone 2	Trip on Close	TOR Trip Zone 2
706	TOR Trip Zone 3	Trip on Close	TOR Trip Zone 3
707	TOR Trip Zone 4	Trip on Close	TOR Trip Zone 4
708	TOR Trip Zone P	Trip on Close	TOR Trip Zone P
709	SOTF Trip Zone 1	Trip on Close	SOTF Trip Zone 1 (switch on to fault)
710	SOTF Trip Zone 2	Trip on Close	SOTF Trip Zone 2
711	SOTF Trip Zone 3	Trip on Close	SOTF Trip Zone 3
712	SOTF Trip Zone 4	Trip on Close	SOTF Trip Zone 4
713	SOTF Trip Zone P	Trip on Close	SOTF Trip Zone P
714 to 720	Unused		Unused
721	Unused	PSL	Unused
722 to 728	Unused		Unused
729 to 735	Unused	SW	Unused
736	Any Start	PSL	Any Start
737	Defrost Start	PSL	Defrost Protection Start Signal.
738	Allow Defrost	PSL	Enable defrost protection
739	Catenary ZCD	SW	Zero Cross Detector for catenary
740	Feeder ZCD	SW	Zero Cross Detector for feeder
741	Zone 1 Cat Start	Distance Basic Scheme	Zone 1 Cat Phase Start
742	Zone 1 Fdr Start	Distance Basic Scheme	Zone 1 Fdr Phase Start
743	Unused		Unused
744	Zone 1 GND Start	Distance Basic Scheme	Zone 1 GND Start
745	Zone 2 Cat Start	Distance Basic Scheme	Zone 2 Cat Phase Start

DDB No	Text	Source	Description
746	Zone 2 Fdr Start	Distance Basic Scheme	Zone 2 Fdr Phase Start
747	Unused		Unused
748	Zone 2 GND Start	Distance Basic Scheme	Zone 2 GND start
749	Zone 3 Cat Start	Distance Basic Scheme	Zone 3 Cat Phase Start
750	Zone 3 Fdr Start	Distance Basic Scheme	Zone 3 Fdr Phase Start
751	Unused		Unused
752	Zone 3 GND Start	Distance Basic Scheme	Zone 3 GND Start
753	Zone P Cat Start	Distance Basic Scheme	Zone P Cat Phase Start
754	Zone P Fdr Start	Distance Basic Scheme	Zone P Fdr Phase Start
755	Unused		Unused
756	Zone P GND Start	Distance Basic Scheme	Zone P GND Start
757	Zone 4 Cat Start	Distance Basic Scheme	Zone 4 Cat Phase Start
758	Zone 4 Fdr Start	Distance Basic Scheme	Zone 4 Fdr Phase Start
759	Unused		Unused
760	Zone 4 GND Start	Distance Basic Scheme	Zone 4 GND Start
761	I>1 Start	Overcurrent	1st stage overcurrent start all phase
762	I>1 Start Cat	Overcurrent	1st stage overcurrent start phase Cat
763	I>1 Start Fdr	Overcurrent	1st stage overcurrent start phase Fdr
764	Unused		Unused
765	I>2 Start	Overcurrent	2nd stage overcurrent start all phase
766	I>2 Start Cat	Overcurrent	2nd stage overcurrent start phase Cat
767	I>2 Start Fdr	Overcurrent	2nd stage overcurrent start phase Fdr
768	Unused		Unused
769	I>3 Start	Overcurrent	3rd stage overcurrent start all phase
770	I>3 Start Cat	Overcurrent	3rd stage overcurrent start phase Cat
771	I>3 Start Fdr	Overcurrent	3rd stage overcurrent start phase Fdr
772	Unused		Unused
773	I>4 Start	Overcurrent	4th stage overcurrent start all phase
774	I>4 Start Cat	Overcurrent	4th stage overcurrent start phase Cat
775	I>4 Start Fdr	Overcurrent	4th stage overcurrent start phase Fdr
776	Unused		Unused
777	Unused		Unused
778	Unused		Unused
779	Unused		Unused
780	Unused		Unused
781	Unused		Unused
782	Unused		Unused
783	Unused		Unused
784	Unused		Unused
785	Thermal Alarm	Thermal overload	Thermal Overload Alarm
786	Unused		Unused
787	Unused		Unused
788	V<1 Start	Undervoltage	Undervoltage stage 1, all phase start
789	V<1 Start Cat	Undervoltage	Undervoltage stage 1, Cat phase start

DDB No	Text	Source	Description
790	V<1 Start Fdr	Undervoltage	Undervoltage stage 1, Fdr phase start
791	Unused		Unused
792	V<2 Start	Undervoltage	Undervoltage stage 2, all phase start
793	V<2 Start Cat	Undervoltage	Undervoltage stage 2, Cat phase start
794	V<2 Start Fdr	Undervoltage	Undervoltage stage 2, Fdr phase start
795	Unused		Unused
796	V>1 Start	Overvoltage	Overvoltage stage 1, all phase start
797	V>1 Start Cat	Overvoltage	Overvoltage stage 1, Cat phase start
798	V>1 Start Fdr	Overvoltage	Overvoltage stage 1, Fdr phase start
799	Unused		Unused
800	V>2 Start	Overvoltage	Overvoltage stage 2, all phase start
801	V>2 Start Cat	Overvoltage	Overvoltage stage 2, Cat phase start
802	V>2 Start Fdr	Overvoltage	Overvoltage stage 2, Fdr phase start
803	Unused		Unused
804	Unused		Unused
805	Unused		Unused
806	Unused		Unused
807	PantoFlash Start	Panto Flash Over	The panto flash over overvoltage element start
808	PantoFlash Start	Panto Flash Over	The panto flash over overvoltage element issue a trip
809	Unused		Unused
810	Z2di/dt inactive	Train Startup	It indicate train start-up di/dt stage is inactive in zone 2
811	Z2dv/dt inactive	Train Startup	It indicate train start-up dv/dt stage is inactive in zone 2
812	Z2dphi/dt inact.	Train Startup	It indicate train start-up dphi/dt stage is inactive in zone 2
813	Z3di/dt inactive	Train Startup	It indicate train start-up di/dt stage is inactive in zone 3
814	Z3dv/dt inactive	Train Startup	It indicate train start-up dv/dt stage is inactive in zone 3
815	Z3dphi/dt inact.	Train Startup	It indicate train start-up dphi/dt stage is inactive in zone 3
816	Z2di/dt start	Train Startup	It indicate train start-up di/dt stage is starting in zone 2
817	Z2dv/dt start	Train Startup	It indicate train start-up dv/dt stage is starting in zone 2
818	Z2dphi/dt start	Train Startup	It indicate train start-up dphi/dt stage is starting in zone 2
819	Z3di/dt start	Train Startup	It indicate train start-up di/dt stage is starting in zone 3
820	Z3dv/dt start	Train Startup	It indicate train start-up dv/dt stage is starting in zone 3
821	Z3dphi/dt start	Train Startup	It indicate train start-up dphi/dt stage is starting in zone 3
822	tZ2A enable	Train Startup	It indicate train start-up shorter time delay enable in zone 2
823	tZ23S enable	Train Startup	It indicate train start-up shorter time delay enable in zone 3
824 to 828	Unused		Unused
829	VCat< start	Poledead	Phase Cat undervoltage level detector used in the pole dead logic. Detectors have a settable threshold: default undervoltage pickup 38.1 V-drop off 43.8 V
830	VFdr< start	Poledead	Phase Fdr undervoltage level detector used in the pole dead logic. Detectors have a settable threshold: default undervoltage pickup 38.1 V-drop off 43.8 V
831	Unused		Unused
832	VTS Fast Block	VT Supervision	VT supervision fast block - blocks elements which would otherwise maloperate immediately a fuse failure event occurs
833	VTS Slow Block	VT Supervision	VT supervision slow block - blocks elements which would otherwise maloperate some time after a fuse failure event occurs

DDB No	Text	Source	Description
834	Bfail1 Trip All	CB Fail	All phase output from circuit breaker failure logic, stage 1
835	Bfail2 Trip All	CB Fail	All phase output from circuit breaker failure logic, stage 2
836	Unused	CB Fail	Unused
837	Unused	CB Fail	Unused
838	Control Trip	CB Control	Control trip - operator trip instruction to the circuit breaker, via menu, or SCADA. (Does not operate for protection element trips)
839	Control Close	CB Control	Control close command to the circuit breaker. Operates for a manual close command (menu, SCADA), and additionally is driven by the auto-reclose close command
840	Unused	CB Control	Unused
841	Unused	CB Control	Unused
842	Close in Prog	CB Control	Control close in progress - the relay has been given an instruction to close the circuit breaker, but the manual close timer delay has not yet finished timing out
843	Unused	Autoreclose	Unused
844	AR Apole in prog	Autoreclose	Auto Reclose All pole in Progress
845	AR Spole in prog	Autoreclose	Auto Reclose AR Single1 pole in Progress
846	Seq Counter = 0	Autoreclose	Sequence Counter = 0
847	Seq Counter = 1	Autoreclose	Sequence Counter = 1
848	Seq Counter = 2	Autoreclose	Sequence Counter = 2
849	Seq Counter = 3	Autoreclose	Sequence Counter = 3
850	Seq Counter = 4	Autoreclose	Sequence Counter = 4
851	Seq Counter > 4	Autoreclose	Sequence Counter > 4
852	CB Succ AP AR	Autoreclose	This signal is set when CB has successfully completed a all phase autoreclose cycle.
853	AP Dead Time IP	Autoreclose	All pole dead time in progress
854	Auto Close	Autoreclose	This is a signal issued by the autoreclose logic to the general CB Control logic when the conditions to autoreclose CB are satisfied (dead time complete, CB healthy etc).
855	Unused		Unused
856	Unused	Autoreclose	Unused
857	Unused	Autoreclose	Unused
858	AR Force Apole	Autoreclose	Used by in-built Trip conversion logic to allow AR to convert CB to all pole tripping
859	AR Blocked	Autoreclose	Indicates that AR is in one of the following states, Disabled, Inhibited, AR In Progress or Locked out
860	Lockout Alarm	CB Control	Composite lockout alarm - circuit breaker locked out due to auto-recloser, or condition monitoring reasons
861	Unused	C Diff	Unused
862	Block Contacts	PSL	DDB to block output contacts, same as setting Commissioning Column -> Test Mode -> Contacts Blocked
863	Contacts Blocked	SW	Indicates contacts blocked mode enabled. Can be mapped in PSL and sent via InterMiCOM/IM64 to block contacts at the remote end.
864	Icat< Start	Undercurrent	Cat phase undercurrent level detector pickup (detects low current). It is used for breaker failure and for fault record reset.
865	Ifdr< Start	Undercurrent	Fdr phase undercurrent level detector pickup (detects low current). It is used for breaker failure and for fault record reset.
866 to 873	Unused		Unused

DDB No	Text	Source	Description
874	CBF Non I Trip	PSL	Mapped in PSL to all none current protection trip signals to initiate CB Fail
875	Unused		Unused
876	Z1X Active	Zone 1 Extension Scheme	Zone 1 extension active - zone 1 is operating in its reach extended mode
877	TOC Active	Trip on Close	Trip on close functions (either SOTF or TOR) active. These elements are in-service for a period of time following circuit breaker closure
878	TOR Active	Trip on Close	Trip on re-close protection is active - indicated TOC delay timer has elapsed after circuit breaker opening, and remains in-service on auto-reclosure for the duration of the trip on close window
879	SOTF Active	Trip on Close	Switch on to fault protection is active - in service on manual breaker closure, and then remains in-service for the duration of the trip on close window
880	SysChks Inactive	Check sync	System checks inactive (output from the check synchronism, and other voltage checks)
881	CS1 Enabled	PSL	DDB input must be high to enable check sync stage 1 logic to operate. Defaults to high if not mapped in PSL; if mapped in PSL must be driven high.
882	CS2 Enabled	PSL	DDB input must be high to enable check sync stage 2 logic to operate. Defaults to high if not mapped in PSL; if mapped in PSL must be driven high.
883	Check Sync 1 OK	Check sync	Output from Check Sync logic, when enabled: indicates set conditions for sync check stage 1 are satisfied.
884	Check Sync 2 OK	Check sync	Output from Check Sync logic, when enabled: indicates set conditions for sync check stage 2 are satisfied.
885	Unused	PSL	Unused
886	Live Bus	Voltage Monitoring	Indicates Bus input is live, i.e. voltage >= setting "Live Bus"
887	Dead Bus	Voltage Monitoring	Indicates Bus input is dead, i.e. voltage < setting "Dead Bus"
888	Live Line	Voltage Monitoring	Indicates Line input is live, i.e. voltage >= setting "Live Line"
889	Dead Line	Voltage Monitoring	Indicates Line input is dead, i.e. voltage < setting "Dead Line"
890	All Poles Dead	Poledead logic	Pole dead logic detects 3 phase breaker open
891	Any Pole Dead	Poledead logic	Pole dead logic detects at least one breaker pole open
892	Pole Dead Cat	Poledead logic	Phase Cat Pole Dead
893	Pole Dead Fdr	Poledead logic	Phase Fdr Pole Dead
894	Unused	Poledead logic	Unused
895	VTS Acc Ind	Fixed Logic	Any Trip
896	VTS Volt Dep	Fixed Logic	Any Voltage Dependent Function
897	Unused	PSL	Unused
898	Ctl Check Sync	PSL	Input to the circuit breaker control logic to indicate manual check synchronization conditions are satisfied
899	Unused	PSL	Unused
900	Ext CS OK	PSL	External check-sync is OK
901	Unused	PSL	Unused
902	Unused	PSL	Unused
903	CB Open All	CB Status	Circuit breaker is open, all phases
904	CB Open Cat	CB Status	Circuit breaker Cat phase is open
905	CB Open Fdr	CB Status	Circuit breaker Fdr phase is open
906	Unused	CB Status	Unused

DDB No	Text	Source	Description
907	CB Closed All	CB Status	Circuit breaker is closed, all phases
908	CB Closed Cat	CB Status	Circuit breaker Cat phase is closed
909	CB Closed Fdr	CB Status	Circuit breaker Fdr phase is closed
910 to 919	Unused		Unused
920	PubPres VIP 97	GOOSE Input Command	GOOSE virtual input 97- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
921	PubPres VIP 98	GOOSE Input Command	GOOSE virtual input 98- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
922	PubPres VIP 99	GOOSE Input Command	GOOSE virtual input 99- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
923	PubPres VIP 100	GOOSE Input Command	GOOSE virtual input 100- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
924	PubPres VIP 101	GOOSE Input Command	GOOSE virtual input 101- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
925	PubPres VIP 102	GOOSE Input Command	GOOSE virtual input 102- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
926	PubPres VIP 103	GOOSE Input Command	GOOSE virtual input 103- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
927	PubPres VIP 104	GOOSE Input Command	GOOSE virtual input 104- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
928	PubPres VIP 105	GOOSE Input Command	GOOSE virtual input 105- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
929	PubPres VIP 106	GOOSE Input Command	GOOSE virtual input 106- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
930	PubPres VIP 107	GOOSE Input Command	GOOSE virtual input 107- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
931	PubPres VIP 108	GOOSE Input Command	GOOSE virtual input 108- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
932	PubPres VIP 109	GOOSE Input Command	GOOSE virtual input 109- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
933	PubPres VIP 110	GOOSE Input Command	GOOSE virtual input 110- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
934	PubPres VIP 111	GOOSE Input Command	GOOSE virtual input 111- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
935	PubPres VIP 112	GOOSE Input Command	GOOSE virtual input 112- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
936	PubPres VIP 113	GOOSE Input Command	GOOSE virtual input 113- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.

