Easergy MiCOM P746

Numerical Busbar Protection

P746/EN M/M82

Software Version	B4 (P746_1) / C4 (P746_2)
Hardware Suffix	M
Issue Date	12/2017

Technical Manual

CONTENTS

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Software Version:	B4 (P746_1) / C4 (P746_2)
Hardware Suffix:	M
Connection Diagrams:	10P746xx (xx = 00 to 21)

SAFETY INFORMATION

CHAPTER SI

Date:	07/2016	
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.	
Hardware Suffix:	All MiCOM Px4x products	
Software Version:	All MiCOM Px4x products	
Connection Diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P341: 10P341xx (xx = 01 to 12) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P445: 10P445xx (xx = 01 to 04) P44x (P442 & P444): 10P44101 (SH 1 & 2) 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)	P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 01 to 10) 10P643xx (xx = 01 to 06) 10P645xx (xx = 01 to 09) P74x (P741, P742 & P743): 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)

CONTENTS

Notes:

1 INTRODUCTION

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

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

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

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

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

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

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

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

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

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

2 HEALTH AND SAFETY

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

People

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

Receipt, Handling, Storage and Unpacking Relays

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

Planning

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

Live and Stored Voltages

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

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

Warnings and Barricades

Everyone must observe all warning notices. This is because the incorrect use of equipment, or improper use may endanger personnel and equipment and also cause personal injury or physical damage.

Unauthorized entry should also be prevented with suitably marked fixed barricades which will notify people of any dangers and screen off work areas.

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

Electrical Isolation

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

Depending on the location, you may also need to isolate and de-energize other items which are electrically connected to it as well as those which are close enough to pose a risk of electrocution in the event of accidental physical or electrical contact.

Remember too that, where necessary, both load and line sides should be de-energized.

Before you make contact with any equipment use an approved voltage detection device to reduce the risk of electric shock.

Risk of Accidental Contact or Arc Flash

Be aware of the risk of accidental contact with hands, long hair, tools or other equipment; and be aware of the possibility of the increased risk of arc flash from areas of high voltage.

Always wear appropriate shock and arc flash personal protective equipment while isolating and de-energizing electrical equipment and until a de-energized state is confirmed.

Temporary Protection

Consider the use of temporary protective Earthing Clamps. This is required to establish and maintain de-energization when electrical equipment operates at greater than 1000 volts or there is potential for back-feed at any voltage.

Temporary protective earthing can be accomplished by installing cables designed for that purpose or by the use of intrinsic earthing clamp equipment. Temporary protective earthing clamp equipment must be able to carry maximum fault current available and have an impedance low enough to cause the applicable protective device to operate.

Restoring Power

To reduce the risks, the work plan should have a check list of things which must be completed and checks made before electrical power can be restored.

Be aware of the risk that electrical systems may have power restored to them at a remote location (possibly by the customer or a utility company). You should consider the use of lockouts so that the electrical system can be restored only when you unlock it. In any event, you should be aware of and be part of the process which determines when electrical power can be restored; and that people working on the system have control over when power is restored.

Inspect and test the electrical equipment to ensure it has been restored to a “safe” condition prior re-energizing. Replace all devices, doors and covers before turning on the power to any device.

Qualified Personnel

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

Qualified personnel are individuals who:

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

Documentation

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

3 SYMBOLS AND LABELS ON THE EQUIPMENT

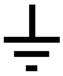
For safety reasons the following symbols and external labels, which may be used on the equipment or referred to in the equipment documentation, should be understood before the equipment is installed or commissioned.

3.1 Symbols


Caution: refer to equipment documentation


Caution: risk of electric shock


Protective Conductor (*Earth) terminal


Functional/Protective Conductor (*Earth) terminal

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

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

3.2 Labels

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

4 INSTALLING, COMMISSIONING AND SERVICING

Manual Handling

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

Many injuries are caused by:

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

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

Equipment Connections

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

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

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

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

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

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

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

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

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

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

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

Protection Class I Equipment

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

The recommended minimum protective conductor (earth) wire size is 2.5 mm² (3.3 mm² for North America) unless otherwise stated in the technical data section of the equipment documentation, or otherwise required by local or country wiring regulations.

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

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

Pre-Energization Checklist

Before energizing the equipment, the following should be checked:

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

Accidental Touching of Exposed Terminals

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

Equipment Use

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

Removal of the Equipment Front Panel/Cover

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

UL and CSA/CUL Listed or Recognized Equipment

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

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

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

Equipment Operating Conditions

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

Current Transformer Circuits

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

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

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

External Resistors, including Voltage Dependent Resistors (VDRs)

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

Battery Replacement

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

Insulation and Dielectric Strength Testing

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

Insertion of Modules and PCB Cards

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

Insertion and Withdrawal of Extender Cards

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

External Test Blocks and Test Plugs

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

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

Fiber Optic Communication

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

Cleaning

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

5 DE-COMMISSIONING AND DISPOSAL

De-Commissioning

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

Disposal

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

6 TECHNICAL SPECIFICATIONS FOR SAFETY

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

6.1 Protective Fuse Rating

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

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

6.2 Protective Class

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

6.3 Installation Category

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

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

6.4 Environment

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

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

Notes:

INTRODUCTION

CHAPTER 1

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Hardware Suffix:	M
Software Version:	B4 (P746_1) / C4 (P746_2)
Connection Diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

FIGURES

Notes:

1 DOCUMENTATION STRUCTURE

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

	Description	Chapter Code
	Safety Information	**Px4x/EN SI**
	A guide to the safe handling, commissioning and testing of equipment. This provides typical information and advice which covers a range of MiCOM Px4x products. It explains how to work with equipment safely.	
1	**Introduction**	**P746/EN IT**
	A guide to the MiCOM range of relays and the documentation structure. General safety aspects of handling Electronic Equipment are discussed with particular reference to relay safety symbols. Also a general functional overview of the relay and brief application summary is given.	
2	**Technical Data**	**P746/EN TD**
	Technical data including setting ranges, accuracy limits, recommended operating conditions, ratings and performance data. Compliance with norms and international standards is quoted where appropriate.	
3	**Getting Started**	**P746/EN GS**
	A guide to the different user interfaces of the IED describing how to start using it. This chapter provides detailed information regarding the communication interfaces of the IED, including a detailed description of how to access the settings database stored within the IED.	
4	**Settings**	**P746/EN ST**
	List of all relay settings, including ranges, step sizes and defaults, together with a brief explanation of each setting.	
5	**Operation**	**P746/EN OP**
	A comprehensive and detailed functional description of all protection and non-protection functions.	
6	**Application Notes**	**P746/EN AP**
	This section includes a description of common power system applications of the relay, calculation of suitable settings, some typical worked examples, and how to apply the settings to the relay.	
7	**Using the PSL Editor**	**Px4x/EN SE**
	This provides a short introduction to using the PSL Editor application.	
8	**Programmable Logic**	**P746/EN PL**
	Overview of the Programmable Scheme Logic (PSL) and a description of each logical node. This chapter includes the factory default and an explanation of typical applications.	
9	**Measurements and Recording**	**P746/EN MR**
	Detailed description of the relays recording and measurements functions including the configuration of the event and disturbance recorder and measurement functions.	
10	**Product Design**	**P746/EN PD**
	Overview of the operation of the relay's hardware and software. This chapter includes information on the self-checking features and diagnostics of the relay.	
11	**Commissioning**	**P746/EN CM**
	Instructions on how to commission the relay, comprising checks on the calibration and functionality of the relay.	
12	**Test and Setting Records**	**P746/EN RC**
	This is a list of the tests made and the settings stored on the MiCOM IED.	

	Description	Chapter Code
13	**Maintenance**	**Px4x/EN MT**
	A general maintenance policy for the relay is outlined.	
14	**Troubleshooting**	**Px4x/EN TS**
	Advice on how to recognize failure modes and the recommended course of action. Includes guidance on whom within Schneider Electric to contact for advice.	
15	**SCADA Communications**	**P746/EN SC**
	This chapter provides an overview regarding the SCADA communication interfaces of the relay. Detailed protocol mappings, semantics, profiles and interoperability tables are not provided within this manual. Separate documents are available per protocol, available for download from our website.	
16	**Installation**	**Px4x/EN IN**
	Recommendations on unpacking, handling, inspection and storage of the relay. A guide to the mechanical and electrical installation of the relay is provided, incorporating earthing recommendations.	
17	**Connection Diagrams**	**P746/EN CD**
	A list of connection diagrams, which show the relevant wiring details for this relay.	
18	**Cyber Security**	**Px4x/EN CS**
	An overview of cyber security protection (to secure communication and equipment within a substation environment). Relevant cyber security standards and implementation are described too.	
19	**Dual Redundant Ethernet Board (DREB)**	**Pxxx/EN REB**
	Information about how MiCOM products can be equipped with Dual Redundant Ethernet Boards (DREBs) and the different protocols which are available. Also covers how to configure and commission these types of boards.	
20	**Parallel Redundancy Protocol (PRP) Notes**	**Pxxx/EN PR**
	Includes an introduction to Parallel Redundancy Protocols (PRP) and the different networks PRP can be used with. Also includes details of PRP and MiCOM functions.	
21	**High-availability Seamless Redundancy (HSR)**	**Pxxx/EN HS**
	Introduction to the High-availability Seamless Redundancy (HSR); and how it is implemented on MiCOM-based products manufactured by Schneider Electric.	
22	**Menu Maps**	**P746/EN MM**
	This is a series of charts of the various menus which are contained in this IED. This shows you how to move from one menu option to another, if you are using the IED at the front panel.	
23	**Remote HMI**	**P746/EN HI**
	This section provides instructions for MiCOM P746 Remote HMI. This application is used to define and create scheme and display the P746 measured data.	
24	**Version History (of Firmware and Service Manual)**	**P746/EN VH**
	This is a history of all hardware and software releases for this product.	
	Symbols and Glossary	**P746/EN SG**
	List of common technical terms, abbreviations and symbols found in this documentation.	

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

2 INTRODUCTION TO MICOM

About MiCOM Range

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

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

The components within MiCOM are:

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

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

For up-to-date information, please see:

www.schneider-electric.com

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

3 PRODUCT SCOPE

The MiCOM P746 differential busbar protection relay has been designed for the protection of a wide range of substation busbars from distribution to transmission voltage levels. The relay includes a comprehensive range of non-protection features to aid with system diagnosis and fault analysis. The P746 offers phase segregated biased differential busbar, breaker failure, dead zone and overcurrent protection and is particularly suitable for application on solidly grounded systems. The relay is especially suitable where a Centralised scheme solution is required.

The scheme can comprise:

- A single MiCOM P746 up to
  - 6 sets of CTs and 1 set of VTs (P746_1) or
  - 7 sets of CTs (P746_2)
- Three MiCOM P746 for up to
  - 18 CTs (single phase) and 1 set of VTs (P746_1) or
  - 21 (single phase) CTs per relay (P746_2)
- Additional MiCOM P746 for redundancy

Which, with the Easergy Studio software and the Remote HMI monitoring tool, allow full flexibility for all configurations up to 4 zones.

3.1 Functional Overview

The P746 Busbar protection contains a wide variety of protection functions.

The protection features are summarized below:

Functions Overview			
ANSI	**IEC 61850**	**Description**	**P746**
87BB / P	PhsPDIF	Zone segregated biased phase current differential high speed busbar protection	Yes
87CZ / P	CzPPDIF	Check Zone segregated biased phase current differential high speed busbar protection	Yes
50 / 51 / P	OcpPTOC	Phase overcurrent protection (2 stages)	Yes
50 / 51 / N	EfmPTOC	Earth overcurrent protection (2 stages)	Yes
50ST / P	DzpPhsPTOC	Dead zone phase protection (short zone between CTs and open Isolators or CB)	Yes
CTS		Current transformer supervision (single box mode only)	Yes
VTS		Voltage Transformer Supervision (VTS) VTS is only supported by P746_1	Yes (P746_1 only)
50BF	RBRF	Breaker failure protection (CBF)	Yes
86		Lockout	Yes
		Isolator (ISL) discrepancy alarm	Yes
	OptGGIO	Digital inputs	16 to 40*
	RlyGGIO	Output relays	16 to 32*
	FnkGGIO	Function keys	10
	LedGGIO	Programmable tri-colour LEDs	18
		Front communication port (RS232)	Yes
		Rear communication port (Kbus/EIA(RS)485)	Yes
		Rear communication port (Ethernet) *	Option
		Dual and Redundant Ethernet Ports *	Option
		Time synchronization port (modulated / un-modulated IRIG-B)	Option
		IEC 61850 Ed2 / Ed1	Option

Note *	*Refer to the data sheet for model selection*

The P746 supports these relay management functions as well as the above functions.

- Four alternative setting groups
- Programmable function keys
- Control inputs
- Programmable scheme logic
- Programmable allocation of digital inputs and outputs
- Sequence of event recording
- Comprehensive disturbance recording (waveform capture)
- Fully customizable menu texts
- Power-up diagnostics and continuous self-monitoring of relay
- Read only mode
- Commissioning test facilities
- Real time clock/time synchronization - time synchronization possible from IRIG-B input, opto input or communications
- Simple password management:
  CSL0 - No Security Administration Tool (SAT) required
- Advanced Cyber Security:
  CSL1 - Security Administration Tool (SAT) required

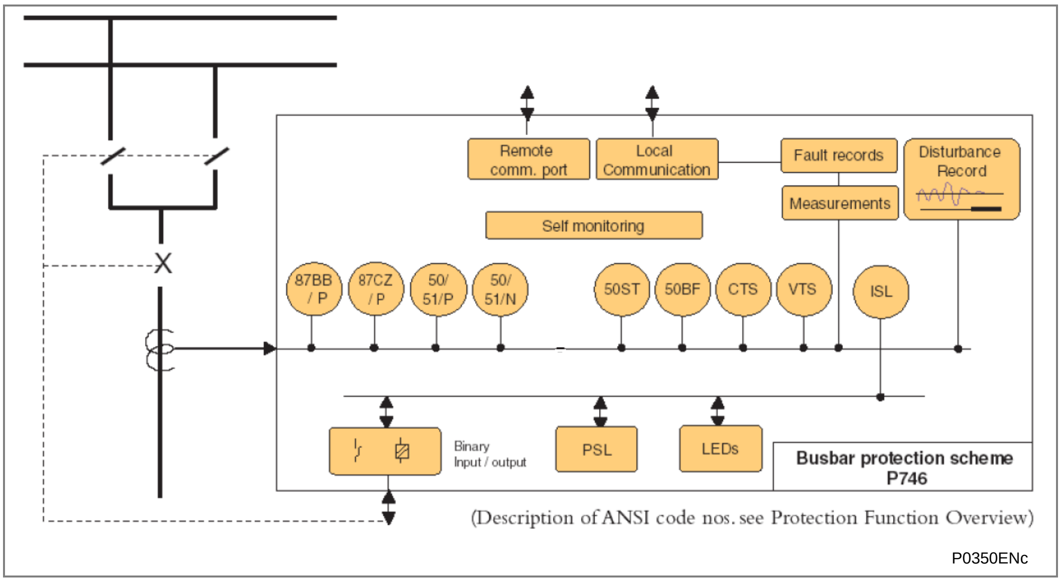


Figure 1 - Functional diagram

3.2 Ordering Options

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

Important	***Although several hardware options are produced by (labeled as 1 to S), the only ones available for the P746 relay (using Software Version B4 (P746_1) / C4 (P746_2)) are shown here.***

Busbar Protection Relay	P746									
Vx Aux Rating:										
24 - 32 Vdc		9								
48 - 110 Vdc		2								
110 - 250 Vdc (100 - 240 Vac)		3								
In/Vn Rating:										
CT1 - CT18 In = 1A/5A, Vn = (100/120V), 18CT, 3VT			1							
CT1 - CT21 In = 1A/5A, 21CT, No VT			2							
Hardware Options:										
Standard: no options				1						
IRIG-B (Modulated) only				2						
Fibre Optic Converter only				3						
IRIG-B (Modulated) & Fibre Optic Converter				4						
2nd Rear Comms port				7						
2nd Rear comms port + IRIG-B (Modulated)				8						
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 2 LC ports + 1 RJ45 port + Modulated/Un-modulated IRIG-B				Q						
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 3 RJ45 ports + Modulated/Un-modulated IRIG-B				R						
Ethernet (100Mbit/s), 1 RJ45 port + Modulated/Un-modulated IRIG-B				S						
Product Specific Options:										
Size 16 Case, 16 optos + 16 Relays					A					
Size 16 Case, 16 optos + 8 Relays + 8 High Break Relays					B					
Size 16 Case, 16 optos + 32 Relays					C					
Size 16 Case, 16 optos + 24 Relays + 4 High Break Relays					D					
Size 16 Case, 24 optos + 24 Relays					E					
Size 16 Case, 24 optos + 16 Relays + 8 High Break Relays					F					
Size 16 Case, 24 optos + 8 Relays + 12 High Break Relays					G					
Size 16 Case, 32 optos + 24 Relays					H					
Size 16 Case, 32 optos + 16 Relays + 8 High Break Relays					J					
Size 16 Case, 40 optos + 24 Relays					K					
Size 16 Case, 32 optos + 32 Relays					L					
Protocol Options:										
K-Bus/Courier with simple password management - (CSL0)						1				
Modbus - (CSL0)						2				
IEC60870-5-103 with simple password management - (CSL0)						3				
DNP3.0 with simple password management - (CSL0)						4				
IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485 with simple password management - (CSL0)						6				
IEC 61850 Edition 1 / 2 and IEC60870-5-103 via rear RS485 only with simple password management - (CSL0)						7				
IEC 61850 Edition 1 / 2 and DNP3.0 over Ethernet and DNP3.0 via rear RS485 with simple password management - (CSL0)						B				
IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required						G				
IEC 61850 Edition 1 / 2 and CS103 via rear port RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required						H				
IEC 61850 Edition 1 / 2 and DNP3 over Ethernet and DNP3.0 via rear RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required						L				
Mounting Options:										

Busbar Protection Relay	P746										
Panel Mounting							M				
Rack Mounting							N				
Language Options:											
English, French, German, Spanish								0			
English, French, German, Russian								5			
Chinese, English or French via HMI, with English or French only via Communications port								C			
Software Version Options:											
Unless specified the latest version will be delivered									**		
Customisation:											
Default										8	
Customer Specific										9	
Design Suffix:											
Extended Phase 3 CPU											M

Notes:

TECHNICAL DATA

CHAPTER 2

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Hardware Suffix:	M
Software Version:	B4 (P746_1) / C4 (P746_2)
Connection Diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

TABLES

Page (TD) 2-

1 MECHANICAL SPECIFICATION

1.1 Design

Modular MiCOM Px40 platform relay, 80TE, front of panel flush mounting, or 19” rack mounted (ordering option).

1.2 Enclosure Protection

Per IEC 60529: 2001

- IP 52 Protection (front panel) against dust and dripping water.
- IP 50 Protection for sides of the case.
- IP 10 Protection for the rear.

1.3 Weight

P746: 13.4 kg

2 TERMINALS

2.1 AC Current and Voltage Measuring Inputs

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

2.2 General Input/Output Terminals

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

2.3 Case Protective Earth Connection

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

2.4 Front Port Serial PC Interface

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

2.5 Front Download/Monitor Port

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

2.6 Rear Communications Port (RP1)

K-Bus/EIA (RS)485 signal levels, two-wire connections located on general purpose block, M4 screw.
For screened twisted-pair cable, multidrop, 1000 m max.
Ethernet (copper and fibre). Courier protocol SELV* rated circuit

2.7 Optional Second Rear Communications Port

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

2.8 Optional Rear IRIG-B Interface Modulated or Un-modulated

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

2.9 Optional Rear Fiber Connection for SCADA/DCS

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

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

100Base-TX Communications

Interface in accordance with IEEE802.3 and IEC 61850

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

2.10.1 Optional Redundant Rear Ethernet Connection

Above copper port plus two copper or two fiber ports.

100Base-TX Communications

Interface in accordance with IEEE802.3 and IEC 61850

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

100Base-FX Interface

Interface in accordance with IEEE802.3 and IEC 61850

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

3 RATINGS

3.1 AC Measuring Inputs

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

3.2 AC Current

Nominal current (In):	1 and 5 A dual rated.
Nominal burden per phase 1 A:	<0.04VA at rated current
Impedance per phase 1 A:	<40mΩ over 0 - 30In
Nominal burden per phase 5 A:	<0.30VA at rated current
Impedance per phase 5 A:	<8mΩ over 0 - 30In
Thermal withstand:	continuous, 4 In for 10 s: 30 In for 1 s; 100 In

Linear to 35 In (non-offset AC current).

3.3 AC Voltage

Nominal voltage (Vn): 100 to 120 V phase-phase
Nominal burden per phase: < 0.02 VA at 110/√3 V
Thermal withstand: continuous 2 Vn for 10s: 2.6 Vn

4 POWER SUPPLY

4.1 Auxiliary Voltage (Vx)

Three ordering options:

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

4.2 Operating Range

(i) 10 to 38Vdc (dc only for this variant)

(ii) 37 to 150V (dc only for this variant)

(iii) 87 to 300V (dc), 80 to 265 V (ac).

With a tolerable ac ripple of up to 12% for a dc supply, as for IEC 60255-11: 1979.

4.3 Nominal Burden

Quiescent burden:	12 W
Additions for energized binary inputs/outputs:	
Per opto input:	0.09W…(24 to 54V), 0.12W...(110/125V), 0.19W...(220/250V).
Per energized output relay:	0.13W
Per energized high break output relay:	0.73W

4.4 Power-up Time

Main Processor including User Interface and front access port < 25 s.
Ethernet Communications <120 s.

4.5 Power Supply Interruption

Per IEC 60255-11: 1979

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

Per IEC 61000-4-11: 1994

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

Note	*The use of a E124 extends these limits*

In addition to IEC 60255-11 compliance, P746/P849 withstands:

DC Power supply voltage	DC Power supply interruption
24V	20ms
48V	20ms with Vx ordering option (ii)
110V	200ms with Vx ordering option (ii), 50ms with Vx ordering option (iii)
220V	200ms

4.6 Battery Backup

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

4.7 Field Voltage Output

Regulated 48 Vdc
Current limited at 112 mA maximum output

4.8 Digital ("Opto") Inputs

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

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

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

Nominal pick-up and reset thresholds:

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

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

5 OUTPUT CONTACTS

5.1 Standard Contacts

General purpose relay outputs for signaling, tripping and alarming:

Rated voltage:	300 V	
Continuous current:	10 A	
Short-duration current:	30 A for 3 s	
Making capacity:	250 A for 30 ms	
Breaking capacity:	DC: 50 W resistive	
	DC: 62.5 W inductive	(L/R = 50 ms)
	AC: 2500 VA resistive	(cos ϕ = unity)
	AC: 2500 VA inductive	(cos ϕ = 0.7)
	AC: 1250 VA inductive	(cos ϕ = 0.5)

Subject to maxima of 10 A and 300 V

Response to command:	< 5 ms	
Durability:	Loaded contact:	10 000 operations minimum,
	Unloaded contact:	100 000 operations minimum.

5.2 Fast Operation and High Break Contacts

Dedicated purpose relay outputs for tripping: Uses IGBT technology

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

5.3 Watchdog Contacts

Non-programmable contacts for relay healthy or relay fail indication:

Breaking capacity:	DC: 30 W resistive
	DC: 15 W inductive (L/R = 40 ms)
	AC: 375 VA inductive (cos ϕ = 0.7)

5.4 IRIG-B 12X Interface (Modulated)

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

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

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

6 ENVIRONMENTAL CONDITIONS

6.1 Ambient Temperature Range

As for EN 60088-2-1: 2007: EN 60168-2-2: 2007

Operating temperature range: -25°C to +55°C (or -13°F to +131°F)

Storage and transit: -25°C to +70°C (or -13°F to +158°F)

6.2 Ambient Humidity Range

As for EN 60078-2-78: 2002:

56 days at 93% relative humidity and +40 °C

As for IEC 60068-2-14: 2000

5 cycles, -25°C to +55 °C 1°C / min rate of change

As for IEC 60068-2-30: 2005

Damp heat cyclic, six (12 + 12) hour cycles, +25 to +55°C, variant 1

6.3 Corrosive Environments

Per 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 +30°C

Exposure to elevated concentrations of H_2S, (100 ppb), NO_2, (200 ppb) & Cl_2 (20 ppb).

Per IEC 60068-2-52 Salt mist (7 days)

Per IEC 60068-2-43 for H_2S (21 days), 15 ppm

Per IEC 60068-2-42 for SO_2 (21 days), 25 ppm

7 TYPE TESTS

7.1 Insulation

As for IEC 60255-27: 2005 (incorporating corrigendum March 2007):
Insulation resistance > 100 MΩ at 500 Vdc
(Using only electronic/brushless insulation tester).

7.2 Creepage Distances and Clearances

EN 60255-27: 2005 (incorporating corrigendum March 2007)
Pollution degree 2, Overvoltage category III.

7.3 High Voltage (Dielectric) Withstand

(i) As for EN 60255-27: 2005 (incorporating corrigendum March 2007):

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

(ii) As for ANSI/IEEE C37.90-1989 (reaffirmed 1994):

1.5 kV rms AC for 1 minute, across open contacts of normally open output relays.
1k V rms AC for 1 minute, across open watchdog contacts.
1k V rms AC for 1 minute, across open contacts of changeover output relays.
EIA (RS)-232 ports excepted

7.4 Impulse Voltage Withstand Test

As for IEC 60255-27: 2005 (incorporating corrigendum March 2007):

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

Peak value: 5 kV, 0.5 J
Between all independent circuits.
Between independent circuits and case earth ground).
EIA(RS)-232 & EIA(RS)-485 ports and normally open contacts of output relays excepted.

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

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

8 ELECTROMAGNETIC COMPATIBILITY (EMC)

8.1 1 MHz Burst High Frequency Disturbance Test

As for EN 60255-22-1: 2008, Class III,

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

(EIA(RS)-232 ports excepted).

8.2 100 kHz and 1 MHz Damped Oscillatory Test

EN 61000-4-18: 2007:	Level 3
Common mode test voltage:	2.5 kV
Differential mode test voltage:	1 kV

8.3 Immunity to Electrostatic Discharge

As for EN 60255-22-2: 2008

15 kV discharge in air to user interface, display, communication ports and exposed metalwork.

6 kV contact discharge to the screws of the front communication ports.

8 kV point contact discharge to any part of the front of the product.

8.4 Electrical Fast Transient or Burst Requirements

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

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

±2.0 kV 5kHz or 100kHz applied to all communication ports

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

±4.0 kV, 5kHz and 100kHz applied to all power supply and earth port

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

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

8.5 Surge Withstand Capability

As for IEEE/ANSI C37.90.1: 2002:

4 kV fast transient and 2.5 kV oscillatory applied directly across each output contact, optically isolated input, and power supply circuit.

8.6 Surge Immunity Test

(EIA(RS)-232 ports excepted).

As for IEC 61000-4-5: 2006

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

8.7 Conducted/Radiated Immunity

For RTDs used for tripping applications the conducted and radiated immunity performance is guaranteed only when using totally shielded RTD cables (twisted leads).

8.8 Immunity to Radiated Electromagnetic Energy

EN 61000-4-3:2010 and EN 60255-22-3: 2008, Class III:
Test field strength, frequency band 80 to 1000 MHz and 1.4 GHz to 2.7GHz: 10 V/m,
Test using AM: 1 kHz / 80%,
Spot tests at 80, 160, 450, 900, 1850, 2150 MHz

IEEE/ANSI C37.90.2: 2004:
80 MHz to 1000 MHz, zero and 100% square wave modulated, 1 kHz 80% am modulated.

Field strength 35 V/m.

8.9 Radiated Immunity from Digital Communications

EN61000-4-3: 2010, Level 4:
Test field strength, frequency band 800 to 960 MHz, and 1.4 to 2.0 GHz: 30 V/m,
Test using AM: 1 kHz/80%.

8.10 Radiated Immunity from Digital Radio Telephones

EN 61000-4-3: 2010: 10 V/m, 900 MHz and 1.89 GHz.

8.11 Immunity to Conducted Disturbances Induced by Radio Frequency Fields

EN 61000-4-6: 2008, Level 3, Disturbing test voltage: 10 V.

8.12 Power Frequency Magnetic Field Immunity

EN 61000-4-8: 2010, Level 5: 100 A/m applied continuously, 1000 A/m applied for 3 s.
EN 61000-4-9: 1993+A1:2001, Level 5: 1000 A/m applied in all planes.
EN 61000-4-10: 1993+A1:2001, Level 5:
100 A/m applied in all planes at 100 kHz to 1 MHz with a burst duration of 2 s.

8.13 Conducted Emissions

EN 55022: 2007 Class A:

- Power supply:
  - 0.15 - 0.5 MHz, 79 dBµV (quasi peak) 66 dBµV (average)
  - 0.5 - 30 MHz, 73 dBµV (quasi peak) 60 dBµV (average).
- Permanently connected communications ports:
  - 0.15 - 0.5MHz, 97dBµV (quasi peak) 84dBµV (average).
  - 0.5 - 30MHz, 87dBµV (quasi peak) 74dBµV (average)

8.14 Radiated Emissions

EN 55022: 2007 Class A:

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

9 EU DIRECTIVES

9.1 EMC Compliance

2004/108/EC:
Compliance to the European Commission Directive on EMC is demonstrated using a Technical File. Product Specific Standards were used to establish conformity:
EN 50263: 2000

9.2 Product Safety

2006/95/EC:
Compliance to the European Commission Low Voltage Directive. Compliance is demonstrated by reference to generic safety standards:
EN60255-27: 2005 (incorporating corrigendum March 2007)

9.3 ATEX Compliance

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

II (2) G

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

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

Compliance demonstrated by Notified Body certificates of compliance.

10 MECHANICAL ROBUSTNESS

10.1 Vibration Test

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

10.2 Shock and Bump

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

10.3 Seismic Test

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

11 THIRD PARTY COMPLIANCES

11.1 Underwriters Laboratory (UL)

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

11.2 Energy Network Association (ENA)

Notice of Conformity: No 0168

12 PROTECTION FUNCTIONS

12.1 Three-Phase Overcurrent Protection

Accuracy

Pick-up:		Setting ±5% or 20 mA whichever is greater
Drop-off:		0.95 x Setting ±5% or 20 mA whichever is greater
Min. trip level of IDMT elements:		1.05 x Setting ±5% or 10 mA whichever is greater
IDMT characteristic shape:		±5% or 40ms whichever is greater (under reference conditions)*
IEEE reset:		±5% or 50ms whichever is greater
DT operation:		±2% or 50ms whichever is greater
DT reset:		Setting ±5% or 50 ms whichever is greater
Characteristic:	UK curves:	IEC 60255-3 – 1998
	US curves:	IEEE C37.112 – 1996

12.2 Earth Fault Protection

Accuracy

Pick-up:	Setting ±5% or 20 mA whichever is greater
Drop-off:	0.9 x Setting or 20 mA whichever is greater
Min. trip level of IDMT elements:	1.05 x Setting ±5% or 10 mA whichever is greater
IDMT characteristic shape:	±5% or 40ms whichever is greater (under reference conditions)*
IEEE reset:	±5% or 40ms whichever is greater
DT operation and reset:	±2% or 50ms whichever is greater

12.3 Busbar Protection

12.3.1 Busbar Fault Accuracy

Pick-up:	Setting ± 5% or 20 mA whichever is greater
Drop-off:	>0.95 × Setting or 20 mA whichever is greater
Busbar trip with high speed contact:	15 ms (typical) at 3.5 × tripping threshold
Busbar trip with standard contact:	less than 20 ms (typical) at 3.5 × tripping threshold

12.3.2 Circuitry Fault Accuracy

Pick-up:	Setting ± 5% or 20 mA whichever is greater
Drop-off:	0.95 × Setting or 20 mA whichever is greater
DT operation:	±5 % or 50 ms whichever is greater

12.4 Dead Zone Protection

Accuracy

Pick-up:	Setting ± 5% or 20 mA whichever is greater
Drop-off:	0.95 × Setting or 20 mA whichever is greater
Min. trip level:	1.05 × Setting ± 5% or 20 mA whichever is greater
DT operation:	±5 % or 50 ms whichever is greater

12.5 Transient Overreach and Overshoot

Accuracy

Additional tolerance due to increasing X/R ratios: ±5% over X/R 1 to 120
Overshoot of overcurrent elements: <40 ms

12.6 Breaker Failure

Accuracy

Reset time	= 20 ms from:	start to [(TBF2 or TBF4) - 30ms] (50 Hz)
	= 15 ms from:	[(TBF2 or TBF4) - 30ms] to [TBF2 or TBF4]
Timers	±2 % or 20 ms whichever is greater	
I<, I>	±2 % or 20 mA whichever is greater	

12.7 Reference Conditions

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

13 PROGRAMMABLE SCHEME LOGIC

Accuracy

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

14 MEASUREMENTS AND RECORDING FACILITIES

14.1 Timing and Accuracy

All quoted operating times include the closure of the standard trip output contact (unless otherwise specified).

14.2 Measurements

Accuracy

Voltage:	0.05 to 3 Vn: ±1.0% of reading
Phase current:	0.05 to 3 In: ±1.0% of reading
Phase differential current:	±5.0%
Bias current:	±5.0%
Frequency:	45 to 65 Hz ±0.025 Hz

14.3 Real Time Clock

Performance

Year 2000:	Compliant
Real time accuracy:	< ±2 seconds / day

Features

Real time 24 hour clock settable in hours, minutes and seconds
Calendar settable from January 1994 to December 2092
Clock and calendar maintained via battery after loss of auxiliary supply

14.4 Disturbance Records

Accuracy

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

The pre-fault time could be less than configured due to memory constraints.

14.5 IEC 61850 Ethernet Data

14.5.1 100Base FX Interface

14.5.1.1 Transmitter Optical Characteristics (LC)

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

Table 1 - Transmitter optical characteristics (LC)

14.5.2 Receiver Optical Characteristics (LC)

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

Table 2 - Receiver optical characteristics (LC)

15 SETTINGS LIST

15.1 Global Settings (System Data)

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

15.2 Date and Time

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

15.3 Configuration

Setting Group:	Select via Menu or Select via Opto
Active Settings:	Group 1/2/3/4
Setting Group 1:	Disabled/Enabled
Setting Group 2:	Disabled/Enabled
Setting Group 3:	Disabled/Enabled
Setting Group 4:	Disabled/Enabled
OP Mode	One BOX Mode
Diff Protection	Disabled/Enabled
Dead Zone OC	Disabled/Enabled
Overcurrent	Disabled/Enabled
Earth Fault	Disabled/Enabled
CB Fail	Disabled/Enabled
Supervision	Disabled/Enabled
Input Labels	Invisible/Visible
Output Labels	Invisible/Visible
CT & VT Ratios	Invisible/Visible
Record Control	Invisible/Visible
Disturb Recorder	Invisible/Visible
Measure't Setup	Invisible/Visible
Comms Settings	Invisible/Visible
Commission Tests	Invisible/Visible

Setting Values	Primary
Control Inputs	Invisible/Visible
Ctrl I/P Config	Invisible/Visible
Ctrl I/P Labels	Invisible/Visible
Direct Access	Disabled/Enabled
Function Key	Invisible/Visible
VIR I/P Labels	Invisible/Visible
VIR O/P Labels	Invisible/Visible
Usr Alarm Labels	Invisible/Visible
RP1 Read Only	Disabled/Enabled
RP2 Read Only	Disabled/Enabled
NIC Read Only	Disabled/Enabled
LCD Contrast:	11

15.4 Oscillography (Disturbance Recorder)

Duration: Settable from 0.1 to 10.5s
Trigger Position: 0...100% (step 0.1%)
Trigger Mode: Single/Extended
Analog Channel 1: up to 21
Digital Input 1: up to 32
Selected binary channel assignment from any DDB status of G32 list point within the relay (opto input, output contact, alarms, starts, trips, controls, logic…).
Sampling frequency: 1200Hz

15.5 Voltage Transformers (VTs)

Phase VT Primary: 100V...1MV
Phase VT Secondary V: 80…140V

15.6 Current Transformers (CTs)

Phase CT Primary: 1A...30kA
Phase CT Secondary I_n: 1A or 5A
Current Transformer and Feeder Characteristics
Class: 5P (IEC185)
X (BS3958)
TPX (IEC 44-6)
TPY (IEC 44-6)
TPZ (IEC 44-6)

15.7 Communications

RP1 Protocol:	Courier /Modbus / IEC870-5-103 / DNP3.0
RP1 Address (Courier)	0…255
RP1 Address (MODBUS)	1…247
RP1 Address (IEC870-5-103)	0…254
RP1 Address (DNP3.0)	0…65519
RP1 Inactivity Timer:	1…30 minutes
RP1 Port Config (Courier):	K Bus/EIA485 (RS485)
RP1 Comms Mode (EIA485 (RS485)):	IEC60870 FT1.2 Frame IEC60870 10-Bit Frame
RP1 Baud Rate (EIA485 (RS485)):	9600/19200/38400 bits/s

15.8 Optional Additional Second Rear Port Communication (RP2)

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

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

15.9 Optional Ethernet Port

ETH Tunl TImeout: 1…30 mins(step 1 min)

15.10 Commission Tests

15.10.1 Monitor Bits

Monitor bit 1: Binary function link strings, selecting which
(up to): DDB signals have their status visible in the
Monitor bit 8: Commissioning menu, for test purposes

15.10.2 Test Mode

Test Mode Disabled / Test Mode / Contacts Blocked

15.10.3 Test Pattern

Configuration of which output contacts are to be energized when the contact test is applied.

15.10.4 Contact Test

Contact Test: No Operation / Apply Test / Remove Test

15.10.5 Test Zone

Test Zone: 87BB and 50BF trip blocked per zone

15.11 Opto Coupled Binary Inputs

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

Opto Input 1: (up to):

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

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

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

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

15.12 IED Configurator

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

16 SETTINGS IN MULTIPLE GROUPS

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

17 PROTECTION FUNCTIONS (IN MULTIPLE GROUPS)

17.1 Differential Protection

17.1.1 Busbar Diff

Busbar Diff:	Disabled/Enabled
I_D>2:	50A to 30kA (step 10A)
k2:	20%...90% (step 1%)
tDiff:	0…10s (step 10ms)

17.1.2 Check Zone (CZ)

Check Zone Status:	Disabled/Enabled
kCZ:	0%…90% (step 1%)
IDCZ>2:	50A to 30kA (step 10A)

17.1.3 Circuitry Fail

Circuitry Fail:	Disabled/Enabled
I_D>1:	50A to 5kA (step 10A)
k1:	0%…50% (step 1%)
tI_D>1:	0…600.0s (step 10ms)

CZ Circuitry Modes:	Alarm & No Block / AlarmSR&No Block / Blocking Latched / Alarm Latched / Sel-Reset
Zx Circuitry Modes:	Self-Reset / Alarm Latched / Blocking Latched
Circuitry fail blocking mode:	per phase/3 phase
Circuitry reset:	0…600.0s (step 100ms)

17.1.4 Voltage Check

Voltage Check:	Disabled/Enabled
VT connected to:	BB1/BB2/BB3/BB4
Voltage Mode:	Phase-Phase/Phase-Neutral
V<Status / V1<Status / V2>Status / VN>Status:	Disabled / Enabled
V<Set / V1<Set:	10…120V (step 1V)
V2>Set:	1…110V (step 1V)
VN>Set:	1…80V (step 1V)
Pickup timer:	0…10.00s (step 10ms)

17.1.5 Phase Comparison

PhComp PU ratio	5..250% (step 1%)

17.2 Dead Zone Protection

Caution	***These current set values are expressed in multiple of the local CTs nominal rated current Inp (primary) or Ins (secondary).***

Dead Zone Protection:	Disabled/Enabled
I>Current Set:	10%...400% (step 1%)
Time delay:	0,00…100,00s (step 10ms)

17.3 Breaker Failure Protection

Caution	***These current set values are expressed in multiple of the local CTs nominal rated current Inp (primary) or Ins (secondary).***

Breaker Failure

I< Current Set (dead pole detection for 50BF): 0.05…4.00xIn
Confirmation I>: Disabled / Enabled
I>: 0.05…4.00xIn

Timers for 50BF internal tripping

CB fail 1 timer:	tBF1:	0.00…10.00s (step 1ms)
CB fail 2 timer:	tBF2:	0.04…10.00s (step 1ms)

Timers for 50BF external tripping (orders from 21 or 87T etc.)