DDB No	Text	Source	Description
937	PubPres VIP 114	GOOSE Input Command	GOOSE virtual input 114- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
938	PubPres VIP 115	GOOSE Input Command	GOOSE virtual input 115- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
939	PubPres VIP 116	GOOSE Input Command	GOOSE virtual input 116- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
940	PubPres VIP 117	GOOSE Input Command	GOOSE virtual input 117- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
941	PubPres VIP 118	GOOSE Input Command	GOOSE virtual input 118- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
942	PubPres VIP 119	GOOSE Input Command	GOOSE virtual input 119- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
943	PubPres VIP 120	GOOSE Input Command	GOOSE virtual input 120- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
944	PubPres VIP 121	GOOSE Input Command	GOOSE virtual input 121- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
945	PubPres VIP 122	GOOSE Input Command	GOOSE virtual input 122- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
946	PubPres VIP 123	GOOSE Input Command	GOOSE virtual input 123- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
947	PubPres VIP 124	GOOSE Input Command	GOOSE virtual input 124- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
948	PubPres VIP 125	GOOSE Input Command	GOOSE virtual input 125- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
949	PubPres VIP 126	GOOSE Input Command	GOOSE virtual input 126- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
950	PubPres VIP 127	GOOSE Input Command	GOOSE virtual input 127- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
951	PubPres VIP 128	GOOSE Input Command	GOOSE virtual input 128- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
952	Faulted Phase Cat	PSL	Faulted phase Cat - must be assigned, as this sets the start flag used in records, and on the LCD display
953	Faulted Phase Fdr	PSL	Faulted phase Fdr - must be assigned, as this sets the start flag used in records, and on the LCD display
954	Unused		Unused
955	Faulted Phase GND	PSL	Faulted phase GND (fault involves ground) - must be assigned, as this sets the start flag used in records, and on the LCD display
956	Started Phase Cat	PSL	Started phase Cat - must be assigned, as this sets the start flag used in records, and on the LCD display

DDB No	Text	Source	Description
957	Started Phase Fdr	PSL	Started phase Fdr - must be assigned, as this sets the start flag used in records, and on the LCD display
958	Unused		Unused
959	Started Phase GND	PSL	Started phase GND (fault involves ground) - must be assigned, as this sets the start flag used in records, and on the LCD display
960	Zone1 Cat	Distance Elements	Zone 1 Cat ground fault element
961	Zone1 Fdr	Distance Elements	Zone 1 Fdr ground fault element
962	Unused		Unused
963	Zone1 Cat-Fdr Element	Distance Elements	Zone 1 Cat-Fdr phase fault element
964	Unused		Unused
965	Unused		Unused
966	Zone2 Cat	Distance Elements	Zone 2 Cat ground fault element
967	Zone2 Fdr	Distance Elements	Zone 2 Fdr ground fault element
968	Unused		Unused
969	Zone2 Cat-Fdr	Distance Elements	Zone 2 Cat-Fdr phase fault element
970	Unused		Unused
971	Unused		Unused
972	Zone3 Cat	Distance Elements	Zone 3 Cat ground fault element
973	Zone3 Fdr	Distance Elements	Zone 3 Fdr ground fault element
974	Unused		Unused
975	Zone3 Cat-Fdr	Distance Elements	Zone 3 Cat-Fdr phase fault element
976	Unused		Unused
977	Unused		Unused
978	ZoneP Cat	Distance Elements	Zone P Cat ground fault element
979	ZoneP Fdr	Distance Elements	Zone P Fdr ground fault element
980	Unused		Unused
981	ZoneP Cat-Fdr	Distance Elements	Zone P Cat-Fdr phase fault element
982	Unused		Unused
983	Unused		Unused
984	Zone4 Cat	Distance Elements	Zone 4 Cat ground fault element
985	Zone4 Fdr	Distance Elements	Zone 4 Fdr ground fault element
986	Unused		Unused
987	Zone4 Cat-Fdr	Distance Elements	Zone 4 Cat-Fdr phase fault element
988 to 993	Unused		Unused
994	Virtual Output97	PSL	Virtual output 97 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
995	Virtual Output98	PSL	Virtual output 98 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
996	Virtual Output99	PSL	Virtual output 99 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
997	VirtualOutput100	PSL	Virtual output 100 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
998	VirtualOutput101	PSL	Virtual output 101 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
999	VirtualOutput102	PSL	Virtual output 102 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices

DDB No	Text	Source	Description
1000	VirtualOutput103	PSL	Virtual output 103 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1001	VirtualOutput104	PSL	Virtual output 104 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1002	VirtualOutput105	PSL	Virtual output 105 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1003	VirtualOutput106	PSL	Virtual output 106 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1004	VirtualOutput107	PSL	Virtual output 107 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1005	VirtualOutput108	PSL	Virtual output 108 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1006	VirtualOutput109	PSL	Virtual output 109 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1007	VirtualOutput110	PSL	Virtual output 110 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1008	VirtualOutput111	PSL	Virtual output 111 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1009	VirtualOutput112	PSL	Virtual output 112 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1010	Phase Select Cat	Phase Selector	Phase selector - phase Cat pickup
1011	Phase Select Fdr	Phase Selector	Phase selector - phase Fdr pickup
1012	Unused		Unused
1013	Unused		Unused
1014	Unused		Unused
1015	Unused		Unused
1016	Unused		Unused
1017	Ih(2) Blk Fdr	Inrush Detector	2nd harmonic current ratio exceeds threshold on phase B (may be used to block any instantaneous distance elements that reach through the reactance of a power transformer)
1018	Ih(3) Blk Cat	Supervision	3rd harmonic current ratio exceeds threshold on phase A (may be used to block high impedance delta I protection or desensitise it)
1019	Ih(3) Blk Fdr	Supervision	3rd harmonic current ratio exceeds threshold on phase B (may be used to block high impedance delta I protection or desensitise it)
1020	Ih(5) Blk Cat	Supervision	5th harmonic current ratio exceeds threshold on phase A (may be used to block high impedance delta I protection or desensitise it)
1021	Ih(5) Blk Fdr	Supervision	5th harmonic current ratio exceeds threshold on phase B (may be used to block high impedance delta I protection or desensitise it)
1022 to 1023	Unused		Unused
1024	LED1 Red	Tri LED Red 1	Programmable LED 1 red is energized
1025	LED1 Grn	Tri LED Green 1	Programmable LED 1 green is energized
1026	LED2 Red	Tri LED Red 2	Programmable LED 2 red is energized
1027	LED2 Grn	Tri LED Green 2	Programmable LED 2 green is energized
1028	LED3 Red	Tri LED Red 3	Programmable LED 3 red is energized
1029	LED3 Grn	Tri LED Green 3	Programmable LED 3 green is energized
1030	LED4 Red	Tri LED Red 4	Programmable LED 4 red is energized
1031	LED4 Grn	Tri LED Green 4	Programmable LED 4 green is energized
1032	LED5 Red	Tri LED Red 5	Programmable LED 5 red is energized
1033	LED5 Grn	Tri LED Green 5	Programmable LED 5 green is energized

DDB No	Text	Source	Description
1034	LED6 Red	Tri LED Red 6	Programmable LED 6 red is energized
1035	LED6 Grn	Tri LED Green 6	Programmable LED 6 green is energized
1036	LED7 Red	Tri LED Red 7	Programmable LED 7 red is energized
1037	LED7 Grn	Tri LED Green 7	Programmable LED 7 green is energized
1038	LED8 Red	Tri LED Red 8	Programmable LED 8 red is energized
1039	LED8 Grn	Tri LED Green 8	Programmable LED 8 green is energized
1040	FnKey LED1 Red	Tri LED Red 9	Programmable function key LED 1 red is energized
1041	FnKey LED1 Grn	Tri LED Green 9	Programmable function key LED 1 green is energized
1042	FnKey LED2 Red	Tri LED Red 10	Programmable function key LED 2 red is energized
1043	FnKey LED2 Grn	Tri LED Green 10	Programmable function key LED 2 green is energized
1044	FnKey LED3 Red	Tri LED Red 11	Programmable function key LED 3 red is energized
1045	FnKey LED3 Grn	Tri LED Green 11	Programmable function key LED 3 green is energized
1046	FnKey LED4 Red	Tri LED Red 12	Programmable function key LED 4 red is energized
1047	FnKey LED4 Grn	Tri LED Green 12	Programmable function key LED 4 green is energized
1048	FnKey LED5 Red	Tri LED Red 13	Programmable function key LED 5 red is energized
1049	FnKey LED5 Grn	Tri LED Green 13	Programmable function key LED 5 green is energized
1050	FnKey LED6 Red	Tri LED Red 14	Programmable function key LED 6 red is energized
1051	FnKey LED6 Grn	Tri LED Green 14	Programmable function key LED 6 green is energized
1052	FnKey LED7 Red	Tri LED Red 15	Programmable function key LED 7 red is energized
1053	FnKey LED7 Grn	Tri LED Green 15	Programmable function key LED 7 green is energized
1054	FnKey LED8 Red	Tri LED Red 16	Programmable function key LED 8 red is energized
1055	FnKey LED8 Grn	Tri LED Green 16	Programmable function key LED 8 green is energized
1056	FnKey LED9 Red	Tri LED Red 17	Programmable function key LED 9 red is energized
1057	FnKey LED9 Grn	Tri LED Green 17	Programmable function key LED 9 green is energized
1058	FnKey LED10 Red	Tri LED Red 18	Programmable function key LED 10 red is energized
1059	FnKey LED10 Grn	Tri LED Green 18	Programmable function key LED 10 green is energized
1060	LED1 Con R	LED_CON_R1	Assignment of input signal to drive output LED 1 red
1061	LED1 Con G	LED_CON_G1	Assignment of signal to drive output LED 1 green. To drive LED 1 yellow DDB 1024 and DDB 1025 must be driven at the same time
1062	LED2 Con R	LED_CON_R2	Assignment of input signal to drive output LED 2 red
1063	LED2 Con G	LED_CON_G2	Assignment of signal to drive output LED 2 green. To drive LED 2 yellow DDB 1026 and DDB 1027 must be driven at the same time
1064	LED3 Con R	LED_CON_R3	Assignment of input signal to drive output LED 3 red
1065	LED3 Con G	LED_CON_G3	Assignment of signal to drive output LED 3 green. To drive LED 3 yellow DDB 1028 and DDB 1029 must be driven at the same time
1066	LED4 Con R	LED_CON_R4	Assignment of input signal to drive output LED 4 red
1067	LED4 Con G	LED_CON_G4	Assignment of signal to drive output LED 4 green. To drive LED 4 yellow DDB 1030 and DDB 1031 must be driven at the same time
1068	LED5 Con R	LED_CON_R5	Assignment of input signal to drive output LED 5 red
1069	LED5 Con G	LED_CON_G5	Assignment of signal to drive output LED 5 green. To drive LED 5 yellow DDB 1032 and DDB 1033 must be driven at the same time
1070	LED6 Con R	LED_CON_R6	Assignment of input signal to drive output LED 6 red