CB fail 3 timer:	tBF3:	0.00…10.00 s (step 1ms)
CB fail 4 timer:	tBF4:	0.04…10.00 s (step 1ms)

17.4 Overcurrent Protection

17.4.1 Phase Fault Protection (50/51)

I>1 Function:	Disabled / DT / IEC S Inverse / IEC V Inverse / IEC E Inverse / UK LT Inverse / UK Rectifier / RI / IEEE M Inverse / IEEE V Inverse / IEEE E Inverse / US Inverse / US ST Inverse
I>1 Current Set:	0.08...4.00 xIn
I>1 Time Delay:	0.00...100.00 s
I>1 TMS:	0.025...1.200 xIn (step 0.025)
I>1 Time Dial:	0.01...100 xIn
I>1 k (RI):	0.10…10.00
I>1 Reset Char:	DT or Inverse
I>1 tRESET:	0.0...100.0 s
I>2 Function:	Disabled / DT
I>2 Current Set:	0.08...10.00 xIn
I>2 Time Delay:	0.00...100.00 s

17.4.2 Earth Fault Protection (50N/51N) (One Box Mode only)

I_N>1 Function:	Disabled / DT / IEC S Inverse / IEC V Inverse / IEC E Inverse / UK LT Inverse / RI / IEEE M Inverse / IEEE V Inverse / IEEE E Inverse / US Inverse / US ST Inverse / IDG
IN>1 Current Set:	0.08...4.00 xIn
IN>1 IDG Is:	1.0…4.0 In
IN>1 Time Delay:	0.00...200.00 s
IN>1 TMS:	0.025...1.200 (step 0.025)
IN>1 Time Dial:	0.01...100
IN>1 k (RI):	0.10..10.00
IN>1 IDG Time:	1.00…2.00
IN>1 Reset Char:	DT or Inverse
IN>1 tRESET:	0.0...100.0 s
IN>2 Function:	Disabled / DT
IN>2 Current Set:	0.08 xIn...32.00 xIn
IN>2 Time Delay:	0.00...200.00 s

18 SUPERVISION FUNCTIONS (IN MULTIPLE GROUPS)

18.1 Voltage Transformer Supervision (VTS)

Status:	Blocking & indication
Modes:	Manual & automatic mode
Time delay:	0s...10.00s (step 2ms)

18.2 Current Transformer Supervision (CTS)

One box mode only

Status:	Blocking & indication
Setting accuracy:	±5%
Time delay:	0…10.00s (step 100ms)
CTS I1 / CTS I2/I1>1 / CTS I2/I1 >2:	5%...100% (step 1%)

19 MEASUREMENTS LIST

19.1 Measurements 1

One-box Mode

IA-x Magnitude
IA-x Phase Angle
IB-x Magnitude
IB-x Phase Angle
IC-x Magnitude
IC-x Phase Angle
I0-x Magnitude
I1-x Magnitude
I2-x Magnitude
IN-x Derived Mag
IN-x Derived Ang
x=1 to 6 for P746_1 or 1 to 7 for P746_2

Three-box Mode

IX-x Magnitude
IX-x Phase Angle
x=1 to 18 for P746_1 or 1 to 21 for P746_2
X=A or B or C

Voltage measurements only available on P746_1

VAN Magnitude
VAN Phase Angle
VBN Magnitude
VBN Phase Angle
VCN Magnitude
VCN Phase Angle
V1 Magnitude
V2 Magnitude
V0 Magnitude
VN Derived Mag
VN Derived Angle
VAB Magnitude
VAB Phase Angle
VBC Magnitude
VBC Phase Angle
VCA Magnitude
VCA Phase Angle
VAN RMS
VBN RMS
VCN RMS
Frequency

19.2 Measurements 2

IA Z1 Diff
IB Z1 Diff
IC Z1 Diff
IA Z1 Bias
IB Z1 Bias
IC Z1 Bias
IA Z2 Diff
IB Z2 Diff
IC Z2 Diff

IA Z2 Bias
IB Z2 Bias
IC Z2 Bias
IA Z3 Diff
IB Z3 Diff
IC Z3 Diff
IA Z3 Bias
IB Z3 Bias
IC Z3 Bias
IA Z4 Diff
IB Z4 Diff
IC Z4 Diff
IA Z4 Bias
IB Z4 Bias
IC Z4 Bias
IA CZ Diff
IB CZ Diff
IC CZ Diff
IA CZ Bias
IB CZ Bias

19.3 Fault Recorder

Records for the last 5 faults:

- Indication of the faulty zone
- Protection element operated
- Active setting group
- Fault duration
- Currents and frequency
- Faulty zone differential and bias current

19.4 Event Recorder

Records for the last 512 events

20 FUNCTION KEYS AND LABELS

20.1 Function Keys

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

20.2 Opto Input Labels

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

20.3 Output Labels

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

20.4 Control Input Labels

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

20.5 Virtual Input Labels

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

20.6 Virtual Output Labels

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

20.7 SR/MR User Alarm Labels

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

GETTING STARTED

CHAPTER 3

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Hardware Suffix:	M
Software Version:	B4 (P746_1) / C4 (P746_2)
Connection Diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

TABLES

FIGURES

1 INTRODUCTION TO THE RELAY

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

1.1 User Interfaces and Menu Structure

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

1.2 Front Panel

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

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

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

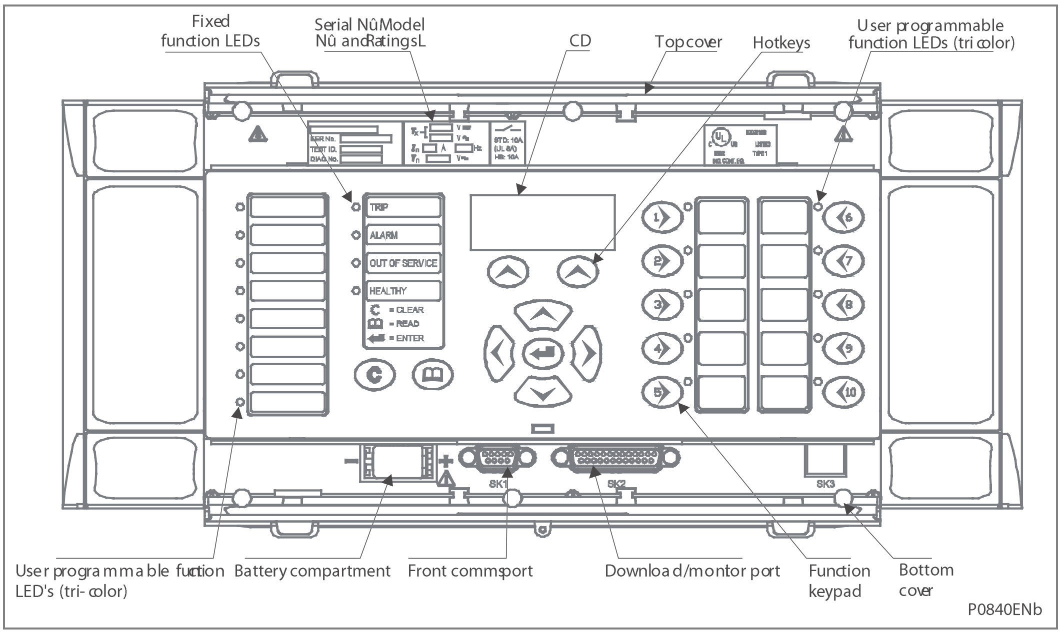


Figure 1 - Relay front view

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

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

1.2.1 Function Key Functionality:

- The relay front panel has control keys with programmable LEDs for local control. Factory default settings associate specific relay functions with these 10 direct-action keys and LEDs e.g. reset indications. Using programmable scheme logic, the user can change the default functions of the keys and LEDs to fit specific needs.
- Hotkey functionality: When the functionality is disabled:
  - SCROLL Starts scrolling through the various default displays.
  - STOP Stops scrolling the default display.

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

- 22 LEDs; 4 fixed function LEDs, 8 tri-colour programmable function LEDs on the left hand side of the front panel and 10 tri-colour programmable function LEDs on the right hand side associated with the function keys

Under the top hinged cover:

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

Under the bottom hinged cover:

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

1.2.2 LED Indications

1.2.2.1 Fixed Function

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

- **Trip (Red)** indicates that the relay has issued a trip signal. It is reset when the associated fault record is cleared from the front display.
- **Alarm (Yellow)** flashes when the relay has registered an alarm. This may be triggered by a fault, event or maintenance record. The LED will flash until the alarms have been accepted (read), after which the LED will change to constant illumination, and will extinguish, when the alarms have been cleared.
- **Out of Service** (Yellow) is ON when the relay is not fully operational.
- **Healthy (Green)** indicates that the relay is in correct working order, and should be on at all times. It will be extinguished if the relay's self-test facilities show that there is an error with the relay's hardware or software. The state of the healthy LED is reflected by the watchdog contact at the back of the relay.

To improve the visibility of the settings via the front panel, the LCD contrast can be adjusted using the "LCD Contrast" setting in the CONFIGURATION column. This should only be necessary in very hot or cold ambient temperatures.

1.2.2.2 Programmable LEDs

All the programmable LEDs are tri-colour and can be programmed to show red, yellow or green depending on the requirements. The eight programmable LEDs on the left are suitable for programming alarm indications. The 10 programmable LEDs associated with the function keys, are used to show the status of the key's function. The default behaviour and mappings for each of the programmable LEDs are as shown in this table:

LED No	LED Input Connection/Text	Latched	P746 LED Function Indication
1	LED1 Red LED1 Yellow LED1 Green	No	CB1 closed CB1 Alarm CB1 open
2	LED2 Red LED2 Yellow LED2 Green	No	CB2 closed CB2 Alarm CB2 open
3	LED3 Red LED3 Yellow LED3 Green	No	CB3 closed CB3 alarm CB3 open
4	LED4 Red LED4 Yellow LED4 Green	No	CB4 closed CB4 Alarm CB4 open
5	LED5 Red LED5 Yellow LED5 Green	No	CB5 closed CB5 Alarm CB5 open
6	LED6 Red LED6 Yellow LED6 Green	No	BB12 CB closed BB12 CB Alarm BB12 CB open
7	LED7 Red LED7 Yellow LED7 Green	No	50BF Trip zone 1 87BB & 50 BF trip zone 1 87BB Trip zone 1
8	LED8 Red LED8 Yellow LED8 Green	No	50BF Trip zone 2 87BB & 50 BF trip zone 2 87BB Trip zone 2
9	FnKey LED1 Red FnKey LED1 Yellow FnKey LED1 Green	No	Zone 1: blocked Zone 1: alarm (CZ blocked but not the Zone1) Zone 1: healthy
10	FnKey LED2 Red FnKey LED2 Yellow FnKey LED2 Green	No	CZ blocked Zone 1: Test Mode Zone 1: healthy
11	FnKey LED3 Red FnKey LED3 Yellow FnKey LED3 Green	No	Fault on phase A Not used Not used
12	FnKey LED4 Red FnKey LED4 Yellow FnKey LED4 Green	No	Fault on phase B Not used Not used
13	FnKey LED5 Red FnKey LED5 Yellow FnKey LED5 Green	No	Fault on phase C Not used Not used
14	FnKey LED6 Red FnKey LED6 Yellow FnKey LED6 Green	No	Zone 2: blocked Zone 2: alarm (CZ blocked but not the Zone2) Zone 2: healthy
15	FnKey LED7 Red FnKey LED7 Yellow FnKey LED7 Green	No	CZ blocked Zone 2: Test Mode Zone 2: healthy

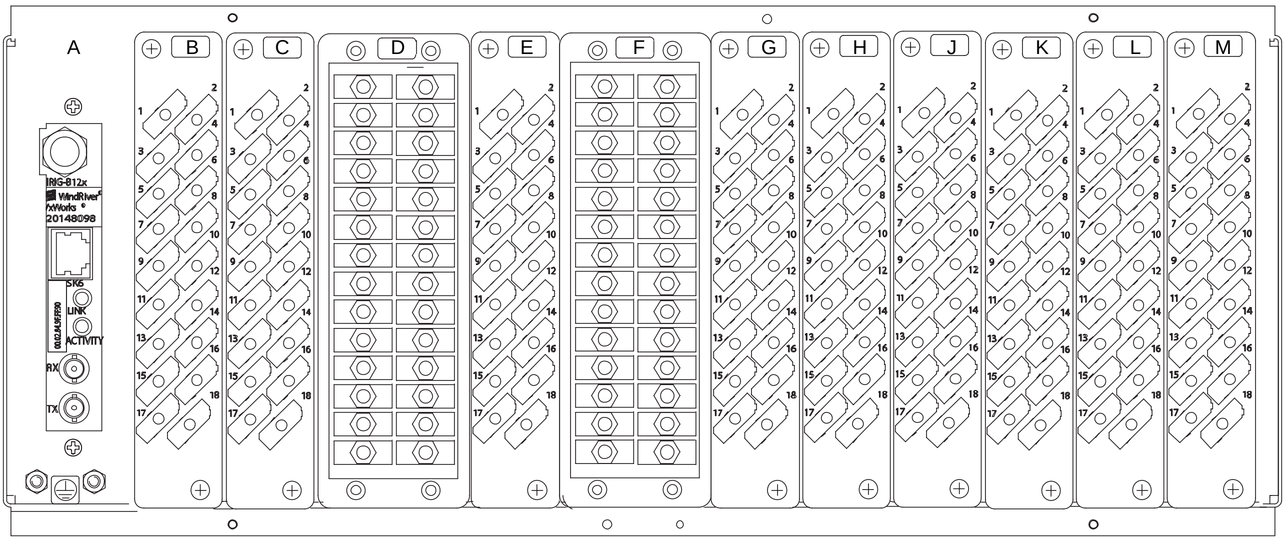
<table>
<tr><th>LED No</th><th>LED Input Connection/Text</th><th>Latched</th><th colspan="2">P746 LED Function Indication</th></tr>
<tr><td>16</td><td>FnKey LED8 Red
FnKey LED8 Yellow
FnKey LED8 Green</td><td>No</td><td colspan="2">Circuit fault blocked Z1 & Z2 AND CZ alarm
Circuit fault Alarm
Z1 & Z2 Healthy</td></tr>
<tr><td rowspan="2">17</td><td rowspan="2">FnKey LED9 Red
FnKey LED9 Yellow
FnKey LED9 Green</td><td rowspan="2">No</td><td>Applies to P746_1</td><td>Applies to P746_2</td></tr>
<tr><td>Not used
Not used
Indications resetting</td><td>CB6 closed
CB6 Alarm
CB6 open</td></tr>
<tr><td>18</td><td>FnKey LED10 Red
FnKey LED10 Yellow
FnKey LED10 Green</td><td>No</td><td colspan="2">Not used
Any start or Any trip
Trigger Disturbance record & fault record manually</td></tr>
</table>

Table 1 - LED Mappings

1.3 Rear Panel

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

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



A – IRIG-B / Ethernet / COMMS
B – Opto / high break
C - Opto / high break
D – Sigma Delta analogue input board
E – Sigma Delta Opto Board
F – Sigma Delta analogue input board
G – Sigma Delta Opto Board
H – Relay / Opto / high break
J – Relay / high break
K - Relay / high break
L – Relay board
M – Power supply board

P3xxxENx

Figure 2 - P746 relay rear view 80TE

1.4 Relay Connection and Power-Up

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

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

Table 2 - Nominal ranges for ac and dc

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

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

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

2 USER INTERFACES AND SETTINGS OPTIONS

The relay has these user interfaces:

- The front panel using the LCD and keypad
- The front port which supports Courier communication
- The rear port which supports one of these protocols:
  - Courier
  - MODBUS
  - IEC 60870-5-103
  - DNP3
- The optional Ethernet port supports IEC 61850-8-1, Courier and DNP3
- The protocol for the rear port must be specified when the relay is ordered.

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

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

Table 3 - Measurement information and relay settings

3 MENU STRUCTURE

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

A complete list of all of the menu settings is given in the Menu Maps chapter.

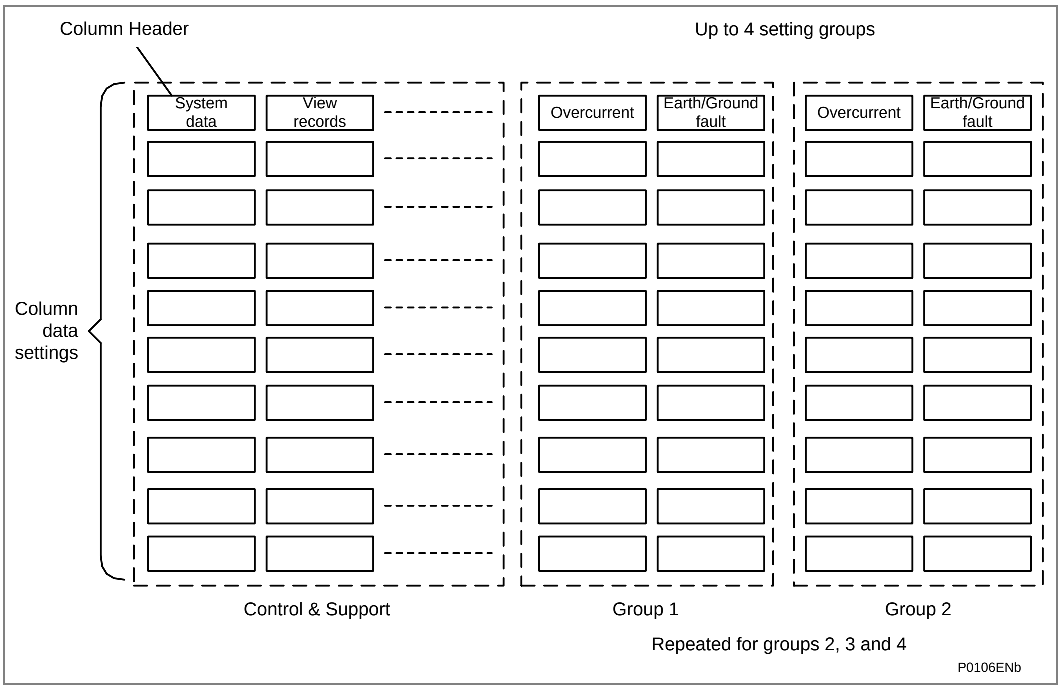


Figure 3 - Menu structure

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

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

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

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

3.1 Protection Settings

The protection settings include the following items:

- Protection element settings
- Scheme logic settings

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

3.2 Disturbance Recorder Settings

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

3.3 Control and Support Setting

The control and support settings include:

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

4 CYBER SECURITY

4.1 Cyber Security Settings

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

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

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

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

4.2 Role Based Access Control (RBAC)

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

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

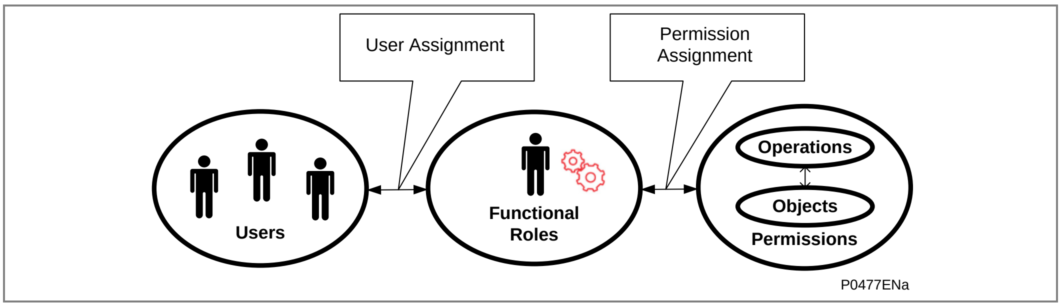


Figure 4 - RBAC Role structure

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

4.3 User Roles and Rights

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

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

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

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

5 RELAY CONFIGURATION

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

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

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

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

To restore the default values to the settings in any protection settings group, set the ‘Restore defaults’ cell to the relevant group number. Alternatively it is possible to set the ‘Restore defaults’ cell to ‘All settings’ to restore the default values to all of the relay’s settings, not just the protection groups’ settings. The default settings will initially be placed in the scratchpad and will only be used by the relay after they have been confirmed. Note that restoring defaults to all settings includes the rear communication port settings, which may result in communication via the rear port being disrupted if the new (default) settings do not match those of the master station.

6 FRONT PANEL USER INTERFACE (KEYPAD AND LCD)

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

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

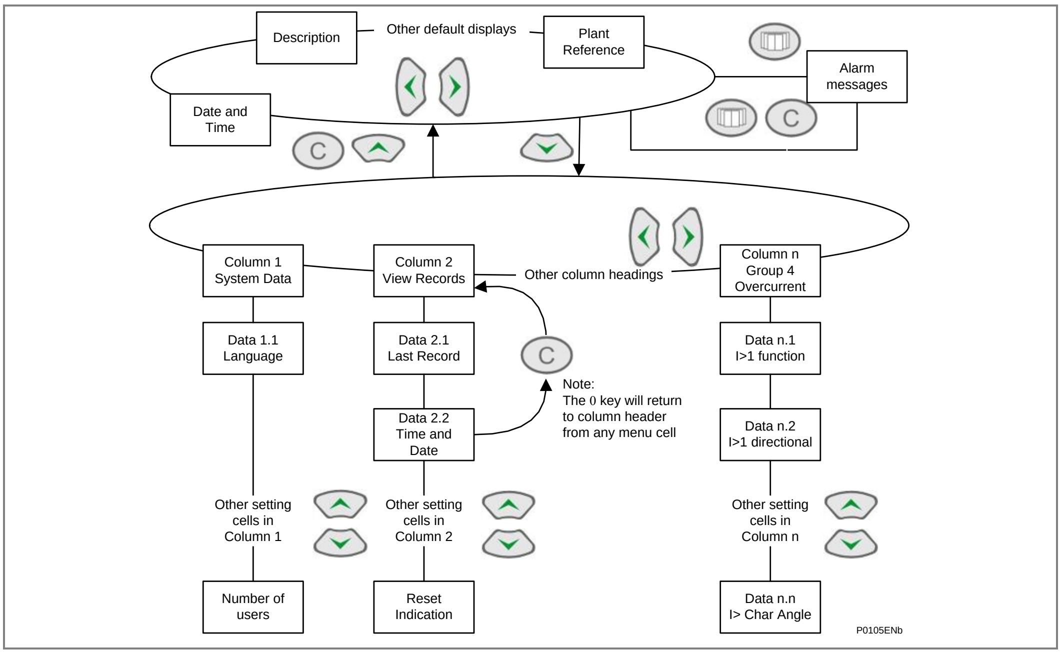


Figure 5 - Front panel user interface

6.1 Default Display and Menu Time-Out

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

- Banner
- Date and time
- Relay Description (user defined)
- Plant Reference (user defined)
- System Frequency
- 3-Ph-neutral Voltage (P746_1)
- Access Level

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

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

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

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

```
Alarms/Faults
Present
```

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

6.2 Navigating Menus and Browsing the Settings

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

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

6.3 Navigating the Hotkey Menu

To access the hotkey menu from the default display:

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

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

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

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

6.3.1 Setting Group Selection

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

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

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

6.3.2 Control Inputs - User Assignable Functions

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

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

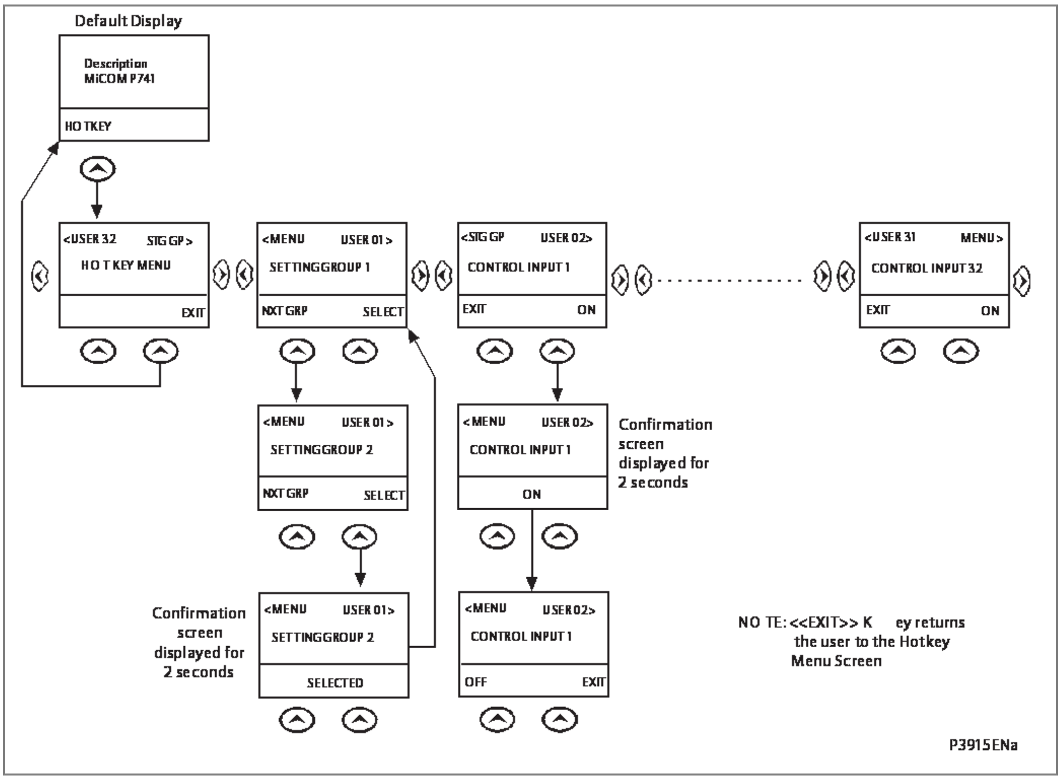


Figure 6 - Hotkey menu navigation

6.4 How to Login

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

6.4.1 Local Default Access

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

See Table 4 for the applied cases.

6.4.2 Auto Login

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

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

Table 4 - Auto Login process

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

6.4.3 Login with Prompt User List

This login process will happen if:

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

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

6.5 Reading and Clearing of Alarm Messages and Fault Records

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

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

```
Press clear to
reset alarms
```

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

6.6 Setting Changes

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

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

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

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

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

6.7 How to Logout (at the Front Panel)

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

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

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

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

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

Where x is the current fallback level.

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

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

Where x is the current access level.

7 FRONT COMMUNICATION PORT USER INTERFACE

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

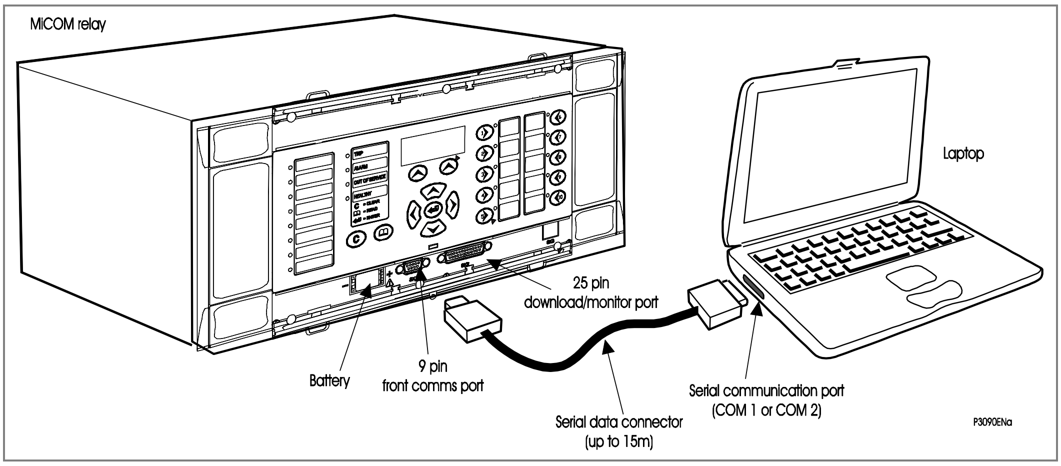


Figure 7 - Front port connection

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

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

Table 5 - 9-pin front port connections

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

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

Table 6 - 25-way and 9-way serial pin connections

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

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

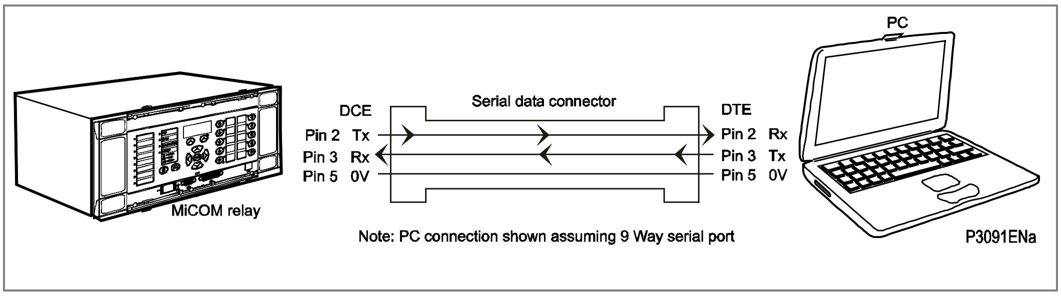


Figure 8 - PC - relay signal connection

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

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

Table 7 - Front port communications settings

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

7.1 Front Courier Port

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

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

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

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

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

8 EASERGY STUDIO RELAY COMMUNICATIONS BASICS

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

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

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

8.1 PC Requirements

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

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

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

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

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

Easergy Studio Additional components

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

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

8.2 Connecting to the Relay using Easergy Studio

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

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

8.3 Off-Line Use of Easergy Studio

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

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

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

SETTINGS

CHAPTER 4

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Software Version:	B4 (P746_1) / C4 (P746_2)
Hardware Suffix:	M
Connection Diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

Page (ST) 4-

TABLES

1 INTRODUCTION

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

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

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

2 RELAY SETTINGS

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

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

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

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

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

2.1 Default Settings Restore

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

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

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

3 CONFIGURATION MENU

To simplify the setting of the IED, there is a configuration settings column which is used to enable or disable many of its functions. If a function is disabled, the settings associated with that function are not shown in the menu. To disable a function, change the relevant cell in the Configuration column from Enabled to Disabled.

The **Active settings** cell of the configuration column controls which of the four applications setting groups is used by the IED.

The configuration column can also be used to copy the contents of one of the setting Groups to that of another Group.

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

The settings of the configuration column are detailed below.

Menu Text	Col	Row	Default Setting	Available Setting
Description				
CONFIGURATION	09	00		
CONFIGURATION				
Restore Defaults	09	01	No Operation	No Operation, All Settings, Setting Group 1, Setting Group 2, Setting Group 3 or Setting Group 4
Setting to restore a setting group to factory default settings				
Setting Group	09	02	Menu	Select via Menu or Select via PSL
Allows setting group changes to be initiated via Opto Input or via Menu.				
Active Settings	09	03	1	Group 1, Group 2, Group 3 or Group 4
Selects the active setting group.				
Save Changes	09	04	No Operation	No Operation, Save or Abort
Saves all relay settings.				
Copy From	09	05	Group 1	Group 1, 2, 3 or 4
Allows displayed settings to be copied from a selected setting group.				
Copy To	09	06	No Operation	No Operation, Group 1, Group 2, Group 3 or Group 4
Allows displayed settings to be copied to a selected group (ready to paste)				
Setting Group 1	09	07	Enabled	Enabled or Disabled
If the setting is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this settings (paste).				
Setting Group 2	09	08	Disabled	Enabled or Disabled
If the setting is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this settings (paste).				
Setting Group 3	09	09	Disabled	Enabled or Disabled
If the setting is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this settings (paste).				
Setting Group 4	09	0A	Disabled	Enabled or Disabled
If the setting is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this settings (paste).				
OP.Mode	09	0B	0 (One BOX Mode)	One BOX Mode or Three BOX Mode

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Setting for one box mode or three box mode relay configuration according to the installation. One box mode configuration: The relay protects the three phases. Standard or reverse phase sequence can be selected. Three box mode configuration: The relay protects the phase A, B or C (selected in the phase sequence menu).				
Diff Protection	09	0C	Enabled	Enabled or Disabled
To enable (activate) or disable (turn off) the Differential Protection function.				
Dead Zone OC	09	0D	Enabled	Enabled or Disabled
To enable (activate) or disable (turn off) the dead zone overcurrent function.				
Over Current	09	10	Enabled	Enabled or Disabled
To enable (activate) or disable (turn off) the overcurrent function.				
Earth Fault	09	13	Enabled	
To enable (activate) or disable (turn off) the earth fault overcurrent function.				
CB Fail	09	20	Disabled	Enabled or Disabled
To enable (activate) or disable (turn off) the Circuit Breaker (CB) failure function.				
Supervision	09	21	Disabled	Enabled or Disabled
To enable (activate) or disable (turn off) the supervision function.				
Input Labels	09	25	Visible	Invisible or Visible
Sets the Input Labels menu visible further on in the relay settings menu.				
Output Labels	09	26	Visible	Invisible or Visible
Sets the Output Labels menu visible further on in the relay settings menu.				
CT and VT Ratios	09	28	Visible	Invisible or Visible
Sets the current transformer and voltage transformer ratios and directions visible further in the menu.				
Recorder Control	09	29	Visible	Invisible or Visible
Sets the Record Control menu visible further on in the relay settings menu.				
Disturb Recorder	09	2A	Visible	Invisible or Visible
Sets the Disturbance Recorder menu visible further on in the relay settings menu.				
Measure't Setup	09	2B	Visible	Invisible or Visible
Sets the Measurement Setup menu visible further on in the relay settings menu.				
Comms Settings	09	2C	Visible	Invisible or Visible
Sets the Communications Settings menu visible further on in the relay settings menu. These are the settings associated with the 1st and 2nd rear communications ports.				
Commission Tests	09	2D	Visible	Invisible or Visible
Sets the Commissioning Tests menu visible further on in the relay settings menu.				
Setting Values	09	2E	Primary	Primary or Secondary
This affects all protection settings that are dependent upon CT and VT ratios. All subsequent settings input must be based in terms of this reference.				
Control Inputs	09	2F	Visible	Invisible or Visible
Activates the Control Input status and operation menu further on in the relay setting menu.				
Control I/P Config	09	35	Visible	Invisible or Visible
Sets the Control Input Configuration menu visible further on in the relay setting menu.				
Ctrl I/P Labels	09	36	Primary	Invisible or Visible
Sets the Control Input Labels menu visible further on in the relay setting menu.				
Direct Access	09	39	Enabled	Enabled/Disabled/Hotkey only/CB Cntrl. Only
Defines what CB control direct access is allowed. Enabled implies control via menu, hotkeys etc.				
IEC GOOSE	09	49	Visible	Invisible or Visible

Menu Text	Col	Row	Default Setting	Available Setting
Description				
This makes the IEC GOOSE setting visible or invisible.				
Function Keys	09	50	Visible	Invisible or Visible
Sets the Function Key menu visible further on in the relay setting menu.				
VIR I/P Labels	09	70	Invisible	0 = Invisible, 1 = Visible
VIR O/P Labels	09	80	Invisible	0 = Invisible, 1 = Visible
Usr Alarm Labels	09	90	Invisible	0 = Invisible, 1 = Visible
RP1 Read Only	09	FB	Disabled	Enabled or Disabled
Enable Remote Read Only Mode on RP1 courier or IEC60870-5-103 communication protocol. Visible when comms options are: 1 - Courier, 3 - CS103, 6 - IEC61850 with 1st Rear Courier, 7 - IEC61850 with 1st Rear CS103.				
RP2 Read Only	09	FC	Disabled	Enabled or Disabled
Enable Remote Read Only Mode on RP2 courier communication protocol. Visible when comms options are: 1 - Courier, or 3 - CS103; and hardware options are: 7, 8, E or F.				
NIC Read Only	09	FD	Disabled	Enabled or Disabled
Enable Remote Read Only Mode on the Network Interface card (IEC 61850 tunneled courier). Visible when comms options are: 6 - IEC61850 with 1st Rear Courier, 7 - IEC61850 with 1st Rear CS103, B- IEC61850 with DNPoE with DNP .				
SettingValueBeh.	09	FE	Independent	0 = Independent or 1 = Locked Mode
Independent: cell [092E] Setting Values will be independent in each interfaces Locked Mode: cell [092E] Setting Values are locked to the same value for all interfaces				
LCD Contrast	09	FF	11	0 to 31 (step 1)
Sets the LCD contrast.				

Table 1 - Configuration settings

4 GROUPED PROTECTION SETTINGS

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

- Protection Element Settings.
- Programmable Scheme Logic (PSL).

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

4.1 System Configuration

Note The OP Mode may be used as One Box Mode / Three Box Mode. This is displayed as one box mode or three box mode relay configuration (on the front panel only). This is set using Col = 30 and Row =30, where a setting of "0" means One Box Mode and "1" means Three Box Mode.

Menu Text	Col	Row	Default Setting	Available Setting
Description				
GROUP 1: SYSTEM CONFIG	30	00		
GROUP 1: SYSTEM CONFIG				
OP.Mode	30	30		Not Settable
Displays one box mode (0) or three box mode (1) relay configuration (Only visible on UI).				
Protected Phase	30	31	Phase A	Phase A / Phase B / Phase C
Sets the connected phase to be protected (Three box mode only).				
Phase Sequence	30	32	Standard ABC	Standard ABC / Reverse ACB
Sets the phase sequence (standard or reverse, one box mode only)				
Feeder Numbers	30	33	6 for P746_1 7 for P746_2	0 to 6 step 1 for P746_1 0 to 7 step 1 for P746_2
Sets the number of feeders connected to the relay.				
Busbar Numbers	30	34	2	1 to 4 step 1
Sets the number of Busbars connected to the relay				
BB1 Terminals	30	35	010011(bin) for P746_1 0010011(bin) for P746_2	6-bit(P746_1) or 7-bit(P746_2) binary setting: 0=not connected or 1=can be connected
Determines which feeders may be connected to BB1 depending upon isolator status. Sets the configuration of the feeders from feeder 6 or 7 (1st digit) to feeder 1 (last digit).				
BB2 Terminals	30	36	011100(bin) for P746_1 0011100(bin) for P746_2	6-bit(P746_1) or 7-bit(P746_2) binary setting: 0=not connected or 1=can be connected
Determines which feeders may be connected to BB2 depending upon isolator status. Sets the configuration of the feeders from feeder 6 or 7 (1st digit) to feeder 1 (last digit).				
BB3 Terminals	30	37	000000(bin) for P746_1 0000000(bin) for P746_2	6-bit(P746_1) or 7-bit(P746_2) binary setting: 0=not connected or 1=can be connected
Determines which feeders may be connected to BB3 depending upon isolator status. Sets the configuration of the feeders from feeder 6 or 7 (1st digit) to feeder 1 (last digit).				
BB4 Terminals	30	38	000000(bin) for P746_1 0000000(bin) for P746_2	6-bit(P746_1) or 7-bit(P746_2) binary setting: 0=not connected or 1=can be connected
Determines which feeders may be connected to BB4 depending upon isolator status. Sets the configuration of the feeders from feeder 6 or 7 (1st digit) to feeder 1 (last digit).				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
ChZONE Terminal	30	39	011111(bin) for P746_1 0011111(bin) for P746_2	6-bit(P746_1) or 7-bit(P746_2) binary setting: 0=not connected or 1=can be connected
Determines which feeders are included in the Check Zone. Sets the configuration of the feeders from feeder 6 or 7 (1st digit) to feeder 1 (last digit).				
BB1 Terminals	30	3A	000000000000000000(bin) for P746_1 000000000000000000000(bin) for P746_2	18-bit(P746_1) or 21-bit(P746_2) binary setting: 0=not connected or 1=can be connected
Determines which feeders may be connected to BB1 depending upon isolator status. Sets the configuration of the feeders from feeder 18 or 21 (1st digit) to feeder 1 (last digit).				
BB2 Terminals	30	3B	000000000000000000(bin) for P746_1 000000000000000000000(bin) for P746_2	18-bit(P746_1) or 21-bit(P746_2) binary setting: 0=not connected or 1=can be connected
Determines which feeders may be connected to BB2 depending upon isolator status. Sets the configuration of the feeders from feeder 18 or 21 (1st digit) to feeder 1 (last digit).				
BB3 Terminals	30	3C	000000000000000000(bin) for P746_1 000000000000000000000(bin) for P746_2	18-bit(P746_1) or 21-bit(P746_2) binary setting: 0=not connected or 1=can be connected
Determines which feeders may be connected to BB3 depending upon isolator status. Sets the configuration of the feeders from feeder 18 or 21 (1st digit) to feeder 1 (last digit).				
BB4 Terminals	30	3D	000000000000000000(bin) for P746_1 000000000000000000000(bin) for P746_2	18-bit(P746_1) or 21-bit(P746_2) binary setting: 0=not connected or 1=can be connected
Determines which feeders may be connected to BB4 depending upon isolator status. Sets the configuration of the feeders from feeder 18 or 21 (1st digit) to feeder 1 (last digit).				
ChZone Terminal	30	3E	000000000000000000(bin) for P746_1 000000000000000000000(bin) for P746_2	18-bit(P746_1) or 21-bit(P746_2) binary setting: 0=not included or 1=included
Determines which feeders are included in the Check Zone. Sets the configuration of the feeders from feeder 18 or 21 (1st digit) to feeder 1 (last digit).				
BB12 coupling by	30	3F	Breaker&Isolator	Breaker / None / Isolator / Breaker&Isolator
Sets the configuration of the bus 1 to bus 2 coupling. It indicates whether bus is coupled by breaker, (coupler CB and bus CT with two isolators) isolator or not (none).				
BB12 Bus CT/BB1	30	40	No CT	No CT, CT1 to CT6 for P746_1 No CT, CT1 to CT7 for P746_2
Sets the busbar current transformer belonging to BB12 connected to BB1.				
BB12:BB1 CT Pol	30	41	Inverted	Inverted or Standard
Sets the direction of the busbar current transformer in BB12 connected to BB1.				
BB12 Bus CT/BB2	30	42	No CT	No CT, CT1 to CT6 for P746_1 No CT, CT1 to CT7 for P746_2
Sets the busbar current transformer belonging to BB12 connected to BB2.				
BB12:BB2 CT Pol	30	43	Standard	Inverted or Standard
Sets the direction of the busbar current transformer in BB12 connected to BB2.				
BB12 Bus CT/BB1	30	44	No CT	No CT, CT1 to CT18 for P746_1 No CT, CT1 to CT21 for P746_2
Indicate whether bus is coupled by breaker or isolator or none. Sets the busbar current transformer belonging to BB12 connected to BB1.				
BB12:BB1 CT Pol	30	45	Inverted	Inverted or Standard
Sets the direction of the busbar current transformer in BB12 connected to BB1.				
BB12 Bus CT/BB2	30	46	No CT	No CT, CT1 to CT18 for P746_1 No CT, CT1 to CT21 for P746_2

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Indicate whether bus is coupled by breaker or isolator or none. Sets the busbar current transformer belonging to BB12 connected to BB2.				
BB12:BB2 CT Pol	30	47	Standard	Inverted or Standard
Sets the direction of the busbar current transformer in BB12 connected to BB2.				
BB13 coupling by	30	48	Breaker&Isolator	Breaker / None / Isolator / Breaker&Isolator
Sets the configuration of the bus 1 to bus 3 coupling. It indicates whether bus is coupled by breaker, (coupler CB and bus CT with two isolators) isolator or not (none).				
BB13 Bus CT/BB1	30	49	No CT	No CT, CT1 to CT6 for P746_1 No CT, CT1 to CT7 for P746_2
Sets the busbar current transformer belonging to BB13 connected to BB1.				
BB13:BB1 CT Pol	30	4A	Inverted	Inverted or Standard
Sets the direction of the busbar current transformer in BB13 connected to BB1.				
BB13 Bus CT/BB3	30	4B	No CT	No CT, CT1 to CT6 for P746_1 No CT, CT1 to CT7 for P746_2
Sets the busbar current transformer belonging to BB13 connected to BB3.				
BB13:BB3 CT Pol	30	4C	Standard	Inverted or Standard
Sets the direction of the busbar current transformer in BB13 connected to BB3.				
BB13 Bus CT/BB1	30	4D	No CT	No CT, CT1 to CT18 for P746_1 No CT, CT1 to CT21 for P746_2
Indicate whether bus is coupled by breaker or isolator or none. Sets the busbar current transformer belonging to BB13 connected to BB1.				
BB13:BB1 CT Pol	30	4E	Inverted	Inverted or Standard
Sets the direction of the busbar current transformer in BB13 connected to BB1.				
BB13 Bus CT/BB3	30	4F	No CT	No CT, CT1 to CT18 for P746_1 No CT, CT1 to CT21 for P746_2
Indicate whether bus is coupled by breaker or isolator or none. Sets the busbar current transformer belonging to BB13 connected to BB3.				
BB13:BB3 CT Pol	30	50	Standard	Inverted or Standard
Sets the direction of the busbar current transformer in BB13 connected to BB3.				
BB23 coupling by	30	51	Breaker&Isolator	Breaker / None / Isolator / Breaker&Isolator
Sets the configuration of the bus 2 to bus 3 coupling. It indicates whether bus is coupled by breaker, (coupler CB and bus CT with two isolators) isolator or not (none).				
BB23 Bus CT/BB2	30	52	No CT	No CT, CT1 to CT6 for P746_1 No CT, CT1 to CT7 for P746_2
Sets the busbar current transformer belonging to BB23 connected to BB2.				
BB23:BB2 CT Pol	30	53	Inverted	Inverted or Standard
Sets the direction of the busbar current transformer in BB23 connected to BB2.				
BB23 Bus CT/BB3	30	54	No CT	No CT, CT1 to CT6 for P746_1 No CT, CT1 to CT7 for P746_2
Sets the busbar current transformer belonging to BB23 connected to BB3.				
BB23:BB3 CT Pol	30	55	Standard	Inverted or Standard
Sets the direction of the busbar current transformer in BB23 connected to BB3.				
BB23 Bus CT/BB2	30	56	No CT	No CT, CT1 to CT18 for P746_1 No CT, CT1 to CT21 for P746_2
Indicate whether bus is coupled by breaker or isolator or none. Sets the busbar current transformer belonging to BB23 connected to BB2.				
BB23:BB2 CT Pol	30	57	Inverted	Inverted or Standard

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Sets the direction of the busbar current transformer in BB23 connected to BB2.				
BB23 Bus CT/BB3	30	58	No CT	No CT, CT1 to CT18 for P746_1 No CT, CT1 to CT21 for P746_2
Indicate whether bus is coupled by breaker or isolator or none. Sets the busbar current transformer belonging to BB23 connected to BB3.				
BB23:BB3 CT Pol	30	59	Standard	Inverted or Standard
Sets the direction of the busbar current transformer in BB23 connected to BB3.				
BB14 coupling by	30	5A	Breaker&Isolator	Breaker / None / Isolator / Breaker&Isolator
Sets the configuration of the bus 1 to bus 4 coupling. It indicates whether bus is coupled by breaker, (coupler CB and bus CT with two isolators) isolator or not (none).				
BB14 Bus CT/BB1	30	5B	No CT	No CT, CT1 to CT6 for P746_1 No CT, CT1 to CT7 for P746_2
Sets the busbar current transformer belonging to BB14 connected to BB1.				
BB14:BB1 CT Pol	30	5C	Inverted	Inverted or Standard
Sets the direction of the busbar current transformer in BB14 connected to BB1.				
BB14 Bus CT/BB4	30	5D	No CT	No CT, CT1 to CT6 for P746_1 No CT, CT1 to CT7 for P746_2
Sets the busbar current transformer belonging to BB14 connected to BB4.				
BB14:BB4 CT Pol	30	5E	Standard	Inverted or Standard
Sets the direction of the busbar current transformer in BB14 connected to BB4.				
BB14 Bus CT/BB1	30	5F	No CT	No CT, CT1 to CT18 for P746_1 No CT, CT1 to CT21 for P746_2
Indicate whether bus is coupled by breaker or isolator or none. Sets the busbar current transformer belonging to BB14 connected to BB1.				
BB14:BB1 CT Pol	30	60	Inverted	Inverted or Standard
Sets the direction of the busbar current transformer in BB14 connected to BB1.				
BB14 Bus CT/BB4	30	61	No CT	No CT, CT1 to CT18 for P746_1 No CT, CT1 to CT21 for P746_2
Indicate whether bus is coupled by breaker or isolator or none. Sets the busbar current transformer belonging to BB14 connected to BB4.				
BB14:BB4 CT Pol	30	62	Standard	Inverted or Standard
Sets the direction of the busbar current transformer in BB14 connected to BB4.				
BB24 coupling by	30	63	Breaker&Isolator	Breaker / None / Isolator / Breaker&Isolator
Sets the configuration of the bus 2 to bus 4 coupling. It indicates whether bus is coupled by breaker, (coupler CB and bus CT with two isolators) isolator or not (none).				
BB24 Bus CT/BB2	30	64	No CT	No CT, CT1 to CT6 for P746_1 No CT, CT1 to CT7 for P746_2
Sets the busbar current transformer belonging to BB24 connected to BB2.				
BB24:BB2 CT Pol	30	65	Inverted	Inverted or Standard
Sets the direction of the busbar current transformer in BB24 connected to BB2.				
BB24 Bus CT/BB4	30	66	No CT	No CT, CT1 to CT6 for P746_1 No CT, CT1 to CT7 for P746_2
Sets the busbar current transformer belonging to BB24 connected to BB4.				
BB24:BB4 CT Pol	30	67	Standard	Inverted or Standard
Sets the direction of the busbar current transformer in BB24 connected to BB4.				
BB24 Bus CT/BB2	30	68	No CT	No CT, CT1 to CT18 for P746_1 No CT, CT1 to CT21 for P746_2

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Indicate whether bus is coupled by breaker or isolator or none. Sets the busbar current transformer belonging to BB24 connected to BB2.				
BB24:BB2 CT Pol	30	69	Inverted	Inverted or Standard
Sets the direction of the busbar current transformer in BB24 connected to BB2.				
BB24 Bus CT/BB4	30	6A	No CT	No CT, CT1 to CT18 for P746_1 No CT, CT1 to CT21 for P746_2
Indicate whether bus is coupled by breaker or isolator or none. Sets the busbar current transformer belonging to BB24 connected to BB4.				
BB24:BB4 CT Pol	30	6B	Standard	Inverted or Standard
Sets the direction of the busbar current transformer in BB24 connected to BB4.				
BB34 coupling by	30	6C	Breaker&Isolator	Breaker / None / Isolator / Breaker&Isolator
Sets the configuration of the bus 3 to bus 4 coupling. It indicates whether bus is coupled by breaker, (coupler CB and bus CT with two isolators) isolator or not (none).				
BB34 Bus CT/BB3	30	6D	No CT	No CT, CT1 to CT6 for P746_1 No CT, CT1 to CT7 for P746_2
Sets the busbar current transformer belonging to BB34 connected to BB3.				
BB34:BB3 CT Pol	30	6E	Inverted	Inverted or Standard
Sets the direction of the busbar current transformer in BB34 connected to BB3.				
BB34 Bus CT/BB4	30	6F	No CT	No CT, CT1 to CT6 for P746_1 No CT, CT1 to CT7 for P746_2
Sets the busbar current transformer belonging to BB34 connected to BB4.				
BB34:BB4 CT Pol	30	70	Standard	Inverted or Standard
Sets the direction of the busbar current transformer in BB34 connected to BB4.				
BB34 Bus CT/BB3	30	71	No CT	No CT, CT1 to CT18 for P746_1 No CT, CT1 to CT21 for P746_2
Indicate whether bus is coupled by breaker or isolator or none. Sets the busbar current transformer belonging to BB34 connected to BB3.				
BB34:BB3 CT Pol	30	72	Inverted	Inverted or Standard
Sets the direction of the busbar current transformer in BB34 connected to BB3.				
BB34 Bus CT/BB4	30	73	No CT	No CT, CT1 to CT18 for P746_1 No CT, CT1 to CT21 for P746_2
Indicate whether bus is coupled by breaker or isolator or none. Sets the busbar current transformer belonging to BB34 connected to BB4.				
BB34:BB4 CT Pol	30	74	Standard	Inverted or Standard
Sets the direction of the busbar current transformer in BB34 connected to BB4.				

Table 2 - Group 1 system config settings

4.2 Differential Protection

The differential element has independent settings for phase and earth (sensitive) faults, which are used for all zones and the check zone independently.

Menu Text	Col	Row	Default Setting	Available Setting
Description				
GROUP 1: DIFF PROTECTION	31	00		
GROUP 1: DIFF PROTECTION				
Busbar Diff	31	01	Enabled	Enabled or Disabled

Menu Text	Col	Row	Default Setting	Available Setting
Description				
To enable (activate) or disable (turn off) the busbar differential protection. If the function is activated, the following options are accessible.				
ID>2 Current	31	03	2400A	50A to 30kA step 10A (primary)
Setting that determines the minimum differential operating current for all the discriminating zone biased differential elements.				
Slope k2	31	04	60%	20% to 90% step 1%
Slope angle setting for all the discriminating zone biased differential element.				
tDIFF	31	07	0s	From 0s to 10s step 10ms
Sets the tripping time delay (up to 10 seconds)				
CheckZone Status	31	12	Enabled	Enabled or Disabled
To enable (activate) or disable (turn off)				
IDCZ>2 Current	31	13	2400A	50A to 30kA step 10A (primary)
Setting that determines the minimum differential operating current for the Check Zone biased differential element.				
Slope kCZ	31	14	30%	0% to 90% step 1%
Slope angle setting for the Check Zone biased differential element.				
Circuitry Fail	31	40	Enabled	Enabled or Disabled
To enable (activate) or disable (turn off) the circuitry fail protection. If the function is activated, the following options are accessible.				
ID>1 Current	31	41	200A	50A to 5kA step 10A (primary)
Setting that determines the minimum differential operating current for the Circutry fault biased differential element due to wrong position of CB or isolator or CT failure.				
Slope k1	31	42	10%	10% to 50% step 1%
Slope angle setting for the Circuitry fault biased differential element.				
ID>1 Alarm Timer	31	43	5s	From 0s to 600s step 0.01s
Setting for the operating time delay of the phase circuitry fault monitoring				
CZ CCTFAIL MODE	31	44	AlarmSR&No Block	Alarm & No Block / AlarmSR&No Block / Blocking Latched / Alarm Latched / Sel-Reset
Options for the Check Zone differential element faulty calculation due to wrong position of CB or isolator or CT failure are as follow: – AlarmSR&No Block: The CZ does not block any zone trip and the alarm disappears as soon as the CZ calculation is right. – Alarm & No Block: The CZ does not block any zone trip and the alarm disappears only after manual reset. – Self-Reset: The CZ blocks any zone trip and both the blocking and the alarm disappear as soon as the CZ calculation is right. – Alarm Latched: The CZ blocks any zone trip, the blocking disappears as soon as the CZ calculation is right but the alarm disappears only after manual reset. – Blocking Latched: The CZ blocks any zone trip and both the blocking and the alarm disappear only after manual reset.				
ZX CCTFAIL MODE	31	45	Self-Reset	Self-Reset / Alarm Latched / Blocking Latched
Options for all the Zones differential element faulty calculation due to wrong position of CB or isolator or CT failure are as follow: – Self-Reset: The Zone is blocked and both the blocking and the alarm disappear as soon as the Zone calculation is right. – Alarm Latched: The Zone is blocked, the blocking disappears as soon as the Zone calculation is right but the alarm disappears only after manual reset. – Blocking Latched: The Zone is blocked and both the blocking and the alarm disappear only after manual reset.				
CctFail Blk Mode	31	47	Blocking / phase	Blocking/Phase or 3phase Blocking
Options for all the Zones and Check Zone differential element faulty calculation due to wrong position of CB or isolator or CT failure are as follow: – Blocking / phase: If the faulty calculation occurs on one phase only, the Zone and/or Check Zone is blocked for this phase only. – 3phase Blocking: If the faulty calculation occurs on one phase only, the Zone and/or Check Zone is blocked for the 3 phases. One Box Mode.				
CCTFAIL tReset	31	48	5s	From 0s to 600s step 0.1s
Setting for the reset time delay of the circuitry fail reset option.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Voltage Check	31	60		
The following settings Voltage Check settings are only available on P746_1				
Voltage Check	31	61	Disabled	Disabled or Enabled
To enable (activate) or disable (turn off) voltage criteria.				
VT connected to	31	62	BB1	Zone1 or Zone 2
If “voltage check” is enabled, used to indicate the voltage connected zone.				
Voltage Mode	31	63	Phase-Phase	Phase-Phase / Phase-Neutral
Sets the voltage mode				
V< Status	31	64	Disabled	Disabled or Enabled
To enable (activate) or disable (turn off) the phase undervoltage check.				
V< Set	31	65	80*V1	From 10*V1 to 120*V1 step 1*V1
If “V< Status” is enabled, pickup setting for phase undervoltage element.				
V<PickUpTimer	31	66	0s	0s to 10s step 2ms
If “V< Status” is enabled, sets the minimum pickup for phase undervoltage timer.				
V1< Status	31	67	Disabled	Disabled or Enabled
To enable (activate) or disable (turn off) the first stage of positive sequence undervoltage element.				
V1< Set	31	68	50*V1	From 10*V1 to 80*V1 step 1*V1
If “V1< Status” is enabled, pickup setting for first stage of positive sequence undervoltage element.				
V1< PickUpTimer	31	69	0s	From 0s to 10s step 2ms
If “V1< Status” is enabled, sets the minimum pickup for first stage of positive sequence undervoltage timer.				
V2> Status	31	6A	Disabled	Disabled or Enabled
To enable (activate) or disable (turn off) second stage of negative sequence overvoltage. When activated, V2> configuration is visible.				
V2> Set	31	6B	10*V1	From 1*V1 to 80*V1 step 1*V1
If “V2> Status” is enabled, pickup setting for second stage of negative sequence overvoltage element.				
V2> PickUpTimer	31	6C	0s	From 0s to 10s step 2ms
If “V2> Status” is enabled, sets the minimum pickup for first stage of negative sequence overvoltage timer.				
VN> Status	31	6D	Disabled	Disabled or Enabled
To enable (activate) or disable (turn off) the residual voltage check.				
VN> Set	31	6E	10*V1	From 1*V1 to 80*V1 step 1*V1
If “VN> Status” is enabled, pickup setting for residual voltage element..				
VN> PickUpTimer	31	6F	0s	From 0s to 10s step 2ms
If “VN> Status” is enabled, sets the minimum pickup for residual voltage timer.				
PhComp PU Ratio	31	70	50%	5% to 250% step 1%
Phase comparison is used to define the minimum current to be included in the phase comparison algorithm (see the Operations and Application Notes chapters for more details)sections P746/EN OP and P746/EN AP).				

Table 3 - Group 1 DIFF protection settings

4.3 Dead Zone Overcurrent Configuration

The Dead Zone element is a global set of settings that applies to all feeders. In order to accommodate different CT ratios, the overcurrent is a percentage of the nominal of the CT.

Menu Text	Col	Row	Default Setting	Available Setting
Description				
GROUP 1: DEAD ZONE OC	33	00		
GROUP 1: DEAD ZONE OC				
DEAD ZONE OC	33	01		(Sub Heading)
I> Status	33	02	Disabled	Disabled or Enabled
To enable (activate) or disable (turn off) the overcurrent protection.				
I> Current Set	33	03	120%	10% to 400% step 1%
Pick-up setting for overcurrent element.				
I> Time Delay	33	04	50ms	From 0s to 100s step 10ms
Sets the time-delay for the overcurrent element.				

Table 4 - Dead Zone OC settings

4.4 Non-Directional Phase Overcurrent Protection

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

The first stage of overcurrent protection has time-delayed characteristics which are selectable between Inverse Definite Minimum Time (IDMT), or Definite Time (DT). The second stage has DT characteristics only.

Notes *P746_1: Terminal 1 to 6 (one box mode) (Overcurrent1).*
P746_2: Terminal 1 to 7 (one box mode) (Overcurrent1).
P746_1: Terminal 1 to 18 (three box mode) (Overcurrent1 and Overcurrent2).
P746_2: Terminal 1 to 21 (three box mode) (Overcurrent1 and Overcurrent2).

Menu Text	Col	Row	Default Setting	Available Setting
Description				
GROUP 1: OVERCURRENT	35	00		
GROUP 1: OVERCURRENT				
TERMINAL 1	35	01		
The following settings apply to Terminal 1 (one box or three box)				
I>1 Function	35	02	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	35	04	1*I1	From 0.08*I1 to 4.0*I1 step 0.01*I1
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	35	05	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	35	06	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	35	07	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.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
I>1 k (RI)	35	08	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	35	09	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	35	0A	0s	From 0s to 100s step 10ms
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	35	0B	1	Disabled / DT
I>2 Current Set	35	0D	1*I1	From 0.08*I1 to 10.0*I1 step 0.01*I1
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	35	0E	1s	0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 2	35	21		
The following settings apply to Terminal 2 (one box or three box)				
I>1 Function	35	22	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	35	24	1*I2	From 0.08*I2 to 4.0*I2 step 0.01*I2
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	35	25	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	35	26	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	35	27	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.				
I>1 k (RI)	35	28	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	35	29	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	35	2A	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	35	2B	1	Disabled / DT
I>2 Current Set	35	2D	1*I2	From 0.08*I2 to 10.0*I2 step 0.01*I2
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	35	2E	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 3	35	41		
The following settings apply to Terminal 3 (one box or three box)				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
I>1 Function	35	42	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	35	44	1*I3	From 0.08*I3 to 4.0*I3 step 0.01*I3
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	35	45	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	35	46	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	35	47	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. Applies to P643, P746_1 and P746_2 only.				
I>1 k (RI)	35	48	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection Applies to P643, P746_1 and P746_2 only.				
I>1 Reset Char	35	49	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	35	4A	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	35	4B	1	Disabled / DT
I>2 Current Set	35	4D	1*I3	From 0.08*I3 to 10.0*I3 step 0.01*I3
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	35	4E	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element. Applies to P643, P746_1 and P746_2 only.				
TERMINAL 4	35	61		
The following settings apply to Terminal 4 (one box or three box)				
I>1 Function	35	62	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	35	64	1*I4	From 0.08*I4 to 4.0*I4 step 0.01*I4
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	35	65	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	35	66	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	35	67	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.				
I>1 k (RI)	35	68	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
I>1 Reset Char	35	69	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	35	6A	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	35	6B	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	35	6D	1*I4	From 0.08*I4 to 10.0*I4 step 0.01*I4
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	35	6E	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 5	35	81		
The following settings apply to Terminal 5 (one box or three box)				
I>1 Function	35	82	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	35	84	1*I5	From 0.08*I5 to 4.0*I5 step 0.01*I5
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	35	85	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	35	86	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	35	87	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.				
I>1 k (RI)	35	88	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	35	89	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	35	8A	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	35	8B	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	35	8D	1*I5	From 0.08*I5 to 10.0*I5 step 0.01*I5
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	35	8E	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 6	35	A1		
The following settings apply to Terminal 6 (one box or three box)				
I>1 Function	35	A2	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
I>1 Current Set	35	A4	1*I6	From 0.08*I6 to 4.0*I6 step 0.01*I6
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	35	A5	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	35	A6	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	35	A7	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.				
I>1 k (RI)	35	A8	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	35	A9	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	35	AA	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	35	AB	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	35	AD	1*I6	From 0.08*I6 to 10.0*I6 step 0.01*I6
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	35	AE	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 7	35	C1		
The following settings apply to Terminal 7 (one box or three box). P746_2 only.				
I>1 Function	35	C2	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element. P746_2 only.				
I>1 Current Set	35	C4	1*I7	From 0.08*I7 to 4.0*I7 step 0.01*I7
Pick-up setting for first stage overcurrent element. P746_2 only.				
I>1 Time Delay	35	C5	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element. P746_2 only.				
I>1 TMS	35	C6	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic. P746_2 only.				
I>1 Time Dial	35	C7	1	0.01 to 100 step 0.01
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection. P746_2 only.				
I>1 k (RI)	35	C8	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection P746_2 only.				
I>1 Reset Char	35	C9	DT	DT / Inverse

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Setting to determine the type of reset/release characteristic of the IEEE/US curves. P746_2 only.				
I>1 tRESET	35	CA	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic. P746_2 only.				
I>2 Function	35	CB	1	Disabled / DT
Setting for the second stage overcurrent element. P746_2 only.				
I>2 Current Set	35	CD	1*I7	From 0.08*I7 to 10.0*I7 step 0.01*I7
Pick-up setting for second stage overcurrent element. P746_2 only.				
I>2 Time Delay	35	CE	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element. P746_2 only.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
GROUP 1: OVERCURRENT 2	36	00		
GROUP 1: OVERCURRENT (Three Box Mode)				
TERMINAL 7	36	01		
The following settings apply to TERMINAL 7 (Three Box Mode, P746_1 only)				
I>1 Function	36	02	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	04	1*I7	From 0.08*I7 to 4.0*I7 step 0.01*I7
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	05	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	06	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	07	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. P746_1 only.				
I>1 k (RI)	36	08	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection P746_1 only.				
I>1 Reset Char	36	09	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	0A	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	0B	1	Disabled / DT
Setting for the second stage overcurrent element.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
I>2 Current Set	36	0D	1*I7	From 0.08*I7 to 10.0*I7 step 0.01*I7
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	0E	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 8	36	20		
The following settings apply to TERMINAL 8 (Three Box Mode, P746_1 only)				
I>1 Function	36	21	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	23	1*I8	From 0.08*I8 to 4.0*I8 step 0.01*I8
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	24	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	25	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	26	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. P746_1 only.				
I>1 k (RI)	36	27	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection P746_1 only.				
I>1 Reset Char	36	28	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	29	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	2A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	2C	1*I8	From 0.08*I8 to 10.0*I8 step 0.01*I8
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	2D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 9	36	30		
The following settings apply to TERMINAL 9 (Three Box Mode, P746_1 only)				
I>1 Function	36	31	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	33	1*I9	From 0.08*I9 to 4.0*I9 step 0.01*I9
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	34	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	35	1	0.025 to 1.2 step 0.025

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	36	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.				
I>1 k (RI)	36	37	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	38	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	39	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	3A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	3C	1*I9	From 0.08*I9 to 10.0*I9 step 0.01*I9
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	3D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 10	36	40		
The following settings apply to TERMINAL 10 (Three Box Mode, P746_1 only)				
I>1 Function	36	41	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	43	1*I10	From 0.08*I10 to 4.0*I10 step 0.01*I10
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	44	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	45	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	46	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.				
I>1 k (RI)	36	47	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	48	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	49	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	4A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	4C	1*I10	From 0.08*I10 to 10.0*I10 step 0.01*I10
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	4D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 11	36	50		

Menu Text	Col	Row	Default Setting	Available Setting
Description				
The following settings apply to TERMINAL 11 (Three Box Mode, P746_1 only)				
I>1 Function	36	51	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	53	1*I11	From 0.08*I11 to 4.0*I11 step 0.01*I11
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	54	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	55	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	56	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.				
I>1 k (RI)	36	57	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	58	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	59	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	5A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	5C	1*I11	From 0.08*I11 to 10.0*I11 step 0.01*I11
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	5D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 12	36	60		
The following settings apply to TERMINAL 12 (Three Box Mode, P746_1 only)				
I>1 Function	36	61	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	63	1*I12	From 0.08*I12 to 4.0*I12 step 0.01*I12
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	64	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	65	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	66	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.				
I>1 k (RI)	36	67	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	68	DT	DT / Inverse

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	69	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	6A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	6C	1*I12	From 0.08*I12 to 10.0*I12 step 0.01*I12
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	6D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 13	36	70		
The following settings apply to TERMINAL 13 (Three Box Mode, P746_1 only)				
I>1 Function	36	71	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	73	1*I13	From 0.08*I13 to 4.0*I13 step 0.01*I13
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	74	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	75	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	76	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.				
I>1 k (RI)	36	77	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	78	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	79	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	7A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	7C	1*I13	From 0.08*I13 to 10.0*I13 step 0.01*I13
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	7D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 14	36	80		
The following settings apply to TERMINAL 14 (Three Box Mode, P746_1 only)				
I>1 Function	36	81	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	83	1*I14	From 0.08*I14 to 4.0*I14 step 0.01*I14

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	84	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	85	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	86	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.				
I>1 k (RI)	36	87	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	88	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	89	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	8A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	8C	1*I14	From 0.08*I14 to 10.0*I14 step 0.01*I14
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	8D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 15	36	90		
The following settings apply to TERMINAL 15 (Three Box Mode, P746_1 only)				
I>1 Function	36	91	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	93	1*I15	From 0.08*I15 to 4.0*I15 step 0.01*I15
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	94	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	95	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	96	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.				
I>1 k (RI)	36	97	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	98	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	99	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	9A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	9C	1*I15	From 0.08*I15 to 10.0*I15 step 0.01*I15

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	9D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 16	36	B0		
The following settings apply to TERMINAL 16 (Three Box Mode, P746_1 only)				
I>1 Function	36	B1	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	B3	1*I16	From 0.08*I16 to 4.0*I16 step 0.01*I16
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	B4	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	B5	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	B6	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.				
I>1 k (RI)	36	B7	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	B8	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	B9	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	BA	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	BC	1*I16	From 0.08*I16 to 10.0*I16 step 0.01*I16
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	BD	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 17	36	C0		
The following settings apply to TERMINAL 17 (Three Box Mode, P746_1 only)				
I>1 Function	36	C1	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	C3	1*I17	From 0.08*I17 to 4.0*I17 step 0.01*I17
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	C4	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	C5	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	C6	1	0.01 to 100 step 0.01

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Setting for the time multiplier setting to adjust the operating time of the IEEE/US IDMT curves.				
I>1 k (RI)	36	C7	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	C8	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	C9	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	CA	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	CC	1*I17	From 0.08*I17 to 10.0*I17 step 0.01*I17
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	CD	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 18	36	D0		
The following settings apply to TERMINAL 18 (Three Box Mode, P746_1 only)				
I>1 Function	36	D1	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	D3	1*I18	From 0.08*I18 to 4.0*I18 step 0.01*I18
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	D4	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	D5	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	D6	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.				
I>1 k (RI)	36	D7	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	D8	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	D9	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	DA	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	DD	1*I18	From 0.08*I18 to 10.0*I18 step 0.01*I18
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	DD	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 8	36	01		
The following settings apply to TERMINAL 8 (Three Box Mode, P746_2 only)				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
I>1 Function	36	02	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	04	1*I8	From 0.08*I8 to 4.0*I8 step 0.01*I8
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	05	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	06	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	07	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.				
I>1 k (RI)	36	08	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	09	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	0A	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	0B	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	0D	1*I8	80A to 10kA step 10A
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	0E	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 9	36	20		
The following settings apply to TERMINAL 9 (Three Box Mode, P746_2 only)				
I>1 Function	36	21	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	23	1*I9	From 0.08*I9 to 4.0*I9 step 0.01*I9
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	24	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	25	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	26	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.				
I>1 k (RI)	36	27	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	28	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
I>1 tRESET	36	29	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	2A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	2C	1*I9	From 0.08*I9 to 10.0*I9 step 0.01*I9
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	2D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 10	36	30		
The following settings apply to TERMINAL 10 (Three Box Mode, P746_2 only)				
I>1 Function	36	31	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	33	1*I10	From 0.08*I10 to 4.0*I10 step 0.01*I10
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	34	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	35	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	36	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.				
I>1 k (RI)	36	37	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	38	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	39	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	3A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	3C	1*I10	From 0.08*I10 to 10.0*I10 step 0.01*I10
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	3D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 11	36	40		
The following settings apply to TERMINAL 11 (Three Box Mode, P746_2 only)				
I>1 Function	36	41	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	43	1*I11	From 0.08*I11 to 4.0*I11 step 0.01*I11
Pick-up setting for first stage overcurrent element.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
I>1 Time Delay	36	44	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	45	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	46	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.				
I>1 k (RI)	36	47	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	48	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	49	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	4A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	4C	1*I11	From 0.08*I11 to 10.0*I11 step 0.01*I11
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	4D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 12	36	50		
The following settings apply to TERMINAL 12 (Three Box Mode, P746_2 only)				
I>1 Function	36	51	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	53	1*I12	From 0.08*I12 to 4.0*I12 step 0.01*I12
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	54	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	55	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	56	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.				
I>1 k (RI)	36	57	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	58	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	59	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	5A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	5C	1*I12	From 0.08*I12 to 10.0*I12 step 0.01*I12
Pick-up setting for second stage overcurrent element.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
I>2 Time Delay	36	5D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 13	36	60		
The following settings apply to TERMINAL 13 (Three Box Mode, P746_2 only)				
I>1 Function	36	61	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	63	1*I13	From 0.08*I13 to 4.0*I13 step 0.01*I13
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	64	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	65	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	66	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.				
I>1 k (RI)	36	67	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	68	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	69	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	6A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	6C	1*I13	From 0.08*I13 to 10.0*I13 step 0.01*I13
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	6D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 14	36	70		
The following settings apply to TERMINAL 14 (Three Box Mode, P746_2 only)				
I>1 Function	36	71	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	73	1*I14	From 0.08*I14 to 4.0*I14 step 0.01*I14
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	74	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	75	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	76	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.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
I>1 k (RI)	36	77	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	78	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	79	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	7A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	7C	1*I14	From 0.08*I14 to 10.0*I14 step 0.01*I14
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	7D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 15	36	80		
The following settings apply to TERMINAL 15 (Three Box Mode, P746_2 only)				
I>1 Function	36	81	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	83	1*I15	From 0.08*I15 to 4.0*I15 step 0.01*I15
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	84	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	85	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	86	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.				
I>1 k (RI)	36	87	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	88	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	89	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	8A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	8C	1*I15	From 0.08*I15 to 10.0*I15 step 0.01*I15
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	8D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 16	36	90		
The following settings apply to TERMINAL 16 (Three Box Mode, P746_2 only)				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
I>1 Function	36	91	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	93	1*I16	From 0.08*I16 to 4.0*I16 step 0.01*I16
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	94	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	95	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	96	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.				
I>1 k (RI)	36	97	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	98	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	99	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	9A	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	9C	1*I16	From 0.08*I16 to 10.0*I16 step 0.01*I16
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	9D	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 17	36	A0		
The following settings apply to TERMINAL 17 (Three Box Mode, P746_2 only)				
I>1 Function	36	A1	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	A3	1*I17	From 0.08*I17 to 4.0*I17 step 0.01*I17
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	A4	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	A5	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	A6	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.				
I>1 k (RI)	36	A7	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	A8	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
I>1 tRESET	36	C9	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	AA	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	AC	1*I17	From 0.08*I17 to 10.0*I17 step 0.01*I17
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	AD	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 18	36	B0		
The following settings apply to TERMINAL 18 (Three Box Mode, P746_2 only)				
I>1 Function	36	B1	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	B3	1*I18	From 0.08*I18 to 4.0*I18 step 0.01*I18
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	B4	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	B5	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	B6	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.				
I>1 k (RI)	36	B7	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	B8	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	B9	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	BA	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	BC	1*I18	From 0.08*I18 to 10.0*I18 step 0.01*I18
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	BD	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 19	36	C0		
The following settings apply to TERMINAL 19 (Three Box Mode, P746_2 only)				
I>1 Function	36	C1	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	C3	1*I19	From 0.08*I19 to 4.0*I19 step 0.01*I19
Pick-up setting for first stage overcurrent element.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
I>1 Time Delay	36	C4	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	C5	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	C6	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.				
I>1 k (RI)	36	C7	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	C8	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	C9	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	CA	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	CC	1*I19	From 0.08*I19 to 10.0*I19 step 0.01*I19
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	CD	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 20	36	D0		
The following settings apply to TERMINAL 20 (Three Box Mode, P746_2 only)				
I>1 Function	36	D1	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	D3	1*I20	From 0.08*I20 to 4.0*I20 step 0.01*I20
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	D4	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	D5	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	D6	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.				
I>1 k (RI)	36	D7	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	D8	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	D9	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	DA	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	DC	1*I20	From 0.08*I20 to 10.0*I20 step 0.01*I20
Pick-up setting for second stage overcurrent element.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
I>2 Time Delay	36	DD	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				
TERMINAL 21	36	E0		
The following settings apply to TERMINAL 21 (Three Box Mode, P746_2 only)				
I>1 Function	36	E1	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEEE M Inverse / RI / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse
Setting for the tripping characteristic for the first stage overcurrent element.				
I>1 Current Set	36	E3	1*I21	From 0.08*I21 to 4.0*I21 step 0.01*I21
Pick-up setting for first stage overcurrent element.				
I>1 Time Delay	36	E4	1s	From 0s to 100s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>1 TMS	36	E5	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
I>1 Time Dial	36	E6	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.				
I>1 k (RI)	36	E7	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of phase overcurrent protection				
I>1 Reset Char	36	E8	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tRESET	36	E9	0	0 to 100 step 0.01
Setting that determines the reset/release time for definite time reset characteristic.				
I>2 Function	36	EA	1	Disabled / DT
Setting for the second stage overcurrent element.				
I>2 Current Set	36	EC	1*I21	From 0.08*I21 to 10.0*I21 step 0.01*I21
Pick-up setting for second stage overcurrent element.				
I>2 Time Delay	36	ED	1s	From 0s to 100s step 10ms
Setting for the operating time-delay for second stage overcurrent element.				

Table 5 - Overcurrent settings

4.5 Earth Fault (Only Available for One Box Mode)

The relays which include these functions include extra or backup non-directional earth fault protection. The earth fault element has two stages of protection. The earth fault element needs to be co- ordinated with any other protection elements on the system, in order to provide discriminative fault clearance. The inverse time characteristics available for the earth fault protection, are the same as those for the Overcurrent element.

Note	*In is the CT nominal current.*

Menu Text	Col	Row	Default Setting	Available Setting
Description				
GROUP 1: EARTH FAULT	38	00		
GROUP 1: EARTH FAULT (One Box Mode)				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Terminal 1	38	01		
GROUP 1: EARTH FAULT - Terminal 1				
IN>1 Function	38	03	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEE M Inverse / IDG / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse /DT / RI
Setting for the tripping characteristic for the first stage earth fault element.				
IN>1 Current	38	06	0.2*I1	From 0.08*I1 to 4.0*I1 step 0.01*I1
Pick-up setting for the first stage earth fault element				
IN>1 IDG Is	38	07	1.5	1 to 4 step 0.1
Setting to determine the IDG characteristics				
IN>1 Time Delay	38	08	1s	From 0s to 200s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
IN>1 TMS	38	09	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
IN>1 Time Dial	38	0A	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.				
IN>1 k (RI)	38	0B	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of ground overcurrent protection				
IN>1 IDG Time	38	0D	1.2s	From 1s to 2s step 10ms
Setting that determines the IDG time.				
IN>1 Reset Char	38	0E	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
IN>1 tRESET	38	0F	0	0 to 100s step 10ms
Setting that determines the reset/release time for definite time reset characteristic.				
IN>2 Function	38	11	Disabled	Disabled or Enabled
Setting to enable or disable the second stage overcurrent element.				
IN>2 Current	38	13	0.2*I1	From 0.08*I1 to 32.0*I1 step 0.01*I1
Pick-up setting for the second stage earth fault element				
IN>2 Time Delay	38	15	1s	From 0s to 200s step 10ms
Setting for the operating time-delay for the second stage overcurrent element				
Terminal 2	38	31		
GROUP 1: EARTH FAULT - Terminal 2				
IN>1 Function	38	33	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEE M Inverse / IDG / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse /DT / RI
Setting for the tripping characteristic for the first stage earth fault element.				
IN>1 Current	38	36	0.2*I2	From 0.08*I2 to 4.0*I2 step 0.01*I2
Pick-up setting for the first stage earth fault element				
IN>1 IDG Is	38	37	1.5	1 to 4 step 0.1
Setting to determine the IDG characteristics				
IN>1 Time Delay	38	38	1s	From 0s to 200s step 10ms

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Setting for the time-delay for the definite time setting if selected for first stage element				
IN>1 TMS	38	39	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
IN>1 Time Dial	38	3A	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.				
IN>1 k (RI)	38	3B	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of ground overcurrent protection				
IN>1 IDG Time	38	3D	1.2s	From 1s to 2s step 10ms
Setting that determines the IDG time.				
IN>1 Reset Char	38	3E	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
IN>1 tRESET	38	3F	0	0 to 100s step 10ms
Setting that determines the reset/release time for definite time reset characteristic.				
IN>2 Function	38	41	Disabled	Disabled or Enabled
Setting to enable or disable the second stage overcurrent element.				
IN>2 Current	38	43	0.2*I2	From 0.08*I2 to 32.0*I2 step 0.01*I2
Pick-up setting for the second stage earth fault element				
IN>2 Time Delay	38	45	1s	From 0s to 200s step 10ms
Setting for the operating time-delay for the second stage overcurrent element				
Terminal 3	38	61		
GROUP 1: EARTH FAULT - Terminal 3				
IN>1 Function	38	63	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEE M Inverse / IDG / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse /DT / RI
Setting for the tripping characteristic for the first stage earth fault element.				
IN>1 Current	38	66	0.2*I3	From 0.08*I3 to 4.0*I3 step 0.01*I3
Pick-up setting for the first stage earth fault element				
IN>1 IDG Is	38	67	1.5	1 to 4 step 0.1
Setting to determine the IDG characteristics				
IN>1 Time Delay	38	68	1	From 0s to 200s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
IN>1 TMS	38	69	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
IN>1 Time Dial	38	6A	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.				
IN>1 k (RI)	38	6B	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of ground overcurrent protection				
IN>1 IDG Time	38	6C	1.2	From 1s to 2s step 10ms
Setting that determines the IDG time.				
IN>1 Reset Char	38	6D	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
IN>1 tRESET	38	6E	0	0 to 100s step 10ms
Setting that determines the reset/release time for definite time reset characteristic.				
IN>2 Function	38	71	Disabled	Disabled or Enabled
Setting to enable or disable the second stage overcurrent element.				
IN>2 Current	38	73	0.2*I3	From 0.08*I3 to 32.0*I3 step 0.01*I3
Pick-up setting for the second stage earth fault element				
IN>2 Time Delay	38	75	1	From 0s to 200s step 10ms
Setting for the operating time-delay for the second stage overcurrent element				
Terminal 4	38	90		
GROUP 1: EARTH FAULT - Terminal 4				
IN>1 Function	38	91	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEE M Inverse / IDG / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse /DT / RI
Setting for the tripping characteristic for the first stage earth fault element.				
IN>1 Current	38	93	0.2*I4	From 0.08*I4 to 4.0*I4 step 0.01*I4
Pick-up setting for the first stage earth fault element				
IN>1 IDG Is	38	95	1.5	1 to 4 step 0.1
Setting to determine the IDG characteristics				
IN>1 Time Delay	38	96	1s	From 0s to 200s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
IN>1 TMS	38	97	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
IN>1 Time Dial	38	98	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.				
IN>1 k (RI)	38	99	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of ground overcurrent protection				
IN>1 IDG Time	38	9A	1.2s	From 1s to 2s step 10ms
Setting that determines the IDG time.				
IN>1 Reset Char	38	9B	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
IN>1 tRESET	38	9C	0	0 to 100s step 10ms
Setting that determines the reset/release time for definite time reset characteristic.				
IN>2 Function	38	A0	Disabled	Disabled or Enabled
Setting to enable or disable the second stage overcurrent element.				
IN>2 Current	38	A2	0.2*I4	From 0.08*I4 to 32.0*I4 step 0.01*I4
Pick-up setting for second stage overcurrent element.				
IN>2 Time Delay	38	A4	1s	From 0s to 200s step 10ms
Setting for the operating time-delay for the second stage overcurrent element				
Terminal 5	38	B0		
GROUP 1: EARTH FAULT - Terminal 5				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
IN>1 Function	38	B1	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEE M Inverse / IDG / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse /DT / RI
Setting for the tripping characteristic for the first stage earth fault element.				
IN>1 Current	38	B3	0.2*I5	From 0.08*I5 to 4.0*I5 step 0.01*I5
Pick-up setting for the first stage earth fault element				
IN>1 IDG Is	38	B5	1.5	1 to 4 step 0.1
Setting to determine the IDG characteristics				
IN>1 Time Delay	38	B6	1s	From 0s to 200s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
IN>1 TMS	38	B7	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
IN>1 Time Dial	38	B8	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.				
IN>1 k (RI)	38	B9	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of ground overcurrent protection				
IN>1 IDG Time	38	BA	1.2s	From 1s to 2s step 10ms
Setting that determines the IDG time.				
IN>1 Reset Char	38	BB	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
IN>1 tRESET	38	BC	0	0 to 100s step 10ms
Setting that determines the reset/release time for definite time reset characteristic.				
IN>2 Function	38	C0	Disabled	Disabled or Enabled
Setting to enable or disable the second stage overcurrent element.				
IN>2 Current	38	C2	0.2*I5	From 0.08*I5 to 32.0*I5 step 0.01*I5
Pick-up setting for second stage overcurrent element.				
IN>2 Time Delay	38	C4	1s	From 0s to 200s step 10ms
Setting for the operating time-delay for the second stage overcurrent element				
Terminal 6	38	D0		
GROUP 1: EARTH FAULT - Terminal 6				
IN>1 Function	38	D1	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEE M Inverse / IDG / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse /DT / RI
Setting for the tripping characteristic for the first stage earth fault element.				
IN>1 Current	38	D3	0.2*I6	From 0.08*I6 to 4.0*I6 step 0.01*I6
Pick-up setting for the first stage earth fault element				
IN>1 IDG Is	38	D5	1.5	1 to 4 step 0.1
Setting to determine the IDG characteristics				
IN>1 Time Delay	38	D6	1s	From 0s to 200s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element				
IN>1 TMS	38	D7	1	0.025 to 1.2 step 0.025

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
IN>1 Time Dial	38	D8	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.				
IN>1 k (RI)	38	D9	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of ground overcurrent protection				
IN>1 IDG Time	38	DA	1.2s	From 1s to 2s step 10ms
Setting that determines the IDG time.				
IN>1 Reset Char	38	DB	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
IN>1 tRESET	38	DC	0	0 to 100s step 10ms
Setting that determines the reset/release time for definite time reset characteristic.				
IN>2 Function	38	E0	Disabled	Disabled or Enabled
Setting to enable or disable the second stage overcurrent element.				
IN>2 Current	38	E2	0.2*I6	From 0.08*I6 to 32.0*I6 step 0.01*I6
Pick-up setting for second stage overcurrent element.				
IN>2 Time Delay	38	E4	1s	From 0s to 200s step 10ms
Setting for the operating time-delay for the second stage overcurrent element				
Terminal 7	38	F0		
GROUP 1: EARTH FAULT - Terminal 6 P746_2 only.				
IN>1 Function	38	F1	IEC S Inverse	Disabled / US ST Inverse / US Inverse / IEEE E Inverse / IEEE V Inverse / IEEE M Inverse / IDG / UK Rectifier /UK LT Inverse / IEC E Inverse / IEC V inverse / IEC S Inverse /DT / RI
Setting for the tripping characteristic for the first stage earth fault element. P746_2 only.				
IN>1 Current	38	F3	0.2*I7	From 0.08*I7 to 4.0*I7 step 0.01*I7
Pick-up setting for the first stage earth fault element P746_2 only.				
IN>1 IDG Is	38	F5	1.5	1 to 4 step 0.1
Setting to determine the IDG characteristics P746_2 only.				
IN>1 Time Delay	38	F6	1s	From 0s to 200s step 10ms
Setting for the time-delay for the definite time setting if selected for first stage element P746_2 only.				
IN>1 TMS	38	F7	1	0.025 to 1.2 step 0.025
Setting for the time multiplier setting to adjust the operating time of the IEC/UK IDMT characteristic				
IN>1 Time Dial	38	F8	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. P746_2 only.				
IN>1 k (RI)	38	F9	1	0.1 to 10 step 0.05
Selects the electromechanical inverse time curve (RI) curve K value from 0.100 to 10 for the first stage of ground overcurrent protection P746_2 only.				
IN>1 IDG Time	38	FA	1.2s	From 1s to 2s step 10ms

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Setting that determines the IDG time. P746_2 only.				
IN>1 Reset Char	38	FB	DT	DT / Inverse
Setting to determine the type of reset/release characteristic of the IEEE/US curves. P746_2 only.				
IN>1 tRESET	38	FC	0	0 to 100s step 10ms
Setting that determines the reset/release time for definite time reset characteristic. P746_2 only.				
IN>2 Function	38	FD	Disabled	Disabled or Enabled
Setting to enable or disable the second stage overcurrent element. P746_2 only.				
IN>2 Current	38	FE	0.2*I7	From 0.08*I7 to 32.0*I7 step 0.01*I7
Pick-up setting for second stage overcurrent element. P746_2 only.				
IN>2 Time Delay	38	FF	1s	From 0s to 200s step 10ms
Setting for the operating time-delay for the second stage overcurrent element P746_2 only.				

Table 6 - Earth Fault settings

4.6 Circuit Breaker Fail

This function consists of two-stage Circuit Breaker (CB) fail functions that can be initiated by:

- Internal protection element
- External protection element

For current-based protection, the reset condition is based on zero crossing detection with hysteresis to determine that the CB has opened. For the non-current based protection, the reset criteria may be selected by means of a setting for determining a CB open detection.