DDB No	Text	Source	Description
1071	LED6 Con G	LED_CON_G6	Assignment of signal to drive output LED 6 green. To drive LED 6 yellow DDB 1034 and DDB 1035 must be driven at the same time
1072	LED7 Con R	LED_CON_R7	Assignment of input signal to drive output LED 7 red
1073	LED7 Con G	LED_CON_G7	Assignment of signal to drive output LED 7 green. To drive LED 7 yellow DDB 1036 and DDB 1037 must be driven at the same time
1074	LED8 Con R	LED_CON_R8	Assignment of input signal to drive output LED 8 red
1075	LED8 Con G	LED_CON_G8	Assignment of signal to drive output LED 8 green. To drive LED 8 yellow DDB 1038 and DDB 1039 must be driven at the same time
1076	FnKey LED1 ConR	LED_CON_R9	Assignment of signal to drive output function key LED 1 red. This LED is associated with function key 1
1077	FnKey LED1 ConG	LED_CON_G9	Assignment of signal to drive output function key LED 1 green. This LED is associated with function key 1. To drive function key LED, yellow DDB 1040 and DDB 1041 must be active at the same time
1078	FnKey LED2 ConR	LED_CON_R10	Assignment of signal to drive output function key LED 2 red. This LED is associated with function key 2
1079	FnKey LED2 ConG	LED_CON_G10	Assignment of signal to drive output function key LED 2 green. This LED is associated with function key 2. To drive function key LED, yellow DDB 1042 and DDB 1043 must be active at the same time
1080	FnKey LED3 ConR	LED_CON_R11	Assignment of signal to drive output function key LED 3 red. This LED is associated with function key 3
1081	FnKey LED3 ConG	LED_CON_G11	Assignment of signal to drive output function key LED 3 green. This LED is associated with function key 3. To drive function key LED, yellow DDB 1044 and DDB 1045 must be active at the same time
1082	FnKey LED4 ConR	LED_CON_R12	Assignment of signal to drive output function key LED 4 red. This LED is associated with function key 4
1083	FnKey LED4 ConG	LED_CON_G12	Assignment of signal to drive output function key LED 4 green. This LED is associated with function key 4. To drive function key LED, yellow DDB 1046 and DDB 1047 must be active at the same time
1084	FnKey LED5 ConR	LED_CON_R13	Assignment of signal to drive output function key LED 5 red. This LED is associated with function key 5
1085	FnKey LED5 ConG	LED_CON_G13	Assignment of signal to drive output function key LED 5 green. This LED is associated with function key 5. To drive function key LED, yellow DDB 1048 and DDB 1049 must be active at the same time
1086	FnKey LED6 ConR	LED_CON_R14	Assignment of signal to drive output function key LED 6 red. This LED is associated with function key 6
1087	FnKey LED6 ConG	LED_CON_G14	Assignment of signal to drive output function key LED 6 green. This LED is associated with function key 6. To drive function key LED, yellow DDB 1050 and DDB 1051 must be active at the same time
1088	FnKey LED7 ConR	LED_CON_R15	Assignment of signal to drive output function key LED 7 red. This LED is associated with function key 7
1089	FnKey LED7 ConG	LED_CON_G15	Assignment of signal to drive output function key LED 7 green. This LED is associated with function key 7. To drive function key LED, yellow DDB 1052 and DDB 1053 must be active at the same time
1090	FnKey LED8 ConR	LED_CON_R16	Assignment of signal to drive output function key LED 8 red. This LED is associated with function key 8

DDB No	Text	Source	Description
1091	FnKey LED8 ConG	LED_CON_G16	Assignment of signal to drive output function key LED 8 green. This LED is associated with function key 8. To drive function key LED, yellow DDB 1054 and DDB 1055 must be active at the same time
1092	FnKey LED9 ConR	LED_CON_R17	Assignment of signal to drive output function key LED 9 red. This LED is associated with function key 9
1093	FnKey LED9 ConG	LED_CON_G17	Assignment of signal to drive output function key LED 9 green. This LED is associated with function key 9. To drive function key LED, yellow DDB 1056 and DDB 1057 must be active at the same time
1094	FnKey LED10 ConR	LED_CON_R18	Assignment of signal to drive output function key LED 10 red. This LED is associated with function key 10
1095	FnKey LED10 ConG	LED_CON_G18	Assignment of signal to drive output function key LED 10 green. This LED is associated with function key 10. To drive function key LED, yellow DDB 1058 and DDB 1059 must be active at the same time
1096	Function Key 1	Function Key 1	Function key 1 is activated. In ‘Normal’ mode it is high on keypress and in ‘Toggle’ mode remains high/low on single keypress
1097	Function Key 2	Function Key 2	Function key 2 is activated. In ‘Normal’ mode it is high on keypress and in ‘Toggle’ mode remains high/low on single keypress
1098	Function Key 3	Function Key 3	Function key 3 is activated. In ‘Normal’ mode it is high on keypress and in ‘Toggle’ mode remains high/low on single keypress
1099	Function Key 4	Function Key 4	Function key 4 is activated. In ‘Normal’ mode it is high on keypress and in ‘Toggle’ mode remains high/low on single keypress
1100	Function Key 5	Function Key 5	Function key 5 is activated. In ‘Normal’ mode it is high on keypress and in ‘Toggle’ mode remains high/low on single keypress
1101	Function Key 6	Function Key 6	Function key 6 is activated. In ‘Normal’ mode it is high on keypress and in ‘Toggle’ mode remains high/low on single keypress
1102	Function Key 7	Function Key 7	Function key 7 is activated. In ‘Normal’ mode it is high on keypress and in ‘Toggle’ mode remains high/low on single keypress
1103	Function Key 8	Function Key 8	Function key 8 is activated. In ‘Normal’ mode it is high on keypress and in ‘Toggle’ mode remains high/low on single keypress
1104	Function Key 9	Function Key 9	Function key 9 is activated. In ‘Normal’ mode it is high on keypress and in ‘Toggle’ mode remains high/low on single keypress
1105	Function Key 10	Function Key 10	Function key 10 is activated. In ‘Normal’ mode it is high on keypress and in ‘Toggle’ mode remains high/low on single keypress
1106	CB I^ Maint	CB Monitoring	Broken current maintenance alarm - circuit breaker cumulative duty alarm set-point
1107	CB I^ Lockout	CB Monitoring	Broken current lockout alarm - circuit breaker cumulative duty has been exceeded
1108	No.CB OPs Maint	CB Monitoring	No of circuit breaker operations maintenance alarm - indicated due to circuit breaker trip operations threshold
1109	No.CB OPs Lock	CB Monitoring	No of circuit breaker operations maintenance lockout - excessive number of circuit breaker trip operations, safety lockout

DDB No	Text	Source	Description
1110	CB Time Maint	CB Monitoring	Excessive circuit breaker operating time maintenance alarm - excessive operation time alarm for the circuit breaker (slow interruption time)
1111	CB Time Lockout	CB Monitoring	Excessive circuit breaker operating time lockout alarm - excessive operation time alarm for the circuit breaker (too slow interruption)
1112	CB FaultFreqLock	CB Monitoring	Excessive fault frequency lockout alarm
1113 to 1122	Unused		Unused
1123	Ch1 Mux Clk	Fibre Monitor Bits	This is an alarm that appears if the channel 1 baud rate is outside the limits 52 kbits/s or 70 Kbits/s
1124	Ch1 Signal Lost	Fibre Monitor Bits	Mux indicates signal lost over channel 1
1125	Ch1 Path Yellow	Fibre Monitor Bits	One way communication. Local relay that is sending over Ch1 indicates that remote end is not receiving
1126	Ch1 Mismatch RxN	Fibre Monitor Bits	Indication of mismatch between Ch1 N*64kbits/s setting and Mux
1127	Ch1 Timeout	Fibre Monitor Bits	Indication that no valid message is received over channel 1 during 'Channel Timeout' window
1128	Ch1 Degraded	Fibre Monitor Bits	Indicates poor channel 1 quality
1129	Ch1 Passthrough	Fibre Monitor Bits	Ch1 data received via Ch 2 in 3 ended configuration - self healing indication -
1130	Unused		Unused
1131	Unused		Unused
1132	Unused		Unused
1133	Ch2 Mux Clk	Fibre Monitor Bits	This is an alarm that appears if the channel 2 baud rate is outside the limits 52kbits/s or 70 kbits/s
1134	Ch2 Signal Lost	Fibre Monitor Bits	Mux indicates signal lost over channel 2
1135	Ch2 Path Yellow	Fibre Monitor Bits	One way communication. Local relay that is sending over Ch2 indicates that remote end is not receiving
1136	Ch2 Mismatch RxN	Fibre Monitor Bits	Indication of mismatch between InterMiCOM64 Ch 2 setting and Mux
1137	Ch2 Timeout	Fibre Monitor Bits	Indication that no valid message is received over channel 2 during 'Channel Timeout' window
1138	Ch2 Degraded	Fibre Monitor Bits	Indicates poor channel 2 quality
1139	Ch2 Passthrough	Fibre Monitor Bits	Ch2 data received via Ch 1 in 3 ended configuration - self healing indication -
1140 to 1143	Unused		Unused
1144	PubPres VIP 65	GOOSE Input Command	GOOSE virtual input 65- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1145	PubPres VIP 66	GOOSE Input Command	GOOSE virtual input 66- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1146	PubPres VIP 67	GOOSE Input Command	GOOSE virtual input 67- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1147	PubPres VIP 68	GOOSE Input Command	GOOSE virtual input 68- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1148	PubPres VIP 69	GOOSE Input Command	GOOSE virtual input 69- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1149	PubPres VIP 70	GOOSE Input Command	GOOSE virtual input 70- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.

DDB No	Text	Source	Description
1150	PubPres VIP 71	GOOSE Input Command	GOOSE virtual input 71- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1151	PubPres VIP 72	GOOSE Input Command	GOOSE virtual input 72- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1152	PubPres VIP 73	GOOSE Input Command	GOOSE virtual input 73- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1153	PubPres VIP 74	GOOSE Input Command	GOOSE virtual input 74- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1154	PubPres VIP 75	GOOSE Input Command	GOOSE virtual input 75- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1155	PubPres VIP 76	GOOSE Input Command	GOOSE virtual input 76- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1156	PubPres VIP 77	GOOSE Input Command	GOOSE virtual input 77- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1157	PubPres VIP 78	GOOSE Input Command	GOOSE virtual input 78- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1158	PubPres VIP 79	GOOSE Input Command	GOOSE virtual input 79- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1159	PubPres VIP 80	GOOSE Input Command	GOOSE virtual input 80- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1160	PubPres VIP 81	GOOSE Input Command	GOOSE virtual input 81- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1161	PubPres VIP 82	GOOSE Input Command	GOOSE virtual input 82- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1162	PubPres VIP 83	GOOSE Input Command	GOOSE virtual input 83- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1163	PubPres VIP 84	GOOSE Input Command	GOOSE virtual input 84- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1164	PubPres VIP 85	GOOSE Input Command	GOOSE virtual input 85- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1165	PubPres VIP 86	GOOSE Input Command	GOOSE virtual input 86- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1166	PubPres VIP 87	GOOSE Input Command	GOOSE virtual input 87- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1167	PubPres VIP 88	GOOSE Input Command	GOOSE virtual input 88- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.

DDB No	Text	Source	Description
1168	PubPres VIP 89	GOOSE Input Command	GOOSE virtual input 89- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1169	PubPres VIP 90	GOOSE Input Command	GOOSE virtual input 90- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1170	PubPres VIP 91	GOOSE Input Command	GOOSE virtual input 91- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1171	PubPres VIP 92	GOOSE Input Command	GOOSE virtual input 92- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1172	PubPres VIP 93	GOOSE Input Command	GOOSE virtual input 93- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1173	PubPres VIP 94	GOOSE Input Command	GOOSE virtual input 94- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1174	PubPres VIP 95	GOOSE Input Command	GOOSE virtual input 95- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1175	PubPres VIP 96	GOOSE Input Command	GOOSE virtual input 96- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1176	HMI Access Lvl 1		Binary encoded with DDB 1177 to indicate HMI interface password level
1177	HMI Access Lvl 2		Binary encoded with DDB 1176 to indicate HMI interface password level
1178	FPort AccessLvl1		Binary encoded with DDB 1179 to indicate front port interface password level
1179	FPort AccessLvl2		Binary encoded with DDB 1178 to indicate front port interface password level
1180	RPrt1 AccessLvl1		Binary encoded with DDB 1181 to indicate rear port 1 interface password level
1181	RPrt1 AccessLvl2		Binary encoded with DDB 1180 to indicate rear port 1 interface password level
1182	RPrt2 AccessLvl1		Binary encoded with DDB 1183 to indicate rear port 2 interface password level
1183	RPrt2 AccessLvl2		Binary encoded with DDB 1182 to indicate rear port 2 interface password level
1184	Monitor Bit 1	Commissioning Test	Monitor port signal 1 - allows mapped monitor signals to be mapped to disturbance recorder or contacts
1185	Monitor Bit 2	Commissioning Test	Monitor port signal 2 - allows mapped monitor signals to be mapped to disturbance recorder or contacts
1186	Monitor Bit 3	Commissioning Test	Monitor port signal 3 - allows mapped monitor signals to be mapped to disturbance recorder or contacts
1187	Monitor Bit 4	Commissioning Test	Monitor port signal 4 - allows mapped monitor signals to be mapped to disturbance recorder or contacts
1188	Monitor Bit 5	Commissioning Test	Monitor port signal 5 - allows mapped monitor signals to be mapped to disturbance recorder or contacts
1189	Monitor Bit 6	Commissioning Test	Monitor port signal 6 - allows mapped monitor signals to be mapped to disturbance recorder or contacts
1190	Monitor Bit 7	Commissioning Test	Monitor port signal 7 - allows mapped monitor signals to be mapped to disturbance recorder or contacts