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

Menu Text	Col	Row	Default Setting	Available Setting
Description				
GROUP 1: CB FAIL	45	00		
GROUP 1: CB FAIL				
BREAKER FAIL	45	01		
Fdr CBF Reset by	45	02	I< and 52a	52a / I< / I< and 52a
only for Feeder CB; for coupler CB, it's fixed to I< Setting which determines the conditions to reset the feeder circuit breaker fail. “I< and 52a” means that disappearance of the current (I<) AND circuit breaker auxiliary contacts open will reset the feeder circuit breaker fail. Note: Coupler CB fails are always reset with current reset (I<) criterion, whatever the choice of ‘Fdr CBF Reset by’ setting.				
I< Current Set	45	05	5%	From 5% to 400% step 1%
Setting that determines the circuit breaker fail reset criteria.				
CB Fail 1 Timer	45	07	50ms	From 0s to 10s step 1ms
Setting for the circuit breaker fail timer stage 1 (retrip) for internal initiation.				
CB Fail 2 Timer	45	09	200ms	From 40ms to 10s step 1ms
Setting for the circuit breaker fail timer stage 2 (backtrip) for internal initiation.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
CB Fail 3 Timer	45	0A	50ms	From 0s to 10s step 1ms
Setting for the circuit breaker fail timer stage 1 (retrip) for external initiation.				
CB Fail 4 Timer	45	0B	200ms	From 40ms to 10s step 1ms
Setting for the circuit breaker fail timer stage 2 (backtrip) for external initiation.				
I> Status	45	0E	Disabled	Disabled or Enabled
To enable (activate) or disable (turn off) the overcurrent confirmation for the start of the circuit breaker fail function				
I> Current Set	45	0F	120%	From 5% to 400% step 1%
If “I> Status” is enabled, pick-up setting for overcurrent confirmation				

Table 7 - CBF settings

4.7 Supervision (VT Supervision is available for P746_1 only)

Menu Text	Col	Row	Default Setting	Available Setting
Description				
GROUP 1: SUPERVISION	46	00		
GROUP 1: SUPERVISION				
VT SUPERVISION	46	01		
GROUP 1: VT SUPERVISION. Note: VT Supervision is avalable for P746_1 ONLY.				
VTS Status	46	02	Blocking	Blocking / Indication
Sets Voltage Transformer Supervision (VTS) operation. The relay respond as follows, on operation of any VTS element: VTS set to provide alarm indication only or blocking of voltage dependent protection elements.				
VTS Reset Mode	46	03	Manual	Manual / Auto
This setting enables the automatic or manual mode (via front panel or remote communications) of the voltage transformer supervision reset mode. If automatic mode is set, VTS will be reset after 240ms (if VTS fault condition is removed)				
VTS Time Delay	46	04	5s	From 0s to 10s step 2ms
This setting determines the operating time-delay of the element upon detection of a voltage transformer supervision condition.				
CT SUPERVISION	46	20		
GROUP 1: CT SUPERVISION (One Box Mode Only)				
Diff CTS	46	21	Enabled	Enabled / Disabled
Setting to enable or disable the differential CT Supervision. Differential CTS is based on measurement of the ratio of I2 and I1 at each zone ends.				
CTS Status	46	22	Blocking	Blocking / Indication
This menu enables or disables Current Transformer Supervision (CTS): when “Blocking” is selected, CTS is enabled, the following “CTS Time Delay” menu is accessible and settable.				
CTS Time Delay	46	23	2s	From 0s to 10s step 100ms
This setting determines the operating time-delay of the element upon detection of a current transformer supervision condition.				
CTS I1	46	24	10%	5% to 100% step 1%
Setting for positive sequence current that is not to be exceeded in order to determine CTS condition				
CTS I2/I1>1	46	25	5%	5% to 100% step 1%
Setting for low set ratio that is not to be exceeded in order to determine CTS condition				
CTS I2/I1>2	46	26	40%	5% to 100% step 1%

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Setting for the high set ratio to be exceeded at only one end in order to determine CTS condition				

Table 8 - Supervision settings

5 CONTROL AND SUPPORT SETTINGS

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

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

5.1 System Data

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

Menu Text	Col	Row	Default Setting	Available Setting
Description				
SYSTEM DATA	00	00		
This column contains general system settings				
Language	00	01	English	English, French, German, Russian, Spanish, Chinese (UI only)
The default language used by the device. Selectable as English, French, German, Russian, Spanish and Chinese. Chinese is UI only.				
Sys Fn Links	00	03	0(bin)	Bit 00=Trip LED S/Reset, Bit 01=Enable Self Reset)
Setting to allow the fixed function trip LED to be self resetting (set to 1 to extinguish the LED after a period of healthy restoration of load current).				
Description	00	04	MiCOM P746	32 to 234 step 1
Editable 16-character description of the unit				
Plant Reference	00	05	MiCOM	32 to 234 step 1
Plant description: Can be edited				
Model Number	00	06	Model number	<Model number>
Displays the model number. This can not be edited				
Serial Number	00	08	Serial number	<Serial number>
Displays the serial numbe. This can not be edited.				
Frequency	00	09	50 Hz	50 Hz or 60 Hz
Sets the mains frequency				
Comms Level	00	0A	2	<conformance level displayed>
Displays the conformance of the relay to the Courier Level 2 comms.				
Relay Address	00	0B	255 1 1 1	0 to 255 step 1 (Courier) 1 to 247 step 1 (Modbus) 1 to 254 step 1 (CS103) 1 to 65534 step 1 (DNP3)

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Set the first rear port relay address. Build = Courier (Address available via LCD) Build = Modbus (Address available via LCD) Build = CS103 (Address available via LCD) Build = DNP3.0 (Address available via LCD)				
Plant Status	00	0C		Not Settable
Displays all the open and closed circuit breaker status (feeders and couplers).				
Control Status	00	0D		Not Used
Not used.				
Active Group	00	0E		Not Settable
Displays the active settings group.				
Software Ref. 1	00	11		<Software Ref. 1>
Displays the relay software version including protocol and relay model.				
Software Ref 2	00	12		<Software Ref. 2>
Relay Ethernet card software reference. Visible when Ethernet card fitted.				
NIC Platform Ref	00	14		<NIC platform reference>
Displays the relay NIC platform reference. Visible when Ethernet card fitted.				
IEC61850 Edition	00	15	2	1 or 2
Selects IEC 61850 Editions, Edition 1 or Edition 2. This setting can only be changed via UI and the changes will cause the Ethernet board to reboot.				
ETH COMM Mode	00	16	Dual IP	Dual IP, PRP, HSR
Selects Ethernet communication mode. This setting can only be changed via the UI and the changes will cause the Ethernet board to reboot.				
Plant Status2	00	25		Not Settable
Displays the additional open and closed feeder circuit breaker status (Three Box Mode.)				
Opto I/P Status	00	30		Not Settable
Displays the status of opto-isolated inputs (number of opto inputs depending on the model).				
Opto I/P Status2	00	31		Not Settable
Displays the status of opto-isolated inputs (number of opto inputs depending on the model).				
Rly O/P Status	00	40		Not Settable
Displays the status of the output relays (number of output relays depending on the model).				
Alarm Status 1	00	50		Not Settable
This menu cell displays the status of the first 32 alarms as a binary string. 1 indicates an ON state and 0 an OFF state. Includes fixed and user settable alarms.				
Alarm Status 2	00	51		Not Settable
This menu cell displays the status of the second 32 alarms as a binary string.1 indicates an ON state and 0 an OFF state.				
Alarm Status 3	00	52		Not Settable
This menu cell displays the status of the third 32 alarms as a binary string. 1 indicates an ON state and 0 an OFF state. Assigned specifically for platform alarms.				
Usr Alarm Status	00	53		Not Settable
This menu cell displays the status of the 32 user alarms as a binary string. 1 indicates an ON state and 0 an OFF state.				
Access Level	00	D0	ENGINEER	Not Settable
Display the Role(s) of the current logged in user, if no one logged in, it shall be "NONE".				
New Eng.Level PW	00	D3		ASCII 33 to 122
Allows user to change password for EngineerLevel. Visible on UI only.				
New Op.Level PW	00	D4		ASCII 33 to 122

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Allows user to change password for OperatorLevel. Visible on UI only.				
Security Feature	00	DF	3	Not Settable
Displays the level of cyber security implemented				
Password	00	E1		<Password>
Used to send encrypted password. Not visible on UI.				
Encryption Salt	00	E5		<Encryption Salt>
Random data used with encrypted password. Not visible on UI.				
Enter username	00	F1		<User Name>
User selection for login. Not visible on UI.				
Number of users	00	F2	2	Not Settable
Shows the number of users configured within the relays RBAC.				
New UI pwd	00	F3		<Second Simple Password>
Hidden cell reserved for second password modification. Not in use currently.				
New password	00	F4		<Encrpted Password>
Allow password change if engineer or operator logged in and CSL0 model. Not visible on UI.				

Table 9 - System data settings

Important	***Dual IP is not mutually exclusive with PRP/HSR, Dual IP is automatically supported even if the IED is operated under HSR or PRP Mode.***

5.2 Date and Time

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

Menu Text	Col	Row	Default Setting	Available Setting
Description				
DATE AND TIME	08	00		
This column contains Date and Time settings				
Date/Time	08	01		Not Settable
Displays the IED’s current date and time. Not visible on UI.				
Date	08	02		<Date>
Front Panel Menu only				
Time	08	03		<Time>
Front Panel Menu only				
IRIG-B Sync	08	04	Disabled	0 = Disabled or 1 = Enabled
Enable IRIG-B time synchronization (with IRIG-B option).				
IRIG-B Status	08	05		Not Settable
Displays the status of IRIG-B (with IRIG-B option).				
Battery Status	08	06		Not Settable
Displays whether the battery is healthy or not.				
Battery Alarm	08	07	Enabled	0 = Disabled or 1 = Enabled
Enables or disables battery alarm. The battery alarm needs to be disabled when a battery is removed or not used				
SNTP Status	08	13		Not Settable
Displays information about the SNTP time synchronization status (IEC61850 or DNP3.0 over Ethernet versions only)				
LocalTime Enable	08	20	Disabled	0 = Disabled, 1 = Fixed or 2 = Flexible

Menu Text	Col	Row	Default Setting	Available Setting
Description				
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 IEC61850 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 IEC61850/SNTP which will always be in the UTC zone.				
LocalTime Offset	08	21	0 mins	From -720 mins to 720 mins step 15 mins
Setting to specify an offset of -12 to +12 hrs in 15 minute intervals for local time zone. This adjustment is applied to the time based on the master clock which is UTC/GMT				
DST Enable	08	22	Disabled	0 = Disabled or 1 = Enabled
Setting to turn on/off daylight saving time adjustment to local time.				
DST Offset	08	23	60 mins	From 30 mins to 60 mins step 30 mins
Setting to specify daylight saving offset which will be used for the time adjustment to local time.				
DST Start	08	24	Last	0 = First, 1 = Second, 2 = Third, 3 = Fourth or 4 = Last
Setting to specify the week of the month in which daylight saving time adjustment starts				
DST Start Day	08	25	Sunday	0 = Sunday, 1 = Monday, 2 = Tuesday, 3 = Wednesday, 4 = Thursday, 5 = Friday or 6 = Saturday
Setting to specify the day of the week in which daylight saving time adjustment starts				
DST Start Month	08	26	March	0 = January, 1 = February, 2 = March, 3 = April, 4 = May, 5 = June, 6 = July, 7 = August, 8 = September, 9 = October, 10 = November or 11 = December
Setting to specify the month in which daylight saving time adjustment starts				
DST Start Mins	08	27	60 mins	From 0 mins to 1425 mins step 15mins
Setting to specify the time of day in which daylight saving time adjustment starts. This is set relative to 00:00 hrs on the selected day when time adjustment is to start.				
DST End	08	28	Last	0 = First, 1 = Second, 2 = Third, 3 = Fourth or 4 = Last
Setting to specify the week of the month in which daylight saving time adjustment ends.				
DST End Day	08	29	Sunday	0 = Sunday, 1 = Monday, 2 = Tuesday, 3 = Wednesday, 4 = Thursday, 5 = Friday or 6 = Saturday
Setting to specify the day of the week in which daylight saving time adjustment ends				
DST End Month	08	2A	October	0 = January, 1 = February, 2 = March, 3 = April, 4 = May, 5 = June, 6 = July, 7 = August, 8 = September, 9 = October, 10 = November or 11 = December
Setting to specify the month in which daylight saving time adjustment ends				
DST End Mins	08	2B	60 mins	From 0 mins to 1425 mins step 15mins
Setting to specify the time of day in which daylight saving time adjustment ends. This is set relative to 00:00 hrs on the selected day when time adjustment is to end.				
RP1 Time Zone	08	30	Local	0 = UTC or 1 = Local
Setting for the rear port 1 interface to specify if time synchronization received will be local or universal time coordinated				
RP2 Time Zone	08	31	Local	0 = UTC or 1 = Local
Setting for the rear port 2 interface to specify if time synchronization received will be local or universal time coordinated				
DNPOE Time Zone	08	32	Local	0 = UTC or 1 = Local

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Setting to specify if time synchronisation received will be local or universal time co-ordinated. (IEC61850+DNP3oE versions only)				
Tunnel Time Zone	08	33	Local	0 = UTC or 1 = Local
Setting to specify if time synchronization received will be local or universal time co-ordinated .(Ethernet versions only for tunnelled courier)				

Table 10 - Date and time settings

5.3 CT and VT Ratios

Menu Text	Col	Row	Default Setting	Available Setting
Description				
CT AND VT RATIOS	0A	00		
This column contains settings for Current and Voltage Transformer ratios				
Main VT Primary	0A	03	110 V	From 100 V to 1 MV step 1 V
Main voltage transformer input, primary voltage setting (P746_1 only) V1=Main VT Secondary Rating/110				
Main VT Sec'y	0A	04	110 V	From 80 V to 140 V step 1 V
Main voltage transformer input, secondary voltage setting (P746_1 only) Multiplier M1=[0A03]/[0A04]				
Reference Current	0A	09	2000 A	1 to 30 kA step 1
Hidden cell used to align all currents against a common primary reference. Fixed at 2000A. Multiplier M21=[0A09]				
T1 CT	0A	10		
The following settings apply to T1 CT (One Box Mode or Three Box Mode)				
Polarity	0A	11	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	12	1000 A	From 1 A to 30 kA step 1 A
Sets CT1 primary rating. Label I1=Phase CT1 primary rating				
Secondary	0A	13	1 A	1 A or 5 A
Sets CT1 secondary rating. Multiplier M3=[0A12]/[0A13]				
T2 CT	0A	14		
The following settings apply to T2 CT (One Box Mode or Three Box Mode)				
Polarity	0A	15	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	16	1000 A	From 1 A to 30 kA step 1 A
Sets CT2 primary rating. Label I2=Phase CT2 primary rating				
Secondary	0A	17	1 A	1 A or 5 A
Sets CT2 secondary rating. Multiplier M4=[0A16]/[0A17]				
T3 CT	0A	18		
The following settings apply to T3 CT (One Box Mode or Three Box Mode)				
Polarity	0A	19	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	1A	1000 A	From 1 A to 30 kA step 1 A
Sets CT3 primary rating. Label I3=Phase CT3 primary rating				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Secondary	0A	1B	1 A	1 A or 5 A
Sets CT3 secondary rating. Multiplier M5=[0A1A]/[0A1B]				
T4 CT	0A	1C		
The following settings apply to T4 CT (One Box Mode or Three Box Mode)				
Polarity	0A	1D	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	1E	1000 A	From 1 A to 30 kA step 1 A
Sets CT4 primary rating. Label I4=Phase CT4 primary rating				
Secondary	0A	1F	1 A	1 A or 5 A
Sets CT4 secondary rating. Multiplier M6=[0A1E]/[0A1F]				
T5 CT	0A	20		
The following settings apply to T5 CT (One Box Mode or Three Box Mode)				
Polarity	0A	21	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	22	1000 A	From 1 A to 30 kA step 1 A
Sets CT5 primary rating. Label I5=Phase CT5 primary rating				
Secondary	0A	23	1 A	1 A or 5 A
Sets CT5 secondary rating. Multiplier M7=[0A22]/[0A23]				
T6 CT	0A	24		
The following settings apply to T6 CT (one box or three box)				
Polarity	0A	25	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	26	1000 A	From 1 A to 30 kA step 1 A
Sets CT6 primary rating. Label I6=Phase CT6 primary rating				
Secondary	0A	27	1 A	1 A or 5 A
Sets CT6 secondary rating. Multiplier M8=[0A26]/[0A27]				
T7 CT	0A	28		
The following settings apply to T7 CT (One Box Mode or Three Box Mode)				
Polarity	0A	29	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	2A	1000 A	From 1 A to 30 kA step 1 A
Sets CT7 primary rating. Label I7=Phase CT7 primary rating				
Secondary	0A	2B	1 A	1 A or 5 A
Sets CT7 secondary rating. Multiplier M9=[0A2A]/[0A2B]				
T8 CT	0A	2C		
The following settings apply to T8 CT (Three Box Mode)				
Polarity	0A	2D	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	2E	1000 A	From 1 A to 30 kA step 1 A
Sets CT8 primary rating. Label I8=Phase CT8 primary rating				
Secondary	0A	2F	1 A	1 A or 5 A
Sets CT8 secondary rating. Multiplier M10=[0A2E]/[0A2F]				
T9 CT	0A	30		

Menu Text	Col	Row	Default Setting	Available Setting
Description				
The following settings apply to T9 CT (Three Box Mode)				
Polarity	0A	31	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	32	1000 A	From 1 A to 30 kA step 1 A
Sets CT9 primary rating. Label I9=Phase CT9 primary rating				
Secondary	0A	33	1 A	1 A or 5 A
Sets CT9 secondary rating. Multiplier M11=[0A32]/[0A33]				
T10 CT	0A	34		
The following settings apply to T10 CT (Three Box Mode)				
Polarity	0A	35	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	36	1000 A	From 1 A to 30 kA step 1 A
Sets CT10 primary rating. Label I10=Phase CT10 primary rating				
Secondary	0A	37	1 A	1 A or 5 A
Sets CT10 secondary rating. Multiplier M12=[0A36]/[0A37]				
T11 CT	0A	38		
The following settings apply to T11 CT (Three Box Mode)				
Polarity	0A	39	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	3A	1000 A	From 1 A to 30 kA step 1 A
Sets CT11 primary rating. Label I11=Phase CT11 primary rating				
Secondary	0A	3B	1 A	1 A or 5 A
Sets CT11 secondary current rating. Multiplier M13=[0A3A]/[0A3D]				
T12 CT	0A	3C		
The following settings apply to T12 CT (Three Box Mode)				
Polarity	0A	3D	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	3E	1000 A	From 1 A to 30 kA step 1 A
Sets CT12 primary rating. Label I12=Phase CT12 primary rating				
Secondary	0A	3F	1 A	1 A or 5 A
Sets CT12 secondary rating. Multiplier M14=[0A3E]/[0A3F]				
T13 CT	0A	40		
The following settings apply to T13 CT (Three Box Mode)				
Polarity	0A	41	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	42	1000 A	From 1 A to 30 kA step 1 A
Sets CT13 primary rating. Label I13=Phase CT13 primary rating				
Secondary	0A	43	1 A	1 A or 5 A
Sets CT13 secondary current rating. Multiplier M15=[0A42]/[0A43]				
T14 CT	0A	44		
The following settings apply to T14 CT (Three Box Mode)				
Polarity	0A	45	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Primary	0A	46	1000 A	From 1 A to 30 kA step 1 A
Sets CT14 primary rating. Label I14=Phase CT14 primary rating				
Secondary	0A	47	1 A	1 A or 5 A
Sets CT14 secondary rating. Multiplier M16=[0A46]/[0A47]				
T15 CT	0A	48		
The following settings apply to T15 CT (Three Box Mode)				
Polarity	0A	49	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	4A	1000 A	From 1 A to 30 kA step 1 A
Sets CT15 primary rating. Label I15=Phase CT15 primary rating				
Secondary	0A	4B	1 A	1 A or 5 A
Sets CT15 secondary rating. Multiplier M17=[0A4A]/[0A4B]				
T16 CT	0A	4C		
The following settings apply to T16 CT (Three Box Mode)				
Polarity	0A	4D	Standard	Standard or Inverted
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	0A	4E	1000 A	From 1 A to 30 kA step 1 A
Sets CT16 primary rating. Label I16=Phase CT16 primary rating				
Secondary	0A	4F	1 A	1 A or 5 A
Sets CT16 secondary rating. Multiplier M18=[0A4E]/[0A4F]				
T17 CT	0A	50		
The following settings apply to T17 CT (Three Box Mode)				
Polarity	0A	51	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	52	1000 A	From 1 A to 30 kA step 1 A
Sets CT17 primary rating. Label I17=Phase CT17 primary rating				
Secondary	0A	53	1 A	1 A or 5 A
Sets CT17 secondary rating. Multiplier M19=[0A52]/[0A53]				
T18 CT	0A	54		
The following settings apply to T18 CT (Three Box Mode)				
Polarity	0A	55	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	56	1000 A	From 1 A to 30 kA step 1 A
Sets CT18 primary rating. Label I18=Phase CT18 primary rating				
Secondary	0A	57	1 A	1 A or 5 A
Sets CT18 secondary current rating. Multiplier M20=[0A56]/[0A57]				
T19 CT	0A	70		
The following settings apply to T19 CT (Three Box Mode, P746_2 only)				
Polarity	0A	71	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	72	1000 A	From 1 A to 30 kA step 1 A
Sets CT19 primary rating. Label I19=Phase CT19 primary rating				
Secondary	0A	73	1 A	1 A or 5 A

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Sets CT19 secondary rating. Multiplier M21=[0A72]/[0A73]				
T20 CT	0A	74		
The following settings apply to T20 CT (Three Box Mode, P746_2 only)				
Polarity	0A	75	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	76	1000 A	From 1 A to 30 kA step 1 A
Sets CT20 primary rating. Label I20=Phase CT20 primary rating				
Secondary	0A	77	1 A	1 A or 5 A
Sets CT20 secondary rating. Multiplier M22=[0A76]/[0A77]				
T21 CT	0A	78		
The following settings apply to T21 CT (Three Box Mode, P746_2 only)				
Polarity	0A	79	Standard	Standard or Inverted
Sets standard or reverse CT polarity.				
Primary	0A	7A	1000 A	From 1 A to 30 kA step 1 A
Sets CT21 primary rating. Label I21=Phase CT21 primary rating				
Secondary	0A	7B	1 A	1 A or 5 A
Sets CT21 secondary rating. Multiplier M23=[0A7A]/[0A7B]				

Table 11 - CT and VT ratio settings

5.4 Record Control

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

Menu Text	Col	Row	Default Setting	Available Setting
Description				
RECORD CONTROL	0B	00		
This column contains settings for Record Controls				
Clear Events	0B	01	No	0 = No or 1 = Yes
Selecting “Yes” will cause the existing event log to be cleared and an event will be generated indicating that the events have been erased.				
Clear Faults	0B	02	No	0 = No or 1 = Yes
Selecting “Yes” will cause the existing fault records to be erased from the relay.				
Clear Maint	0B	03	No	0 = No or 1 = Yes
Selecting “Yes” will cause the existing maintenance records to be erased from the relay.				
Alarm Event	0B	04	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that all the occurrences that produce an alarm will result in no event being generated.				
Relay O/P Event	0B	05	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any change in logic input state.				
Opto Input Event	0B	06	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any change in logic input state.				
General Event	0B	07	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no General Events will be generated				
Fault Rec Event	0B	08	Enabled	0 = Disabled or 1 = Enabled

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Disabling this setting means that no event will be generated for any fault that produces a fault record				
Maint Rec Event	0B	09	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that no event will be generated for any occurrence that produces a maintenance record.				
Protection Event	0B	0A	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that any operation of protection elements will not be logged as an event.				
Clear Dist Recs	0B	30	No	0 = No or 1 = Yes
Selecting “Yes” will cause the existing disturbance records to be cleared and an event will be generated indicating that the disturbance records have been erased.				
Security Event	0B	31	Enabled	0 = Disabled or 1 = Enabled
Disabling this setting means that any operation of security elements will not be logged as an event				
DDB 31 - 0	0B	40	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 63 - 32	0B	41	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 95 - 64	0B	42	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 127 - 96	0B	43	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 159 - 128	0B	44	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 191 - 160	0B	45	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 223 - 192	0B	46	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 255 - 224	0B	47	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 287 - 256	0B	48	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 319 - 288	0B	49	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
DDB 351 - 320	0B	4A	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 383 - 352	0B	4B	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 415 - 384	0B	4C	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 447 - 416	0B	4D	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 479 - 448	0B	4E	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 511 - 480	0B	4F	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 543 - 512	0B	50	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 575 - 544	0B	51	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 607 - 576	0B	52	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 639 - 608	0B	53	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 671 - 640	0B	54	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 703 - 672	0B	55	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 735 - 704	0B	56	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Choose whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 767 - 736	0B	57	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 799 - 768	0B	58	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 831 - 800	0B	59	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 863 - 832	0B	5A	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 895 - 864	0B	5B	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 927 - 896	0B	5C	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 959 - 928	0B	5D	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 991 - 960	0B	5E	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1023 - 992	0B	5F	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1055-1024	0B	60	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1087-1056	0B	61	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1119-1088	0B	62	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
DDB 1151-1120	0B	64	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1183-1152	0B	64	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1215-1184	0B	65	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1247-1216	0B	66	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1279-1248	0B	67	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1311-1280	0B	68	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1343-1312	0B	69	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1375-1344	0B	6A	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1407-1376	0B	6B	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1439-1408	0B	6C	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1471-1440	0B	6D	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1503-1472	0B	6E	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1535-1504	0B	6F	11111111111111111111111111111111 (bin)	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 1567-1536	0B	70	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1599-1568	0B	71	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1631-1600	0B	72	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1663-1632	0B	73	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1695-1664	0B	74	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1727-1696	0B	75	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1759-1728	0B	76	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1791-1760	0B	77	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1823-1792	0B	78	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1855-1824	0B	79	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1887-1856	0B	7A	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1919-1888	0B	7B	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
DDB 1951-1920	0B	7C	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1983-1952	0B	7D	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 2015-1984	0B	7E	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 2047-2016	0B	7F	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Table 12 - Record control settings

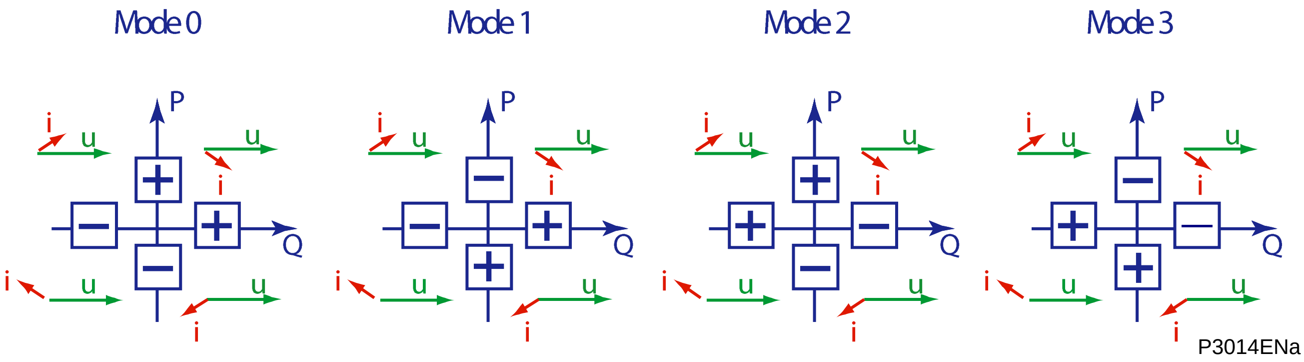
Important	***This column is visible when the "Record Control" setting ("Configuration" column) = "visible".***

5.5 Measurements

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

Menu Text	Col	Row	Default Setting	Available Setting
Description				
MEASURE'T SETUP	0D	00		
This column contains settings for the measurement setup				
Default Display	0D	01	Banner	Not Settable
This displays the default display which is possible to change whilst at the default level using the arrow keys. Only visible on UI.				
Local Values	0D	02	Primary	0 = Primary or 1 = Secondary
Local Measurement Values. This setting controls whether measured values via the front panel user interface and the front Courier port are displayed as primary or secondary quantities.				
Remote Values	0D	03	Primary	0 = Primary or 1 = Secondary
Remote Measurement Values. This setting controls whether measured values via the rear communication port are displayed as primary or secondary quantities.				
Measurement Ref	0D	04	VA	0 = VA, 1 = VB, 2 = VC, 3 = IA, 4 = IB, 5 = IC
Measurement Phase Reference. This menu sets the reference of the measure (phase reference and angle)				
Measurement Mode	0D	05	0	0 to 3 step 1
This setting is used to control the signing of the real and reactive power quantities.				

Table 13 - Measure't setup setting



5.6 Communications Settings

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

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

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

- Courier Protocol Settings
- MODBUS Protocol Settings
- IEC60870-5-103 Protocol Settings
- Ethernet Port

Important ***The Setting ranges are different with different protocols.***

Menu Text	Col	Row	Default Setting	Available Setting
Description				
COMMUNICATIONS	0E	00		
This column contains general communications settings				
RP1 Protocol	0E	01		Not Settable
Indicates the communications protocol that will be used on the rear communications port.				
RP1 Address	0E	02	255 1 1 1	0 to 255 step 1 (Courier) 1 to 247 step 1 (Modbus) 1 to 254 step 1 (CS103) 1 to 65534 step 1 (DNP3)
Rear Port 1 Protocol device address. This cell sets the unique address for the relay such that only one relay is accessed by master station software.				
RP1 InactivTimer	0E	03	15mins	From 1min to 30min step 1min
Rear Port 1 Protocol inactivity timer. This cell controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state, including resetting any password access that was enabled.				
RP1 Baud Rate	0E	04	19200 bits/s	0=9600 bits/s 1=19200 bits/s 2=38400 bits/s (Modbus) 0=9600 bits/s 1=19200 bits/s (CS103) 0=1200 bits/s 1=2400 bits/s 2=4800 bits/s 3=9600 bits/s 4=19200 bits/s 5=38400 bits/s (DNP3)
Rear Port 1 Protocol serial bit/baud rate. This cell controls the communication speed between IED and master station. It is important that both IED and master station are set at the same speed setting.				
RP1 Parity	0E	05	None	0 = Odd, 1 = Even, 2 = None

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Rear Port 1 Protocol parity. This cell controls the parity format used in the data frames. It is important that both IED and master station are set with the same parity setting.				
RP1 Meas Period	0E	06	15s	From 1s to 60s step 1s
Rear Port 1 IEC60870-5-103 Protocol measurment period. IEC60870-5-103 versions only. This cell controls the time interval that the IED will use between sending measurement data to the master station.				
RP1 PhysicalLink	0E	07	Copper	0 = Copper or 1 = Fibre Optic
Rear Port 1 Physical link selector. This cell defines whether an electrical EIA(RS) 485 or fiber optic connection is being used for communication between the master station and IED. This cell is only visible if a fibre optic board is fitted.				
RP1 Time Sync	0E	08	Disabled	0 = Disabled or 1 = Enabled
Rear Port 1 DNP 3.0 Protocol time sync configuration. If set to Enabled the master station can be used to synchronize the time on the IED. If set to Disabled either the internal free running clock or IRIG-B input are used.				
Modbus IEC Time	0E	09	Standard IEC	0=Standard IEC (Existing format) 1=Reverse IEC (Company agreed format)
Controls the format of the time-date G12 data type. Modbus Only. When ‘Standard IEC’ is selected the time format complies with IEC60870-5-4 requirements such that byte 1 of the information is transmitted first, followed by bytes 2 through to 7. If ‘Reverse’ is selected the transmission of information is reversed.				
RP1 CS103Blcking	0E	0A	Disabled	0 = Disabled, 1 = Monitor Blocking or 2 = Command Blocking
IEC60870-5-103 versions only. There are three settings associated with this cell: Disabled - No blocking selected. Monitor Blocking - When the monitor blocking DDB Signal is active high, either by energizing an opto input or control input, reading of the status information and disturbance records is not permitted. When in this mode the IED returns a “termination of general interrogation” message to the master station. Command Blocking - When the command blocking DDB signal is active high, either by energizing an opto input or control input, all remote commands will be ignored (i.e. CB Trip/Close, change setting group etc.). When in this mode the IED returns a “negative acknowledgement of command” message to the master station.				
RP1 Card Status	0E	0B		Not Settable
Rear Port 1 Courier Protocol Status. This cell indicates the status of the communication card.				
RP1 Port Config	0E	0C	K-Bus	0 = K Bus or 1 = EIA485 (RS485)
Rear Port 1 Courier Protocol copper port configuration; K-Bus or EIA485. This cell defines whether an electrical KBus or EIA(RS)485 is being used for communication between the master station and relay.				
RP1 Comms Mode	0E	0D	IEC60870 FT1.2	0 = IEC60870 FT1.2 Frame or 1 = 10-bit no parity
Rear Port 1 Courier Protocol EIA485 mode. The choice is either IEC60870 FT1.2 for normal operation with 11-bit modems, or 10-bit no parity.				
RP1 Baud Rate	0E	0E	19200 bits/s	0 = 9600 bits/s, 1 = 19200 bits/s, 2 = 38400 bits/s
Rear Port 1 Courier Protocol EIA485 bit/baud rate. This cell controls the communication speed between relay and master station. It is important that both relay and master station are set at the same speed setting.				
Meas Scaling	0E	0F	Normalised	0 = Normalised, 1 = Primary, 2 = Secondary
DNP 3.0 and IEC61850+DNP3OE only. Setting to report analogue values in terms of primary, secondary or normalized (with respect to the CT/VT ratio setting) values.				
DNP Need Time	0E	11	10mins	From 1min to 30mins step 1min
DNP 3.0 and IEC61850+DNP3OE only. The duration of time waited before requesting another time sync from the master.				
DNP App Fragment	0E	12	2048	100 to 2048 step 1
DNP 3.0 and IEC61850+DNP3OE only. The maximum message length (application fragment size) transmitted by the IED.				
DNP App Timeout	0E	13	2s	From 1s to 120s step 1s

Menu Text	Col	Row	Default Setting	Available Setting
Description				
DNP 3.0 and IEC61850+DNP3OE only. Duration of time waited, after sending a reply and awaiting a confirmation from the master.				
DNP SBO Timeout	0E	14	10s	From 1s to 10s step 1s
DNP 3.0 and IEC61850+DNP3OE only. Duration of time waited, after receiving a select command and awaiting an operate confirmation from the master				
DNP Link Timeout	0E	15	0s	From 0s to 120s step 1s
DNP 3.0 and IEC61850+DNP3OE only. Duration of time that the IED will wait for a Data Link Confirmation from the master. A value of 0 means data link support disabled and 1 to 120 seconds is the timeout setting.				
ETH Protocol	0E	1F		Not Settable
Indicates the protocol used on the Network Interface Card. Visible when Ethernet card fitted				
MAC Addr 1	0E	22		This is a factory setting
Shows the MAC address of the 1st Ethernet port. Visible when Ethernet card fitted.				
MAC Addr 2	0E	23		This is a factory setting
Shows the MAC address of the 2nd Ethernet port. Visible when Ethernet card fitted.				
ETH Tunl Timeout	0E	64	15mins	From 1min to 30mins step 1min
Duration of time to wait before an inactive tunnel to Easergy Studio is reset. Visible when Ethernet card fitted.				
Redundancy Conf	0E	70		
NIOS PARAMETERS. The redundant agency device configuration is used for SNMP server. This does not affect IEC61850 communications. Visible when Ethernet card fitted and Comm Mode=PRP or HSR				
MAC Address	0E	71		Not Settable
MAC address for the NIOS. Visible when Ethernet card fitted and Comm Mode=PRP or HSR				
IP Address	0E	72	169.254.2.zzz	<IP address of relay>
A default IP address which is encoded from MAC address 169.254.2.zzz, zzz = mod (The last byte of MAC address, 128) + 1. Visible when Ethernet card fitted and Comm Mode=PRP or HSR				
Subnet Mask	0E	73	255.255.255.0	<Subnet mask of relay>
Subnet Mask for the NIOS. Visible when Ethernet card fitted and Comm Mode=PRP or HSR				
Gateway	0E	74	169.254.2.250	<Gateway address>
Gateway for the NIOS. Visible when Ethernet card fitted and Comm Mode=PRP or HSR				
REAR PORT2 (RP2)	0E	80		
Visible when Rear Port 2 fitted.				
RP2 Protocol	0E	81		Not Settable
Rear Port 2 Protocol - "Courier". Indicates the communications protocol that will be used on the rear communications port.				
RP2 Card Status	0E	84		Not Settable
Rear Port 2 Courier Protocol Status				
RP2 Port Config	0E	88	EIA232 (RS232)	0 = EIA232 (RS232), 1 = EIA485 (RS485), 2 = K-Bus
Rear Port 2 Courier Protocol port configuration. This cell defines whether an electrical EIA(RS)232, EIA(RS)485 or KBus is being used for communication.				
RP2 Comms Mode	0E	8A	IEC60870 FT1.2	0 = IEC60870 FT1.2 or 1 = 10-bit no parity
Rear Port 2 Courier Protocol EIA485 mode. The choice is either IEC60870 FT1.2 for normal operation with 11-bit modems, or 10-bit no parity.				
RP2 Address	0E	90	255	0 to 255 step 1
Rear Port 2 Courier Protocol device address. This cell sets the unique address for the relay such that only one relay is accessed by master station software.				
RP2 InactivTimer	0E	92	15mins	From 1min to 30mins step 1min

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Rear Port 2 Courier Protocol inactivity timer. This cell controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state, including resetting any password access that was enabled.				
RP2 Baud Rate	0E	94	19200 bits/s	0 = 9600 bits/s, 1 = 19200 bits/s, 2 = 38400 bits/s
Rear Port 2 Courier Protocol EIA485 bit/baud rate. This cell controls the communication speed between relay and master station. It is important that both relay and master station are set at the same speed setting.				

Table 14 - Communication settings

The destination address on the master side does not need to be configured for DNP3.0 Over Ethernet connection, and it is not linked to the relay address. Using the Ethernet connection, the connection is identified by the IP address.

5.7 Commissioning Tests

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

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

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

Menu Text	Col	Row	Default Setting	Available Setting
Description				
COMMISSION TESTS	0F	00		
This column contains commissioning test settings				
Opto I/P Status	0F	01		Not Settable
This menu cell displays the status of the relay's opto-isolated inputs (L01 to L32) as a binary string, a '1' indicating an energized opto-isolated input and a '0' a de-energized one. The original register 30007 is available for Opto Inputs. #1 to #16.				
Opto I/P Status2	0F	02		Not Settable
Status of the next relay's opto-isolated inputs (L33 to L40). The original register 30007 is available.				
Relay O/P Status	0F	03		Not Settable
This menu cell displays the status of the digital data bus (DDB) signals that result in energisation of the output relays (R01 to R32) 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	05		Not Settable
This menu cell displays the status of the eight digital data bus (DDB) signals that have been allocated in the 'Monitor Bit' cells.				
Monitor Bit 1	0F	07	64	From 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	08	65	From 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	09	66	From 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	0A	67	From 0 to 2047 step 1

Menu Text	Col	Row	Default Setting	Available Setting
Description				
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.				
Monitor Bit 5	0F	0B	68	From 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	0C	69	From 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	0D	70	From 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	0E	71	From 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	0F	Disabled	0 = Disabled, 1 = Test Mode, 2 = Blocked
The Test Mode menu cell is used to allow secondary injection testing to be performed on the IED without operation of the trip contacts. It also enables a facility to directly test the output contacts by applying menu controlled test signals. To select test mode the Test Mode menu cell should be set to 'Test Mode', which takes the IED out of service. It also causes an alarm condition to be recorded and the yellow 'Out of Service' LED to illuminate and an alarm message 'Prot'n. Disabled' is given. In IEC 60870-5-103 builds changes the Cause of Transmission, COT, to Test Mode. To enable testing of output contacts the Test Mode cell should be set to 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. In IEC61850 models using edition 2 mode, selecting Test Mode or Contacts Blocked will change the behaviour of all active logical nodes to test. The quality of all data will also indicate test.				
Test Pattern	0F	10	00000000000000000000000000000000 (bin)	0=Not Operated or 1=Operated
The Test Patern cell is used to select the output relay contacts that will be tested when the 'Contact Test' cell is set to 'Apply Test'. The cell has a binary string with one bit for each user-configurable output contact which can be set to '1' to operate the output under test conditions and '0' to not operate it. IEC60870 Test Mode Change.				
Contact Test	0F	11	No Operation	0 = No Operation, 1 = Apply Test, 2 = Remove Test
When the 'Apply Test' command in this cell is issued the contacts set for operation (set to '1') in the 'Test Pattern' cell change state. After the test has been applied the command text on the LCD will change to 'No Operation' and the contacts will remain in the Test State until reset issuing the 'Remove Test' command. The command text on the LCD will again revert to 'No Operation' after the 'Remove Test' command has been issued. Note: When the 'Test Mode' cell is set to 'Enabled' the 'Relay O/P Status' cell does not show the current status of the output relays and hence can not be used to confirm operation of the output relays. Therefore it will be necessary to monitor the state of each contact in turn.				
Test LEDs	0F	12	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'.				
Red LED Status	0F	15		Not Settable
This cell is an eighteen bit binary string that indicates which of the user-programmable LEDs on the relay are illuminated with the Red LED input active when accessing the relay from a remote location, a '1' indicating a particular LED is lit and a '0' not lit.				
Green LED Status	0F	16		Not Settable
This cell is an eighteen bit binary string that indicates which of the user-programmable LEDs on the relay are illuminated with the Green LED input active when accessing the relay from a remote location, a '1' indicating a particular LED is lit and a '0' not lit.				
Test Zone	0F	17	0000(bin)	Bit 00=Test Zone1 Bit 01=Test Zone2 Bit 02=Test Zone3 Bit 03=Test Zone4

Menu Text	Col	Row	Default Setting	Available Setting
Description				
The Test Zone cell is used to block a zone for test. It blocks 87BB trip. Alarm LED is lit. IEC60870 Test Mode Change.				
DDB 31 - 0	0F	20		Not Settable
Displays the status of signals DDB 31 - 0				
DDB 63 - 32	0F	21		Not Settable
Displays the status of signals DDB 63 - 32				
DDB 95 - 64	0F	22		Not Settable
Displays the status of signals DDB 95 - 64				
DDB 127 - 96	0F	23		Not Settable
Displays the status of signals DDB 127 - 96				
DDB 159 - 128	0F	24		Not Settable
Displays the status of signals DDB 159 - 128				
DDB 191 - 160	0F	25		Not Settable
Displays the status of signals DDB 191 - 160				
DDB 223 - 192	0F	26		Not Settable
Displays the status of signals DDB 223 - 192				
DDB 255 - 224	0F	27		Not Settable
Displays the status of signals DDB 255 - 224				
DDB 287 - 256	0F	28		Not Settable
Displays the status of signals DDB 287 - 256				
DDB 319 - 288	0F	29		Not Settable
Displays the status of signals DDB 319 - 288				
DDB 351 - 320	0F	2A		Not Settable
Displays the status of signals DDB 351 - 320				
DDB 383 - 352	0F	2B		Not Settable
Displays the status of signals DDB 383 - 352				
DDB 415 - 384	0F	2C		Not Settable
Displays the status of signals DDB 415 - 384				
DDB 447 - 416	0F	2D		Not Settable
Displays the status of signals DDB 447 - 416				
DDB 479 - 448	0F	2E		Not Settable
Displays the status of signals DDB 479 - 448				
DDB 511 - 480	0F	2F		Not Settable
Displays the status of signals DDB 511 - 480				
DDB 543 - 512	0F	30		Not Settable
Displays the status of signals DDB 543 - 512				
DDB 575 - 544	0F	31		Not Settable
Displays the status of signals DDB 575 - 544				
DDB 607 - 576	0F	32		Not Settable
Displays the status of signals DDB 607 - 576				
DDB 639 - 608	0F	33		Not Settable
Displays the status of signals DDB 639 - 608				
DDB 671 - 640	0F	34		Not Settable
Displays the status of signals DDB 671 - 640				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
DDB 703 - 672	0F	35		Not Settable
Displays the status of signals DDB 703 - 672				
DDB 735 - 704	0F	36		Not Settable
Displays the status of signals DDB 735 - 704				
DDB 767 - 736	0F	37		Not Settable
Displays the status of signals DDB 767 - 736				
DDB 799 - 768	0F	38		Not Settable
Displays the status of signals DDB 799 - 768				
DDB 831 - 800	0F	39		Not Settable
Displays the status of signals DDB 831 - 800				
DDB 863 - 832	0F	3A		Not Settable
Displays the status of signals DDB 863 - 832				
DDB 895 - 864	0F	3B		Not Settable
Displays the status of signals DDB 895 - 864				
DDB 927 - 896	0F	3C		Not Settable
Displays the status of signals DDB 927 - 896				
DDB 959 - 928	0F	3D		Not Settable
Displays the status of signals DDB 959 - 928				
DDB 991 - 960	0F	3E		Not Settable
Displays the status of signals DDB 991 - 960				
DDB 1023 - 992	0F	3F		Not Settable
Displays the status of signals DDB 1023 - 992				
DDB 1055-1024	0F	40		Not Settable
Displays the status of signals DDB 1055-1024				
DDB 1087-1056	0F	41		Not Settable
Displays the status of signals DDB 1087-1056				
DDB 1119-1088	0F	42		Not Settable
Displays the status of signals DDB 1119-1088				
DDB 1151-1120	0F	43		Not Settable
Displays the status of signals DDB 1151-1120				
DDB 1183-1152	0F	44		Not Settable
Displays the status of signals DDB 1183-1152				
DDB 1215-1184	0F	45		Not Settable
Displays the status of signals DDB 1215-1184				
DDB 1247-1216	0F	46		Not Settable
Displays the status of signals DDB 1247-1216				
DDB 1279-1248	0F	47		Not Settable
Displays the status of signals DDB 1279-1248				
DDB 1311-1280	0F	48		Not Settable
Displays the status of signals DDB 1311-1280				
DDB 1343-1312	0F	49		Not Settable
Displays the status of signals DDB 1343-1312				
DDB 1375-1344	0F	4A		Not Settable

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Displays the status of signals DDB 1375-1344				
DDB 1407-1376	0F	4B		Not Settable
Displays the status of signals DDB 1407-1376				
DDB 1439-1408	0F	4C		Not Settable
Displays the status of signals DDB 1439-1408				
DDB 1471-1440	0F	4D		Not Settable
Displays the status of signals DDB 1471-1440				
DDB 1503-1472	0F	4E		Not Settable
Displays the status of signals DDB 1503-1472				
DDB 1535-1504	0F	4F		Not Settable
Displays the status of signals DDB 1535-1504				
DDB 1567-1536	0F	50		Not Settable
Displays the status of signals DDB 1567-1536				
DDB 1599-1568	0F	51		Not Settable
Displays the status of signals DDB 1599-1568				
DDB 1631-1600	0F	52		Not Settable
Displays the status of signals DDB 1631-1600				
DDB 1663-1632	0F	53		Not Settable
Displays the status of signals DDB 1663-1632				
DDB 1695-1664	0F	54		Not Settable
Displays the status of signals DDB 1695-1664				
DDB 1727-1696	0F	55		Not Settable
Displays the status of signals DDB 1727-1696				
DDB 1759-1728	0F	56		Not Settable
Displays the status of signals DDB 1759-1728				
DDB 1791-1760	0F	57		Not Settable
Displays the status of signals DDB 1791-1760				
DDB 1823-1792	0F	58		Not Settable
Displays the status of signals DDB 1823-1792				
DDB 1855-1824	0F	59		Not Settable
Displays the status of signals DDB 1855-1824				
DDB 1887-1856	0F	5A		Not Settable
Displays the status of signals DDB 1887-1856				
DDB 1919-1888	0F	5B		Not Settable
Displays the status of signals DDB 1919-1888				
DDB 1951-1920	0F	5C		Not Settable
Displays the status of signals DDB 1951-1920				
DDB 1983-1952	0F	5D		Not Settable
Displays the status of signals DDB 1983-1952				
DDB 2015-1984	0F	5E		Not Settable
Displays the status of signals DDB 2015-1984				
DDB 2047-2016	0F	5F		Not Settable
Displays the status of signals DDB 2047-2016. Supported for 1 read would be 1696 DDBs.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Unused	0F	FF		
A dummy cell, used for DNP3				

Table 15 - Commission test settings

5.8 Opto Configuration

This menu is used to set the opto-isolated inputs.

Menu Text	Col	Row	Default Setting	Available Setting
Description				
OPTO CONFIG	11	00		
This column contains opto-input configuration settings				
Global Nominal V	11	01	48-54V	0 = 24-27V, 1 = 30-34V, 2 = 48-54V, 3 = 110-125V, 4 = 220-250V or 5 = Custom
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value. Threshold Voltages				
Opto Input 1	11	02	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 2	11	03	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 3	11	04	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 4	11	05	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 5	11	06	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 6	11	07	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 7	11	08	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 8	11	09	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
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 9	11	0A	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 10	11	0B	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 11	11	0C	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 12	11	0D	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 13	11	0E	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 14	11	0F	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 15	11	10	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 16	11	11	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 17	11	12	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 18	11	13	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 19	11	14	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 20	11	15	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 21	11	16	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 22	11	17	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 23	11	18	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 24	11	19	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 25	11	1A	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 26	11	1B	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 27	11	1C	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 28	11	1D	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 29	11	1E	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 30	11	1F	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 31	11	20	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 32	11	21	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 33	11	22	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
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 34	11	23	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 35	11	24	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 36	11	25	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 37	11	26	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 38	11	27	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 39	11	28	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 40	11	29	48-54V	0 = 24/27V, 1 = 30/34V, 2 = 48/54V, 3 = 110/125V or 4 = 220/250V
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If Custom is selected then each opto input can individually be set to a nominal voltage value.				
Opto Filter Ctrl	11	50	11111111111111111111111111111111 (bin)	32-bit binary setting: 0=disable filtering or 1=enable filtering
Opto filter configuration. This menu is used to control the relay's opto-isolated inputs L1 to L32. A '1' indicates an energized and operating relay, a '0' indicates a de-energized				
Opto Filter Ctrl2	11	51	11111111 (bin)	8-bit binary setting: 0=disable filtering or 1=enable filtering
Opto filter configuration. This menu is used to control the relay's opto-isolated inputs L33 to L40. A '1' indicates an energized and operating relay, a '0' indicates a de-energized.				
Characteristic	11	80	Standard 60%-80%	0 = Standard 60% to 80% or 1 = 50% to 70%
Opto input pickup & drop-off threshold. Controls the changement of state of opto isolated inputs, according to the nominal voltage value. Applicable to design suffix "J" or better.				

Table 16 - Opto Config settings

5.9 Control Inputs

Menu Text	Col	Row	Default Setting	Available Setting
Description				
CONTROL INPUTS	12	00		
This column contains settings for the type of control input (32 in all)				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Ctrl I/P Status	12	01	00000000000000000000000000000000(bin)	32-bit binary setting: 0=Reset or 1=Set
Cell that is used to set (1) and reset (0) the selected Control Input by simply scrolling and changing the status of selected bits. This command will be then recognized and executed in the PSL. Alternatively, each of the 32 Control input can also be set and reset using the individual menu setting cells as follows:				
Control Input 1	12	02	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 1 set/ reset.				
Control Input 2	12	03	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 2 set/ reset.				
Control Input 3	12	04	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 3 set/ reset.				
Control Input 4	12	05	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 4 set/ reset.				
Control Input 5	12	06	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 5 set/ reset.				
Control Input 6	12	07	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 6 set/ reset.				
Control Input 7	12	08	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 7 set/ reset.				
Control Input 8	12	09	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 8 set/ reset.				
Control Input 9	12	0A	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 9 set/ reset.				
Control Input 10	12	0B	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 10 set/ reset.				
Control Input 11	12	0C	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 11 set/ reset.				
Control Input 12	12	0D	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 12 set/ reset.				
Control Input 13	12	0E	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 13 set/ reset.				
Control Input 14	12	0F	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 14 set/ reset.				
Control Input 15	12	10	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 15 set/ reset.				
Control Input 16	12	11	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 16 set/ reset.				
Control Input 17	12	12	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 17 set/ reset.				
Control Input 18	12	13	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 18 set/ reset.				
Control Input 19	12	14	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 19 set/ reset.				
Control Input 20	12	15	No Operation	0 = No Operation, 1 = Set , 2 = Reset
Setting to allow Control Inputs 20 set/ reset.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
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 17 – Control Inputs settings

5.10 Control Input Configuration

The control inputs function as software switches that can be set or reset either locally or remotely. These inputs can be used to trigger any function that they are connected to as part of the PSL.

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

Menu Text	Col	Row	Default Setting	Available Setting
Description				
CTRL I/P CONFIG	13	00		
This column contains settings for the type of control input (32 in all)				
Hotkey Enabled	13	01	11111111111111111111111111111111 (bin)	32-bit binary setting: 0=Not accessible via Hotkey Menu or 1=Accessible via Hotkey Menu
Hotkey Menu - Control Input availability. 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

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Individual Control Input Type. 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 10ms after the set command is given and will then reset automatically (i.e. no reset command required) .				
Ctrl Command 1	13	11	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Individual Control Input Command Text. 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
Same description as Control Input 1				
Ctrl Command 2	13	15	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 3	13	18	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 3	13	19	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 4	13	1C	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 4	13	1D	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 5	13	20	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 5	13	21	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 6	13	24	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 6	13	25	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 7	13	28	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 7	13	29	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 8	13	2C	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 8	13	2D	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 9	13	30	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 9	13	31	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Same description as Ctrl Command 1				
Control Input 10	13	34	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 10	13	35	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 11	13	38	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 11	13	39	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 12	13	3C	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 12	13	3D	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 13	13	40	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 13	13	41	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 14	13	44	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 14	13	45	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 15	13	48	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 15	13	49	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 16	13	4C	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 16	13	4D	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 17	13	50	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 17	13	51	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 18	13	54	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 18	13	55	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Control Input 19	13	58	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 19	13	59	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 20	13	5C	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 20	13	5D	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 21	13	60	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 21	13	61	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 22	13	64	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 22	13	65	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 23	13	68	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 23	13	69	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 24	13	6C	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 24	13	6D	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 25	13	70	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 25	13	71	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 26	13	74	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 26	13	75	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 27	13	78	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 27	13	79	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 28	13	7C	Latched	0 = Latched or 1 = Pulsed

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Same description as Control Input 1				
Ctrl Command 28	13	7D	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 29	13	80	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 29	13	81	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 30	13	84	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 30	13	85	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 31	13	88	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 31	13	89	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				
Control Input 32	13	8C	Latched	0 = Latched or 1 = Pulsed
Same description as Control Input 1				
Ctrl Command 32	13	8D	SET/RESET	0 = ON/OFF, 1 = SET/RESET, 2 = IN/OUT, 3 = ENABLED/DISABLED
Same description as Ctrl Command 1				

Table 18 - Control input config settings

5.11 Function Keys

The lock setting allows a function key output that is set to toggle mode to be locked in its current active state. In toggle mode a single key press will set/latch the function key output as high or low in programmable scheme logic. This feature can be used to enable/disable relay functions. In the normal mode the function key output will remain high as long as the key is pressed. The Fn. Key label allows the text of the function key to be changed to something more suitable for the application.

The “Function keys” column is visible when the “Function key” setting (“Configuration” column) = “visible”.

Menu Text	Col	Row	Default Setting	Available Setting
Description				
FUNCTION KEYS	17	00		
This column contains the function key definitions				
Fn Key Status	17	01		Not Settable
Displays the status of each function key.				
Fn Key 1	17	02	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Setting to activate function key. The ‘Lock’ setting allows a function key output that is set to toggle mode to be locked in its current active state.				
Fn Key 1 Mode	17	03	Normal	0 = Normal or 1 = Toggled

Menu Text	Col	Row	Default Setting	Available Setting
Description				
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 relay functions. In the 'Normal' mode the function key output will remain 'high' as long as key is pressed.				
Fn Key 1 Label	17	04	Function Key 1	From 32 to 234 step 1
Allows the text of the function key to be changed to something more suitable for the application. Default PSL Text for Function Key DDB Applies to P643, P746_1 and P746_2 only.				
Fn Key 2	17	05	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				
Fn Key 2 Mode	17	06	Toggled	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
Fn Key 2 Label	17	07	Function Key 2	From 32 to 234 step 1
Same description as Fn Key 1 Label				
Fn Key 3	17	08	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				
Fn Key 3 Mode	17	09	Toggled	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
Fn Key 3 Label	17	0A	Function Key 3	From 32 to 234 step 1
Same description as Fn Key 1 Label				
Fn Key 4	17	0B	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				
Fn Key 4 Mode	17	0C	Normal	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
Fn Key 4 Label	17	0D	Function Key 4	From 32 to 234 step 1
Same description as Fn Key 1 Label				
Fn Key 5	17	0E	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				
Fn Key 5 Mode	17	0F	Normal	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
Fn Key 5 Label	17	10	Function Key 5	From 32 to 234 step 1
Same description as Fn Key 1 Label				
Fn Key 6	17	11	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				
Fn Key 6 Mode	17	12	Normal	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
Fn Key 6 Label	17	13	Function Key 6	From 32 to 234 step 1
Same description as Fn Key 1 Label				
Fn Key 7	17	14	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked
Same description as Fn Key 1				
Fn Key 7 Mode	17	15	Normal	0 = Normal or 1 = Toggled
Same description as Fn Key 1 Mode				
Fn Key 7 Label	17	16	Function Key 7	From 32 to 234 step 1
Same description as Fn Key 1 Label				
Fn Key 8	17	17	Unlocked	0 = Disabled, 1 = Unlocked (Enabled), 2 = Locked

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

Table 19 - Function keys settings

5.12 IED Configurator Column

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

Menu Text	Col	Row	Default Setting	Available Setting
Description				
IED CONFIGURATOR	19	00		
This column contains settings for IED Configurator settings (IEC61850 builds)				
Switch Conf.Bank	19	05	No action	0 = No action or 1 = Switch banks
Setting which allows the user to switch between the current configuration, held in the Active Memory Bank (and partly displayed below), to the configuration sent to and held in the Inactive Memory Bank.				
Restore Conf.	19	0A	No action	0 = No action or 1 = Restore Conf.
Used to restore data from MCL(MiCOM Configuration Language)/CID (Configured IED Descriptor) file. This file is specific, containing a single devices IEC61850 configuration information, and used for transferring data to/from the MiCOM IED.				
Active Conf.Name	19	10		Not Settable
The name of the configuration in the Active Memory Bank, usually taken from the SCL file.				
Active Conf.Rev	19	11		Not Settable
Configuration Revision number of the configuration in the Active Memory Bank, usually taken from the SCL file.				
Inact.Conf.Name	19	20		Not Settable
The name of the configuration in the Inactive Memory Bank, usually taken from the SCL file.				
Inact.Conf.Rev	19	21		Not Settable
Configuration Revision number of the configuration in the Inactive Memory Bank, usually taken from the SCL file.				
IP PARAMETERS	19	30		

Menu Text	Col	Row	Default Setting	Available Setting
Description				
IP PARAMETERS				
IP Address 1	19	31		Not Settable
Displays the unique network IP address that identifies the relay on interface 1. A default IP address is encoded from MAC address 169.254.0.xxx, xxx = mod (The last byte of MAC1, 128) + 1.				
Subnet Mask 1	19	32		Not Settable
Displays the sub-network mask for interface 1.				
Gateway 1	19	33		Not Settable
Displays the IP address of the gateway (proxy) that interface 1 is connected to.				
IP Address 2	19	34		Not Settable
Displays the unique network IP address that identifies the relay on interface 2. A default IP address is encoded from MAC address 169.254.0.xxx, xxx = mod (The last byte of MAC1, 128) + 1. Visible when redundant Ethernet card fitted.				
Subnet Mask 2	19	35		Not Settable
Displays the sub-network mask for interface 2. Visible when redundant Ethernet card fitted.				
Gateway 2	19	36		Not Settable
Displays the IP address of the gateway (proxy) that interface 2 is connected to. Visible when redundant Ethernet card fitted.				
SNTP PARAMETERS	19	40		
SNTP PARAMETERS				
SNTP Server 1	19	41		Not Settable
Displays the IP address of the primary SNTP server.				
SNTP Server 2	19	42		Not Settable
Displays the IP address of the secondary SNTP server. Visible when Ethernet card fitted.				
IEC 61850 SCL	19	50		
IEC 61850 SCL				
IED Name	19	51		Not Settable
IED name, which is the unique name on the IEC 61850 network for the IED, usually taken from the SCL (Substation Configuration Language for XML) file.				
IEC 61850 GOOSE	19	60		
IEC 61850 GOOSE				
GoEna	19	70	0000000000000000(bin)	Bit 00=gcb01 GoEna to Bit 0F=gcb16 GoEna
Setting to enable GOOSE publisher settings.				
Pub.Simul.Goose	19	71	0000000000000000(bin)	Bit 00=gcb01 Sim Mode to Bit 0F=gcb16 Sim Mode
The Pub.Simul.GOOSE cell controls whether GOOSE are sent as Normal or Simulated GOOSE. When a GOOSE control block is set to Sim Mode its GOOSE is published as simulated. Simulated GOOSE are usually published by test equipment and this setting allows a test IED to be set up to simulate the IEDs in a substation.				
Sub.Simul.Goose	19	73	No	0 = No or 1 = Yes
In edition 2 mode when Sub.Simul.GOOSE is set to Yes the relay will look for simulated GOOSE. If a simulated GOOSE is found the relay will subscribe to it and will not respond to its normal GOOSE until Sub.Simul.GOOSE is set to No. Other GOOSE signals that are not being simulated will remain subscribing to normal GOOSE. In edition 1 mode the relay will respond to both normal and test GOOSE.				

Table 20 - IED configurator settings

5.13 Security Config Column

The SECURITY CONFIG column contains the main configuration settings for Security functions.

Menu Text	Col	Row	Default Setting	Available Setting
Description				
SECURITY CONFIG	25	00		
This column contains settings for Security Configuration				
User Banner	25	01	ACCESS ONLY FOR AUTHORISED USERS	Not Settable
This banner is one of the default display options				
Attempts Limit	25	02	5	From 1 to 99 step 1
Adjust the number of attempts to enter a valid password. When the maximum number of attemps has been reached, access is blocked.				
Blocking Timer	25	04	4	From 1 to 1440 step 1
Adjust the blocking timer (minutes) after a password blocking. Once the password is blocked, this blocking timer is initiated. Only after the blocking timer has expired will access to the interface be unblocked, whereupon the attempts counter is reset to zero.				
Front Port	25	05	Enabled	0 = Disabled or 1 = Enabled
Enable or disable the front port access. To prevent accidental disbling of a port, a warning message “FRONT PORT TO BE DISABLED, CONFIRM” is required to be disabled.				
Rear Port 1	25	06	Enabled	0 = Disabled or 1 = Enabled
Enable or disable the rear port 1 access. To prevent accidental disbling of a port, a warning message “REAR PORT 1 TO BE DISABLED, CONFIRM” is required to be disabled.				
Rear Port 2	25	07	Enabled	0 = Disabled or 1 = Enabled
When fitted, enable or disable the rear port 2 access. To prevent accidental disabling of a port, a warning message “REAR PORT 2 TO BE DISABLED, CONFIRM” is required to be disabled.				
ETH Port 1	25	08	Enabled	0 = Disabled or 1 = Enabled
Enable or disable the Courier tunneling logical port 1 access. Note: if this protocol is enabled or disabled, the Ethernet card will reboot. Hardware option S or Q/R with Comm Mode=PRP or HSR				
ETH Port 1/2	25	09	Enabled	0 = Disabled or 1 = Enabled
Enable or disable the Courier tunneling logical port 1/2 access. Note: if this protocol is enabled or disabled, the Ethernet card will reboot. Hardware option Q/R with Comm Mode=Dual IP				
ETH Port 2/3	25	0A	Enabled	0 = Disabled or 1 = Enabled
Enable or disable the IEC61850 logical port 2/3 access. Note: if this protocol is enabled or disabled, the Ethernet card will reboot. Hardware option Q/R with Comm Mode=PRP or HSR				
ETH Port 3	25	0B	Enabled	0 = Disabled or 1 = Enabled
Enable or disable the IEC61850 logical port 3 access. Note: if this protocol is enabled or disabled, the Ethernet card will reboot. Hardware option Q/R with Comm Mode=Dual IP				
Courier Tunnel	25	0C	Enabled	0 = Disabled or 1 = Enabled
Enable/disable of Logical Tunnelled courier Port				
IEC61850 or IEC61850+DNPoE	25	0D	Enabled	0 = Disabled or 1 = Enabled
Enable or disable IEC61850 (and DNPoE for protocol option B or L) services				
Attempts Remain	25	11	5	Not Settable
Indicates the number of attempts remaining to enter a password.				
Blk Time Remain	25	12	0	Not Settable

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Indicates the blocking time remaining (in minutes).				
Username 1	25	21		Not Settable
User Name, visible in authorized courier client, only.				
Username 2	25	22		Not Settable
User Name, visible in authorized courier client, only.				
Username 3	25	23		Not Settable
User Name, visible in authorized courier client, only.				
Username 4	25	24		Not Settable
User Name, visible in authorized courier client, only.				
Username 5	25	25		Not Settable
User Name, visible in authorized courier client, only.				
Username 6	25	26		Not Settable
User Name, visible in authorized courier client, only.				
Username 7	25	27		Not Settable
User Name, visible in authorized courier client, only.				
Username 8	25	28		Not Settable
User Name, visible in authorized courier client, only.				
Username 9	25	29		Not Settable
User Name, visible in authorized courier client, only.				
Username 10	25	2A		Not Settable
User Name, visible in authorized courier client, only.				
Username 11	25	2B		Not Settable
User Name, visible in authorized courier client, only.				
Username 12	25	2C		Not Settable
User Name, visible in authorized courier client, only.				
Username 13	25	2D		Not Settable
User Name, visible in authorized courier client, only.				
Username 14	25	2E		Not Settable
User Name, visible in authorized courier client, only.				
Username 15	25	2F		Not Settable
User Name, visible in authorized courier client, only.				
Security Code	25	FE		Not Settable
Indicates the security code (user interface only). The security code is a 12-digit number. It is a read-only parameter. The IED generates its own security code randomly. This Security Code should be noted for password recovery.				
Reset RBAC	25	FF		From 33 to 122 step 1
Recovery password obtained from Schneider Electric can be entered here to restore the default RBAC. (user interface only)				

Table 21 - Security Config settings

5.14 Virtual Input Labels

Menu Text	Col	Row	Default Setting	Available Setting
Description				
VIR I/P LABELS	26	00		

Menu Text	Col	Row	Default Setting	Available Setting
Description				
This column contains settings for Virtual Input Labels				
Virtual Input 1	26	01	Virtual Input 1	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 2	26	02	Virtual Input 2	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 3	26	03	Virtual Input 3	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 4	26	04	Virtual Input 4	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 5	26	05	Virtual Input 5	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 6	26	06	Virtual Input 6	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 7	26	07	Virtual Input 7	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 8	26	08	Virtual Input 8	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 9	26	09	Virtual Input 9	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 10	26	0A	Virtual Input 10	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 11	26	0B	Virtual Input 11	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 12	26	0C	Virtual Input 12	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 13	26	0D	Virtual Input 13	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 14	26	0E	Virtual Input 14	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 15	26	0F	Virtual Input 15	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 16	26	10	Virtual Input 16	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 17	26	11	Virtual Input 17	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 18	26	12	Virtual Input 18	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 19	26	13	Virtual Input 19	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 20	26	14	Virtual Input 20	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 21	26	15	Virtual Input 21	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Virtual Input 22	26	16	Virtual Input 22	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 23	26	17	Virtual Input 23	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 24	26	18	Virtual Input 24	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 25	26	19	Virtual Input 25	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 26	26	1A	Virtual Input 26	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 27	26	1B	Virtual Input 27	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 28	26	1C	Virtual Input 28	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 29	26	1D	Virtual Input 29	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 30	26	1E	Virtual Input 30	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 31	26	1F	Virtual Input 31	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 32	26	20	Virtual Input 32	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 33	26	21	Virtual Input 33	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 34	26	22	Virtual Input 34	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 35	26	23	Virtual Input 35	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 36	26	24	Virtual Input 36	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 37	26	25	Virtual Input 37	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 38	26	26	Virtual Input 38	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 39	26	27	Virtual Input 39	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 40	26	28	Virtual Input 40	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 41	26	29	Virtual Input 41	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 42	26	2A	Virtual Input 42	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 43	26	2B	Virtual Input 43	From 32 to 234 step 1

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Text label to describe each individual Virtual Input.				
Virtual Input 44	26	2C	Virtual Input 44	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 45	26	2D	Virtual Input 45	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 46	26	2E	Virtual Input 46	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 47	26	2F	Virtual Input 47	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 48	26	30	Virtual Input 48	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 49	26	31	Virtual Input 49	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 50	26	32	Virtual Input 50	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 51	26	33	Virtual Input 51	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 52	26	34	Virtual Input 52	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 53	26	35	Virtual Input 53	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 54	26	36	Virtual Input 54	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 55	26	37	Virtual Input 55	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 56	26	38	Virtual Input 56	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 57	26	39	Virtual Input 57	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 58	26	3A	Virtual Input 58	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 59	26	3B	Virtual Input 59	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 60	26	3C	Virtual Input 60	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 61	26	3D	Virtual Input 61	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 62	26	3E	Virtual Input 62	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 63	26	3F	Virtual Input 63	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				
Virtual Input 64	26	40	Virtual Input 64	From 32 to 234 step 1
Text label to describe each individual Virtual Input.				

Table 22 – Virtual Input Labels settings

5.15 Virtual Output Labels

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

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

Table 23 – Virtual Output Labels settings

5.16 User Alarm Labels

Menu Text	Col	Row	Default Setting	Available Setting
Description				
USR ALARM LABELS	28	00		
This column contains settings for User Alarm Labels				
SR User Alarm 1	28	01	SR User Alarm 1	From 32 to 234 step 1
Text label to describe each individual User Alarm.				
SR User Alarm 2	28	02	SR User Alarm 2	From 32 to 234 step 1
Text label to describe each individual User Alarm.				
SR User Alarm 3	28	03	SR User Alarm 3	From 32 to 234 step 1
Text label to describe each individual User Alarm.				
SR User Alarm 4	28	04	SR User Alarm 4	From 32 to 234 step 1

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

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

Table 24 – User Alarm Labels settings

5.17 Control Input Labels

This column is visible when the “Control I/P Labels” setting (“Configuration” column) = “visible”.

Menu Text	Col	Row	Default Setting	Available Setting
Description				
CTRL I/P LABELS	29	00		
This column contains settings for Control Input Labels				
Control Input 1	29	01	Control Input 1	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 2	29	02	Control Input 2	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 3	29	03	Control Input 3	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 4	29	04	Control Input 4	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 5	29	05	Control Input 5	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 6	29	06	Control Input 6	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 7	29	07	Control Input 7	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 8	29	08	Control Input 8	From 32 to 234 step 1

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 9	29	09	Control Input 9	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 10	29	0A	Control Input 10	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 11	29	0B	Control Input 11	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 12	29	0C	Control Input 12	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 13	29	0D	Control Input 13	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 14	29	0E	Control Input 14	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 15	29	0F	Control Input 15	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 16	29	10	Control Input 16	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 17	29	11	Control Input 17	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 18	29	12	Control Input 18	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 19	29	13	Control Input 19	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 20	29	14	Control Input 20	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 21	29	15	Control Input 21	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 22	29	16	Control Input 22	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 23	29	17	Control Input 23	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 24	29	18	Control Input 24	From 32 to 234 step 1

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 25	29	19	Control Input 25	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 26	29	1A	Control Input 26	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 27	29	1B	Control Input 27	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 28	29	1C	Control Input 28	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 29	29	1D	Control Input 29	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 30	29	1E	Control Input 30	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 31	29	1F	Control Input 31	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				
Control Input 32	29	20	Control Input 32	From 32 to 234 step 1
Text label to describe each individual control input. This text is displayed when a control input is accessed by the hotkey menu. It is displayed in the programmable scheme logic description of the control input				

Table 25 - Control Input settings

5.18 Disturbance Recorder Settings

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

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

Menu Text	Col	Row	Default Setting	Available Setting
Description				
DISTURB RECORDER	0C	00		
This column contains settings for the Disturbance Recorder				
Duration	0C	52	1.5 s	From 100 ms to 10.5 s step 10 ms
This sets the overall recording time.				
Trigger Position	0C	54	33.30 %	From 0 % to 100 % step 0.1 %
This sets the trigger point as a percentage of the duration. For example, the default settings show that the overall recording time is set to 1.5s with the trigger point being at 33.3% of this, giving 0.5 s pre-fault and 1.0 s post fault recording times.				
Trigger Mode	0C	56	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.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Analog Channel 1	0C	58	VAN for P746_1 IA-T1/IX-T1 for P746_2	Unused, VAN(P746_1 only), VBN(P746_1 only), VCN(P746_1 only), IA-T1/IX-T1, IB-T1/IX-T2, IC-T1/IX-T3, IA-T2/IX-T4, IB-T2/IX-T5, IC-T2/IX-T6, IA-T3/IX-T7, IB-T3/IX-T8, IC-T3/IX-T9, IA-T4/IX-T10, IB-T4/IX-T11, IC-T4/IX-T12, IA-T5/IX-T13, IB-T5/IX-T14, IC-T5/IX-T15, IA-T6/IX-T16, IB-T6/IX-T17, IC-T6/IX-T18, IA-T7/IX-T19(P746_2 only), IB-T7/IX-T20(P746_2 only), IC-T7/IX-T21(P746_2 only), Z1 IA Diff, Z1 IB Diff, Z1 IC Diff, Z1 IA Bias, Z1 IB Bias, Z1 IC Bias, Z2 IA Diff, Z2 IB Diff, Z2 IC Diff, Z2 IA Bias, Z2 IB Bias, Z2 IC Bias, Z3 IA Diff, Z3 IB Diff, Z3 IC Diff, Z3 IA Bias, Z3 IB Bias, Z3 IC Bias, Z4 IA Diff, Z4 IB Diff, Z4 IC Diff, Z4 IA Bias, Z4 IB Bias, Z4 IC Bias, CZ IA Diff, CZ IB Diff, CZ IC Diff, CZ IA Bias, CZ IB Bias, CZ IC Bias
See Measurements and Recordings chapter. By default in P746_1: The Phase A measured voltage is assigned to this channel. By default in P746_2: The CT 1 phase A measured current is assigned to this channel.				
Analog Channel 2	0C	59	VBN for P746_1 IB-T1/IX-T2 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The Phase B measured voltage is assigned to this channel. By default in P746_2: The CT 1 Phase B measured current is assigned to this channel.				
Analog Channel 3	0C	5A	VCN for P746_1 IC-T1/IX-T3 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The Phase C measured voltage is assigned to this channel. By default in P746_2: The CT 1 Phase C measured current is assigned to this channel.				
Analog Channel 4	0C	5B	IA-T1/IX-T1 for P746_1 IA-T2/IX-T4 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 1 phase A measured current is assigned to this channel. By default in P746_2: The CT 2 Phase A measured current is assigned to this channel.				
Analog Channel 5	0C	5C	IB-T1/IX-T2 for P746_1 IB-T2/IX-T5 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 1 Phase B measured current is assigned to this channel. By default in P746_2: The CT 2 Phase B measured current is assigned to this channel.				
Analog Channel 6	0C	5D	IC-T1/IX-T3 for P746_1 IC-T2/IX-T6 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 1 Phase C measured current is assigned to this channel. By default in P746_2: The CT 2 Phase C measured current is assigned to this channel.				
Analog Channel 7	0C	5E	IA-T2/IX-T4 for P746_1 IA-T3/IX-T7 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 2 Phase A measured current is assigned to this channel. By default in P746_2: The CT 3 Phase A measured current is assigned to this channel.				
Analog Channel 8	0C	5F	IB-T2/IX-T5 for P746_1 IB-T3/IX-T8 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 2 Phase B measured current is assigned to this channel. By default in P746_2: The CT 3 Phase B measured current is assigned to this channel.				
Analog Channel 9	0C	60	IC-T2/IX-T6 for P746_1 IC-T3/IX-T9 for P746_2	Same as Analog Channel 1

Menu Text	Col	Row	Default Setting	Available Setting
Description				
See Measurements and Recordings chapter. By default in P746_1: The CT 2 Phase C measured current is assigned to this channel. By default in P746_2: The CT 3 Phase C measured current is assigned to this channel.				
AnalogChannel 10	0C	61	IA-T3/IX-T7 for P746_1 IA-T4/IX-T10 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 3 Phase A measured current is assigned to this channel. By default in P746_2: The CT 4 Phase A measured current is assigned to this channel.				
AnalogChannel 11	0C	62	IB-T3/IX-T8 for P746_1 IB-T4/IX-T11 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 3 Phase B measured current is assigned to this channel. By default in P746_2: The CT 4 Phase B measured current is assigned to this channel.				
AnalogChannel 12	0C	63	IC-T3/IX-T9 for P746_1 IC-T4/IX-T12 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 3 Phase C measured current is assigned to this channel. By default in P746_2: The CT 4 Phase C measured current is assigned to this channel.				
AnalogChannel 13	0C	64	IA-T4/IX-T10 for P746_1 IA-T5/IX-T13 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 4 Phase A measured current is assigned to this channel. By default in P746_2: The CT 5 Phase A measured current is assigned to this channel.				
AnalogChannel 14	0C	65	IB-T4/IX-T11 for P746_1 IB-T5/IX-T14 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 4 Phase B measured current is assigned to this channel. By default in P746_2: The CT 5 Phase B measured current is assigned to this channel.				
AnalogChannel 15	0C	66	IC-T4/IX-T12 for P746_1 IC-T5/IX-T15 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 4 Phase C measured current is assigned to this channel. By default in P746_2: The CT 5 Phase C measured current is assigned to this channel.				
AnalogChannel 16	0C	67	IA-T5/IX-T13 for P746_1 IA-T6/IX-T16 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 5 Phase A measured current is assigned to this channel. By default in P746_2: The CT 6 Phase A measured current is assigned to this channel.				
AnalogChannel 17	0C	68	IB-T5/IX-T14 for P746_1 IB-T6/IX-T17 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 5 Phase B measured current is assigned to this channel. By default in P746_2: The CT 6 Phase B measured current is assigned to this channel.				
AnalogChannel 18	0C	69	IC-T5/IX-T15 for P746_1 IC-T6/IX-T18 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 5 Phase C measured current is assigned to this channel. By default in P746_2: The CT 6 Phase C measured current is assigned to this channel.				
AnalogChannel 19	0C	6A	IA-T6/IX-T16 for P746_1 IA-T7/IX-T19 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 6 Phase A measured current is assigned to this channel. By default in P746_2: The CT 7 Phase A measured current is assigned to this channel.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
AnalogChannel 20	0C	6B	IB-T6/IX-T17 for P746_1 IB-T7/IX-T20 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 6 Phase B measured current is assigned to this channel. By default in P746_2: The CT 7 Phase B measured current is assigned to this channel.				
AnalogChannel 21	0C	6C	IC-T6/IX-T18 for P746_1 IC-T7/IX-T21 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 6 Phase C measured current is assigned to this channel. By default in P746_2: The CT 7 Phase C measured current is assigned to this channel.				
Digital Input 1	0C	80	Output R1	Any O/P Contacts or Any Opto Inputs or Internal Digital Signals. See data type G32.
The digital channels may monitor any 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	81	No Trigger	No Trigger, Trigger L/H, 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	82	Output R2	Same as Digital Input 1
Same as Digital Input 1				
Input 2 Trigger	0C	83	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 3	0C	84	Output R3	Same as Digital Input 1
Same as Digital Input 1				
Input 3 Trigger	0C	85	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 4	0C	86	Output R4	Same as Digital Input 1
Same as Digital Input 1				
Input 4 Trigger	0C	87	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 5	0C	88	Output R5	Same as Digital Input 1
Same as Digital Input 1				
Input 5 Trigger	0C	89	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 6	0C	8A	Output R6	Same as Digital Input 1
Same as Digital Input 1				
Input 6 Trigger	0C	8B	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 7	0C	8C	Output R7	Same as Digital Input 1
Same as Digital Input 1				
Input 7 Trigger	0C	8D	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 8	0C	8E	Output R8	Same as Digital Input 1
Same as Digital Input 1				
Input 8 Trigger	0C	8F	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 9	0C	90	Any Trip	Same as Digital Input 1

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Same as Digital Input 1				
Input 9 Trigger	0C	91	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 10	0C	92	Output R10	Same as Digital Input 1
Same as Digital Input 1				
Input 10 Trigger	0C	93	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 11	0C	94	Diff fault Z1	Same as Digital Input 1
Same as Digital Input 1				
Input 11 Trigger	0C	95	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 12	0C	96	Diff fault Z2	Same as Digital Input 1
Same as Digital Input 1				
Input 12 Trigger	0C	97	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 13	0C	98	Diff fault CZ	Same as Digital Input 1
Same as Digital Input 1				
Input 13 Trigger	0C	99	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 14	0C	9A	Idiff Z1 Start	Same as Digital Input 1
Same as Digital Input 1				
Input 14 Trigger	0C	9B	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 15	0C	9C	Idiff Z2 Start	Same as Digital Input 1
Same as Digital Input 1				
Input 15 Trigger	0C	9D	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 16	0C	9E	Idiff CZ Start	Same as Digital Input 1
Same as Digital Input 1				
Input 16 Trigger	0C	9F	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 17	0C	A0	PhComp Blk Z1	Same as Digital Input 1
Same as Digital Input 1				
Input 17 Trigger	0C	A1	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 18	0C	A2	PhComp Blk Z2	Same as Digital Input 1
Same as Digital Input 1				
Input 18 Trigger	0C	A3	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 19	0C	A4	Unused	Same as Digital Input 1
Same as Digital Input 1				
Input 19 Trigger	0C	A5	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Digital Input 20	0C	A6	Idiff Trip Z1	Same as Digital Input 1
Same as Digital Input 1				
Input 20 Trigger	0C	A7	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 21	0C	A8	Idiff Trip Z2	Same as Digital Input 1
Same as Digital Input 1				
Input 21 Trigger	0C	A9	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 22	0C	AA	CctFail Blk Z1	Same as Digital Input 1
Same as Digital Input 1				
Input 22 Trigger	0C	AB	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 23	0C	AC	CctFail Blk Z2	Same as Digital Input 1
Same as Digital Input 1				
Input 23 Trigger	0C	AD	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 24	0C	AE	CctFail Blk CZ	Same as Digital Input 1
Same as Digital Input 1				
Input 24 Trigger	0C	AF	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 25	0C	B0	Diff Z1 Blked	Same as Digital Input 1
Same as Digital Input 1				
Input 25 Trigger	0C	B1	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 26	0C	B2	Diff Z2 Blked	Same as Digital Input 1
Same as Digital Input 1				
Input 26 Trigger	0C	B3	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 27	0C	B4	Diff CZ Blked	Same as Digital Input 1
Same as Digital Input 1				
Input 27 Trigger	0C	B5	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 28	0C	B6	Fault A	Same as Digital Input 1
Same as Digital Input 1				
Input 28 Trigger	0C	B7	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 29	0C	B8	Fault B	Same as Digital Input 1
Same as Digital Input 1				
Input 29 Trigger	0C	B9	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 30	0C	BA	Fault C	Same as Digital Input 1
Same as Digital Input 1				
Input 30 Trigger	0C	BB	No Trigger	No Trigger, Trigger L/H, Trigger H/L

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Same as Input 1 Trigger				
Digital Input 31	0C	BC	Fault N	Same as Digital Input 1
Same as Digital Input 1				
Input 31 Trigger	0C	BD	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 32	0C	BE	Function Key 10	Same as Digital Input 1
Same as Digital Input 1				
Input 32 Trigger	0C	BF	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				

Table 26 - Disturbance recorder settings

Notes:

OPERATION

CHAPTER 5

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Software Version:	B4 (P746_1) / C4 (P746_2)
Hardware Suffix:	M
Connection Diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

Page (OP) 5-

TABLES

FIGURES

1 OPERATION OF INDIVIDUAL PROTECTION FUNCTIONS

The following sections detail the individual protection functions.

Important	**Not all the protection functions listed below are applicable to every relay.**

1.1 Busbar Biased Current Differential Protection

The primary protection element of the scheme is phase-segregated biased current differential protection. The technique used is purely numerical and uses nodal analysis throughout the scheme, on a per zone and per scheme basis.

1.1.1 Operating Principle

The basic operating principle of the differential protection is based on the application of Kirchhoff's law. This compares the amount of current entering and leaving the protected zone and the check zone. Under normal operation, the amount of current flowing into the area and the check zone concerned is equal in to the amount of the current flowing out of the area. Therefore the currents cancel out. In contrast, when a fault occurs the differential current that arises is equal to the derived fault current.

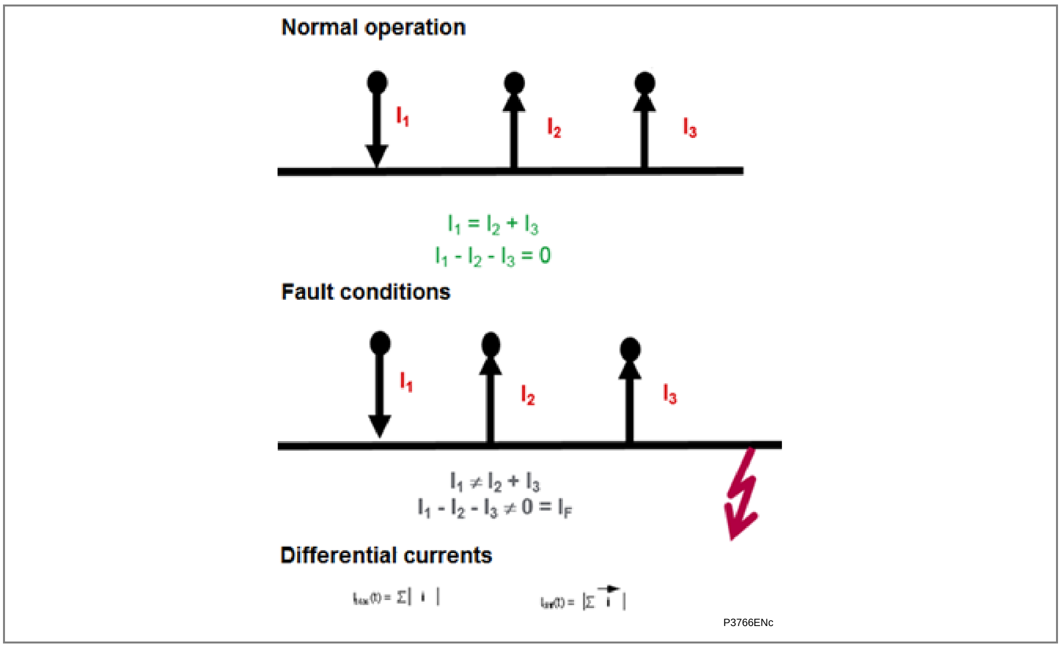


Figure 1 - Differential busbar protection principle

1.1.2 Application of Kirchoffs Law

The bias current is the scalar sum and the differential is the vector sum of the currents in the protected and check zones.