DDB No	Text	Source	Description
1191	Monitor Bit 8	Commissioning Test	Monitor port signal 8 - allows mapped monitor signals to be mapped to disturbance recorder or contacts
1192	New Fault Record	Fault recorder	New Fault Record
1193	Unused		Unused
1194	PSL Int 1	PSL	PSL Internal Node
1195	PSL Int 2	PSL	PSL Internal Node
1196	PSL Int 3	PSL	PSL Internal Node
1197	PSL Int 4	PSL	PSL Internal Node
1198	PSL Int 5	PSL	PSL Internal Node
1199	PSL Int 6	PSL	PSL Internal Node
1200	PSL Int 7	PSL	PSL Internal Node
1201	PSL Int 8	PSL	PSL Internal Node
1202	PSL Int 9	PSL	PSL Internal Node
1203	PSL Int 10	PSL	PSL Internal Node
1204	PSL Int 11	PSL	PSL Internal Node
1205	PSL Int 12	PSL	PSL Internal Node
1206	PSL Int 13	PSL	PSL Internal Node
1207	PSL Int 14	PSL	PSL Internal Node
1208	PSL Int 15	PSL	PSL Internal Node
1209	PSL Int 16	PSL	PSL Internal Node
1210	PSL Int 17	PSL	PSL Internal Node
1211	PSL Int 18	PSL	PSL Internal Node
1212	PSL Int 19	PSL	PSL Internal Node
1213	PSL Int 20	PSL	PSL Internal Node
1214	PSL Int 21	PSL	PSL Internal Node
1215	PSL Int 22	PSL	PSL Internal Node
1216	PSL Int 23	PSL	PSL Internal Node
1217	PSL Int 24	PSL	PSL Internal Node
1218	PSL Int 25	PSL	PSL Internal Node
1219	PSL Int 26	PSL	PSL Internal Node
1220	PSL Int 27	PSL	PSL Internal Node
1221	PSL Int 28	PSL	PSL Internal Node
1222	PSL Int 29	PSL	PSL Internal Node
1223	PSL Int 30	PSL	PSL Internal Node
1224	PSL Int 31	PSL	PSL Internal Node
1225	PSL Int 32	PSL	PSL Internal Node
1226	PSL Int 33	PSL	PSL Internal Node
1227	PSL Int 34	PSL	PSL Internal Node
1228	PSL Int 35	PSL	PSL Internal Node
1229	PSL Int 36	PSL	PSL Internal Node
1230	PSL Int 37	PSL	PSL Internal Node
1231	PSL Int 38	PSL	PSL Internal Node
1232	PSL Int 39	PSL	PSL Internal Node
1233	PSL Int 40	PSL	PSL Internal Node
1234	PSL Int 41	PSL	PSL Internal Node

DDB No	Text	Source	Description
1235	PSL Int 42	PSL	PSL Internal Node
1236	PSL Int 43	PSL	PSL Internal Node
1237	PSL Int 44	PSL	PSL Internal Node
1238	PSL Int 45	PSL	PSL Internal Node
1239	PSL Int 46	PSL	PSL Internal Node
1240	PSL Int 47	PSL	PSL Internal Node
1241	PSL Int 48	PSL	PSL Internal Node
1242	PSL Int 49	PSL	PSL Internal Node
1243	PSL Int 50	PSL	PSL Internal Node
1244	PSL Int 51	PSL	PSL Internal Node
1245	PSL Int 52	PSL	PSL Internal Node
1246	PSL Int 53	PSL	PSL Internal Node
1247	PSL Int 54	PSL	PSL Internal Node
1248	PSL Int 55	PSL	PSL Internal Node
1249	PSL Int 56	PSL	PSL Internal Node
1250	PSL Int 57	PSL	PSL Internal Node
1251	PSL Int 58	PSL	PSL Internal Node
1252	PSL Int 59	PSL	PSL Internal Node
1253	PSL Int 60	PSL	PSL Internal Node
1254	PSL Int 61	PSL	PSL Internal Node
1255	PSL Int 62	PSL	PSL Internal Node
1256	PSL Int 63	PSL	PSL Internal Node
1257	PSL Int 64	PSL	PSL Internal Node
1258	PSL Int 65	PSL	PSL Internal Node
1259	PSL Int 66	PSL	PSL Internal Node
1260	PSL Int 67	PSL	PSL Internal Node
1261	PSL Int 68	PSL	PSL Internal Node
1262	PSL Int 69	PSL	PSL Internal Node
1263	PSL Int 70	PSL	PSL Internal Node
1264	PSL Int 71	PSL	PSL Internal Node
1265	PSL Int 72	PSL	PSL Internal Node
1266	PSL Int 73	PSL	PSL Internal Node
1267	PSL Int 74	PSL	PSL Internal Node
1268	PSL Int 75	PSL	PSL Internal Node
1269	PSL Int 76	PSL	PSL Internal Node
1270	PSL Int 77	PSL	PSL Internal Node
1271	PSL Int 78	PSL	PSL Internal Node
1272	PSL Int 79	PSL	PSL Internal Node
1273	PSL Int 80	PSL	PSL Internal Node
1274	PSL Int 81	PSL	PSL Internal Node
1275	PSL Int 82	PSL	PSL Internal Node
1276	PSL Int 83	PSL	PSL Internal Node
1277	PSL Int 84	PSL	PSL Internal Node
1278	PSL Int 85	PSL	PSL Internal Node

DDB No	Text	Source	Description
1279	PSL Int 86	PSL	PSL Internal Node
1280	PSL Int 87	PSL	PSL Internal Node
1281	PSL Int 88	PSL	PSL Internal Node
1282	PSL Int 89	PSL	PSL Internal Node
1283	PSL Int 90	PSL	PSL Internal Node
1284	PSL Int 91	PSL	PSL Internal Node
1285	PSL Int 92	PSL	PSL Internal Node
1286	PSL Int 93	PSL	PSL Internal Node
1287	PSL Int 94	PSL	PSL Internal Node
1288	PSL Int 95	PSL	PSL Internal Node
1289	PSL Int 96	PSL	PSL Internal Node
1290	PSL Int 97	PSL	PSL Internal Node
1291	PSL Int 98	PSL	PSL Internal Node
1292	PSL Int 99	PSL	PSL Internal Node
1293	PSL Int 100	PSL	PSL Internal Node
1294	VTS Icat>	VT Supervision	“VTS I> Inhibit “ setting has been exceeded in Phase Cat
1295	VTS Ifdr>	VT Supervision	“VTS I> Inhibit “ setting has been exceeded in Phase Fdr
1296	Unused		Unused
1297	VTS Vcat>	VT Supervision	Vcat has exceed 30 volts (drop off at 10 volts)
1298	VTS Vfdr>	VT Supervision	Vfdr has exceed 30 volts (drop off at 10 volts)
1299	Unused		Unused
1300	Unused		Unused
1301	Unused		Unused
1302	VTS Icat delta>	VT Supervision	Superimposed Phase Cat current has exceed 0.1In
1303	VTS Ifdr delta>	VT Supervision	Superimposed Phase Fdr current has exceed 0.1In
1304	Unused		Unused
1305	Z1 Cat Comp	Distance diagnostic	Z1 Cat Comparator
1306	Z1 Fdr Comp	Distance diagnostic	Z1 Fdr Comparator
1307	Unused		Unused
1308	Z1 Cat-Fdr Comp	Distance diagnostic	Z1 Cat-Fdr Comparator
1309	Unused		Unused
1310	Unused		Unused
1311	Z2 Cat Comp	Distance diagnostic	Z2 Cat Comparator
1312	Z2 Fdr Comp	Distance diagnostic	Z2 Fdr Comparator
1313	Unused		Unused
1314	Z2 Cat-Fdr Comp	Distance diagnostic	Z2 Cat-Fdr Comparator
1315	Unused		Unused
1316	Unused		Unused
1317	Z3 Cat Comp	Distance diagnostic	Z3 Cat Comparator
1318	Z3 Fdr Comp	Distance diagnostic	Z3 Fdr Comparator
1319	Unused		Unused
1320	Z3 Cat-Fdr Comp	Distance diagnostic	Z3 Cat-Fdr Comparator
1321	Unused		Unused
1322	Unused		Unused

DDB No	Text	Source	Description
1323	ZP Cat Comp	Distance diagnostic	ZP Cat Comparator
1324	ZP Fdr Comp	Distance diagnostic	ZP Fdr Comparator
1325	Unused		Unused
1326	ZP Cat-Fdr Comp	Distance diagnostic	ZP Cat-Fdr Comparator
1327	Unused		Unused
1328	Unused		Unused
1329	Z4 Cat Comp	Distance diagnostic	Z4 Cat Comparator
1330	Z4 Fdr Comp	Distance diagnostic	Z4 Fdr Comparator
1331	Unused		Unused
1332	Z4 Cat-Fdr Comp	Distance diagnostic	Z4 Cat-Fdr Comparator
1333	Unused		Unused
1334	Unused		Unused
1335	IN> Bias	Distance diagnostic	Biased Neutral Level Detector
1336	Unused		Unused
1337	Delta FWD Cat	Delta directional Diagnostic	Delta Directional Forward Cat
1338	Delta FWD Fdr	Delta directional Diagnostic	Delta Directional Forward Fdr
1339	Unused		Unused
1340	DeltaFWD Cat-Fdr	Delta directional Diagnostic	Delta Directional Forward Cat-Fdr
1341	Unused		Unused
1342	Unused		Unused
1343	Delta Rev Cat	Delta directional Diagnostic	Delta Directional Reverse Cat
1344	Delta Rev Fdr	Delta directional Diagnostic	Delta Directional Reverse Fdr
1345	Unused		Unused
1346	DeltaRev Cat-Fdr	Delta directional Diagnostic	Delta Directional Reverse Cat-Fdr
1347	Unused		Unused
1348	Unused		Unused
1349	Unused		Unused
1350	Unused		Unused
1351	Unused		Unused
1352	Unused		Unused
1353	Unused		Unused
1354	Mem. Valid	Distance diagnostic	Memory Valid
1355	Ph Two Cycle	Phase Selector	Phase Sel Two Cycle
1356	Ph Five Cycle	Phase Selector	Phase Sel Five Cycle
1357	Ph Frozen	Phase Selector	Buffer Frozen
1358	Aided 1 WI V< Cat	Aided Scheme Logic	Aided 1 WI V< Cat
1359	Aided 1 WI V< Fdr	Aided Scheme Logic	Aided 1 WI V< Fdr
1360	Unused		Unused
1361	Aided 2 WI V< Cat	Aided Scheme Logic	Aided 2 WI V< Cat
1362	Aided 2 WI V< Fdr	Aided Scheme Logic	Aided 2 WI V< Fdr
1363	Unused		Unused
1364	Pre-Lockout	CB Control	CB Condition Monitoring Pre-Lockout condition
1365	Unused		Unused
1366	Unused		Unused

DDB No	Text	Source	Description
1367	Unused		Unused
1368	Freq High	Frequency Tracking	Freq High
1369	Freq Low	Frequency Tracking	Freq Low
1370	Freq Not found	Frequency Tracking	Freq Not found
1371	Stop Freq Track	Frequency Tracking	Stop Freq Track
1372	3d/4th HarmonicCat	3d/4th Harmonic Restraint Cat Phase	3rd/4th Harmonic Restraint Cat Phase
1373	3d/4th HarmonicFdr	3d/4th Harmonic Restraint Fdr Phase	3rd/4th Harmonic Restraint Fdr Phase
1374	Unused		Unused
1375	Teleprot Disturb		This is an output signal available in the PSL, that could be mapped to "C Diff Failure" for IEC870-5-103
1376	I>> Backup Super		This applies only if distance primary FUN is selected (in IEC870-5-103) This signal is ON if an overcurrent stage is selected to be enabled on VTS and distance is blocked by VTS
1377	I> Trip by VTS		This applies only if distance primary FUN is selected (in IEC870-5-103) This signal is ON if DDB 1376 is ON and one of the overcurrent stages set to be enabled on VTS condition trips
1378	Teleprot Tx		This applies only if distance primary FUN is selected (in IEC870-5-103) This is an output signal available in the PSL, which could be mapped to a signal send of one of the two teleprotection channels
1379	Teleprot Rx		This applies only if distance primary FUN is selected (in IEC870-5-103) This is an output signal available in the PSL, which could be mapped to a signal receive of one of the two teleprotection channels
1380	Group Warning		This is an output signal available in the PSL, which can be mapped in IEC870-5-103 to a minor defect which does not shut down the main protection
1381	Group Alarm		This is an output signal available in the PSL, which can be mapped in IEC870-5-103 to a major problem normally linked to the watchdog
1382	AR On Pulse		This is an output signal available in the PSL, which can be mapped to enable AR via pulse
1383	AR Off Pulse		This is an output signal available in the PSL, which can be mapped to disable AR via pulse
1384	AR Enable		External input via DDB mapped in PSL to enable AR if Enable AR CB1 or Enable AR CB2 is set and AR Configuration setting is enabled
1385	AR In Service		Auto-reclose in service
1386	MaxCh1 PropDelay		Setting MaxCh 1 PropDelay has been exceeded
1387	MaxCh2 PropDelay		Setting MaxCh 2 PropDelay has been exceeded
1388 to 1403	Unused		Unused
1404	VTS Blk Distance	Transfer	Signal from the VTS logic that can be used to block operation of the distance elements
1405 to 1419	Unused		Unused
1420	Inhibit AR	PSL	DDB mapped in PSL from opto or comms input. External signal to inhibit autoreclose.
1421 to 1431	Unused		Unused

DDB No	Text	Source	Description
1432	Quality VIP 97	GOOSE Input Command	GOOSE virtual input 97 - provides the Quality attributes of any data object in an incoming GOOSE message
1433	Quality VIP 98	GOOSE Input Command	GOOSE virtual input 98 - provides the Quality attributes of any data object in an incoming GOOSE message
1434	Quality VIP 99	GOOSE Input Command	GOOSE virtual input 99 - provides the Quality attributes of any data object in an incoming GOOSE message
1435	Quality VIP 100	GOOSE Input Command	GOOSE virtual input 100 - provides the Quality attributes of any data object in an incoming GOOSE message
1436	Quality VIP 101	GOOSE Input Command	GOOSE virtual input 101 - provides the Quality attributes of any data object in an incoming GOOSE message
1437	Quality VIP 102	GOOSE Input Command	GOOSE virtual input 102 - provides the Quality attributes of any data object in an incoming GOOSE message
1438	Quality VIP 103	GOOSE Input Command	GOOSE virtual input 103 - provides the Quality attributes of any data object in an incoming GOOSE message
1439	Quality VIP 104	GOOSE Input Command	GOOSE virtual input 104 - provides the Quality attributes of any data object in an incoming GOOSE message
1440	Quality VIP 105	GOOSE Input Command	GOOSE virtual input 105 - provides the Quality attributes of any data object in an incoming GOOSE message
1441	Quality VIP 106	GOOSE Input Command	GOOSE virtual input 106 - provides the Quality attributes of any data object in an incoming GOOSE message
1442	Quality VIP 107	GOOSE Input Command	GOOSE virtual input 107 - provides the Quality attributes of any data object in an incoming GOOSE message
1443	Quality VIP 108	GOOSE Input Command	GOOSE virtual input 108 - provides the Quality attributes of any data object in an incoming GOOSE message
1444	Quality VIP 109	GOOSE Input Command	GOOSE virtual input 109 - provides the Quality attributes of any data object in an incoming GOOSE message
1445	Quality VIP 110	GOOSE Input Command	GOOSE virtual input 110 - provides the Quality attributes of any data object in an incoming GOOSE message
1446	Quality VIP 111	GOOSE Input Command	GOOSE virtual input 111 - provides the Quality attributes of any data object in an incoming GOOSE message
1447	Quality VIP 112	GOOSE Input Command	GOOSE virtual input 112 - provides the Quality attributes of any data object in an incoming GOOSE message
1448	Quality VIP 113	GOOSE Input Command	GOOSE virtual input 113 - provides the Quality attributes of any data object in an incoming GOOSE message
1449	Quality VIP 114	GOOSE Input Command	GOOSE virtual input 114 - provides the Quality attributes of any data object in an incoming GOOSE message
1450	Quality VIP 115	GOOSE Input Command	GOOSE virtual input 115 - provides the Quality attributes of any data object in an incoming GOOSE message
1432	Quality VIP 116	GOOSE Input Command	GOOSE virtual input 116 - provides the Quality attributes of any data object in an incoming GOOSE message
1433	Quality VIP 117	GOOSE Input Command	GOOSE virtual input 117 - provides the Quality attributes of any data object in an incoming GOOSE message
1434	Quality VIP 118	GOOSE Input Command	GOOSE virtual input 118 - provides the Quality attributes of any data object in an incoming GOOSE message
1435	Quality VIP 119	GOOSE Input Command	GOOSE virtual input 119 - provides the Quality attributes of any data object in an incoming GOOSE message
1436	Quality VIP 120	GOOSE Input Command	GOOSE virtual input 120 - provides the Quality attributes of any data object in an incoming GOOSE message
1437	Quality VIP 121	GOOSE Input Command	GOOSE virtual input 121 - provides the Quality attributes of any data object in an incoming GOOSE message
1438	Quality VIP 122	GOOSE Input Command	GOOSE virtual input 122 - provides the Quality attributes of any data object in an incoming GOOSE message

DDB No	Text	Source	Description
1439	Quality VIP 123	GOOSE Input Command	GOOSE virtual input 123 - provides the Quality attributes of any data object in an incoming GOOSE message
1440	Quality VIP 124	GOOSE Input Command	GOOSE virtual input 124 - provides the Quality attributes of any data object in an incoming GOOSE message
1441	Quality VIP 125	GOOSE Input Command	GOOSE virtual input 125 - provides the Quality attributes of any data object in an incoming GOOSE message
1442	Quality VIP 126	GOOSE Input Command	GOOSE virtual input 126 - provides the Quality attributes of any data object in an incoming GOOSE message
1443	Quality VIP 127	GOOSE Input Command	GOOSE virtual input 127 - provides the Quality attributes of any data object in an incoming GOOSE message
1444	Quality VIP 128	GOOSE Input Command	GOOSE virtual input 128 - provides the Quality attributes of any data object in an incoming GOOSE message
1445	Quality VIP 97	GOOSE Input Command	GOOSE virtual input 97 - provides the Quality attributes of any data object in an incoming GOOSE message
1446	Quality VIP 98	GOOSE Input Command	GOOSE virtual input 98 - provides the Quality attributes of any data object in an incoming GOOSE message
1447	Quality VIP 99	GOOSE Input Command	GOOSE virtual input 99 - provides the Quality attributes of any data object in an incoming GOOSE message
1448	Quality VIP 100	GOOSE Input Command	GOOSE virtual input 100 - provides the Quality attributes of any data object in an incoming GOOSE message
1449	Quality VIP 101	GOOSE Input Command	GOOSE virtual input 101 - provides the Quality attributes of any data object in an incoming GOOSE message
1451	Quality VIP 102	GOOSE Input Command	GOOSE virtual input 102 - provides the Quality attributes of any data object in an incoming GOOSE message
1452	Quality VIP 103	GOOSE Input Command	GOOSE virtual input 103 - provides the Quality attributes of any data object in an incoming GOOSE message
1453	Quality VIP 104	GOOSE Input Command	GOOSE virtual input 104 - provides the Quality attributes of any data object in an incoming GOOSE message
1454	Quality VIP 105	GOOSE Input Command	GOOSE virtual input 105 - provides the Quality attributes of any data object in an incoming GOOSE message
1455	Quality VIP 106	GOOSE Input Command	GOOSE virtual input 106 - provides the Quality attributes of any data object in an incoming GOOSE message
1456	Quality VIP 107	GOOSE Input Command	GOOSE virtual input 107 - provides the Quality attributes of any data object in an incoming GOOSE message
1457	Quality VIP 108	GOOSE Input Command	GOOSE virtual input 108 - provides the Quality attributes of any data object in an incoming GOOSE message
1458	Quality VIP 109	GOOSE Input Command	GOOSE virtual input 109 - provides the Quality attributes of any data object in an incoming GOOSE message
1459	Quality VIP 110	GOOSE Input Command	GOOSE virtual input 110 - provides the Quality attributes of any data object in an incoming GOOSE message
1460	Quality VIP 111	GOOSE Input Command	GOOSE virtual input 111 - provides the Quality attributes of any data object in an incoming GOOSE message
1461	Quality VIP 112	GOOSE Input Command	GOOSE virtual input 112 - provides the Quality attributes of any data object in an incoming GOOSE message
1462	Quality VIP 113	GOOSE Input Command	GOOSE virtual input 113 - provides the Quality attributes of any data object in an incoming GOOSE message
1463	Quality VIP 114	GOOSE Input Command	GOOSE virtual input 114 - provides the Quality attributes of any data object in an incoming GOOSE message
1464	CS2 SlipF>		Line-Bus 1 slip freq > setting [48 98] (frequency difference (slip) between line voltage and bus 1 voltage is greater than maximum slip permitted for CB synchronism check stage 2)

DDB No	Text	Source	Description
1465	CS2 SlipF<		Line-Bus 1 slip freq < setting [48 98] (frequency difference (slip) between line voltage and bus voltage is within the permitted range for CB synchronism check stage 2)
1466 to 1476	Unused		Unused
1477	Virtual Output81	PSL	Virtual output 81 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1478	Virtual Output82	PSL	Virtual output 82 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1479	Virtual Output83	PSL	Virtual output 83 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1480	Virtual Output84	PSL	Virtual output 84 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1481	Virtual Output85	PSL	Virtual output 85 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1482	Virtual Output86	PSL	Virtual output 86 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1483	Virtual Output87	PSL	Virtual output 87 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1484	Virtual Output88	PSL	Virtual output 88 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1485	Virtual Output89	PSL	Virtual output 89 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1486	Virtual Output90	PSL	Virtual output 90 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1487	Virtual Output91	PSL	Virtual output 91 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1488	Virtual Output92	PSL	Virtual output 92 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1489	Virtual Output93	PSL	Virtual output 93 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1490	Virtual Output94	PSL	Virtual output 94 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1491	Virtual Output95	PSL	Virtual output 95 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1492	Virtual Output96	PSL	Virtual output 96 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1493	CS2 FL>FB		Frequency difference between Line V and Bus1 V is greater than setting [48 98] (line freq > Bus freq)
1494	CS2 FL<FB		Frequency difference between Line V and Bus1 V is greater than setting [48 98] (line freq < Bus freq)
1495	CS2 AngHigh+		Line/Bus1 phase angle in range: setting [48 95] to +180deg (anticlockwise from Vbus)
1496	CS2 AngHigh-		Line/Bus1 phase angle in range: setting [48 95] to -180deg (clockwise from Vbus)
1497	AR Mode SP	PSL	If setting "Lead AR Mode" = Opto, then if input DDB "AR Mode SP" is high, the leader CB is enabled for single phase autoreclose, if "AR Mode SP" is low, the leader CB is NOT enabled for single phase autoreclose.
1498	AR Mode AP	PSL	If setting "Lead AR Mode" = Opto, then if input DDB "AR Mode AP" is high, the leader CB is enabled for all phase autoreclose, if "AR Mode AP" is low, the leader CB is NOT enabled for all phase autoreclose.
1499 to 1503	Unused		Unused

DDB No	Text	Source	Description
1504	Init Cat AR Test	PSL	DDB mapped in PSL from opto or comms input. Input operation will initiate Cat test trip & autoreclose cycle
1505	Init Fdr AR Test	PSL	DDB mapped in PSL from opto or comms input. Input operation will initiate Fdr test trip & autoreclose cycle
1506	Unused		Unused
1507	Init All P AR Test	PSL	DDB mapped in PSL from opto or comms input. Input operation will initiate All Ph test trip & autoreclose cycle
1508	Ext Fault Cat	PSL	DDB mapped in PSL from opto or comms input: indicates external protection operated for fault involving Cat phase
1509	Ext Fault Fdr	PSL	DDB mapped in PSL from opto or comms input: indicates external protection operated for fault involving Fdr phase
1510	Unused		Unused
1511	AR Skip Shot1	PSL	DDB mapped in PSL from opto or comms input: if setting "AR Skip Shot 1" = Enable and this input is high when a protection operation initiates an autoreclose cycle, then the sequence counter advances directly to SC:COUNT = 2 so the autoreclose cycle skips
1512 to 1516	Unused		Unused
1517	Ext Rst AROK	PSL	DDB mapped in PSL from opto or comms input. This input DDB is used when required to reset any CB "Successful Autoreclose" signal.
1518	Ext Rst CB Shots	PSL	DDB mapped in PSL from opto or comms input. This input DDB is used when required to reset the CB cumulative "Shots" counters.
1519	Unused	PSL	Unused
1520	Unused	PSL	Unused
1521	MCB/VTS CB CS	PSL	DDB mapped in PSL from opto input (Bus VT secondary MCB tripped or VT fail detected by external VTS scheme), or signal from host relay VTS scheme
1522	Inhibit LL	PSL	DDB mapped in PSL from opto input (external signal to inhibit Live Line function)
1523	Inhibit DL	PSL	DDB mapped in PSL from opto input (external signal to inhibit Dead Line function)
1524	Inhibit LB	PSL	DDB mapped in PSL from opto input (external signal to inhibit Live Bus function)
1525	Inhibit DB	PSL	DDB mapped in PSL from opto input (external signal to inhibit Dead Bus function)
1526	CB In Service		CB In Service (can be initiated for autoreclose)
1527	Unused		Unused
1528	CB NoAR	Autoreclose	CB not available for autoreclose
1529 to 1534	Unused		Unused
1535	Trip AR MemCat		Cat trip & AR initiation memory
1536	Trip AR MemFdr		Fdr trip & AR initiation memory
1537 to 1540	Unused		Unused
1541	AR Start	Autoreclose	Any AR initiation signal present
1542	ARIP	Autoreclose	Any AR cycle in progress
1543	AR Initiation	Autoreclose	CB AR cycle initiation
1544	CB ARIP	Autoreclose	CB AR cycle in progress
1545	Unused		Unused
1546	Seq Counter>Set		Sequence counts greater than AR Shots settings

DDB No	Text	Source	Description
1547	Evolve Fault		If a single phase fault evolves to a multi-phase fault during the single phase dead time, this DDB indicates the fault has evolved and that SPAR will be stopped and APAR started.
1548	Unused		Unused
1549	Unused		Unused
1550	CB Failed AR		CB AR failed due to persistent fault
1551	DTOK All		Enabling condition for any dead time
1552	DTOK CB SP		Output DDB indicates conditions to enable single phase autoreclose dead time to run are satisfied
1553	DTOK CB AP		Output DDB indicates conditions to enable three phase autoreclose dead time to run are satisfied
1554	SP DTime		Indicates single phase autoreclose dead time running
1555	OK Time AP		OK to start All PAR dead time
1556	AP DTime1		All Phase dead time 1 running
1557	AP DTime2		All Phase dead time 2 running
1558	AP DTime3		All Phase dead time 3 running
1559	AP DTime4		All Phase dead time 4 running
1560	AP Dtime		Indicates all phase autoreclose dead time running
1561 to 1564	Unused		Unused
1565	Set CB Close		Indicates Auto Close signal has been issued
1566	CB Control		Output DDB can be applied to inhibit reclose by adjacent scheme until local autoreclose scheme confirms it is OK to close CB
1567	SP Reclaim Time		Single Phase AR reclaim time running
1568	SP Reclaim TComp		Single Phase AR reclaim time complete
1569	AP Reclaim Time		All Phase AR reclaim time running
1570	AP Reclaim TComp		All Phase AR reclaim time complete
1571	CB Succ SP AR		This signal is set when CB has successfully completed a single phase autoreclose cycle.
1572	CB Fast SCOK		OK to reclose CB with sync check without waiting for dead time to complete
1573	CB SCOK		System conditions OK to reclose CB when dead time complete
1574	CB Man SCOK		System conditions OK to manually close CB
1575	CB Fail Pr Trip		signal to force CB AR lockout
1576	Unused		Unused
1577	Unused		Unused
1578	CS1 SlipF>		Line-Bus slip freq > setting [48 93] (frequency difference (slip) between line voltage and bus voltage is greater than maximum slip permitted for CB synchronism check type 1)
1579	CS1 SlipF<		Line-Bus slip freq < setting [48 93] (frequency difference (slip) between line voltage and bus voltage is greater than maximum slip permitted for CB synchronism check type 1)
1580	CS VLine<		Line Volts < setting [48 8B]
1581	CS VLine>		Line Volts > setting [48 8C]
1582	CS VBus<		Bus Volts < setting [48 8B]
1583	CS VBus>		Bus Volts > setting [48 8C]
1584	Unused		Unused
1585	Unused		Unused