1.1.2.1 Bias Characteristic and Differential Current

The operation of the busbar differential protection is based on the application of an algorithm having a biased characteristic (as shown in the following scheme characteristic diagram), in which a comparison is made between the differential current and a bias or restraining current. A fault is detected if this differential current exceeds the set slope of the bias characteristic. This characteristic is intended to guarantee the stability of protection during external faults where the scheme has current transformers with differing characteristics, likely to provide differing performance.

The algorithm operands are as follows:

- Differential Current:

  $I_{diff}(t) = \left| \sum \vec{i} \right|$

- Bias or Restraining current:

  $I_{bias}(t) = \sum \left| i \right|$

- Slope of the bias characteristic:

  kx

- Tripping permitted by bias element for:

  $I_{diff}(t) > kx \times i_{bias}(t)$

The main differential current element of the busbar protection will only be able to operate if the differential current reaches a threshold I_D>2. In general, this setting will be adjusted above the normal full load current.

1.1.2.2 Scheme Supervision by "Check Zone" Element

The use of a "Check Zone" element is based on the principle that in the event of a fault on one of the substation busbars, the differential current measured in the faulty zone will be equal to that measured in the entire scheme.

One of the most frequent causes of maloperation of differential busbar protection schemes is an error in the actual position of an isolator or CB in the substation to that replicated in the scheme (auxiliary contacts discrepancy). This would produce a differential current in one or more current nodes. However, if an element monitors only the currents "entering" and "leaving" the substation, the resultant will remain negligible in the absence of a fault, and the error will lie with the zone's assumption of the plant position at this particular point in time.

1.2 Busbar Protection

1.2.1 Bias Characteristic and Differential Current Setting

This diagram shows the characteristics of the scheme phase differential element.

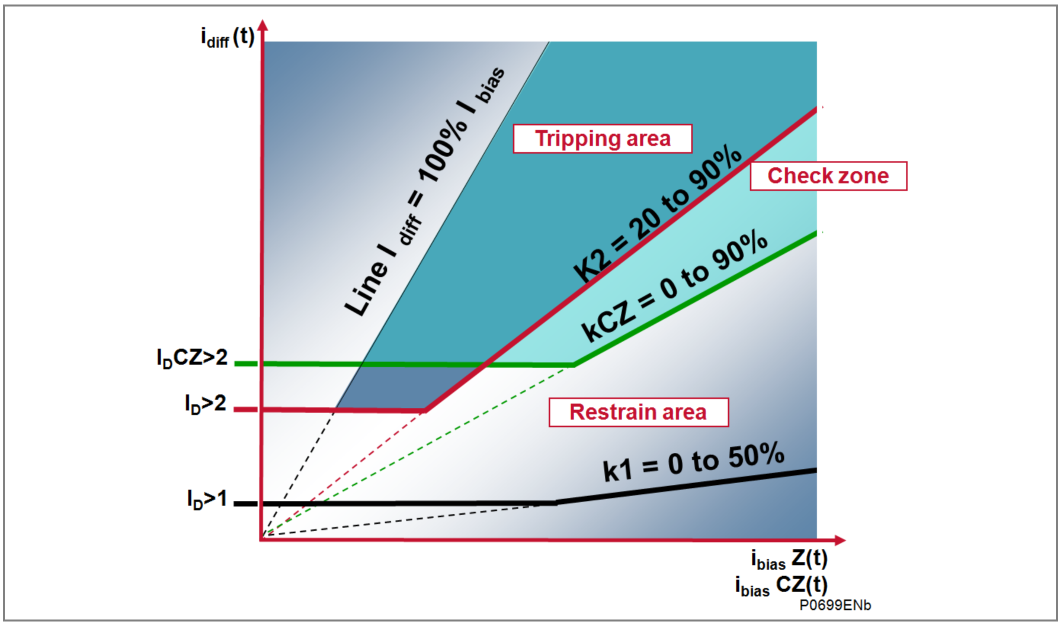


Figure 2 - P746 scheme characteristic

The Phase characteristic is determined from the following protection settings:

- Area above the I_D>2 threshold zone differential current threshold setting and the set slope of the bias characteristic (k2 × I_{bias}) (k2 is the percentage bias setting “slope” for the zone)

Note	*The origin of the bias characteristic slope is 0.*
Note	*Differential protection Settings are usually set in primary values. Secondary Differential Protection setting values are calculated based on a unique virtual CT of fixed ratio 2000/1. For example: If ID>2 =2400A in primary values, it means that ID>2 = 1.2A in secondary values irrespective of the substation CT ratios.*

1.2.2 Scheme Supervision by Phase Comparison Element

When an external fault condition causes CT saturation, a differential current is apparent and is equal to the current of the saturated CT. The measured differential current may be detected as an internal fault and initiate an unwanted trip of the busbar.

In order to avoid a risk of tripping under these circumstances, the busbar protection uses a phase comparison algorithm to detect if the fault is internal or external.

The characteristics of this algorithm are:

- It works without voltage information
- A per phase current angle is taken for every sample
- Only the currents above a certain magnitude are taken into account
  - This settable threshold is a percentage of In of each CT
  - This threshold depends on the number of Infeeds (to be calculated with the dedicated spreadsheet tool)
- Differential operation is permitted when all per phase current angles are within 90° (the calculated phase angle of a saturated current can only vary from -90° to +90° of the unsaturated value)
  - If only one current is taken into account, it's an internal fault

Example:

- 1 bar, 1 infeed (CT1 = 2000/1) and 2 outfeeds (CT2 = 1000/1 and CT3 = 500/1)

If the setting of the phase comparison threshold is 50%, the phase comparison algorithm will use:

- CT1 phase when a current higher than 1000A will flow in CT1,
- CT2 phase when a current higher than 500A will flow in CT2,
- CT3 phase when a current higher than 250A will flow in CT3.

The phase comparison algorithm will prevent a maloperation as long as all the phase currents are not within a 90° area.

Case 1: If 200A is flowing in through CT1 and 100A are flowing out through CT2 and CT3, no current is taken into account and the phase algorithm is not blocking busbar trip.

Case 2: If 500A is flowing in through CT1 and 250A are flowing out through CT2 and CT3, only one current (CT3) is taken into account and the phase algorithm is not blocking busbar trip.

Case 3: If 900A is flowing in through CT1 and 600A are flowing out through CT2 and 300A in CT3, 2 currents (CT2 and CT3) are taken into account, both are within a 90° area and the phase algorithm is not blocking busbar trip.

Case 4: If 1000A is flowing in through CT1 and 500A are flowing out through CT2 and CT3, the 3 currents are taken into account, they are not within any 90° area and the phase algorithm is blocking busbar trip.

Case 5: Case 1 then External fault: Over 1000A is flowing from CT1 through CT2 and:

- Current 3 decreases below 250A then the 2 currents are not within any 90° area and the phase algorithm is blocking busbar trip.
- Current 3 does not decrease below 250A then the 3 currents are not within any 90° area and the phase algorithm is blocking busbar trip.

Case 6: Case 1 then Internal fault: Over 1000A is flowing from CT1 and:

- Current 2 or 3 decreases below 500A or 250A then there is only one current thus the phase algorithm is releasing the busbar trip.
- Current 2 or 3 does not decrease below 500 or 250A but reverses then they are within a 90° area and the phase algorithm is releasing the busbar trip.

1.2.3 Scheme Supervision by "Check Zone" Element

For security, the busbar protection will only trip a particular busbar zone if that zone differential element AND the check zone element are in agreement to trip.

The principal advantage of this element is total insensitivity to topological discrepancies. Under such circumstances the "check zone" element will see zero differential current since the currents entering and leaving the substation as a whole are balanced

The Check Zone characteristic is determined from the following protection settings:

- Area above the I_DCZ>2 threshold check zone differential current threshold setting and the set slope of the bias characteristic (kCZ × I_{bias}) (kCZ is the percentage bias setting ("slope") for the Check Zone)

Note	*The origin of the bias characteristic slope is 0.*

The check zone is limited by all the current nodes entering and leaving the substation (feeders).

Scheme differential current = sum of all check zone terminals:

$i_{diff}(t)$ CZ = $\left| \Sigma \text{ ChZone Terminals} \right|$

1.2.4 Tripping Criteria (Per Phase)

A trip signal for a zone will be issued:

If the fault is detected in the zone AND

confirmed by the check zone AND

the zone phase comparison doesn't block the trip.

For the Zone

For a fault to be detected, the following criterions must be met:

- If 2 consecutive calculations of i_{diff2}Zone are above (ID>2) and k_2 × Ibias
- For the P746_1 only: optional Voltage criteria (V<(connected phase) or V1< or V2> or 3V0>

For the Check Zone (to confirm the fault):

- If 2 consecutive calculations of $i_{diff}(t)$ CZ are above (IDCZ>2) and kCZ × Ibias

1.2.5 Current Circuit Supervision

During normal operation the differential current in the scheme should be zero or negligible. Any anomaly is detected via a given threshold I_D>1.

A biased differential element is used to supervise the current circuit. A differential current will result if the secondary circuit of a CT becomes open circuited, short circuited; the amplitude of this current is proportional to the load current flowing in the circuit monitored by the faulty current circuit.

The setting I_D>1 is chosen to be as low as possible (minimum suggested setting is 2% of the biggest CT primary winding) but also allow for standing differential current for example due to CT mismatch and varying magnetising current losses. 5 to 20% is a typical application range.

The element is typically time delayed for 5 seconds (set greater than the maximum clearance time of an external fault). The time delay allows the relevant protection element (which should be substantially faster) to clear the fault instead i.e. I_D>2 in the case of an internal phase fault.

1.3 Additional Protection

1.3.1 Dead Zone (DZ) Protection

On a feeder, if the isolators or the breaker is open, a dead zone (or end zone) is said to exist between the open element and the CT. The P746 can protect this zone with the Dead Zone protection. This is a simple time delayed overcurrent which is only active when a dead zone is identified in the local topology. It is checked by comparison to the CZ differential to avoid maloperations due to invalid position indication.
The logic is shown below:

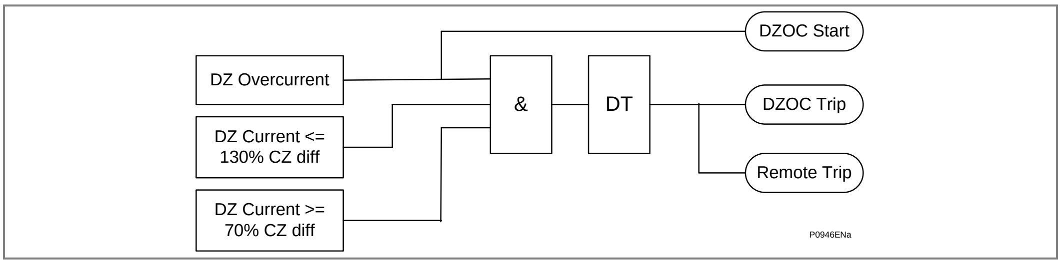


Figure 3 - Dead zone protection logic diagram

CZ Diff is the unbias differential current seen by the Check Zone.
It is not linked to IDCZ>2.

1.3.2 Circuit Breaker Fail (CBF)

The detailed logic of the circuit breaker failure element follows.

The P746 hardware corresponds to up to 7 or 21 circuit breaker (7 for one-box mode or 21 for three-box mode) and can accommodate 1 or 2 trip coils per breaker (depending on relay number, defined by P746 model number, and PSL(CB trip signal connection to the relay output)):

- 1 main trip coil
- 1 back-up trip coil

Furthermore these can be either 3 single-phase trip coils or 1 three-phase trip coil. These can be combined for example 3 single-phase trip coils on the main system and 1 three-phase trip coil for the back-up system.

In one-box mode the main and back-up trips are always three-phase. In three-box mode these signals are phase segregated which can provide single-phase or three-phase back-up tripping as requried.

1.3.2.1 Circuit Breaker Fail Reset Criteria

Overcurrent Criterion

One of the most common causes of busbar mal-tripping is error introduced in the back tripping of adjacent sections. To prevent such an error it is possible to condition the operation of 50BF protection only when there is presence of a significant current i.e. a short-circuit on the concerned feeder. This confirmation is provided by the I> threshold which is set by default at 1.2 times the nominal rated current of the CT.

Undercurrent Reset Criterion

The criterion normally used for the detection of a circuit breaker pole opening is the disappearance of the current i.e. undercurrent element. This function is generally preferred above other elements due to its very fast response time. In MiCOM P74x/P746, this method of detection may be selected and has the threshold I<.

Note	*The algorithm is applied on a per phase basis.*

These Undercurrent elements have an I< threshold, which is used to supervise that each circuit breaker has opened correctly, when commanded to do so. By use of the I< threshold, it is possible to ensure that all load and fault currents have been interrupted, ensuring that no arcing remains across the circuit breaker primary contacts. Optionally, the user can decide to include 52a supervision in the breaker fail logic (see the *Logic Reset Criterion (Feeder CB Fail only)* section and the *Logic AND Current reset Criterion (Feeder CB Fail only)* section below).

Note	*52a is the setting name, it means CB closed.* *The CB closed position is created in the PSL either using 52b reversed or a combination of (52a and 52b).* *Logic Reset Criteria (52a supervision with or without I< criterion) is settable for Feeder CB Fail only. Coupler CB fails are always reset with current reset (I<) criterion, whatever the choice of 'Fdr CBF Reset by' setting.*

The first function is to compare the current sample to the I< threshold and check for the following sequence:

- positive value of the current
- no current (below the threshold)
- negative value of the current
- no current (below the threshold)
- positive value of the current
- …

The output signal is pI(t), it changes between 0 and 1.

Internal overcurrent signals are available per phase and confirm that the CB failure algorithm has started to count down.

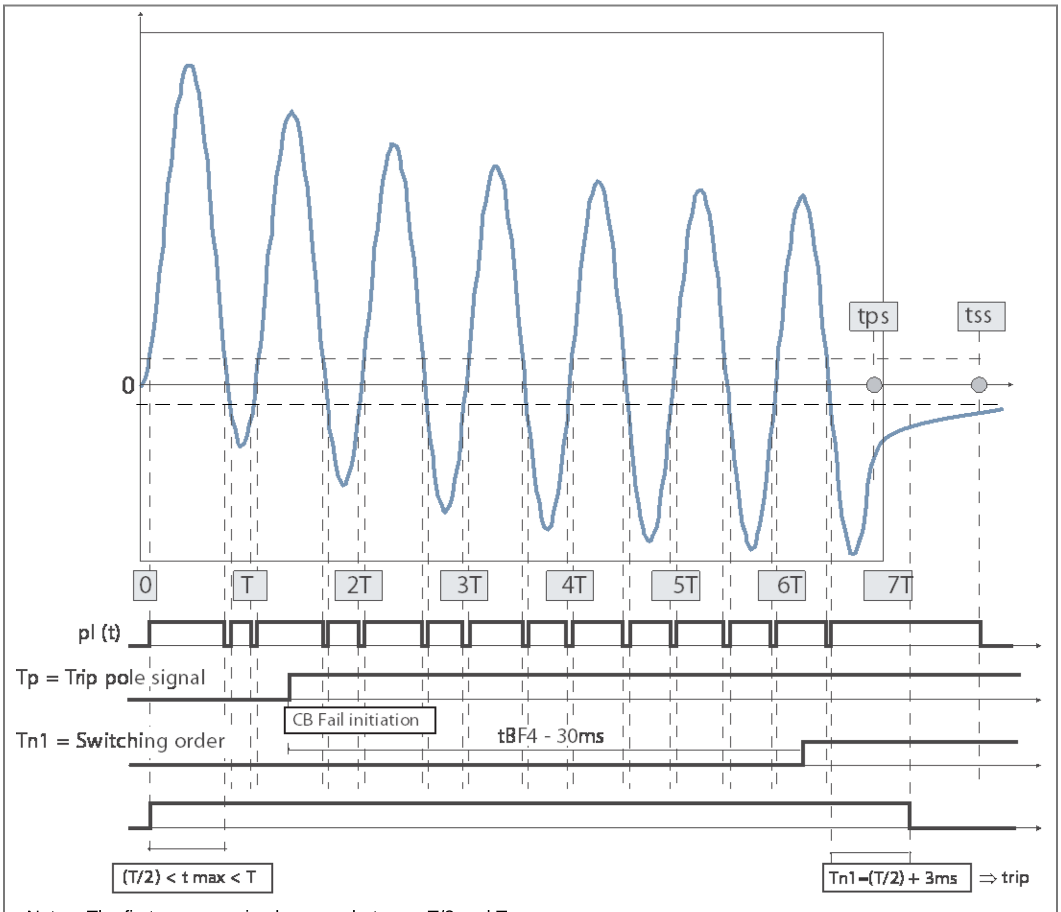
Internal undercurrent signals are available per phase to confirm that each pole has opened.

To maintain the current criterion active while the signal crosses zero, there is a drop-off timer associated with the pI(t) signal. The latching duration is variable in order to take all cases into account:

- Just after the initiation of the CB fail function, the waveform can include a DC component, and the time between two successive zero crossings can be longer than half-period. Therefore, the retrip time shall be set long enough for the DC component to have disappeared so that the time between two successive zero crossings should be close to one half-period. Moreover it is important to detect the opening of the circuit breaker quickly because the end of the back trip timer is near. The drop-off duration is therefore equal to one half period + 3ms (13ms at 50Hz, 11.3ms at 60Hz).

  Internal CB Fail: drop-off time = T + 3ms from 0s to [tBF2–30ms]
  External CB Fail: drop-off time = T + 3ms from 0s to [tBF4–30ms]
  Where T = one full cycle.

- For the last 30ms before the end of the stage 2 timer, the DC component should have disappeared so that the time between two successive zero crossings should be close to one half-period. Moreover, it is important to detect the opening of the circuit breaker quickly because the end of the back trip timer is near. The drop-off duration is therefore equal to one half period + 3ms (13ms at 50Hz, 11.3ms at 60Hz). In this case:
  Internal CB Fail: drop-off time = T/2 + 3ms from [tBF2–30ms] to tBF2.
  External CB Fail: drop-off time = T/2 + 3ms from [tBF4–30ms] to tBF4.
  Where T = one full cycle.



Note The first zero crossing happens between T/2 and T.

Figure 4 - CB Element logic

Principle of the Undercurrent Function

Instantaneous current measurements are taken for both the positive and negative half cycles, ensuring immunity to DC offset waveforms, and CT current ring-down.

The two horizontal dotted lines are instantaneous thresholds, fixed in proportion to the user's I< setting. The instantaneous threshold is at 141 percent of the I< setting. As any current rises above the dotted line instantaneous threshold, this rising measurement triggers a pulse timer to declare that current is flowing. The duration of the pulse is one full cycle plus 3ms (T+3ms). It does not matter whether the magnitude of the current stays above the dotted line further, as the detector is effectively edge-triggered. Current flow has been declared based on this half cycle, and not until the current falls below the detector setting is the edge-trigger ready to declare an output again. Whilst current is flowing, on the rise of current in each half-cycle the pulse timer is retriggered. This sequential retriggering ensures that current is detected.

The detection of breaker opening is made upon one of two scenarios:

1. The current falls below the instantaneous detection threshold, and does not rise again before the pulse timer expires; or
2. A CT remnance does not change sign, and remains in one polarity sense up until the timer expires.

Note	*The pulse timer length is variable, and adapts according to the anticipated proportion of DC current offset that may be present in the measured waveform. The pulse timer initially is fixed at one cycle plus 3ms, as described previously, as upon fault inception the DC offset could be appreciable. Near the end of the breaker fail time, the pulse length is shortened to half a power cycle plus 3ms (T/2 + 3ms). The presumption is that the DC offset in real fault current has decayed, and that the shorter time is all that is required. The pulse length is reduced 30ms before expiry of the tBF2 timer (for internally-initiated CBF) and 30ms before expiry of the tBF4 timer (for externally-initiated CBF). The reduced pulse length means faster resetting of the current detector.*

1.3.2.2 Logic Reset Criterion (Feeder CB Fail only)

This is for instances where circuits may carry a very low level of load, or even may operate unloaded from time to time. Where 52a contact (CB closed) supervision is set, the relay looks only for the opening of the breaker to stop the breaker fail timers.

This criterion is based on checking the state of the circuit breaker auxiliary contacts. i.e. to see if the 52b reverse or a combination of (52a and 52b) contact is open for open circuit breaker conditions. In the MiCOM P74x/P746 protection system, this detection method is used with the '52a' setting.

Logic AND Current reset Criterion (Feeder CB Fail only)

This is for instances where circuits may carry a very low level of load, or even may operate unloaded from time to time. Where 52a contact (CB closed) supervision is set, the relay looks for I< undercurrent, and the opening of the breaker to stop the breaker fail timers.

This criterion relies on verifying the disappearance of the current AND of the state of the CB auxiliary contacts. In the MiCOM P74x/P746 protection system, this detection method is used with the 'I< AND 52a' (setting) threshold.

Processing a Circuit Breaker Failure Condition

Due to the nature of the busbar protection, the substation topology can manage the system under circuit breaker failure conditions (50BF).

There are several options for circuit breaker failure protection installations. Generally these depend on the substation construction and wiring:

- Internally initiated CBF i.e. Initiation from the differential element,
- Externally initiated, for example by the feeder protection, but using the busbar protection’s integral 50BF protection to execute tripping procedure
- Separate 50BF protection to the busbar protection (such as a MiCOM P821)

The breaker failure logic uses fast acting undercurrent elements to provide the required current check. These elements reset within 15ms, thereby allowing the use of the P746 relay at all voltage levels.

Note	*The CB fail alarm is raised as soon as tBF1 or tBF2 or tBF3 or tBF4 has been reached.*

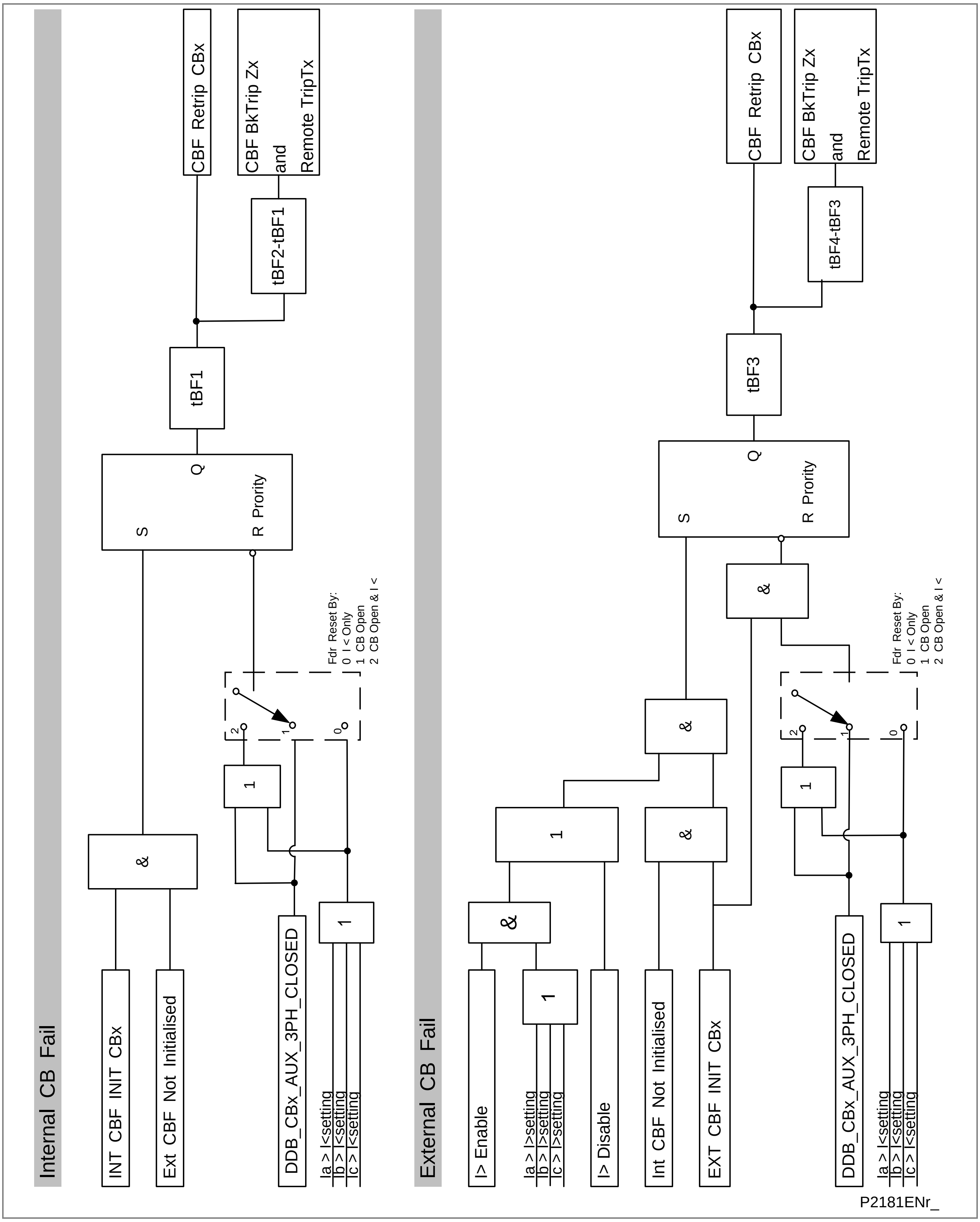


Figure 5 - CB FAIL logic diagram

External CB Fail is a per zone signal.

- External CB Fail Zone 1 will immediately trip zone 1 at reception of the signal.
- External CB Fail Zone 2 will immediately trip zone 2 at reception of the signal.
- External CB Fail Zone 3 will immediately trip zone 3 at reception of the signal.
- External CB Fail Zone 4 will immediately trip zone 4 at reception of the signal.

Even if CB Fail function is disabled, a change of state of External CB Fail Zone 1/2/3/4 will be immediately processed by P746 logic and lead to zone trip.

1.3.2.3 Internally Initiated CBF i.e. Tripping from the Differential Element 87BB

For internally initiated CB Fail, the CB fail reset only when the reset condition satisfied.

When a tripping order is generated but not executed due to a circuit breaker failure condition, the following circuit breakers are required to be tripped instead:

All the circuit breakers in the adjacent busbar zone if the faulty circuit breaker is that of a bus coupler or bus section.

The remote end circuit breaker if the faulty circuit breaker is that of a feeder (line or transformer). This intertripping is done via PSL and may not be required on feeders, which may be serviced automatically via the distance or other line protection.

Initiation is via the Int CBF Int Tx and BBxx signals which are connected to tripping functions in the PSL. Initiation is always three-phase for one-box mode and single-phase for three-box mode and initiates timers tBF1 and tBF2. The first timer is associated with the local re-trip function while the second timer is associated with the conveyance of the signal for tripping of the adjacent zone in the cases of bus coupler/bus section circuit breaker failure.

Note	*87BB, 50BF, OC, EF or DZOC can initialize internal CB fail via PSL*

Re-Trip after time tBF1

The dead pole detection threshold (I<) triggers the first breaker failure timer (tBF1). Re-trip output contacts should be assigned using the PSL editor (including in default PSL settings).

If a dead pole is not detected (I< and/or 52a) after tBF1 a Re-Trip will be issued. Re-trip output contacts should be assigned using the PSL editor.

Back-Trip after time tBF2

A signal from the Re-Trip timer (tBF1) triggers the second breaker failure timer (tBF2) which must be set greater than tBF1 + 40ms to allow retripping to occur. If a circuit breaker failure condition persists a general bus-zone back-trip signal will be issued.

In summary, tBF1 is used for re-trip and tBF2 for general bus zone back-trip

Because the busbar protection scheme uses the substation topology, during circuit breaker failure conditions, circuit breaker operations are executed according to the current state of the system. It is therefore of paramount importance that the circuit breaker tripping orders (Zone Trip Tx or BBxxCB Tripped) are defined within the scheme topology to guarantee correct scheme operation.

1.3.2.4 Externally Initiated 50BF

For externally initiated CB Fail, the CB fail will reset when the external initiation resets OR the reset condition (I< and/or 52a) is satisfied.

Note	*Signal for back-trip (including adjacent zone(s)) if failed CB is bus section or bus coupler circuit breaker or Terminal circuit breaker.*
Note 2	*Optional (refer to the **Local re-trip after time tBf3** section below).*
Note 3	*I> could be enabled or disabled.*

Taking into account the relationship between the busbar protection and the circuit breaker failure protection certain operators prefer an integrated solution where the breaker failure may be initiated by external protection but executed in the busbar scheme. Tripping is then worked out in the section or zone.

On an overhead line for example the external commands may be generated by the distance protection (21). These commands and tripping commands are on a 3-phase basis.

Local Re-Trip after Time tBf3

I> can be set for externally initiated CBF to increase the current required to indicate breaker failure. If a dead pole is not detected (I< and/or 52a) after tBF1 a Re-Trip will be issued providing the initiating signal is still present and the current is above the I> setting if enabled. Internal and External re-trips operate the same signal in PSL which should be assigned to output contacts using the PSL editor.

General Zone Trip after Time tBF4

When both the local trip and re-trip have failed, the countdown continues with a second timer adjusted to have a value of tBF4 - tBF3. The end of this time thus corresponds to total time tBF4, beyond which a persistent circuit breaker failure condition is declared.

Back trip information is then routed to the associated circuit breakers in the adjacent zone(s) for tripping.

1.3.2.5 CB Fail Alarm

The CB Fail alarm is raised on any timer reached (tBF1 or tBF2 or tBF3 or tBF4).

1.3.2.6 Separate External 50BF Protection to the Busbar Protection

This is the most common solution utilising conventional wiring. The 50BF relay is completely independent of all others. When a circuit breaker failure condition occurs the external protection trips all adjacent circuit breakers as defined in the separate scheme (DDB Ext CBF Zx).

In view of the connection between the functions of the busbar protection and the circuit breaker failure protection some operators prefer one of the more integrated system solutions previously mentioned.

1.4 Three-Phase Overcurrent Protection

1.4.1 Inverse Time (IDMT) Characteristic

The IEC/UK IDMT curves conform to the following formula:

$$t = T \times \left(\frac{K}{(I/Is)^{\alpha} - 1} + L \right)$$

The IEEE/US IDMT curves conform to the following formula:

$$t = TD \times \left(\frac{K}{(I/Is)^{\alpha} - 1} + L \right)$$

Where:
- t = Operation time
- K = Constant
- I = Measured current
- Is = Current threshold setting
- α = Constant
- L = ANSI/IEEE constant (zero for IEC/UK curves)
- T = Time Multiplier Setting for IEC/UK curves
- TD = Time Dial Setting for IEEE/US curves

IDMT Curve description	Standard	K Constant	α Constant	L Constant
Standard Inverse	IEC	0.14	0.02	0
Very Inverse	IEC	13.5	1	0
Extremely Inverse	IEC	80	2	0
Long Time Inverse	UK	120	1	0
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-C02	0.16758	0.02	0.11858

Table 1 - IDMT curves

1.4.2 RI Curve

The RI curve (electromechanical) has been included in the first stage characteristic setting options for phase overcurrent and the first stage characteristic setting options for earth fault protection. The curve is represented by the following equation (where t is in seconds and K is adjustable from 0.1 to 10 in steps of 0.05).

$$t = K \times \left(\frac{1}{0.339 - \left(\frac{0.236}{I / Is} \right)} \right)$$

1.4.3 Reset Characteristics

For all IEC/UK curves, the reset characteristic is definite time only.

For all IEEE/US curves, the reset characteristic can be selected as either inverse curve or definite time.

The definite time can be set (as defined in IEC) to zero. Range 0 to 100 seconds in steps of 0.01 seconds.

The Inverse Reset characteristics are dependent upon the selected IEEE/US IDMT curve as shown in the table below.

All inverse reset curves conform to the following formula:

$$t_{Reset} = TD \times \left(\frac{tr}{1 - (I / Is)^{\alpha}}\right)$$

Where:

t_{Reset} = Reset time
tr = Constant
I = Measured current
Is = Current threshold setting
α = Constant
TD = Time Dial Setting (Same setting as that employed by IDMT curve)

IEEE/US IDMT Curve description	Standard	tr Constant	α Constant
Moderately Inverse	IEEE	4.85	2
Very Inverse	IEEE	21.6	2
Extremely Inverse	IEEE	29.1	2
Inverse	US-C08	5.95	2
Short Time Inverse	US-C02	2.261	2

Table 2 - Inverse Reset Characteristics

1.5 Earth Fault Protection

1.5.1 EF Time Delay Characteristics

The earth fault element has the same characteristics as the Phase Overcurrent except for UK Rectifier. The reset time characteristics are also the same.

The IDG curve is commonly used for time delayed earth fault protection and is available in stage 1.

The IDG curve is represented by the following equation:

$$t = 5.8 - 1.35 \log_e \left(\frac{I}{IN > Setting}\right) \text{in seconds}$$

Where:

I = Measured current

IN>Setting = An adjustable setting which defines the start point of the characteristic

Although the start point of the characteristic is defined by the “IN>” setting, the actual relay current threshold is a different setting called “IDG Is”. The “IDG Is” setting is set as a multiple of “IN>”.

An additional setting “IDG Time” is also used to set the minimum operating time at high levels of fault current.

The following diagram shows how the IDG characteristic is implemented.

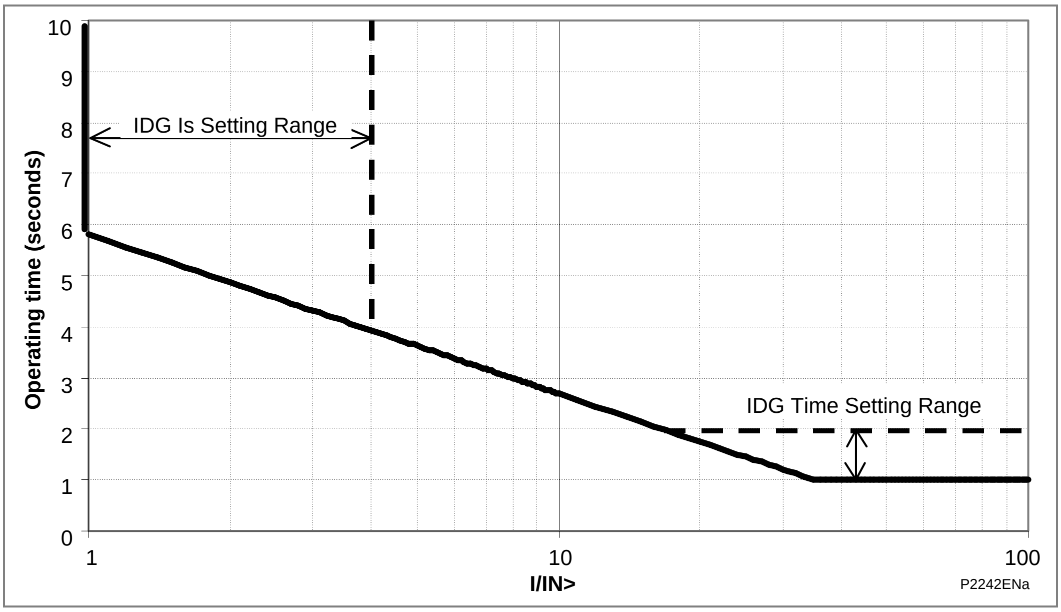


Figure 6 - IDG characteristic

2 ISOLATOR AND CIRCUIT BREAKER FUNCTION

2.1 Isolator State Monitoring Features

The following recommended functions, if used shall be set in the PSL:

MiCOM relays can be set to monitor normally open (89a) and normally closed (89b) auxiliary contacts of the isolators. Under healthy conditions, these contacts will be in opposite states. Should both sets of contacts be open, this would indicate one of the following conditions:

- Auxiliary contacts / wiring defective
- Isolator is defective
- Isolator is in isolated position

Should both sets of contacts be closed, only one of these two conditions would apply:

- Auxiliary contacts / wiring defective
- Isolator is defective

A normally open / normally closed output contact has to be assigned to this function via the Programmable Scheme Logic (PSL). The time delay is set to avoid unwanted operation during normal switching duties. If any of the above conditions exist, an alarm will be issued after the time delay set in the PSL.

In the PSL Qx must be used following the two options:

- 89a (normally open) (recommended) or 89b (normally closed) (not recommended)
- Both 89a and 89b (recommended as long as the number of inputs is sufficient)

If both 89a and 89b are used then status information will be available and in addition a discrepancy alarm will be possible. 89a and 89b inputs are assigned to relay opto-isolated inputs via the PSL.

2.2 Circuit Breaker State Monitoring Features

To monitor the CBs and isolators, the following recommended functions shall be set in the PSL.

MiCOM relays can be set to monitor normally open (52a) and normally closed (52b) auxiliary contacts of the circuit breaker. Under healthy conditions, these contacts will be in opposite states. Should both sets of contacts be open, this would indicate one of the following conditions:

- Auxiliary contacts / wiring defective
- Circuit Breaker (CB) is defective
- CB is in isolated position

Should both sets of contacts be closed, only one of these conditions would apply:

- Auxiliary contacts / wiring defective
- Circuit Breaker (CB) is defective

If any of the above conditions exist, an alarm will be issued after the time delay set in the PSL. 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.

Note	*CB not ready signals are available within the PSL which by default block trips to the affected breaker and accelerate back trips*

In the PSL CB AUX could be used or not, following these options:

- 52a (normally open) (not recommended) or 52b (normally closed) (recommended)
- Both 52a and 52b

Note	*If no CT status is available it will affect any function within the relay that requires this signal. For example, the topology is affected by the bus coupler status and if it is not available then this signal must be forced high within the PSL. This will force the topology boundary to the coupler CTs.*

If both 52a and 52b are used then status information will be available and in addition a discrepancy alarm will be possible, according to the following table. 52a and 52b inputs are assigned to relay opto-isolated inputs via the PSL.

Auxiliary Contact Position		CB State Detected	Action
52a	**52b**		
Open	Closed	Breaker Open	Circuit breaker healthy
Closed	Open	Breaker Closed	Circuit breaker healthy
Closed	Closed	As determined by PSL Logic	Alarm raised if the condition persists for longer than the time delay set in the PSL.
Open	Open	As determined by PSL Logic	Alarm raised if the condition persists for longer than the time delay set in the PSL.

Table 3 - 52a and 52b inputs

The CB status is determined by the CBx or BBxx closed signal in the PSL. CB auxiliary contacts and closing signals are required for all bus-sections and bus-couplers if zone extension is required when these breakers are open.

They are required for feeders to implement the following functions:

- Dead Zone fault, the CB position is required (send remote trip order to the other end of the line)
- CB supervision
- 52a functionality in CBF

No specific auxiliary contacts are required but ideally one 52a and one 52b should be available.

The faster these contacts operate (following real CB operation) the better it is.

When 52a=52b=0 or 52a=52b=1 (most of the time during operation of the CB, but not only), it is recommended that the CB is considered as closed in the topology; this choice is made in the PSL.

3 OPERATION OF NON-PROTECTION FUNCTIONS

3.1 VT and CT Supervision

3.1.1 Voltage Transformer Supervision (18CTs/3VT Models)

The Voltage Transformer Supervision (VTS) feature is used to detect failure of the ac voltage inputs to the relay. This may be caused by internal voltage transformer faults, overloading, or faults on the interconnecting wiring to relays. This usually results in one or more VT fuses blowing. Following a failure of the ac voltage input there would be a misrepresentation of the phase voltages on the power system, as measured by the relay, which may result in maloperation.

The VTS status may be set to blocking or indication. The VTS logic in the relay is designed to detect the voltage failure, and automatically adjust the configuration of protection elements whose stability would otherwise be compromised. A time-delayed alarm output is also available. When choosing “Indication”, a 20ms indication timer will be used to give indication for possible trip.

The next diagram shows the simplified logic of the VTS:

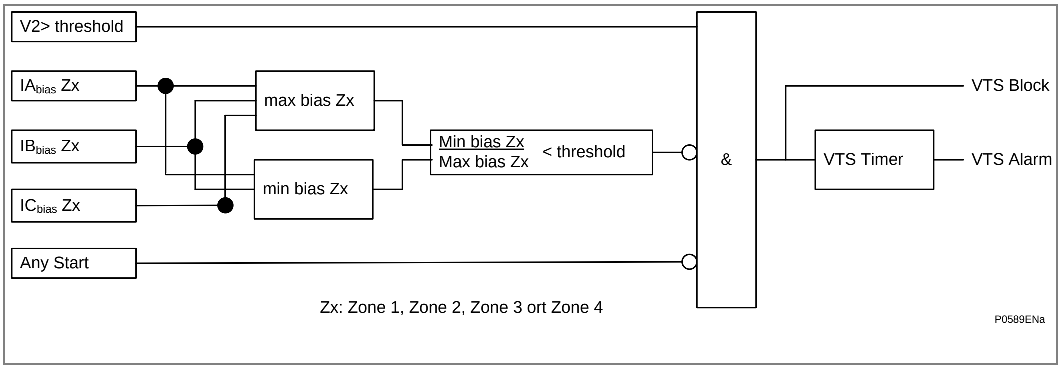


Figure 7 - Voltage Transformer Supervision (VTS)

Note	*In three-box mode, for example, phase A P746 can’t get bias current for other phases, the current criterion is not applicable. Suggest choosing “Indication” mode for VTS.*

The MiCOM P746 compares the Check Zone bias currents from individual phases to detect any unbalance. The ratio between the minimum bias current and the maximimum bias current is compared to the ZoneBiasRatio threshold (by default: 70%).

3.1.2 Current Transformer Supervision (One Box Mode Only)

Current Transformer Supervision (CTS) is based on the measurement of the ratio of I2/I1 at all ends. When this ratio is not zero, one of the following two conditions may be present:

- An unbalanced fault is present on the system - both I2 and I1 are non-zero
- There is a 1 or 2 phase CT problem - both I2 and I1 are non-zero

If the I2/I1 ratio is greater than the set value, CTS I2/I1>2, at all ends, it is almost certainly a genuine fault condition (CTS I2/I1>2 set above maximum unbalanced load and below the minimum unbalanced fault current). Therefore CTS will not operate. If this ratio is detected at one end only, one of the following conditions may be present:

- A CT problem
- A single end fed fault condition

I1 is used to confirm whether it is a CT problem or not. If I1 > CTS I1 is detected at all ends, it must be a CT problem and CTS is allowed to operate. If this condition (I1 > CTS I1) is detected at only one end, it is assumed that either an inrush condition or a single end fed internal fault is present. Therefore, the CTS operation is blocked.

The CTS status under the CT SUPERVISION sub-heading can be set either as indication or blocking. In indication mode, the CTS alarm time delay is automatically set to zero. If a CT failure is present, an alarm would be issued without delay, but the differential protection would remain unrestricted. Therefore, the risk of unwanted tripping under load current is present.

The next figure illustrates the simplified logic of CT Supervision.

For busbar protection: if CTS failure is detected at one terminal, only related zone differential protection will be blocked.

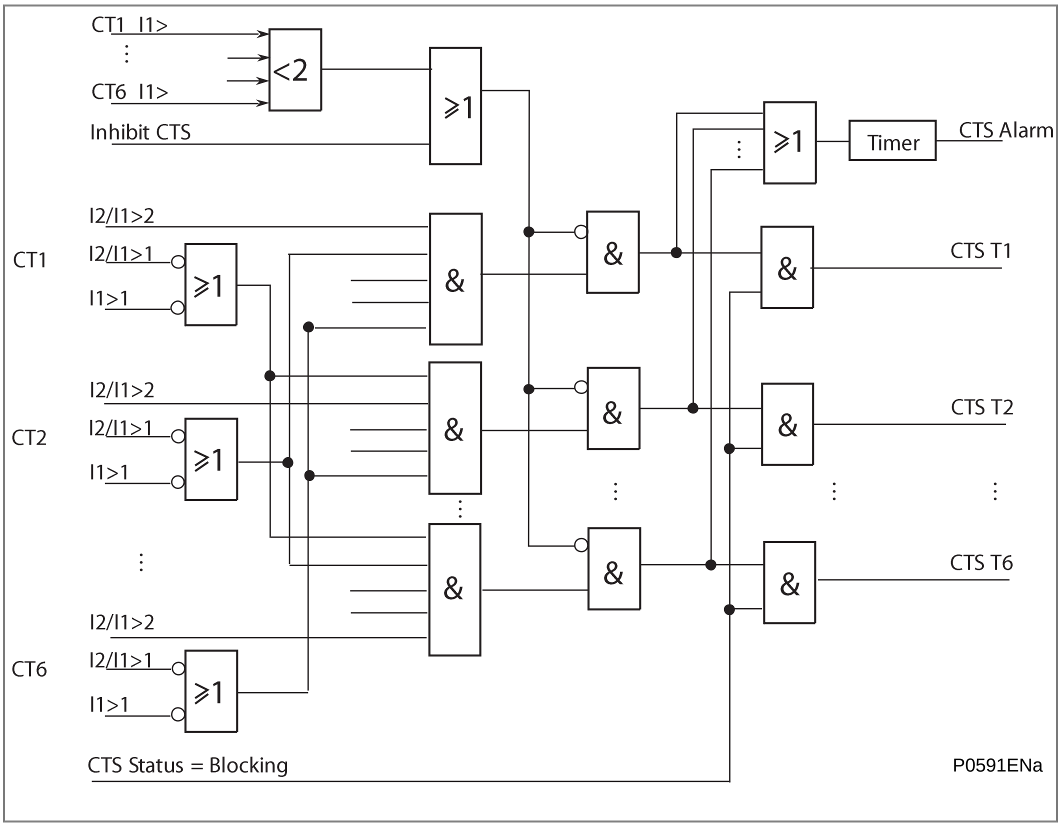


Figure 8 - Current Transformer Supervision (CTS)

3.2 Programmable Scheme Logic

3.2.1 Level Settings

Name	Range	Step Size
Time delay t	0-14400000ms	1ms

Table 4 - Time delay settings

3.2.2 Accuracy

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

Table 5 - Accuracies

3.3 IRIG-B Signal Only

If a satellite time clock signal conforming to IRIG-B is provided and the relay has the optional IRIG-B port fitted, the satellite clock equipment should be energised.

In the event of the auxiliary supply failing, with a battery fitted in the compartment behind the bottom access cover, the time and date will be maintained. Therefore, when the auxiliary supply is restored, the time and date will be correct and not need to be set again.

3.4 Trip LED Logic

The trip LED can be reset when the flags for the last fault are displayed or via dedicated DDBs. The flags are displayed automatically after a trip occurs, or can be selected in the fault record menu. The reset of trip LED and the fault records is performed by pressing the Ⓒ key once the fault record has been read.

3.5 Function Keys

The relay offers users 10 function keys for programming any operator control functionality via PSL. Each function key has an associated programmable tri-colour LED that can be programmed to give the desired indication on function key activation.

These function keys can be used to trigger any function that they are connected to as part of the PSL. The function key commands can be found in the ‘Function Keys’ menu (see the Settings chapter). In the ‘Fn. Key Status’ menu cell there is a 10-bit word which represent the 10 function key commands and their status can be read from this 10-bit word.

In the programmable scheme logic editor 10 function key signals, which can be set to a logic 1 or On state, as described above, are available to perform control functions defined by the user.

The “Function Keys” column has ‘Fn. Key n Mode’ cell which allows the user to configure the function key as either ‘Toggled’ or ‘Normal’. In the ‘Toggle’ mode the function key DDB signal output will remain in the set state until a reset command is given, by activating the function key on the next key press. In the ‘Normal’ mode, the function key DDB signal will remain energized for as long as the function key is pressed and will then reset automatically.

A minimum pulse duration can be programmed for a function key by adding a minimum pulse timer to the function key DDB output signal.

The “Fn. Key n Status” cell is used to enable/unlock or disable the function key signals in PSL. The ‘Lock’ setting has been specifically provided to allow the locking of a function key thus preventing further activation of the key on consequent key presses. This allows function keys that are set to ‘Toggled’ mode and their DDB signal active ‘high’, to be locked in their active state thus preventing any further key presses from deactivating the associated function. Locking a function key that is set to the “Normal” mode causes the associated DDB signals to be permanently off. This safety feature prevents any inadvertent function key presses from activating or deactivating critical relay functions.

The “Fn. Key Labels” cell makes it possible to change the text associated with each individual function key. This text will be displayed when a function key is accessed in the function key menu, or it can be displayed in the PSL.

The status of the function keys is stored in battery backed memory. In the event that the auxiliary supply is interrupted the status of all the function keys will be recorded. Following the restoration of the auxiliary supply the status of the function keys, prior to supply failure, will be reinstated. If the battery is missing or flat the function key DDB signals will set to logic 0 once the auxiliary supply is restored.

Note	*The relay will only recognize a single function key press at a time and that a minimum key press duration of approximately 200msec. is required before the key press is recognized in PSL. This deglitching feature avoids accidental double presses.*

3.6 Setting Groups Selection

The setting groups can be changed either via opto inputs, via a menu selection, via the hotkey menu or via function keys. In the Configuration column if 'Setting Group - select via optos' is selected then any opto input or function key can be programmed in PSL to select the setting group as shown in the table below. If 'Setting Group - select via menu' is selected then in the Configuration column the 'Active Settings - Group1/2/3/4' can be used to select the setting group.

The setting group can be changed via the hotkey menu providing ‘Setting Group select via menu’ is chosen.

Two DDB signals are available in PSL for selecting a setting group via an opto input or function key selection. The following table illustrates the setting group that is active on activation of the relevant DDB signals.

DDB 884 ‘SG Select x1’	DDB 885 ‘SG Select 1x’	Selected setting group
0	0	1
1	0	2
0	1	3
1	1	4

Table 6 - Setting group on DDB signals

3.7 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 7 - Control inputs

The Control Input commands can be found in the ‘Control Input’ menu. In the ‘Ctrl. I/P status’ menu cell there is a 32 bit word which represent the 32 control input commands. The status of the 32 control inputs can be read from this 32-bit word. The 32 control inputs can also be set and reset from this cell by setting a 1 to set or 0 to reset a particular control input. Alternatively, each of the 32 Control Inputs can be set and reset using the individual menu setting cells ‘Control Input 1, 2, 3’ etc. The Control Inputs are available through the relay menu as described above and also via the rear communications.

In the programmable scheme logic editor 32 Control Input signals, DDB 1824 - 1855, 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	
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 8 - Ctrl I/P Config

The “CTRL. I/P CONFIG.” column has several functions one of which allows the user to configure the control inputs as either ‘latched’ or ‘pulsed’. A latched control input will remain in the set state until a reset command is given, either by the menu or the serial communications. A pulsed control input, however, will remain energized for 10ms after the set command is given and will then reset automatically (i.e. no reset command required).

In addition to the latched/pulsed option this column also allows the control inputs to be individually assigned to the “Hotkey” menu by setting ‘1’ in the appropriate bit in the “Hotkey Enabled” cell. The hotkey menu allows the control inputs to be set, reset or pulsed without the need to enter the “CONTROL INPUTS” column. The “Ctrl. Command” cell also allows the SET/RESET text, displayed in the hotkey menu, to be changed to something more suitable for the application of an individual control input, such as “ON/OFF”, “IN/OUT” etc.

The “CTRL. I/P LABELS” column makes it possible to change the text associated with each individual control input. This text will be displayed when a control input is accessed by the hotkey menu, or it can be displayed in the PSL.

Note	*With the exception of pulsed operation, the status of the control inputs is stored in battery backed memory. In the event that the auxiliary supply is interrupted the status of all the inputs will be recorded. Following the restoration of the auxiliary supply the status of the control inputs, prior to supply failure, will be reinstated. If the battery is missing or flat the control inputs will set to logic 0 once the auxiliary supply is restored.*

3.8 User Alarms

Thirty two user alarms are available, the first 16 are self-reset and the next 16 are manual reset. The user alarm labels can be set in the setting file and these labels are displayed in the PSL file as well.

APPLICATION NOTES

CHAPTER 6

Date (month/year):	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.
Hardware suffix:	M
Software version:	B4 (P746_1) / C4 (P746_2)
Connection diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

TABLES

Page (AP) 6-

FIGURES

Notes:

1 INTRODUCTION

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

1.1 Protection of Substation Busbars

The busbars in a substation are possibly one of the most critical elements in a power system. If a fault is not cleared or isolated quickly, not only could substantial damage to the busbars and primary plant result, but also a substantial loss of supply to all consumers who depend upon the substation for their electricity. It is therefore essential that the protection associated with them provide reliable, fast and discriminative operation.

As with any power system the continuity of supply is of the utmost importance, however, faults that occur on substation busbars are rarely transient but more usually of a permanent nature. Circuit breakers should, therefore, be tripped and not subject to any auto-reclosure.

The busbar protection must also remain stable for faults that occur outside of the protected zone as these faults will usually be cleared by external protection devices. In the case of a circuit breaker failure, it may be necessary to open all of the adjacent circuit breakers; this can be achieved by issuing a backtrip to the busbar protection. Security and stability are key requirements of a busbar protection scheme. Should the busbar protection maloperate under such conditions substantial loss of supply could result unnecessarily.

Many different busbar configurations exist. Typical arrangements are single or a double busbar substation. The positioning of the primary plant can also vary and also needs to be considered which in turn introduces variations, all of which have to be able to be accommodated within the busbar protection scheme.

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

2 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 relay.

Up to 7 sets of CTs, the P746 scheme is made with a single relay.

Up to 21 sets of CTs, there are three relays that make up the P746 scheme.

In some cases, 2 sets of one or three relays solutions are possible.

The P746 co-ordinates the scheme, acquires the analogue signals from the associated CT and the binary signals from the auxiliary contacts of the primary plant (CB and isolator(s)) and acts on these signals, initiating a bus zone protection trip when necessary.

The P746 also incorporate the main circuit breaker failure logic together with additional protections. The P746 allows for optional I/O, tricolour LEDs, function keys and additional communication board slot (Ethernet or second rear port).

The main features of the P746 scheme are summarised below:

- Current differential busbar protection – Phase segregated biased differential protection (sometimes referred to as low impedance type)
- Provides the main protection element for the scheme. This protection provides high-speed discriminative protection for all fault types
- Circuit breaker failure protection – two stage breaker fail logic that can be initiated internally or externally.
- Dead Zone phase protection.
- Non-directional phase fault over current protection – provides two stage protection.
- Low Burden – Allows the protection to be installed in series with other equipment on a common CT secondary.
- Accommodates different CT classes, ratios and manufacturers.

2.1 Terminal Settings (for All Protections)

For each Terminal (connected to the secondary of a High voltage CT), the following values have to be known.

2.1.1 CT Ratios

Only **3 values** have to be known and entered:

1. Phase CT Primary current (from 1 to 30000 A) given by the manufacturer.
2. Phase CT secondary current (1 or 5 A) given by the manufacturer.
3. Polarity (Standard (towards the bar) or Inverted (opposite the bar)

Note	*The ratio of virtual CT as reference for secondary currents calculation (Iref) is fixed to 2000/1.*

2.1.2 VT Ratios

Only **2 values** have to be known and entered:

1. Phase VT Primary current (from 100 to 100 kV) given by the manufacturer.
2. Phase VT secondary current (80 or 140 V) given by the manufacturer.

2.2 Busbar Settings

Busbar Biased Current Differential Protection

2.2.1 Setting Guidelines

2.2.1.1 87BB Phase Settings (Solid Earthed Network Schemes)

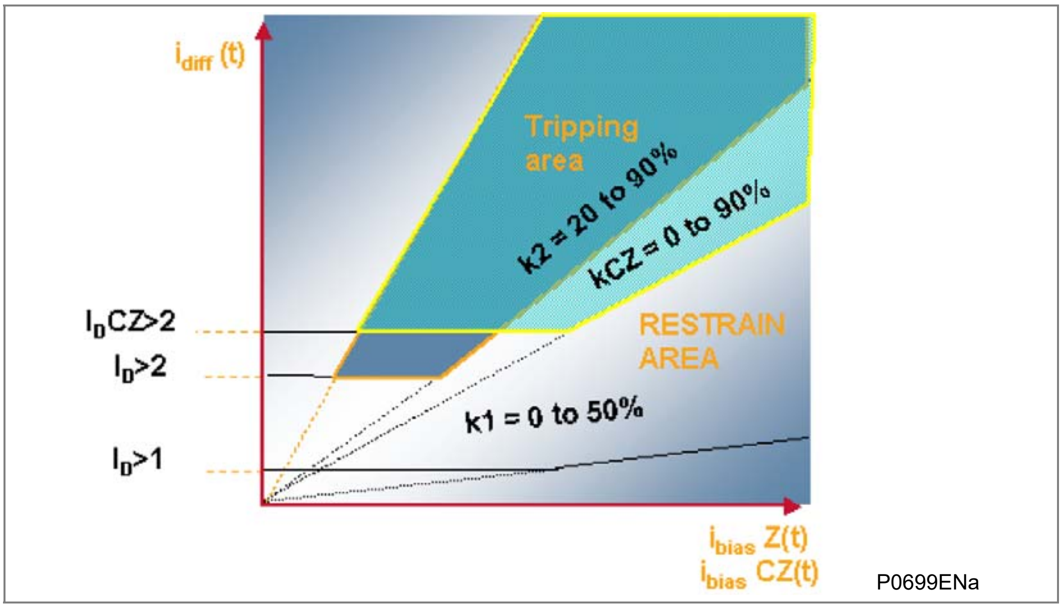


Figure 1 - Tripping and restraint areas

An Excel spreadsheet tool called "P746_Idiff_Ibias_x.xls" is available on our website to assure a reliable setting choice:

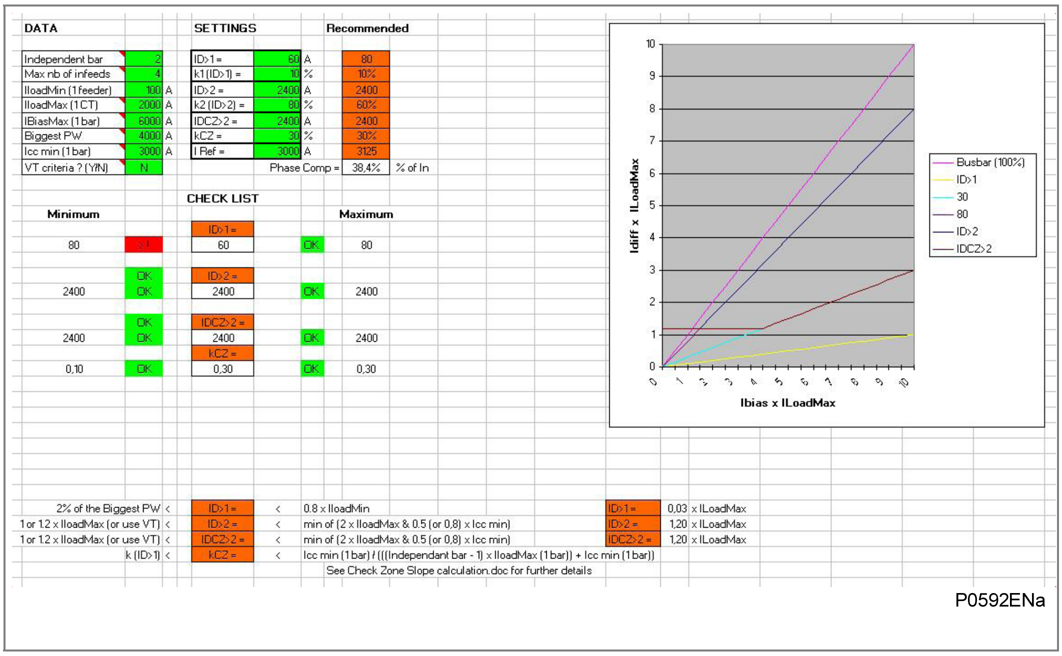


Figure 2 - Idiff_Ibias spreadsheet

Sub-Station Features

Only 8 values have to be known:

1. Number of independent bars
2. Maximum number of infeeds
3. Minimum load current in a feeder
4. Maximum load current in a feeder
5. Maximum load current in a bus
6. Biggest CT primary winding
7. Minimum short-circuit value (phase to phase) in a bus
8. Voltage used (Yes or No)

"Idiff_Ibias" Setting Calculation Spreadsheet

Enter in the Idiff_Ibias spreadsheet the 8 values here above listed and you'll be able to choose the values hereafter listed.

It is important to know that if the minimum internal fault detection is set below the maximum load an additional criterion such as voltage must be used.

Differential Busbar Protection

1. ID>1 as high as possible with a minimum of 2% of the biggest CT primary winding and less than 80% of the minimum load
2. Slope k1 (ID>1), usual recommendation is 10%
3. ID>2 as low as possible, whilst ensuring the single CT failure will not cause tripping under maximum load conditions with no VT.
4. Slope k2 (ID>2), usual recommendation is generally 50 / 65%
5. IDCZ>2 as low as possible
6. Slope kCZ (IDCZ>2), usual recommendation is generally 30%

Explanations of the values:

1. ID>1 shall be higher than 2% of the biggest CT to not detect noise coming from it and less than 80% of the minimum load of a feeder to detect the minimum load imbalance in case of a problem in that particular feeder.
2. Slope k1 recommendation is 10% to meet class 10P current transformers
3. ID>2 shall be:
   - below twice the maximum load for the phase comparison algorithm to pickup the load and if possible below 50% of the minimum fault to be sub-cycle (80% otherwise).
   - and if no voltage criteria is used above 100% (and when possible 120% to allow 20% margin) of the biggest load to not maloperate in case of CT short-circuited or open circuit.
     - Note that the Voltage criteria can be used for single busbar only in one box mode.
4. Slope k2 (ID>2)

   Recommendation is 60%

   To be always stable in the worst CT ratio (between the biggest CT and the smallest CT).

   For operation at this slope the load during fault must be less than one third of the fault current. A lower slope can be used when operation is required for more resistive faults. For example a slope of 50% allows the load current during the fault to be up to 50% of the fault current.

Note	*Operation will only occur if load during the fault is less than the Phase Comparison Pickup ratio on the feeders supplying load.*

5. IDCZ>2 same as ID>2
6. Slope kCZ (IDCZ>2)

Recommendation is 30%

The requirement is to be able to trip for a fault that is counted twice by the Check Zone (for example one and a half circuit breaker substation) or during heavy loading on other bus zones which will depend on the number of bars:

- n bars (Independent bars)
- A minimum internal short-circuit value (IF min (1 bar))
- A maximum load for a bar (IloadMax (1 bar))
- Maximum load current of 1/3 the fault current during the fault corresponding to a discriminating zone slope of 60%

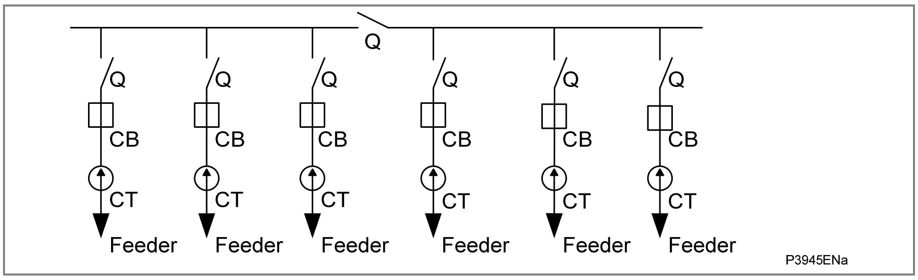


Figure 3 - Multiple zones

The worst case is:

- when all these buses are independent (bus sectionalizers open)
- the maximum load is on all the buses (biggest bias current)
- The internal short-circuit value is minimum.

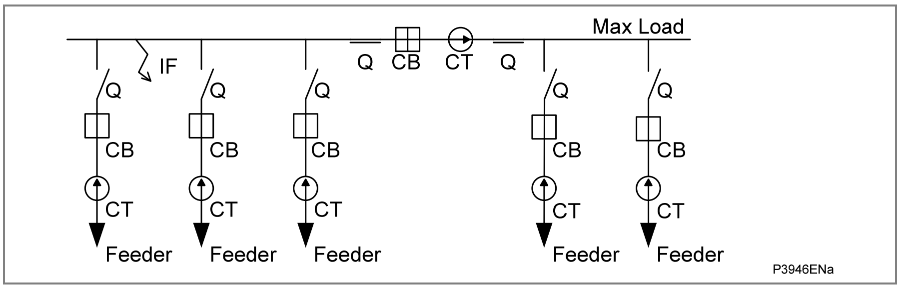


Figure 4 - Multiple zones with internal fault

During the internal fault:

- the bias current is: IF min (1 bar) + (n-1) x IloadMax (1 bar)
- the differential current is: IF min (1 bar)

Thus the biggest slope for the Check Zone to detect the fault is:

$$\frac{\text{IF min (1 bar)}}{\text{((Independent bars - 1) x IloadMax (1 bar)) +IloadFaultedBus + IF min (1 bar)}}$$

If for example:

There are 3 buses and IF min = IloadMax, the slope must be below 30%.

If lower slopes are used for the discriminating zones then a corresponding reduction in the check zone is required.

For one and half breaker scheme there are:

- 2 bars (Independent bars)
- A minimum internal short-circuit value (IF min (1 bar))
- Maximum load current of 1/3 the fault current during the fault corresponding to a discriminating zone slope of 60%.

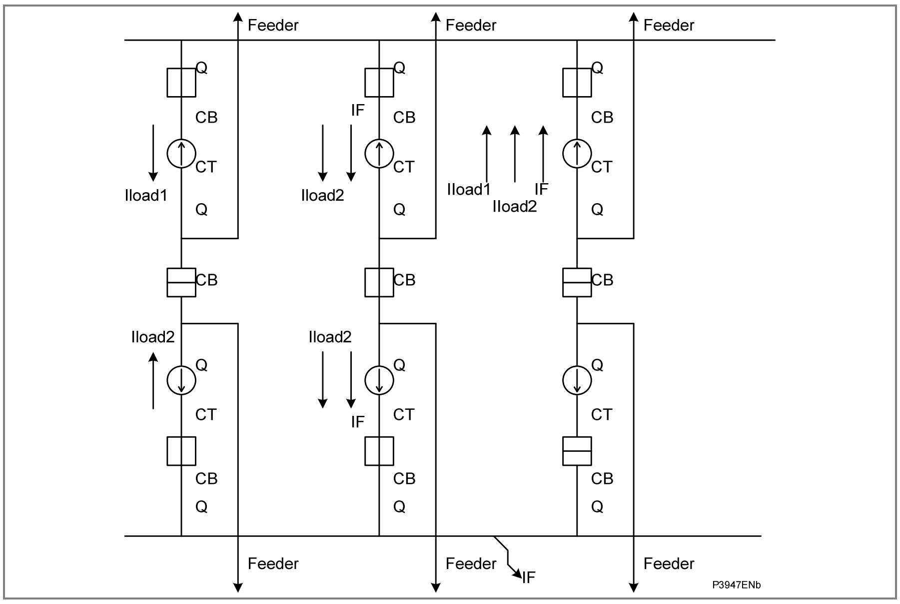


Figure 5 - One and half breaker scheme

The worst case is shown above:

- The fault current is supplied through the opposite bar
- The maximum load is on the 2 buses (biggest bias current)
- The internal short-circuit value is minimum.
- During the internal fault:
  - The CZ bias current is: 3 x IF min (1 bar) + 6 x IloadMax (1 bar)
  - The CZ differential current is: IF min (1 bar)

Thus the biggest slope for the Check Zone to detect the fault is:

$$\frac{\text{IF min (1 bar)}}{(6 \times \text{IloadMax (1 bar)}) + (3 \times \text{IF min (1 bar)})}$$

If for example:

IF min = 3x IloadMax, the slope must be below 20%

A similar situation can occur in other topologies when a fault can be fed through another zone in the same busbar scheme. Examples include parallel lines or transformers. Alternatively separate schemes are often used (See Benefits of Sectionalized Busbar Protection)

7. ID>1 Alarm Timer to not operate for an external fault shall be greater than the longest protection time (such as line, overcurrent, etc.)

8. Phase comparison.

   Phase comparison is used to define the minimum current to be included in the phase comparison algorithm; it is recommended to be 80% of (ID>2 / Σ In of Infeed CTs).

   The requirement is to be able to detect a through fault that is fed by the infeeds; it does not depend on the number of bars but depends on:

   - The minimum internal short-circuit threshold (ID>2)
   - The maximum number of infeeds, and their CT primary nominal currents.

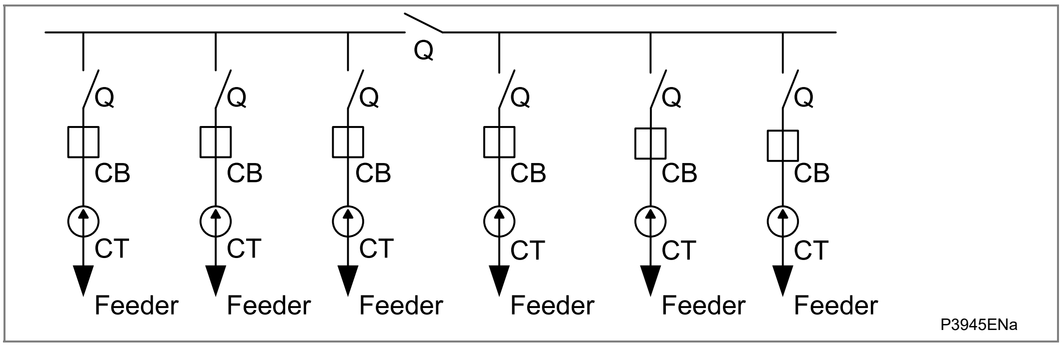


Figure 6 - Multiple feeders

The worst scenario is when the CT is fully saturated and the differential algorithm picks up on the ID>2 threshold. The phase comparison must block the trip by detecting the incoming currents:

We assume the infeeds will contribute to the ID>2 fault in proportion to their CT primary nominal current (worst situation).

- Then we need for each infeed, phase comparison threshold to be lower than:
  - ID>2 × (In CT / Σ(In CTs infeeds))
  - And phase comparison = ID>2 / (In CT / Σ(In CTs infeeds)) / In CT,
  - So, for any infeed, phase comparison max = ID>2 / Σ(In CTs infeeds))
  - We take 80% of this value so that to keep sufficient margin. Recommended setting is then:

  PC max = 0.8 × ID>2 / Σ(In CTs infeeds)

For example assume all feeders in Figure 6 are incomers with different ratios as follows:

Example:

Infeed	CT	Contribution*	PC%
Infeed 1	2500 / 5	2500 / 11300	$\frac{2500 / 11300 - ID>2}{2500} = \frac{ID>2}{11300}$
Infeed 2	2000 / 1	2000 / 11300	$\frac{2000 / 11300 - ID>2}{2000} = \frac{ID>2}{11300}$
Infeed 3	2000 / 1	2000 / 11300	$\frac{2000 / 11300 - ID>2}{2000} = \frac{ID>2}{11300}$
Infeed 4	1200 / 1	2400 / 11300	$\frac{2400 / 11300 - ID>2}{2400} = \frac{ID>2}{11300}$
Infeed 5	1200 / 1	1200 / 11300	$\frac{1200 / 11300 - ID>2}{1200} = \frac{ID>2}{11300}$
Infeed 6	1200 / 1	1200 / 11300	$\frac{1200 / 11300 - ID>2}{1200} = \frac{ID>2}{11300}$
	* ↳ ΣIn = 2500 + (2 × 2000) + 2400 + (2 × 1200) = 11300		
		↳ We assume the infeeds will contribute to the ID>2 fault in proportion to their CT primary current (worst situation)	
			↳ then PC% = 0.8 * ID>2 / Σ In of Infeed CTs

Table 1 - Infeed, CT, Contributions and PC% examples

Therefore a busbar pickup of 2400A gives PC%=17%. However, if the ID>2 setting is 1000A then a PC% of 7% would be required.

2.2.1.2 87BB Settings (Compensated Earthed Network Schemes)

These networks have neutral inductance which is tuned to the system capacitance to provide a high impedance fault path for earth faults. Earth Faults on these systems usually self extinguish but can also be left in service since very little current flows. In these applications the busbar protection will only operate for phase-to-phase faults and must be set above any expected earth fault currents to ensure continuity of supply.

Sub-Station Features

Five values have to be known:

1. Maximum load current in a feeder
2. Minimum phase-to-phase fault current (Ph-Ph min.) in a bus
3. Maximum single-phase steady state faulty current (Ph-N Max.) in a bus
4. Number of independent bars
5. Maximum number of infeeds

Differential Busbar Protection

Seven values have to be chosen:

1. ID>1, usual recommendation is 1,2 × (Ph-N Max.) with a minimum of 2% of the biggest CT primary winding and less than 80% of the minimum load,
2. Slope k1 (ID>1), usual recommendation is 10%.
3. ID>1 Alarm Timer (from 0 to 600 s) shall be greater than the longest Busbar protection time
4. Slope k2 usual recommendation is 50 / 65%.
5. ID>2 recommendation is: Lower than 0.8 × (Ph-Ph min) and higher than 1.2 × Iload Max and if possible, equal to 6 × (ID>1).
6. Slope kCZ usual recommendation is 30%.
7. IDCZ>2 usual recommendation is: Lower than 0.8 × (Ph-Ph min) and higher than 1.2 × Iload Max and if possible equal to 6 × (ID>1).

Explanations of the values:

1. ID>1 shall be higher than 120% of the highest phase to neutral fault to not operate in case of phase to neutral fault.
2. Slope k1 recommendation is 10% to meet class 10P current transformers
3. Slope k2 (ID>2) recommendation is 50 / 65%

To be always stable in the worth CT ratio conditions (between the biggest CT and the smallest CT). 60% is OK as long as the CT ratio is less than 5.

1. ID>2 shall be lower than 80% of the minimum phase to phase fault current to operate sub-cycle for the minimum fault and higher than 120% Iload Max (120% to allow 20% margin) and if possible equal to 6 × (ID>1) to be insensitive to the worth CT saturation.
2. IDCZ>2 same as ID>2
3. Slope kCZ (IDCZ>2) recommendation is 30%

The requirement is to be able to trip for a fault that is counted twice by the Check Zone (for example one and half circuit breaker substation).

2.3 Additional Protection Settings

2.3.1 Dead Zone Protection (DZ)

On a feeder, if the isolators or the breaker is open, a dead zone (or end zone) is said to exist between the open element and the CT. The P746 can protect this zone with the Dead Zone protection. This is a simple time delayed overcurrent element which is only active when a dead zone is identified in the local topology. It is checked by comparison to the CZ differential to avoid maloperations due to invalid position indication.

2.3.1.1 Setting Guidelines

For each CT connected to a Feeder Circuit Breaker (not on bus couplers or bus sections)

For the phase:

- I>DZ must be below 80% of the minimum Dead Zone fault level (and if possible bigger than the maximum load).
- I>DZ Time delay must be at least 50ms longer than the CB status delay (time between breaker closing and 52a/52b changing state) when used. If CB status is not used this is normally set to 0s.

Important	When a feeder isolator is closed and the feeder breaker is open, if a dead zone fault occurs and the bias current flowing through the bus is small, there could be a maloperation of the 87BB. To prevent that, it is recommended to enable an additional criterion such as voltage (voltage criteria can be used for single busbar only in one box mode).

2.3.2 Circuit Breaker Fail (CBF)

2.3.2.1 Setting Guidelines

Typical timer settings to use are as follows:

CB fail reset mechanism	tBF time delay	Typical delay for 2 cycle circuit breaker
CB open	CB auxiliary contacts opening/ closing time (max.) + error in tBF timer + safety margin	50 + 10 + 50 = 110 ms
Undercurrent elements	CB interrupting time + undercurrent element (max.) + safety margin operating time	50 + 15 + 20 = 85 ms

The examples above consider direct tripping of a 2-cycle circuit breaker. Note that where auxiliary tripping relays are used, an additional 10-15ms must be added to allow for trip relay operation.

The phase undercurrent settings (I<) must be set less than load current, to ensure that I< operation indicates that the circuit breaker pole is open. A typical setting for overhead line or cable circuits is 20% In, with 5% In common for generator circuit breaker CBF.

Table 2 - Typical Timer Settings

2.3.2.2 External Backtrip Order

When a direct backtrip order needs to be used to trip a dedicated zone, the following PSL shall be used:

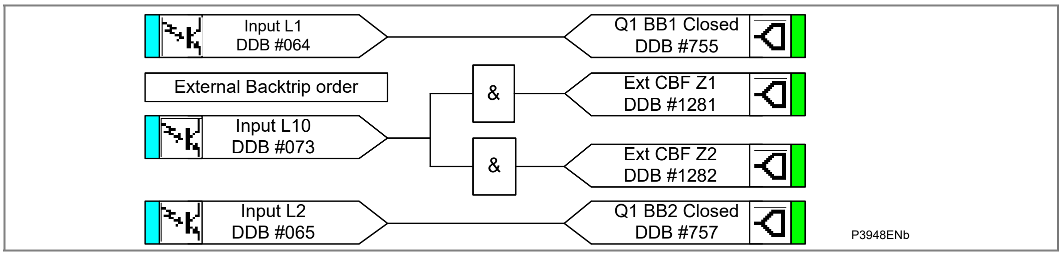


Figure 7 - External backtrip order

3 CURRENT TRANSFORMERS

A P746 can accommodate different CT ratios throughout the protected zone, the maximum difference being 40. In other words, the maximum ratio between the smallest primary CT winding and the biggest primary CT winding is 40. This mix must, therefore, be accounted for by the scheme and this is achieved by using the primary currents for scheme calculations.

In the P746, a virtual current transformer is used as reference for secondary values.

The ratio of the virtual CT (Iref) is fixed to 2000/1.

4 ISOLATOR AND CIRCUIT BREAKER FUNCTION

4.1 Isolator State Monitoring Features

The P746 protections require a reliable indication of the state of the isolators to decide which breaker to trip in case of fault. The relay can incorporate isolator state monitoring, giving an indication of the position of the isolator, or, if the state is unknown, an alarm can be raised using the following PSL:

4.1.1 Use of One Position Information Only

The use of the open position (89b) is highly recommended.

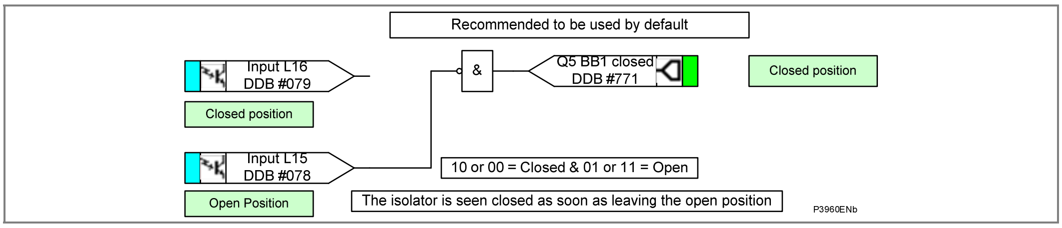


Figure 8 - One position information

In this case, in the P746 topology, the position will be forced to closed as the isolator leaves the open position.

4.1.2 Use of the Two Positions Information

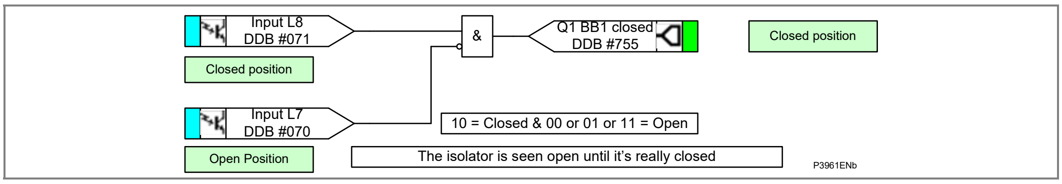


Figure 9 - Two positions information

In that case, in the P746 topology, the position will be forced as open as soon as the isolator will leave the closed position.

This is not recommended as the P746 may trip in 2 steps instead of 1 in case of a fault appearing during the closing period of the isolator.

4.1.3 Use of the Two Positions Information

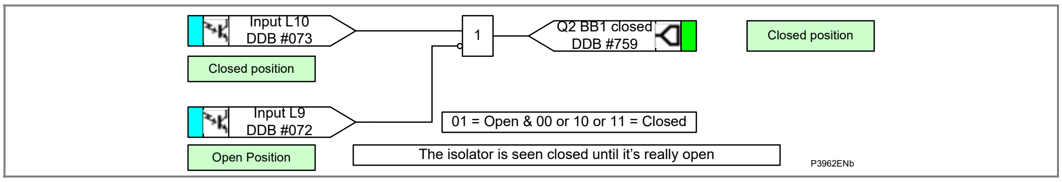


Figure 10 - Use of two positions information

In that case, in the P746 topology, the position will be forced as closed as soon as the isolator will leave the open position.

4.1.4 Use of the Two Positions Information

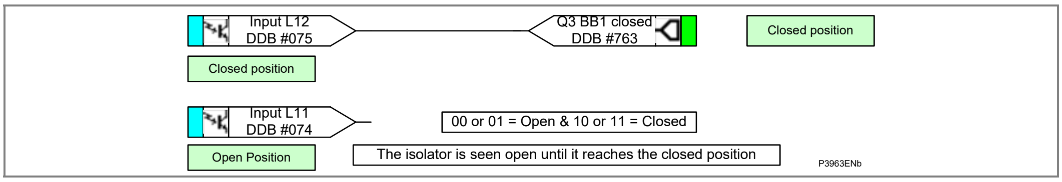


Figure 11 - Use of two positions information

In that case, in the P746 topology, the position will be seen closed only when the isolator will arrive at the closed position.

This is not recommended as the P746 may trip in 2 steps instead of 1 in case of a fault appearing during the closing period of the isolator.

4.1.5 Use of the Two Positions Information

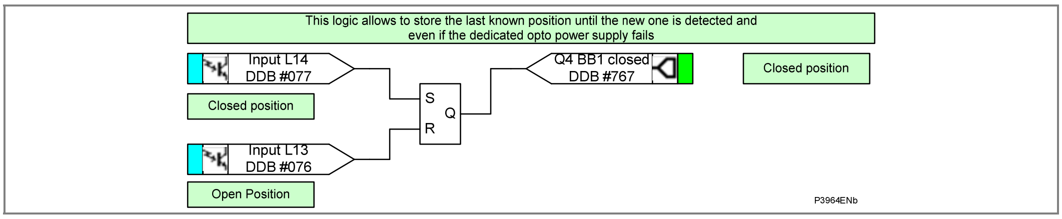


Figure 12 - Use of two positions information

In that case, in the P746 topology, the position will be seen as closed only when the isolator arrives at the closed position and seen as open only when the isolator arrives at the open position.

This is not recommended as the P746 may trip in 2 steps instead of 1 in case of a fault appearing during the closing period of the isolator.

4.1.6 Isolator Supervision Alarm

When using both positions information, an alarm can be raised when the 00 or 11 combination is present during a certain time:

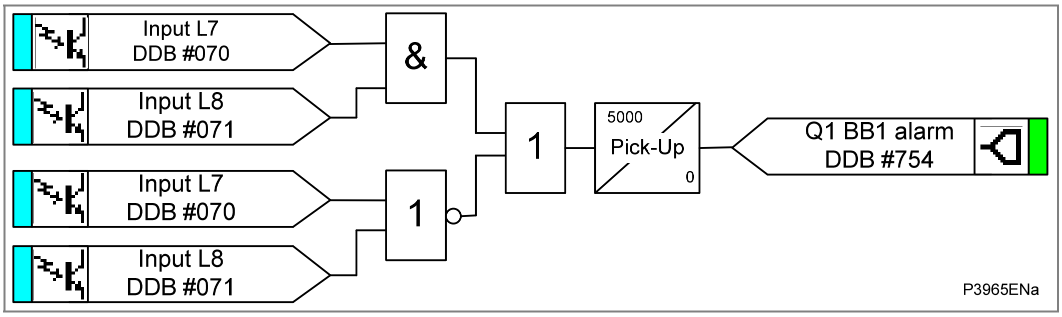


Figure 13 - Isolator supervision alarm

4.2 Circuit Breaker State Monitoring

An operator at a remote location requires a reliable indication of the state of the switchgear. Without an indication that each circuit breaker is either open or closed, the operator has insufficient information to decide on switching operations. The relay incorporates circuit breaker state monitoring, giving an indication of the position of the circuit breaker, or, if the state is unknown, an alarm is raised.

4.3 Trip Circuit Supervision (TCS)

The trip circuit, in most protective schemes, 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 (TCS) schemes with various features can be produced with the P746. Although there are no dedicated settings for TCS, in the P746, the following schemes can be produced using the Programmable Scheme Logic (PSL). A user alarm is used in the PSL to issue an alarm message on the relay front display. This can be named by setting the User Alarm Label to indicate that there is a fault with the trip circuit.

4.3.1 TCS Scheme 1

4.3.1.1 Scheme Description

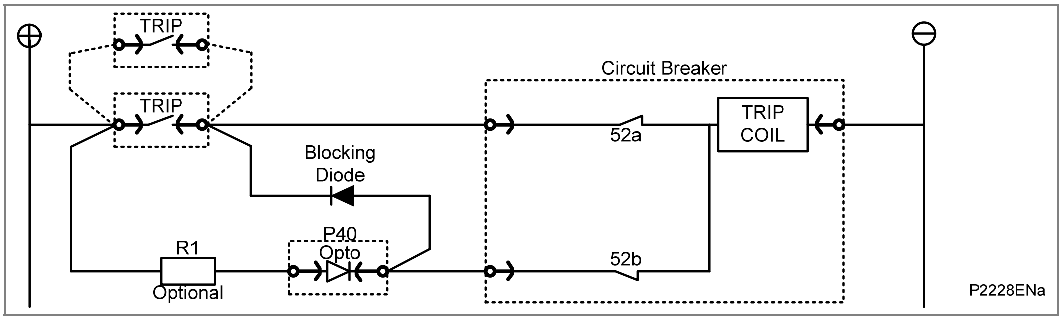


Figure 14 - TCS scheme 1

This scheme provides supervision of the trip coil with the breaker open or closed, however, pre-closing supervision is not provided. This scheme is also incompatible with latched trip contacts, as a latched contact will short out the opto for greater than the recommended DDO timer setting of 400ms. If breaker status monitoring is required a further 1 or 2 opto inputs must be used.

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

When the breaker is closed, supervision current passes through the opto input, blocking diode and trip coil. When the breaker is open current still flows through the opto input and into the trip coil via the 52b auxiliary contact. Hence, no supervision of the trip path is provided whilst the breaker is open. Any fault in the trip path will only be detected on CB closing, after a 400ms delay.