DDB No	Text	Source	Description
1586	CS1 VL>VB		Voltage magnitude difference between Line V and Bus V is greater than setting [48 91] (line V > Bus V)
1587	CS2 VL>VB		Voltage magnitude difference between Line V and Bus V is greater than setting [48 96] (line V > Bus V)
1588	CS1 VL<VB		Voltage magnitude difference between Line V and Bus V is greater than setting [48 91] (line V < Bus V)
1589	CS2 VL<VB		Voltage magnitude difference between Line V and Bus V is greater than setting [48 96] (line V < Bus V)
1590	CS1 FL>FB		Frequency difference between Line V and Bus V is greater than setting [48 93] (line freq > Bus freq)
1591	CS1 FL<FB		Frequency difference between Line V and Bus V is greater than setting [48 93] (line freq < Bus freq)
1592	CS1 AngHigh+		Line/Bus phase angle in range: setting [48 90] to +180deg (anticlockwise from Vbus)
1593	CS1 AngHigh-		Line/Bus phase angle in range: setting [48 90] to -180deg (anticlockwise from Vbus)
1594	CS AngRotACW		Line freq > (Bus freq + 0.001Hz) (Line voltage vector rotating anticlockwise relative to VBus1)
1595	CS AngRotCW		Bus freq > (Line freq + 0.001Hz) (Line voltage vector rotating clockwise relative to VBus1)
1596 to 1608	Unused		Unused
1609	AR Enable CB		External input via DDB to enable CB, if "in service", to be initiated for autoreclosing by an AR initiation signal from protection. DDB input defaults to high if not mapped in PSL, so CB AR initiation is permitted.
1610 to 1615	Unused		Unused
1616	PSL Int 101	PSL	PSL Internal Node
1617	PSL Int 102	PSL	PSL Internal Node
1618	PSL Int 103	PSL	PSL Internal Node
1619	PSL Int 104	PSL	PSL Internal Node
1620	PSL Int 105	PSL	PSL Internal Node
1621	PSL Int 106	PSL	PSL Internal Node
1622	PSL Int 107	PSL	PSL Internal Node
1623	PSL Int 108	PSL	PSL Internal Node
1624	PSL Int 109	PSL	PSL Internal Node
1625	PSL Int 110	PSL	PSL Internal Node
1626	PSL Int 111	PSL	PSL Internal Node
1627	PSL Int 112	PSL	PSL Internal Node
1628	PSL Int 113	PSL	PSL Internal Node
1629	PSL Int 114	PSL	PSL Internal Node
1630	PSL Int 115	PSL	PSL Internal Node
1631	PSL Int 116	PSL	PSL Internal Node
1632	PSL Int 117	PSL	PSL Internal Node
1633	PSL Int 118	PSL	PSL Internal Node
1634	PSL Int 119	PSL	PSL Internal Node
1635	PSL Int 120	PSL	PSL Internal Node
1636	PSL Int 121	PSL	PSL Internal Node
1637	PSL Int 122	PSL	PSL Internal Node

DDB No	Text	Source	Description
1638	PSL Int 123	PSL	PSL Internal Node
1639	PSL Int 124	PSL	PSL Internal Node
1640	PSL Int 125	PSL	PSL Internal Node
1641	PSL Int 126	PSL	PSL Internal Node
1642	PSL Int 127	PSL	PSL Internal Node
1643	PSL Int 128	PSL	PSL Internal Node
1644	PSL Int 129	PSL	PSL Internal Node
1645	PSL Int 130	PSL	PSL Internal Node
1646	PSL Int 131	PSL	PSL Internal Node
1647	PSL Int 132	PSL	PSL Internal Node
1648	PSL Int 133	PSL	PSL Internal Node
1649	PSL Int 134	PSL	PSL Internal Node
1650	PSL Int 135	PSL	PSL Internal Node
1651	PSL Int 136	PSL	PSL Internal Node
1652	PSL Int 137	PSL	PSL Internal Node
1653	PSL Int 138	PSL	PSL Internal Node
1654	PSL Int 139	PSL	PSL Internal Node
1655	PSL Int 140	PSL	PSL Internal Node
1656	PSL Int 141	PSL	PSL Internal Node
1657	PSL Int 142	PSL	PSL Internal Node
1658	PSL Int 143	PSL	PSL Internal Node
1659	PSL Int 144	PSL	PSL Internal Node
1660	PSL Int 145	PSL	PSL Internal Node
1661	PSL Int 146	PSL	PSL Internal Node
1662	PSL Int 147	PSL	PSL Internal Node
1663	PSL Int 148	PSL	PSL Internal Node
1664	PSL Int 149	PSL	PSL Internal Node
1665	PSL Int 150	PSL	PSL Internal Node
1666 to 1671	Unused		Unused
1672	BFail1 Trip Cat	CB Fail	CB Fail1 Trip Cat
1673	BFail1 Trip Fdr	CB Fail	CB Fail1 Trip Fdr
1674	Unused		Unused
1675	BFail2 Trip Cat	CB Fail	CB Fail2 Trip Cat
1676	BFail2 Trip Fdr	CB Fail	CB Fail2 Trip Fdr
1677 to 1690	Unused		Unused
1691	Any Dist Start	PSL	Any Distance Start
1692 to 1695	Unused	SW	Unused
1696	IEC Usr 01 Open	PSL	IEC61850 User Dual Point Status 1 Open
1697	IEC Usr 01 Close	PSL	IEC61850 User Dual Point Status 1 Closed
1698	IEC Usr 02 Open	PSL	IEC61850 User Dual Point Status 2 Open
1699	IEC Usr 02 Close	PSL	IEC61850 User Dual Point Status 2 Closed
1700	IEC Usr 03 Open	PSL	IEC61850 User Dual Point Status 3 Open
1701	IEC Usr 03 Close	PSL	IEC61850 User Dual Point Status 3 Closed
1702	IEC Usr 04 Open	PSL	IEC61850 User Dual Point Status 4 Open

DDB No	Text	Source	Description
1703	IEC Usr 04 Close	PSL	IEC61850 User Dual Point Status 4 Closed
1704	IEC Usr 05 Open	PSL	IEC61850 User Dual Point Status 5 Opened
1705	IEC Usr 05 Close	PSL	IEC61850 User Dual Point Status 5 Closed
1706	IEC Usr 06 Open	PSL	IEC61850 User Dual Point Status 6 Open
1707	IEC Usr 06 Close	PSL	IEC61850 User Dual Point Status 6 Closed
1708	IEC Usr 07 Open	PSL	IEC61850 User Dual Point Status 7 Open
1709	IEC Usr 07 Close	PSL	IEC61850 User Dual Point Status 7 Closed
1710	IEC Usr 08 Open	PSL	IEC61850 User Dual Point Status 8 Open
1711	IEC Usr 08 Close	PSL	IEC61850 User Dual Point Status 8 Closed
1712	Virtual Output65	PSL	Virtual output 65 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1713	Virtual Output66	PSL	Virtual output 66 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1714	Virtual Output67	PSL	Virtual output 67 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1715	Virtual Output68	PSL	Virtual output 68 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1716	Virtual Output69	PSL	Virtual output 69 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1717	Virtual Output70	PSL	Virtual output 70 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1718	Virtual Output71	PSL	Virtual output 71 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1719	Virtual Output72	PSL	Virtual output 72 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1720	Virtual Output73	PSL	Virtual output 73 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1721	Virtual Output74	PSL	Virtual output 74 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1722	Virtual Output75	PSL	Virtual output 75 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1723	Virtual Output76	PSL	Virtual output 76 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1724	Virtual Output77	PSL	Virtual output 77 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1725	Virtual Output78	PSL	Virtual output 78 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1726	Virtual Output79	PSL	Virtual output 79 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1727	Virtual Output80	PSL	Virtual output 80 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1728	Quality VIP 1	GOOSE Input Command	GOOSE virtual input 1 - provides the Quality attributes of any data object in an incoming GOOSE message
1729	Quality VIP 2	GOOSE Input Command	GOOSE virtual input 2 - provides the Quality attributes of any data object in an incoming GOOSE message
1730	Quality VIP 3	GOOSE Input Command	GOOSE virtual input 3 - provides the Quality attributes of any data object in an incoming GOOSE message
1731	Quality VIP 4	GOOSE Input Command	GOOSE virtual input 4 - provides the Quality attributes of any data object in an incoming GOOSE message
1732	Quality VIP 5	GOOSE Input Command	GOOSE virtual input 5 - provides the Quality attributes of any data object in an incoming GOOSE message

DDB No	Text	Source	Description
1733	Quality VIP 6	GOOSE Input Command	GOOSE virtual input 6 - provides the Quality attributes of any data object in an incoming GOOSE message
1734	Quality VIP 7	GOOSE Input Command	GOOSE virtual input 7 - provides the Quality attributes of any data object in an incoming GOOSE message
1735	Quality VIP 8	GOOSE Input Command	GOOSE virtual input 8 - provides the Quality attributes of any data object in an incoming GOOSE message
1736	Quality VIP 9	GOOSE Input Command	GOOSE virtual input 9 - provides the Quality attributes of any data object in an incoming GOOSE message
1737	Quality VIP 10	GOOSE Input Command	GOOSE virtual input 10 - provides the Quality attributes of any data object in an incoming GOOSE message
1738	Quality VIP 11	GOOSE Input Command	GOOSE virtual input 11 - provides the Quality attributes of any data object in an incoming GOOSE message
1739	Quality VIP 12	GOOSE Input Command	GOOSE virtual input 12 - provides the Quality attributes of any data object in an incoming GOOSE message
1740	Quality VIP 13	GOOSE Input Command	GOOSE virtual input 13 - provides the Quality attributes of any data object in an incoming GOOSE message
1741	Quality VIP 14	GOOSE Input Command	GOOSE virtual input 14 - provides the Quality attributes of any data object in an incoming GOOSE message
1742	Quality VIP 15	GOOSE Input Command	GOOSE virtual input 15 - provides the Quality attributes of any data object in an incoming GOOSE message
1743	Quality VIP 16	GOOSE Input Command	GOOSE virtual input 16 - provides the Quality attributes of any data object in an incoming GOOSE message
1744	Quality VIP 17	GOOSE Input Command	GOOSE virtual input 17 - provides the Quality attributes of any data object in an incoming GOOSE message
1745	Quality VIP 18	GOOSE Input Command	GOOSE virtual input 18 - provides the Quality attributes of any data object in an incoming GOOSE message
1746	Quality VIP 19	GOOSE Input Command	GOOSE virtual input 19 - provides the Quality attributes of any data object in an incoming GOOSE message
1747	Quality VIP 20	GOOSE Input Command	GOOSE virtual input 20 - provides the Quality attributes of any data object in an incoming GOOSE message
1748	Quality VIP 21	GOOSE Input Command	GOOSE virtual input 21 - provides the Quality attributes of any data object in an incoming GOOSE message
1749	Quality VIP 22	GOOSE Input Command	GOOSE virtual input 22 - provides the Quality attributes of any data object in an incoming GOOSE message
1750	Quality VIP 23	GOOSE Input Command	GOOSE virtual input 23 - provides the Quality attributes of any data object in an incoming GOOSE message
1751	Quality VIP 24	GOOSE Input Command	GOOSE virtual input 24 - provides the Quality attributes of any data object in an incoming GOOSE message
1752	Quality VIP 25	GOOSE Input Command	GOOSE virtual input 25 - provides the Quality attributes of any data object in an incoming GOOSE message
1753	Quality VIP 26	GOOSE Input Command	GOOSE virtual input 26 - provides the Quality attributes of any data object in an incoming GOOSE message
1754	Quality VIP 27	GOOSE Input Command	GOOSE virtual input 27 - provides the Quality attributes of any data object in an incoming GOOSE message
1755	Quality VIP 28	GOOSE Input Command	GOOSE virtual input 28 - provides the Quality attributes of any data object in an incoming GOOSE message
1756	Quality VIP 29	GOOSE Input Command	GOOSE virtual input 29 - provides the Quality attributes of any data object in an incoming GOOSE message
1757	Quality VIP 30	GOOSE Input Command	GOOSE virtual input 30 - provides the Quality attributes of any data object in an incoming GOOSE message
1758	Quality VIP 31	GOOSE Input Command	GOOSE virtual input 31 - provides the Quality attributes of any data object in an incoming GOOSE message

DDB No	Text	Source	Description
1759	Quality VIP 32	GOOSE Input Command	GOOSE virtual input 32 - provides the Quality attributes of any data object in an incoming GOOSE message
1760	PubPres VIP 1	GOOSE Input Command	GOOSE virtual input 1- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1761	PubPres VIP 2	GOOSE Input Command	GOOSE virtual input 2- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1762	PubPres VIP 3	GOOSE Input Command	GOOSE virtual input 3- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1763	PubPres VIP 4	GOOSE Input Command	GOOSE virtual input 4- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1764	PubPres VIP 5	GOOSE Input Command	GOOSE virtual input 5- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1765	PubPres VIP 6	GOOSE Input Command	GOOSE virtual input 6- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1766	PubPres VIP 7	GOOSE Input Command	GOOSE virtual input 7- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1767	PubPres VIP 8	GOOSE Input Command	GOOSE virtual input 8- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1768	PubPres VIP 9	GOOSE Input Command	GOOSE virtual input 9- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1769	PubPres VIP 10	GOOSE Input Command	GOOSE virtual input 10- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1770	PubPres VIP 11	GOOSE Input Command	GOOSE virtual input 11- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1771	PubPres VIP 12	GOOSE Input Command	GOOSE virtual input 12- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1772	PubPres VIP 13	GOOSE Input Command	GOOSE virtual input 13- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1773	PubPres VIP 14	GOOSE Input Command	GOOSE virtual input 14- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1774	PubPres VIP 15	GOOSE Input Command	GOOSE virtual input 15- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1775	PubPres VIP 16	GOOSE Input Command	GOOSE virtual input 16- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1776	PubPres VIP 17	GOOSE Input Command	GOOSE virtual input 17- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1777	PubPres VIP 18	GOOSE Input Command	GOOSE virtual input 18- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.

DDB No	Text	Source	Description
1778	PubPres VIP 19	GOOSE Input Command	GOOSE virtual input 19- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1779	PubPres VIP 20	GOOSE Input Command	GOOSE virtual input 20- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1780	PubPres VIP 21	GOOSE Input Command	GOOSE virtual input 21- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1781	PubPres VIP 22	GOOSE Input Command	GOOSE virtual input 22- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1782	PubPres VIP 23	GOOSE Input Command	GOOSE virtual input 23- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1783	PubPres VIP 24	GOOSE Input Command	GOOSE virtual input 24- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1784	PubPres VIP 25	GOOSE Input Command	GOOSE virtual input 25- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1785	PubPres VIP 26	GOOSE Input Command	GOOSE virtual input 26- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1786	PubPres VIP 27	GOOSE Input Command	GOOSE virtual input 27- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1787	PubPres VIP 28	GOOSE Input Command	GOOSE virtual input 28- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1788	PubPres VIP 29	GOOSE Input Command	GOOSE virtual input 29- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1789	PubPres VIP 30	GOOSE Input Command	GOOSE virtual input 30- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1790	PubPres VIP 31	GOOSE Input Command	GOOSE virtual input 31- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1791	PubPres VIP 32	GOOSE Input Command	GOOSE virtual input 32- indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1792	Virtual Input 33	GOOSE Input Command	Virtual Input 33 - received from GOOSE message
1793	Virtual Input 34	GOOSE Input Command	Virtual Input 34 - received from GOOSE message
1794	Virtual Input 35	GOOSE Input Command	Virtual Input 35 - received from GOOSE message
1795	Virtual Input 36	GOOSE Input Command	Virtual Input 36 - received from GOOSE message
1796	Virtual Input 37	GOOSE Input Command	Virtual Input 37 - received from GOOSE message
1797	Virtual Input 38	GOOSE Input Command	Virtual Input 38 - received from GOOSE message
1798	Virtual Input 39	GOOSE Input Command	Virtual Input 39 - received from GOOSE message
1799	Virtual Input 40	GOOSE Input Command	Virtual Input 40 - received from GOOSE message
1800	Virtual Input 41	GOOSE Input Command	Virtual Input 41 - received from GOOSE message
1801	Virtual Input 42	GOOSE Input Command	Virtual Input 42 - received from GOOSE message
1802	Virtual Input 43	GOOSE Input Command	Virtual Input 43 - received from GOOSE message

DDB No	Text	Source	Description
1803	Virtual Input 44	GOOSE Input Command	Virtual Input 44 - received from GOOSE message
1804	Virtual Input 45	GOOSE Input Command	Virtual Input 45 - received from GOOSE message
1805	Virtual Input 46	GOOSE Input Command	Virtual Input 46 - received from GOOSE message
1806	Virtual Input 47	GOOSE Input Command	Virtual Input 47 - received from GOOSE message
1807	Virtual Input 48	GOOSE Input Command	Virtual Input 48 - received from GOOSE message
1808	Virtual Input 49	GOOSE Input Command	Virtual Input 49 - received from GOOSE message
1809	Virtual Input 50	GOOSE Input Command	Virtual Input 50 - received from GOOSE message
1810	Virtual Input 51	GOOSE Input Command	Virtual Input 51 - received from GOOSE message
1811	Virtual Input 52	GOOSE Input Command	Virtual Input 52 - received from GOOSE message
1812	Virtual Input 53	GOOSE Input Command	Virtual Input 53 - received from GOOSE message
1813	Virtual Input 54	GOOSE Input Command	Virtual Input 54 - received from GOOSE message
1814	Virtual Input 55	GOOSE Input Command	Virtual Input 55 - received from GOOSE message
1815	Virtual Input 56	GOOSE Input Command	Virtual Input 56 - received from GOOSE message
1816	Virtual Input 57	GOOSE Input Command	Virtual Input 57 - received from GOOSE message
1817	Virtual Input 58	GOOSE Input Command	Virtual Input 58 - received from GOOSE message
1818	Virtual Input 59	GOOSE Input Command	Virtual Input 59 - received from GOOSE message
1819	Virtual Input 60	GOOSE Input Command	Virtual Input 60 - received from GOOSE message
1820	Virtual Input 61	GOOSE Input Command	Virtual Input 61 - received from GOOSE message
1821	Virtual Input 62	GOOSE Input Command	Virtual Input 62 - received from GOOSE message
1822	Virtual Input 63	GOOSE Input Command	Virtual Input 63 - received from GOOSE message
1823	Virtual Input 64	GOOSE Input Command	Virtual Input 64 - received from GOOSE message
1824	Quality VIP 33	GOOSE Input Command	GOOSE virtual input 33 - provides the Quality attributes of any data object in an incoming GOOSE message
1825	Quality VIP 34	GOOSE Input Command	GOOSE virtual input 34 - provides the Quality attributes of any data object in an incoming GOOSE message
1826	Quality VIP 35	GOOSE Input Command	GOOSE virtual input 35 - provides the Quality attributes of any data object in an incoming GOOSE message
1827	Quality VIP 36	GOOSE Input Command	GOOSE virtual input 36 - provides the Quality attributes of any data object in an incoming GOOSE message
1828	Quality VIP 37	GOOSE Input Command	GOOSE virtual input 37 - provides the Quality attributes of any data object in an incoming GOOSE message
1829	Quality VIP 38	GOOSE Input Command	GOOSE virtual input 38 - provides the Quality attributes of any data object in an incoming GOOSE message
1830	Quality VIP 39	GOOSE Input Command	GOOSE virtual input 39 - provides the Quality attributes of any data object in an incoming GOOSE message
1831	Quality VIP 40	GOOSE Input Command	GOOSE virtual input 40 - provides the Quality attributes of any data object in an incoming GOOSE message
1832	Quality VIP 41	GOOSE Input Command	GOOSE virtual input 41 - provides the Quality attributes of any data object in an incoming GOOSE message
1833	Quality VIP 42	GOOSE Input Command	GOOSE virtual input 42 - provides the Quality attributes of any data object in an incoming GOOSE message
1834	Quality VIP 43	GOOSE Input Command	GOOSE virtual input 43 - provides the Quality attributes of any data object in an incoming GOOSE message
1835	Quality VIP 44	GOOSE Input Command	GOOSE virtual input 44 - provides the Quality attributes of any data object in an incoming GOOSE message
1836	Quality VIP 45	GOOSE Input Command	GOOSE virtual input 45 - provides the Quality attributes of any data object in an incoming GOOSE message
1837	Quality VIP 46	GOOSE Input Command	GOOSE virtual input 46 - provides the Quality attributes of any data object in an incoming GOOSE message

DDB No	Text	Source	Description
1838	Quality VIP 47	GOOSE Input Command	GOOSE virtual input 47 - provides the Quality attributes of any data object in an incoming GOOSE message
1839	Quality VIP 48	GOOSE Input Command	GOOSE virtual input 48 - provides the Quality attributes of any data object in an incoming GOOSE message
1840	Quality VIP 49	GOOSE Input Command	GOOSE virtual input 49 - provides the Quality attributes of any data object in an incoming GOOSE message
1841	Quality VIP 50	GOOSE Input Command	GOOSE virtual input 50 - provides the Quality attributes of any data object in an incoming GOOSE message
1842	Quality VIP 51	GOOSE Input Command	GOOSE virtual input 51 - provides the Quality attributes of any data object in an incoming GOOSE message
1843	Quality VIP 52	GOOSE Input Command	GOOSE virtual input 52 - provides the Quality attributes of any data object in an incoming GOOSE message
1844	Quality VIP 53	GOOSE Input Command	GOOSE virtual input 53 - provides the Quality attributes of any data object in an incoming GOOSE message
1845	Quality VIP 54	GOOSE Input Command	GOOSE virtual input 54 - provides the Quality attributes of any data object in an incoming GOOSE message
1846	Quality VIP 55	GOOSE Input Command	GOOSE virtual input 55 - provides the Quality attributes of any data object in an incoming GOOSE message
1847	Quality VIP 56	GOOSE Input Command	GOOSE virtual input 56 - provides the Quality attributes of any data object in an incoming GOOSE message
1848	Quality VIP 57	GOOSE Input Command	GOOSE virtual input 57 - provides the Quality attributes of any data object in an incoming GOOSE message
1849	Quality VIP 58	GOOSE Input Command	GOOSE virtual input 58 - provides the Quality attributes of any data object in an incoming GOOSE message
1850	Quality VIP 59	GOOSE Input Command	GOOSE virtual input 59 - provides the Quality attributes of any data object in an incoming GOOSE message
1851	Quality VIP 60	GOOSE Input Command	GOOSE virtual input 60 - provides the Quality attributes of any data object in an incoming GOOSE message
1852	Quality VIP 61	GOOSE Input Command	GOOSE virtual input 61 - provides the Quality attributes of any data object in an incoming GOOSE message
1853	Quality VIP 62	GOOSE Input Command	GOOSE virtual input 62 - provides the Quality attributes of any data object in an incoming GOOSE message
1854	Quality VIP 63	GOOSE Input Command	GOOSE virtual input 63 - provides the Quality attributes of any data object in an incoming GOOSE message
1855	Quality VIP 64	GOOSE Input Command	GOOSE virtual input 64 - provides the Quality attributes of any data object in an incoming GOOSE message
1856	PubPres VIP 33	GOOSE Input Command	GOOSE virtual input 33 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1857	PubPres VIP 34	GOOSE Input Command	GOOSE virtual input 34 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1858	PubPres VIP 35	GOOSE Input Command	GOOSE virtual input 35 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1859	PubPres VIP 36	GOOSE Input Command	GOOSE virtual input 36 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1860	PubPres VIP 37	GOOSE Input Command	GOOSE virtual input 37 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.

DDB No	Text	Source	Description
1861	PubPres VIP 38	GOOSE Input Command	GOOSE virtual input 38 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1862	PubPres VIP 39	GOOSE Input Command	GOOSE virtual input 39 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1863	PubPres VIP 40	GOOSE Input Command	GOOSE virtual input 40 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1864	PubPres VIP 41	GOOSE Input Command	GOOSE virtual input 41 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1865	PubPres VIP 42	GOOSE Input Command	GOOSE virtual input 42 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1866	PubPres VIP 43	GOOSE Input Command	GOOSE virtual input 43 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1867	PubPres VIP 44	GOOSE Input Command	GOOSE virtual input 44 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1868	PubPres VIP 45#	GOOSE Input Command	GOOSE virtual input 45 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1869	PubPres VIP 46	GOOSE Input Command	GOOSE virtual input 46 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1870	PubPres VIP 47	GOOSE Input Command	GOOSE virtual input 47 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1871	PubPres VIP 48	GOOSE Input Command	GOOSE virtual input 48 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1872	PubPres VIP 49	GOOSE Input Command	GOOSE virtual input 49 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1873	PubPres VIP 50	GOOSE Input Command	GOOSE virtual input 50 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1874	PubPres VIP 51	GOOSE Input Command	GOOSE virtual input 51 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1875	PubPres VIP 52	GOOSE Input Command	GOOSE virtual input 52 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1876	PubPres VIP 53	GOOSE Input Command	GOOSE virtual input 53 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1877	PubPres VIP 54	GOOSE Input Command	GOOSE virtual input 54 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1878	PubPres VIP 55	GOOSE Input Command	GOOSE virtual input 55 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.

DDB No	Text	Source	Description
1879	PubPres VIP 56	GOOSE Input Command	GOOSE virtual input 56 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1880	PubPres VIP 57	GOOSE Input Command	GOOSE virtual input 57 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1881	PubPres VIP 58	GOOSE Input Command	GOOSE virtual input 58 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1882	PubPres VIP 59	GOOSE Input Command	GOOSE virtual input 59 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1883	PubPres VIP 60	GOOSE Input Command	GOOSE virtual input 60 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1884	PubPres VIP 61	GOOSE Input Command	GOOSE virtual input 61 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1885	PubPres VIP 62	GOOSE Input Command	GOOSE virtual input 62 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1886	PubPres VIP 63	GOOSE Input Command	GOOSE virtual input 63 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1887	PubPres VIP 64	GOOSE Input Command	GOOSE virtual input 64 - indicates if the GOOSE publisher responsible for publishing the data that derives a virtual input is present.
1888	Virtual Output 33	PSL	Virtual output 33 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1889	Virtual Output 34	PSL	Virtual output 34 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1890	Virtual Output 35	PSL	Virtual output 35 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1891	Virtual Output 36	PSL	Virtual output 36 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1892	Virtual Output 37	PSL	Virtual output 37 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1893	Virtual Output 38	PSL	Virtual output 38 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1894	Virtual Output 39	PSL	Virtual output 39 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1895	Virtual Output 40	PSL	Virtual output 40 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1896	Virtual Output 41	PSL	Virtual output 41 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1897	Virtual Output 42	PSL	Virtual output 42 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1898	Virtual Output 43	PSL	Virtual output 43 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1899	Virtual Output 44	PSL	Virtual output 44 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1900	Virtual Output 45	PSL	Virtual output 45 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices

DDB No	Text	Source	Description
1901	Virtual Output 46	PSL	Virtual output 46 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1902	Virtual Output 47	PSL	Virtual output 47 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1903	Virtual Output 48	PSL	Virtual output 48 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1904	Virtual Output 49	PSL	Virtual output 49 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1905	Virtual Output 50	PSL	Virtual output 50 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1906	Virtual Output 51	PSL	Virtual output 51 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1907	Virtual Output 52	PSL	Virtual output 52 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1908	Virtual Output 53	PSL	Virtual output 53 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1909	Virtual Output 54	PSL	Virtual output 54 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1910	Virtual Output 55	PSL	Virtual output 55 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1911	Virtual Output 56	PSL	Virtual output 56 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1912	Virtual Output 57	PSL	Virtual output 57 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1913	Virtual Output 58	PSL	Virtual output 58 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1914	Virtual Output 59	PSL	Virtual output 59 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1915	Virtual Output 60	PSL	Virtual output 60 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1916	Virtual Output 61	PSL	Virtual output 61 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1917	Virtual Output 62	PSL	Virtual output 62 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1918	Virtual Output 63	PSL	Virtual output 63 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1919	Virtual Output 64	PSL	Virtual output 64 - allows user to control a binary signal which can be mapped via SCADA protocol output to other devices
1920	Virtual Input 65	GOOSE Input Command	Virtual Input 65 - received from GOOSE message
1921	Virtual Input 66	GOOSE Input Command	Virtual Input 66 - received from GOOSE message
1922	Virtual Input 67	GOOSE Input Command	Virtual Input 67 - received from GOOSE message
1923	Virtual Input 68	GOOSE Input Command	Virtual Input 68 - received from GOOSE message
1924	Virtual Input 69	GOOSE Input Command	Virtual Input 69 - received from GOOSE message
1925	Virtual Input 70	GOOSE Input Command	Virtual Input 70 - received from GOOSE message
1926	Virtual Input 71	GOOSE Input Command	Virtual Input 71 - received from GOOSE message
1927	Virtual Input 72	GOOSE Input Command	Virtual Input 72 - received from GOOSE message
1928	Virtual Input 73	GOOSE Input Command	Virtual Input 73 - received from GOOSE message
1929	Virtual Input 74	GOOSE Input Command	Virtual Input 74 - received from GOOSE message
1930	Virtual Input 75	GOOSE Input Command	Virtual Input 75 - received from GOOSE message
1931	Virtual Input 76	GOOSE Input Command	Virtual Input 76 - received from GOOSE message

DDB No	Text	Source	Description
1932	Virtual Input 77	GOOSE Input Command	Virtual Input 77 - received from GOOSE message
1933	Virtual Input 78	GOOSE Input Command	Virtual Input 78 - received from GOOSE message
1934	Virtual Input 79	GOOSE Input Command	Virtual Input 79 - received from GOOSE message
1935	Virtual Input 80	GOOSE Input Command	Virtual Input 80 - received from GOOSE message
1936	Virtual Input 81	GOOSE Input Command	Virtual Input 81 - received from GOOSE message
1937	Virtual Input 82	GOOSE Input Command	Virtual Input 82 - received from GOOSE message
1938	Virtual Input 83	GOOSE Input Command	Virtual Input 83 - received from GOOSE message
1939	Virtual Input 84	GOOSE Input Command	Virtual Input 84 - received from GOOSE message
1940	Virtual Input 85	GOOSE Input Command	Virtual Input 85 - received from GOOSE message
1941	Virtual Input 86	GOOSE Input Command	Virtual Input 86 - received from GOOSE message
1942	Virtual Input 87	GOOSE Input Command	Virtual Input 87 - received from GOOSE message
1943	Virtual Input 88	GOOSE Input Command	Virtual Input 88 - received from GOOSE message
1944	Virtual Input 89	GOOSE Input Command	Virtual Input 89 - received from GOOSE message
1945	Virtual Input 90	GOOSE Input Command	Virtual Input 90 - received from GOOSE message
1946	Virtual Input 91	GOOSE Input Command	Virtual Input 91 - received from GOOSE message
1947	Virtual Input 92	GOOSE Input Command	Virtual Input 92 - received from GOOSE message
1948	Virtual Input 93	GOOSE Input Command	Virtual Input 93 - received from GOOSE message
1949	Virtual Input 94	GOOSE Input Command	Virtual Input 94 - received from GOOSE message
1950	Virtual Input 95	GOOSE Input Command	Virtual Input 95 - received from GOOSE message
1951	Virtual Input 96	GOOSE Input Command	Virtual Input 96 - received from GOOSE message
1952	Virtual Input 97	GOOSE Input Command	Virtual Input 97 - received from GOOSE message
1953	Virtual Input 98	GOOSE Input Command	Virtual Input 98 - received from GOOSE message
1954	Virtual Input 99	GOOSE Input Command	Virtual Input 99 - received from GOOSE message
1955	Virtual Input100	GOOSE Input Command	Virtual Input 100 - received from GOOSE message
1956	Virtual Input101	GOOSE Input Command	Virtual Input 101 - received from GOOSE message
1957	Virtual Input102	GOOSE Input Command	Virtual Input 102 - received from GOOSE message
1958	Virtual Input103	GOOSE Input Command	Virtual Input 103 - received from GOOSE message
1959	Virtual Input104	GOOSE Input Command	Virtual Input 104 - received from GOOSE message
1960	Virtual Input105	GOOSE Input Command	Virtual Input 105 - received from GOOSE message
1961	Virtual Input106	GOOSE Input Command	Virtual Input 106 - received from GOOSE message
1962	Virtual Input107	GOOSE Input Command	Virtual Input 107 - received from GOOSE message
1963	Virtual Input108	GOOSE Input Command	Virtual Input 108 - received from GOOSE message
1964	Virtual Input109	GOOSE Input Command	Virtual Input 109 - received from GOOSE message
1965	Virtual Input110	GOOSE Input Command	Virtual Input 110 - received from GOOSE message
1966	Virtual Input111	GOOSE Input Command	Virtual Input 111 - received from GOOSE message
1967	Virtual Input112	GOOSE Input Command	Virtual Input 112 - received from GOOSE message
1968	Virtual Input113	GOOSE Input Command	Virtual Input 113 - received from GOOSE message
1969	Virtual Input114	GOOSE Input Command	Virtual Input 114 - received from GOOSE message
1970	Virtual Input115	GOOSE Input Command	Virtual Input 115 - received from GOOSE message
1971	Virtual Input116	GOOSE Input Command	Virtual Input 116 - received from GOOSE message
1972	Virtual Input117	GOOSE Input Command	Virtual Input 117 - received from GOOSE message
1973	Virtual Input118	GOOSE Input Command	Virtual Input 118 - received from GOOSE message
1974	Virtual Input119	GOOSE Input Command	Virtual Input 119 - received from GOOSE message
1975	Virtual Input120	GOOSE Input Command	Virtual Input 120 - received from GOOSE message

DDB No	Text	Source	Description
1976	Virtual Input121	GOOSE Input Command	Virtual Input 121 - received from GOOSE message
1977	Virtual Input122	GOOSE Input Command	Virtual Input 122 - received from GOOSE message
1978	Virtual Input123	GOOSE Input Command	Virtual Input 123 - received from GOOSE message
1979	Virtual Input124	GOOSE Input Command	Virtual Input 124 - received from GOOSE message
1980	Virtual Input125	GOOSE Input Command	Virtual Input 125 - received from GOOSE message
1981	Virtual Input126	GOOSE Input Command	Virtual Input 126 - received from GOOSE message
1982	Virtual Input127	GOOSE Input Command	Virtual Input 127 - received from GOOSE message
1983	Virtual Input128	GOOSE Input Command	Virtual Input 128 - received from GOOSE message
1984	Quality VIP 65	GOOSE Input Command	GOOSE virtual input 65 - provides the Quality attributes of any data object in an incoming GOOSE message
1985	Quality VIP 66	GOOSE Input Command	GOOSE virtual input 66 - provides the Quality attributes of any data object in an incoming GOOSE message
1986	Quality VIP 67	GOOSE Input Command	GOOSE virtual input 67 - provides the Quality attributes of any data object in an incoming GOOSE message
1987	Quality VIP 68	GOOSE Input Command	GOOSE virtual input 68 - provides the Quality attributes of any data object in an incoming GOOSE message
1988	Quality VIP 69	GOOSE Input Command	GOOSE virtual input 69 - provides the Quality attributes of any data object in an incoming GOOSE message
1989	Quality VIP 70	GOOSE Input Command	GOOSE virtual input 70 - provides the Quality attributes of any data object in an incoming GOOSE message
1990	Quality VIP 71	GOOSE Input Command	GOOSE virtual input 71 - provides the Quality attributes of any data object in an incoming GOOSE message
1991	Quality VIP 72	GOOSE Input Command	GOOSE virtual input 72 - provides the Quality attributes of any data object in an incoming GOOSE message
1992	Quality VIP 73	GOOSE Input Command	GOOSE virtual input 73 - provides the Quality attributes of any data object in an incoming GOOSE message
1993	Quality VIP 74	GOOSE Input Command	GOOSE virtual input 74 - provides the Quality attributes of any data object in an incoming GOOSE message
1994	Quality VIP 75	GOOSE Input Command	GOOSE virtual input 75 - provides the Quality attributes of any data object in an incoming GOOSE message
1995	Quality VIP 76	GOOSE Input Command	GOOSE virtual input 76 - provides the Quality attributes of any data object in an incoming GOOSE message
1996	Quality VIP 77	GOOSE Input Command	GOOSE virtual input 77 - provides the Quality attributes of any data object in an incoming GOOSE message
1997	Quality VIP 78	GOOSE Input Command	GOOSE virtual input 78 - provides the Quality attributes of any data object in an incoming GOOSE message
1998	Quality VIP 79	GOOSE Input Command	GOOSE virtual input 79 - provides the Quality attributes of any data object in an incoming GOOSE message
1999	Quality VIP 80	GOOSE Input Command	GOOSE virtual input 80 - provides the Quality attributes of any data object in an incoming GOOSE message
2000	Quality VIP 81	GOOSE Input Command	GOOSE virtual input 81 - provides the Quality attributes of any data object in an incoming GOOSE message
2001	Quality VIP 82	GOOSE Input Command	GOOSE virtual input 82 - provides the Quality attributes of any data object in an incoming GOOSE message
2002	Quality VIP 83	GOOSE Input Command	GOOSE virtual input 83 - provides the Quality attributes of any data object in an incoming GOOSE message
2003	Quality VIP 84	GOOSE Input Command	GOOSE virtual input 84 - provides the Quality attributes of any data object in an incoming GOOSE message
2004	Quality VIP 85	GOOSE Input Command	GOOSE virtual input 85 - provides the Quality attributes of any data object in an incoming GOOSE message

DDB No	Text	Source	Description
2005	Quality VIP 86	GOOSE Input Command	GOOSE virtual input 86 - provides the Quality attributes of any data object in an incoming GOOSE message
2006	Quality VIP 87	GOOSE Input Command	GOOSE virtual input 87 - provides the Quality attributes of any data object in an incoming GOOSE message
2007	Quality VIP 88	GOOSE Input Command	GOOSE virtual input 88 - provides the Quality attributes of any data object in an incoming GOOSE message
2008	Quality VIP 89	GOOSE Input Command	GOOSE virtual input 89 - provides the Quality attributes of any data object in an incoming GOOSE message
2009	Quality VIP 90	GOOSE Input Command	GOOSE virtual input 90 - provides the Quality attributes of any data object in an incoming GOOSE message
2010	Quality VIP 91	GOOSE Input Command	GOOSE virtual input 91 - provides the Quality attributes of any data object in an incoming GOOSE message
2011	Quality VIP 92	GOOSE Input Command	GOOSE virtual input 92 - provides the Quality attributes of any data object in an incoming GOOSE message
2012	Quality VIP 93	GOOSE Input Command	GOOSE virtual input 93 - provides the Quality attributes of any data object in an incoming GOOSE message
2013	Quality VIP 94	GOOSE Input Command	GOOSE virtual input 94 - provides the Quality attributes of any data object in an incoming GOOSE message
2014	Quality VIP 95	GOOSE Input Command	GOOSE virtual input 95 - provides the Quality attributes of any data object in an incoming GOOSE message
2015	Quality VIP 96	GOOSE Input Command	GOOSE virtual input 96 - provides the Quality attributes of any data object in an incoming GOOSE message
2016	Timer in 17	PSL	Input to Auxiliary Timer 17
2017	Timer in 18	PSL	Input to Auxiliary Timer 18
2018	Timer in 19	PSL	Input to Auxiliary Timer 19
2019	Timer in 20	PSL	Input to Auxiliary Timer 20
2020	Timer in 21	PSL	Input to Auxiliary Timer 21
2021	Timer in 22	PSL	Input to Auxiliary Timer 22
2022	Timer in 23	PSL	Input to Auxiliary Timer 23
2023	Timer in 24	PSL	Input to Auxiliary Timer 24
2024	Timer in 25	PSL	Input to Auxiliary Timer 25
2025	Timer in 26	PSL	Input to Auxiliary Timer 26
2026	Timer in 27	PSL	Input to Auxiliary Timer 27
2027	Timer in 28	PSL	Input to Auxiliary Timer 28
2028	Timer in 29	PSL	Input to Auxiliary Timer 29
2029	Timer in 30	PSL	Input to Auxiliary Timer 30
2030	Timer in 31	PSL	Input to Auxiliary Timer 31
2031	Timer in 32	PSL	Input to Auxiliary Timer 32
2032	Timer out 17	Auxiliary Timer	Output from Auxiliary Timer 17
2033	Timer out 18	Auxiliary Timer	Output from Auxiliary Timer 18
2034	Timer out 19	Auxiliary Timer	Output from Auxiliary Timer 19
2035	Timer out 20	Auxiliary Timer	Output from Auxiliary Timer 20
2036	Timer out 21	Auxiliary Timer	Output from Auxiliary Timer 21
2037	Timer out 22	Auxiliary Timer	Output from Auxiliary Timer 22
2038	Timer out 23	Auxiliary Timer	Output from Auxiliary Timer 23
2039	Timer out 24	Auxiliary Timer	Output from Auxiliary Timer 24
2040	Timer out 25	Auxiliary Timer	Output from Auxiliary Timer 25
2041	Timer out 26	Auxiliary Timer	Output from Auxiliary Timer 26

DDB No	Text	Source	Description
2042	Timer out 27	Auxiliary Timer	Output from Auxiliary Timer 27
2043	Timer out 28	Auxiliary Timer	Output from Auxiliary Timer 28
2044	Timer out 29	Auxiliary Timer	Output from Auxiliary Timer 29
2045	Timer out 30	Auxiliary Timer	Output from Auxiliary Timer 30
2046	Timer out 31	Auxiliary Timer	Output from Auxiliary Timer 31
2047	Timer out 32	Auxiliary Timer	Output from Auxiliary Timer 32

Imagination at work

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