Resistor R1 is an optional resistor that can be fitted to prevent maloperation of the circuit breaker if the opto input is inadvertently shorted, by limiting the current to <60mA. The resistor should not be fitted for auxiliary voltage ranges of 30/34 volts or less, as satisfactory operation can no longer be guaranteed. The table below shows the appropriate resistor value and voltage setting (**Opto Config.** menu) for this scheme.

This TCS scheme will function correctly even without resistor R1, since the opto input automatically limits the supervision current to less that 10mA. However, if the opto is accidentally shorted the circuit breaker may trip.

Auxiliary Voltage (Vx)	Resistor R1 (ohms)	Opto Voltage Setting with R1 Fitted
24/27	-	-
30/34	-	-
48/54	1.2k	24/27
110/250	2.5k	48/54
220/250	5.0k	110/125

Note *When R1 is not fitted the opto voltage setting must be set equal to supply voltage of the supervision circuit.*

Table 3 - Scheme 1 optional R1 opto input resistor values

4.3.2 Scheme 1 PSL

The next figure shows the scheme logic diagram for the TCS scheme 1. Any of the available opto inputs can be used to show whether or not the trip circuit is healthy. The delay on drop off timer operates as soon as the opto is energized, but will take 400ms to drop off/reset in the event of a trip circuit failure. The 400ms delay prevents a false alarm due to voltage dips caused by faults in other circuits or during normal tripping operation when the opto input is shorted by a self-reset trip contact. When the timer is operated the NC (normally closed) output relay opens and the LED is reset.

The 50ms delay on pick-up timer prevents false LED indications during the relay power up time, following an auxiliary supply interruption.

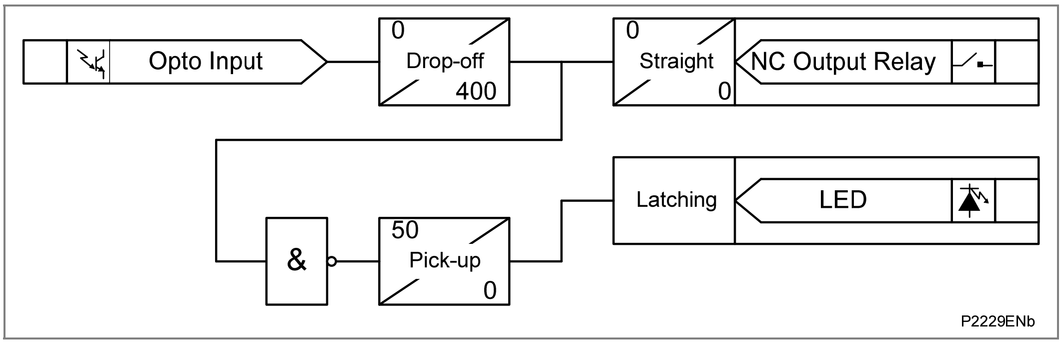


Figure 15 - PSL for TCS schemes 1 and 3

4.3.3 TCS Scheme 2

4.3.3.1 Scheme Description

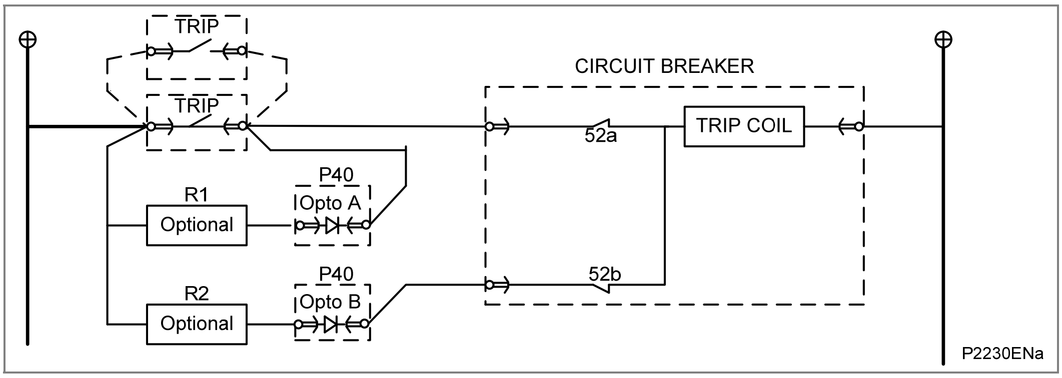


Figure 16 - TCS scheme 2

Much like scheme 1, this scheme provides supervision of the trip coil with the breaker open or closed and also does not provide pre-closing supervision. However, using two opto inputs allows the relay to correctly monitor the circuit breaker status since they are connected in series with the CB auxiliary contacts. This is achieved by assigning Opto A to the 52a contact and Opto B to the 52b contact. This scheme is also fully compatible with latched contacts as the supervision current will be maintained through the 52b contact when the trip contact is closed.

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

As with scheme 1, optional resistors R1 and R2 can be added to prevent tripping of the CB if either opto is shorted. The resistor values of R1 and R2 are equal and can be set the same as R1 in scheme 1.

4.3.4 Scheme 2 PSL

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

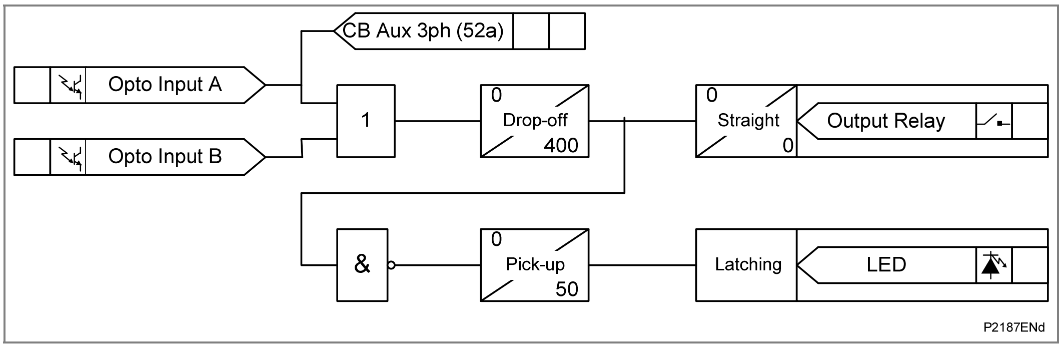


Figure 17 - PSL for TCS scheme 2

4.3.5 TCS Scheme 3

4.3.5.1 Scheme Description

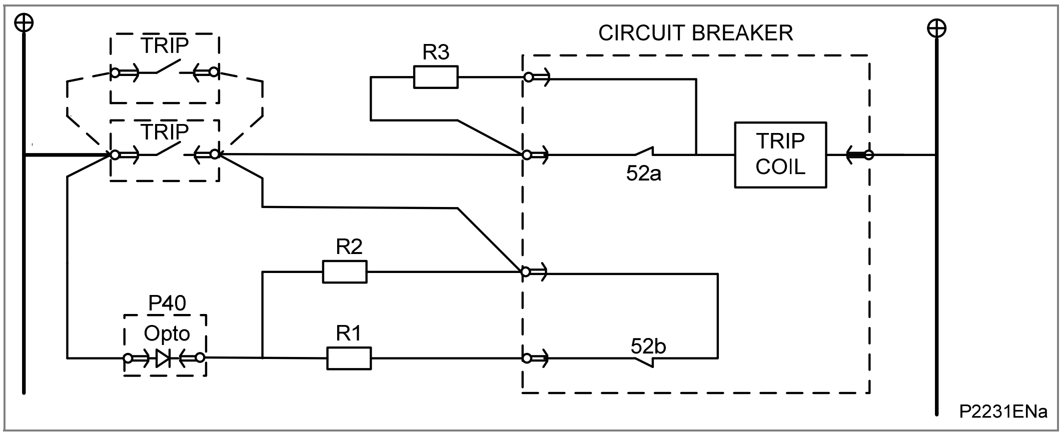


Figure 18 - TCS scheme 3

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

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

As with schemes 1 and 2, resistors R1 and R2 are used to prevent false tripping, if the opto-input is accidentally shorted. However, unlike the other two schemes, this scheme is dependent upon the position and value of these resistors. Removing them would result in incomplete trip circuit monitoring. The table below shows the resistor values and voltage settings required for satisfactory operation.

Auxiliary Voltage (Vx)	Resistor R1 & R2 (ohms)	Resistor R3 (ohms)	Opto Voltage Setting
24/27	-	-	-
30/34	-	-	-
48/54	1.2k	0.6k	24/27
110/250	2.5k	1.2k	48/54
220/250	5.0k	2.5k	110/125

Note *Scheme 3 is not compatible with auxiliary supply voltages of 30/34 volts and below.*

Table 4 - Scheme 3 optional R1, R2 & R3 opto input resistor values

4.3.6 Scheme 3 PSL

The PSL for scheme 3 is identical to that of scheme 1.

4.4 Test Zone Mode

The scheme permits maintenance on the busbar and, or busbar protection whilst maintaining some form of protection if possible. The maintenance mode level in the P746 allows this to be possible and forces the scheme to a reduced operating mode as follows:

87BB Blocked & 50BF disabled:It's a per zone selection.

In this mode, the busbar conditions are monitored but all trips are inhibited for the selected zone.

When a zone is in this mode, the P746 does take into account the local currents and topology and keeps the other zone in normal service.

The signal of zone trip Tx and Zone trip BBxx to the breakers connected to that selected zone will not operate.

A Bus can be tested locally and secondary injection tests can be carried out because the P746 is in 87BB&50BF blocked mode for the selected zone

On a genuine fault on that zone the P746 will not send a 87BB or 50BF backtrip order

5 BENEFITS OF SECTIONALIZED BUSBAR PROTECTION

P746 range of subcycle busbar protection relays are designed and proven for its sensitivity and fast operation for all type of internal faults. P746 ensures the required stability for all the external faults even with extremely high magnitude of fault currents. P746 can be utilized in centralized schemes as per the requirements of the project.

P746 can protect up to 4 zones and 21 feeders with all type of physical layouts like single busbar, double busbar, busbars with reserve bus, one and half breaker schemes etc…

5.1 Limitation of the Number of Feeders

5.1.1 Bias Characteristics

In low impedance busbar schemes, spill current during load or fault conditions due to Imag, CT error, remanence flux, different CT ratios are taken care by the bias characteristics, where the differential settings of the discriminative and check zone will increase based on the restraining current by a factor of the % slope.

> **Disc. Zone – Diff. setting =** Ibias of main zone × slope % or ID>2, whichever is higher.
>
> **Check.Zone – Diff. setting =** Ibias of check zone × slope% or ID>2, whichever is higher.

When bias current increases differential setting will increase proportionately by the factor of slope. In other words bias characteristics provides more stability (to take care of spill) and reduce the sensitivity; however the tripping will occur for internal faults if it falls under operating region

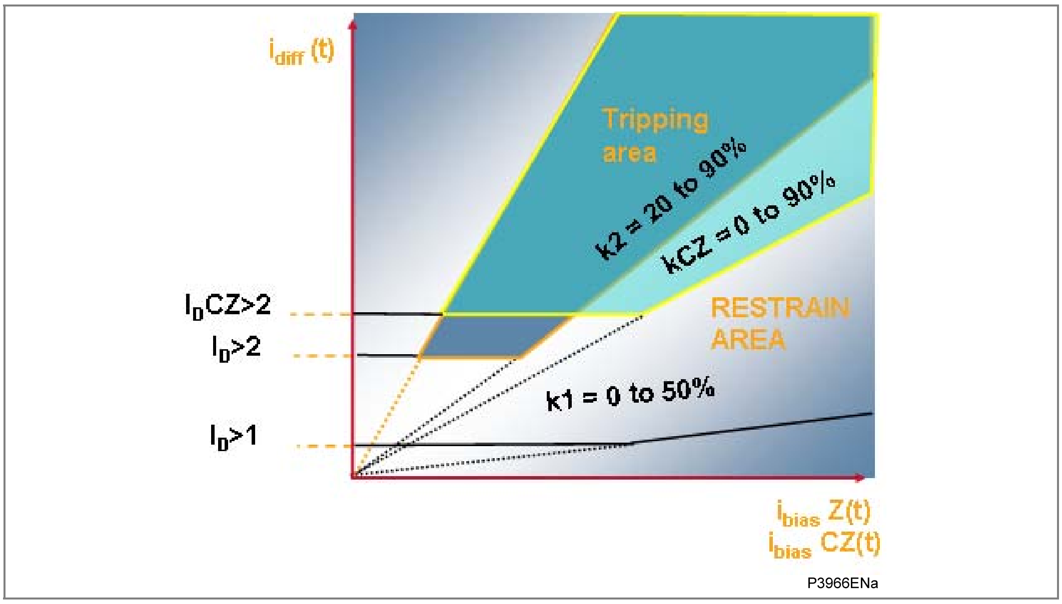


Figure 19 - Bias characteristics graph

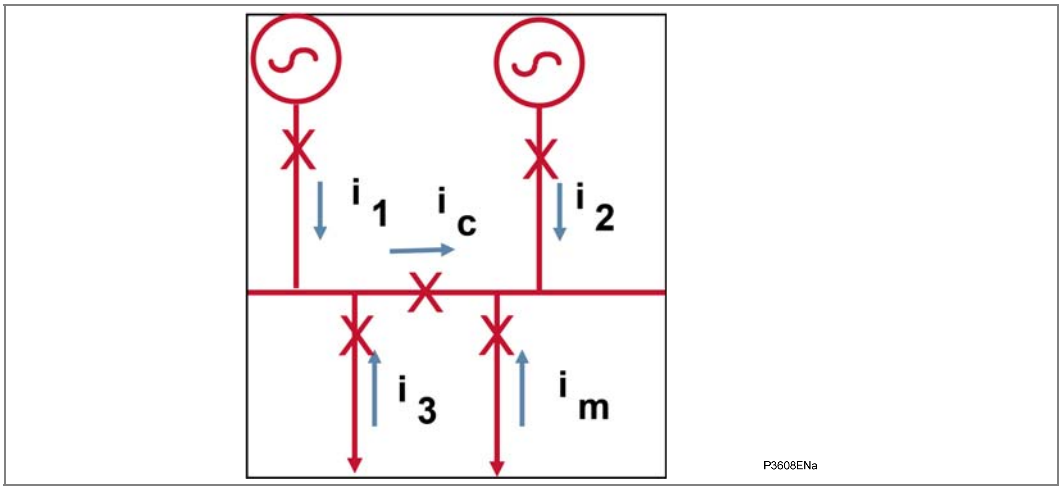


Figure 20 - Bias characteristics circuit diagram

5.1.2 Bias Current in Discriminitative Zones

Magnitude of bias current in discriminative zones will be equal to scalar sum of all the currents entering / leaving that particular zone ONLY.

Zone 1 Bias current: ibiasZ(t) = |i1| + | i3| + … + |ic| = Σ |in1|

Zone 2 Bias current: ibiasZ(t) = |ic| + |i2| + |im| = Σ |in2|

For Example:

Let's consider we have total 8 feeders , and among that we have 5 feeders connected to zone1 / bus1. All the currents involved in that zone1 will be summated as zone1 bias current. If the remaining 3 feeders are connected to zone2 / bus2, all the currents in that zone2 will be summated as zone2 bias current.

5.1.3 Bias Current in Check Zone

Magnitude of bias current in check zone will be equal to scalar sum of all the currents entering / leaving the WHOLE substation (the current flowing into coupling is not used)

CZ Bias current: ibiasCZ(t) = |iFeeder1| + … + |iFeederm| = Σ |iFeederm|

For Example:

Let's consider we have a total of 8 feeders in the station and current through all the outgoing / incoming feeders will be summated and will be considered as check zone bias current. Hence the differential current setting at any point of time could be different for discriminative zones and check zone, based on the bias of discriminative zones and check zone.

5.2 Disadvantages of Busbar Schemes with Check Zone AND High Number of Feeders

5.2.1 Effect on Check Zone Sensitivity

Let’s consider double busbar system, where bus1 has least number of feeders (say 5 feeders) with weak source and busbar 2 has more number of feeders (say 30 feeders). check zone (CZ) bias current will be extremely large since it sums up all the currents entering / leaving the station. When there is a fault in bus1, discriminative zone 1 will operate considering the zone1 bias current, whereas check zone will need higher differential current for the same fault since the bias current for the same situation could be very huge.

This reduction in sensitivity will affect the operation of CZ element based on the level of biasing which is based on the number of feeders, ID>CZ and slope kCZ. In certain cases it can even lead to non-operation of the CZ element during an internal fault.

It’s generally not recommended to use check zone with large number of feeders (typically more than 18) for a low impedance biased differential scheme

5.2.2 Effect of Spill Current in Check Zone

When high numbers of CTs (typically more than 21) are connected to check zone, more spill current is expected during load conditions. Hence, CT circuitry fault setting needs to be set with caution and should be more than the standing spill current in order to avoid spurious blocking of busbar element. But at the same time, the setting should be lower than the minimum loaded feeder current setting. In most cases it may be difficult to satisfy the requirements.

Moreover spill current will increase when the busbar is extended with additional feeders, where the characteristics of new CTs are different from the existing CTs , and it may aggravate the situation.

5.2.3 Contingency During Relay / CT Failure

When CT circuit supervision operates or relay fails in the non segregated busbar schemes it would affect the check zone and completely block the busbar protection. With the help of segregated busbar schemes, effect will be limited to one section of the busbar protection only.

5.3 Benefits of Sectionalized Busbar Protection

5.3.1 Improved Sensitivity for Check Zone

When the busbar protection is segregated in to two or more sections, restraining quantities of the CZ for the individual sections are reduced significantly compared to the check zone of the complete substation. At the same time, check zone element will maintain its inherent advantages but with more sensitivity. Hence it is advantageous to use sectionalized busbar schemes for stations with large number of CTs.

5.3.2 Sectionalizing During Failure of Relays / CTs

When we sectionalize the busbar protection with two or more P746 schemes, the failure or any relay or CT in one section will not block/affect the scheme on the other sections. Sectionalized Busbar Protection is analogous to the primary plant sectionalizing which allows one section to remain in service when there is a fault on another section.

5.3.3 Simplified Topology

In the topology of the P746, it will be very easy to handle the layout since the topology for both sides will be fully independent to each other. Hence extension / addition / modification of bays will be easy and secured.

5.4 Conclusion

With the above advantages and proven experience of P746 busbar protection, Schneider Electric recommend to use the sectionalized busbar protection scheme. Implementing the sectionalized busbar scheme will provide more benefits in all aspects with all the inherent features of typical busbar scheme.

6 TOPOLOGY

The topological analysis of the state of the substation in real time is one of the primary factors of the reliability of numerical differential busbar protection. Thus in the case of a power system fault, this analysis determines the sections of the substation concerned with the fault and only takes those sections out of service. The algorithms available for topological analysis make this level of discrimination possible and it is these algorithms that are used in the scheme.

6.1 Topology Configuration

The P746 topology is determined by replication of the circuit, i.e. the connections between the various pieces of plant on the system. This topological replication is carried out from the setting information in SYSTEM CONFIG:

Note	*Connection No 1 is on the right and increases to the left up to 7 for one box mode and up to 21 for three boxes mode.*

BB1 Terminals xxxxxxx to be set to 1 if the terminal connection can be to BB1

BB2 Terminals xxxxxxx to be set to 1 if the terminal connection can be to BB2

BB3 Terminals xxxxxxx to be set to 1 if the terminal connection can be to BB3

BB4 Terminals xxxxxx xto be set to 1 if the terminal connection can be to BB4

ChZONE Terminal to be set to 1 if the terminal connection is a feeder.
If there is no bus coupling, it is an isolator only or it is a breaker only, the coupler CT related setting will be none.

Important	***For the above settings, any digit set in any zone must be copied into the ChZONE digits.***

6.1.1 Topology Example

Z1 Terminals 0001011for Zone 1

Z2 Terminals 0001100 for Zone 2

Z3 Terminals 0000000 for Zone 3

Z4 Terminals 0000000 for Zone 4

ChZONE Terminal 0001111 for the Check Zone

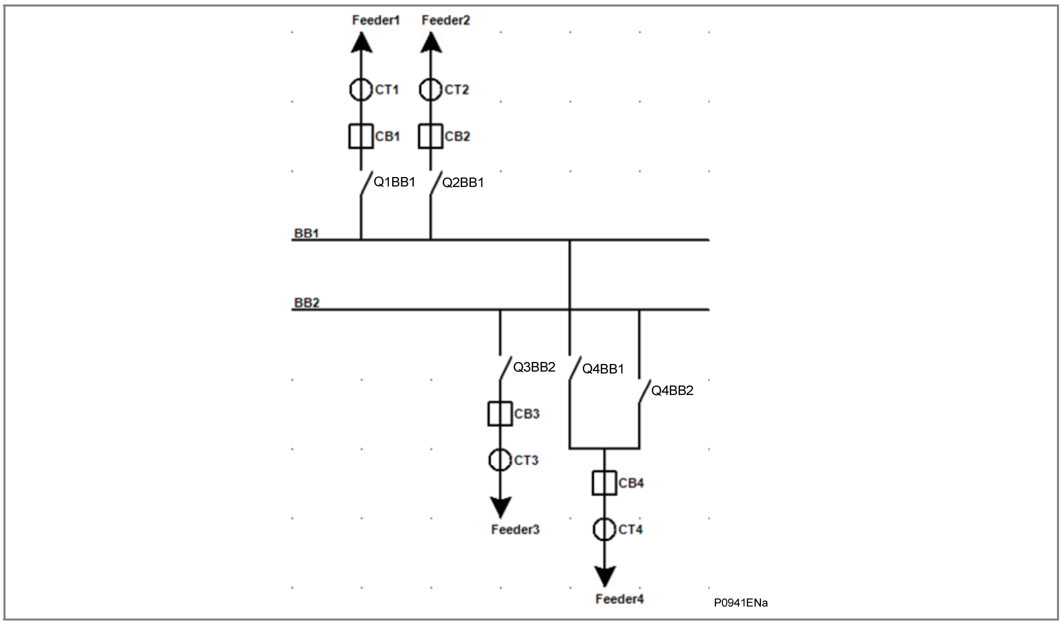


Figure 21 - Topology Example

6.1.2 For Bus Coupling by Breaker with 1 CT

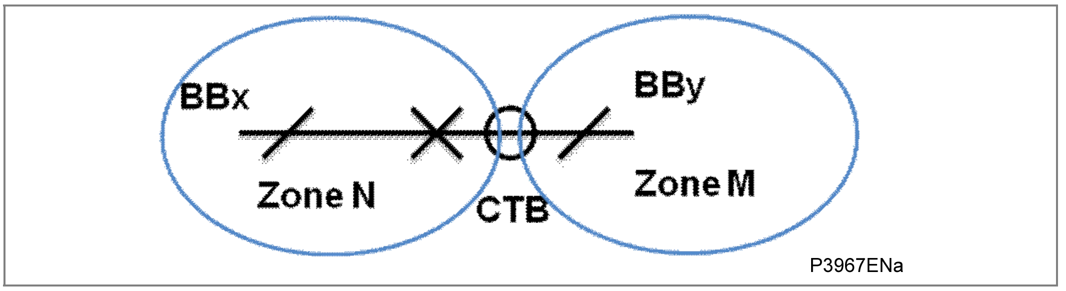


Figure 22 - Bus coupling

BBxy coupling by	Breaker and Isolators
BBxy Bus BBx CT/	No CT
BBxy:BBx CT Pol	Invisible
BBxy Bus BBy CT/	CTB
BBxy:BBy CT Pol	Standard / Inverted

In the topology, for this coupler:

- Zone N will ends at CTB (BBxy Bus CT/BBy) and the polarity of the CTB in Zone N will be the same as the setting of BBxy:BBy CT Pol,
- Zone M will ends at CTB (BBxy Bus CT/BBy) and the polarity of the CTB in Zone M will be opposite with the setting of BBxy:BBy CT Pol.

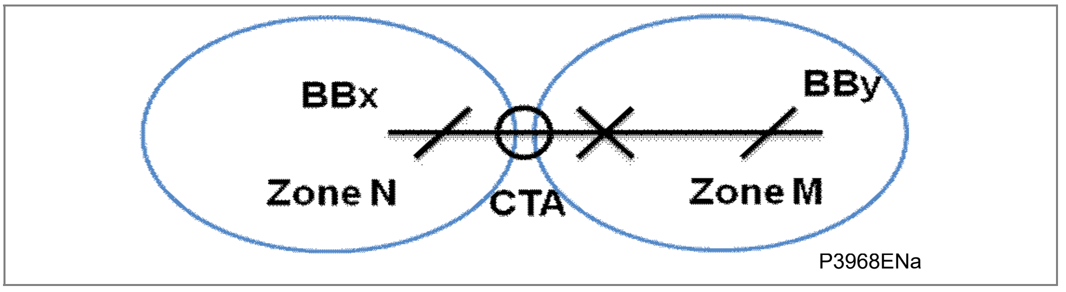


Figure 23 - Bus coupling

BBxy coupling by	Breaker and Isolators
BBxy Bus CT/BBx	CTA
BBxy:BBx CT Pol	Standard / Inverted
BBxy Bus CT/BBy	No CT
BBxy:BBy CT Pol	Invisible

In the topology, for this coupler:

- Zone M will ends at CTA(BBxy Bus CT/BBx) and the polarity of the CTA in Zone M will be the same as the setting of BBxy:BBx CT Pol,
- Zone N will ends at CTA(BBxy Bus CT/BBx) and the polarity of the CTA in Zone N will be opposite with the setting of BBxy:BBx CT Pol.

6.1.2.1 Examples

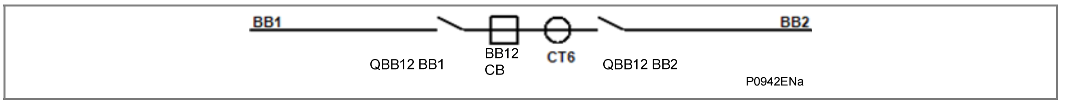


Figure 24 - Bus coupling example

BB12 coupling by	Breaker and Isolators
BB12 Bus BB1 CT/	No CT
BB12:BB1 CT Pol	“Invisible”
BB12 Bus BB2 CT/	CT6
BB12:BB2 CT Pol	Standard

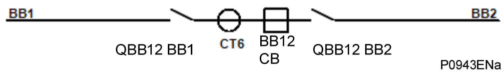


Figure 25 - Bus coupling example

BB12 coupling by	Breaker and Isolators
BB12 Bus BB1 CT/	CT6
BB12:BB1 CT Pol	Standard
BB12 Bus BB2 CT/	No CT
BB12:BB2 CT Pol	“Invisible”

6.1.3 For Bus Coupling by Breaker and 2 CTs

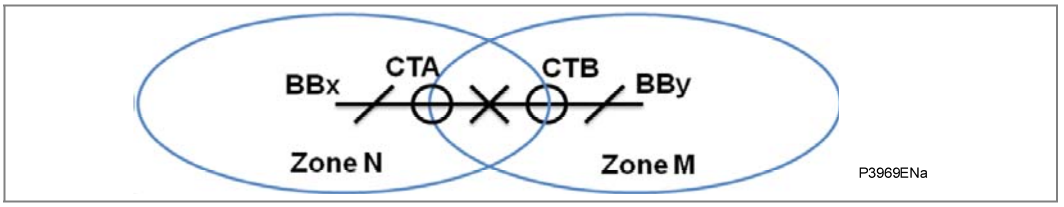


Figure 26 - Bus Coupling

BBxy coupling by	Breaker and Isolators
BBxy Bus CT/BBx	CTA
BBxy:BBx CT Pol	Standard
BBxy Bus CT/BBy	CTB
BBxy:BBy CT Pol	Standard

In the topology, for this coupler,

- Zone N will ends at CTB(BBxy Bus CT/BBy) and the polarity of the CTB in Zone N will the same as the setting of BBxy:BBy CT Pol,
- Zone M will ends at CTA(BBxy Bus CT/BBx) and the polarity of the CTA in Zone M will the same as the setting of BBxy:BBx CT Pol,

6.1.3.1 Example

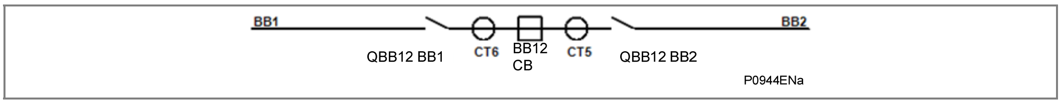


Figure 27 - Bus coupling example

BB12 coupling by	Breaker and Isolators
BB12 Bus BB1 CT/	CT6
BB12:BB1 CT Pol	Standard
BB12 Bus BB2 CT/	CT5
BB12:BB2 CT Pol	Standard

6.2 Topology Monitoring Tool

This tool is part of the Easergy Studio pack. This topological monitoring is carried out from a single line diagram of the system, which is used to recreate the system using the topology configuration software. This can be carried out by customer.

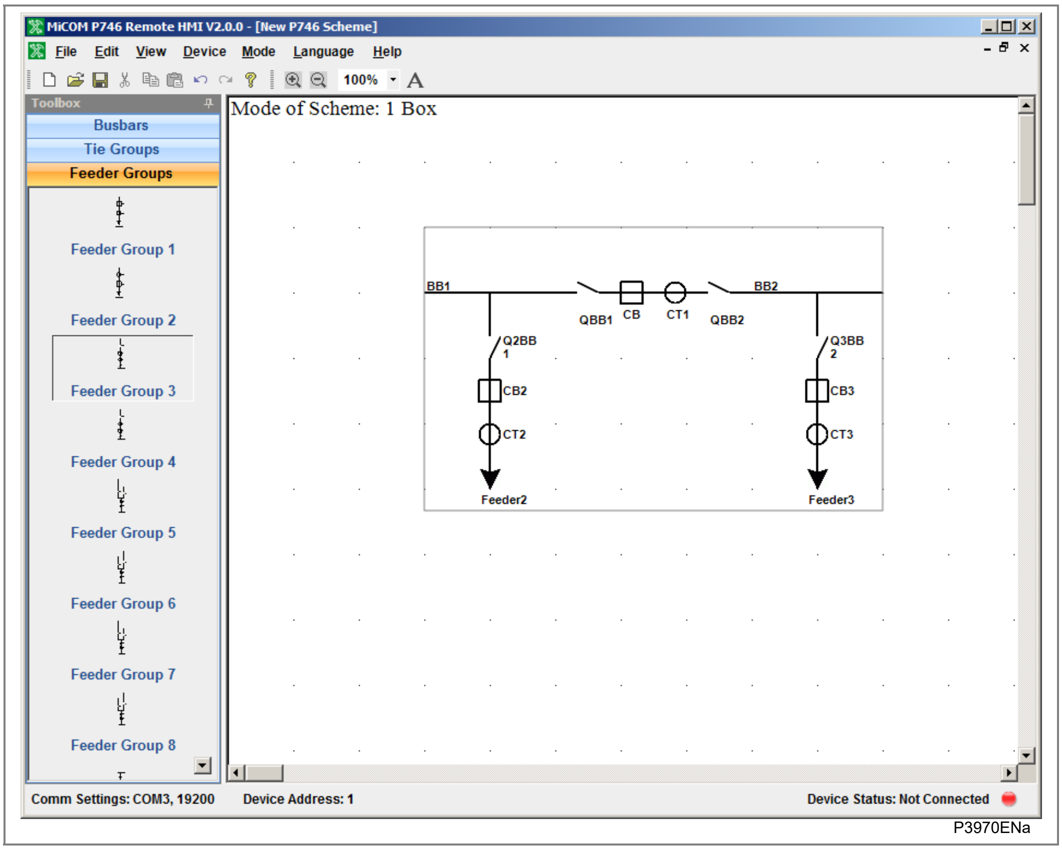


Figure 28 - P746 Scheme editor

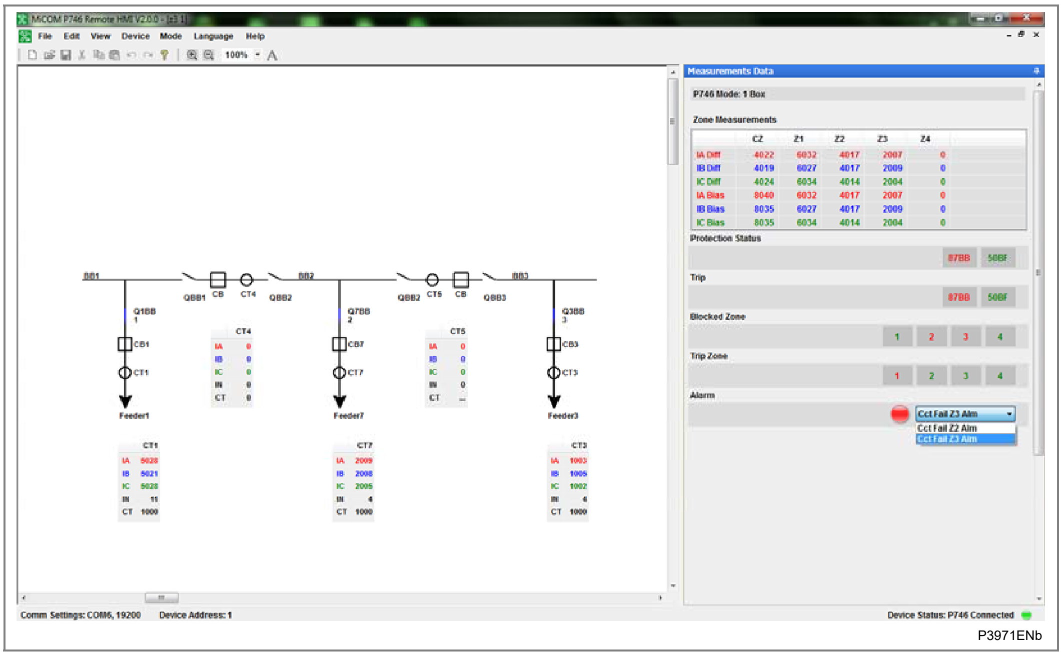


Figure 29 - P746 synoptic

The topology configuration tool uses standard symbols for creating the system model by simply dragging and dropping in the configuration screen.

6.3 Topology Processing

The following scenarios demonstrate how the dynamic topology processing works and accommodates anomalies and discrepancies in the scheme.

6.3.1 Sectionalised Single Bus

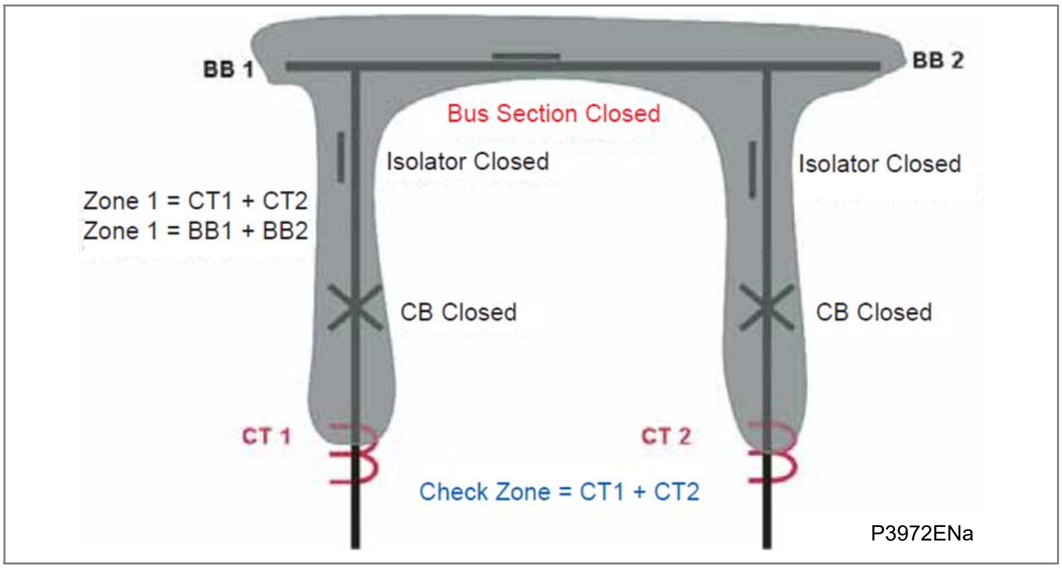


Figure 30 - Bus section closed

A zone is defined from a CT to an other CT or an open electrical element (coupler CB or isolator).

As all the breakers and isolators are closed there is only one zone including BB1 and BB2

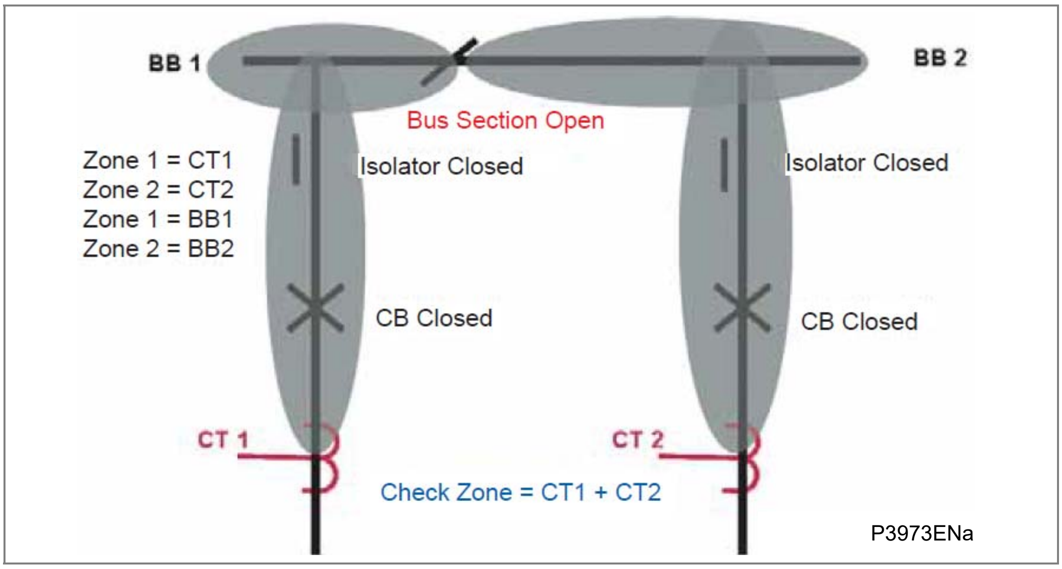


Figure 31 - Bus section open

A zone is defined from a CT to an other CT or an open electrical element (coupler CB or isolator).
When the bus section is open, a zone is created from each bar feeder CT to that open bus section.
There is one zone for BB1 and one zone for BB2.

6.3.2 Single Bus with One CT Bus Coupler

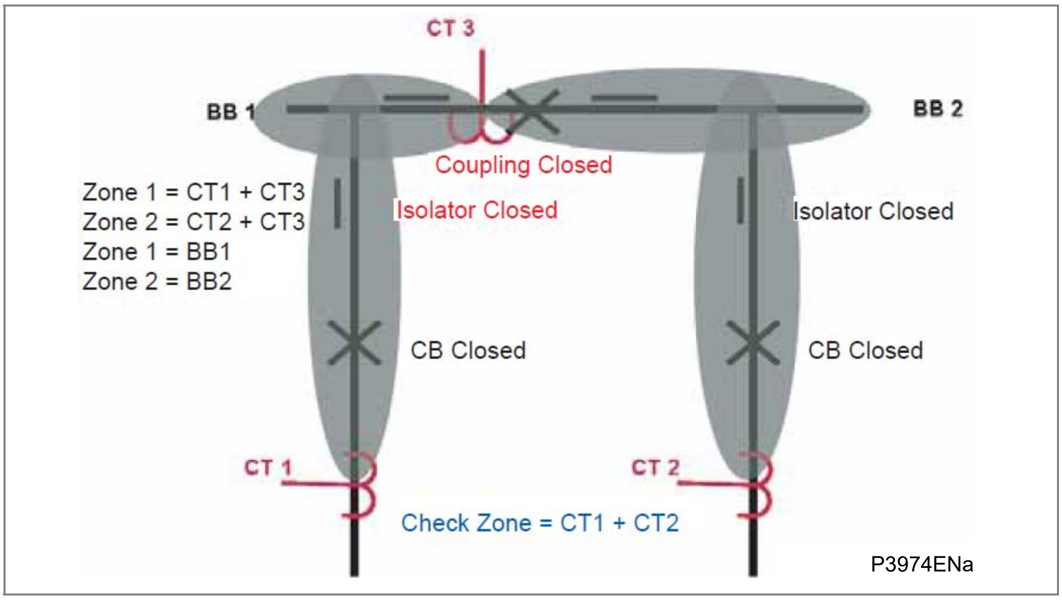


Figure 32 - Bus coupler closed

A zone is defined from a CT to an other CT or an open electrical element (coupler CB or isolator).
When one CT is used in the coupling and the coupler CB is closed, a zone is created from each bar feeder CT to that coupler CT.
There is one zone for BB1 to CT3 and one zone for BB2 to CT3.

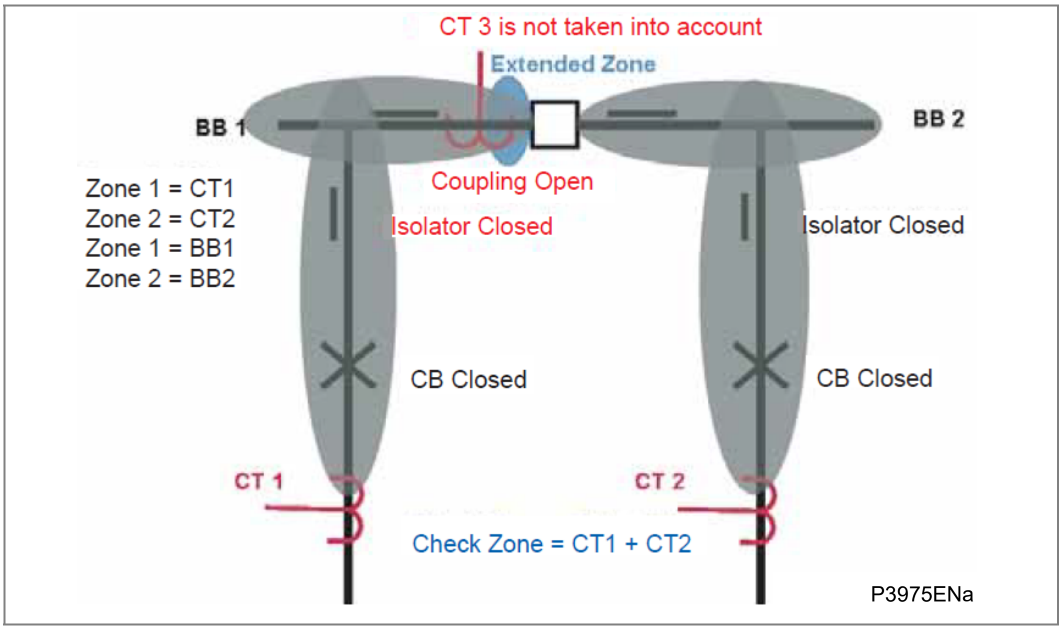


Figure 33 - Bus coupler open

A zone is defined from a CT to an other CT or an open electrical element (coupler CB or isolator).
When one CT is used in the coupling and the coupler CB is open, the coupler CT measurement is not taken into account and a zone is created from each bar feeder CT to that open coupler CB.
There is one zone for BB1 and one zone for BB2.

6.3.3 Single Bus with Two CT Bus Coupler

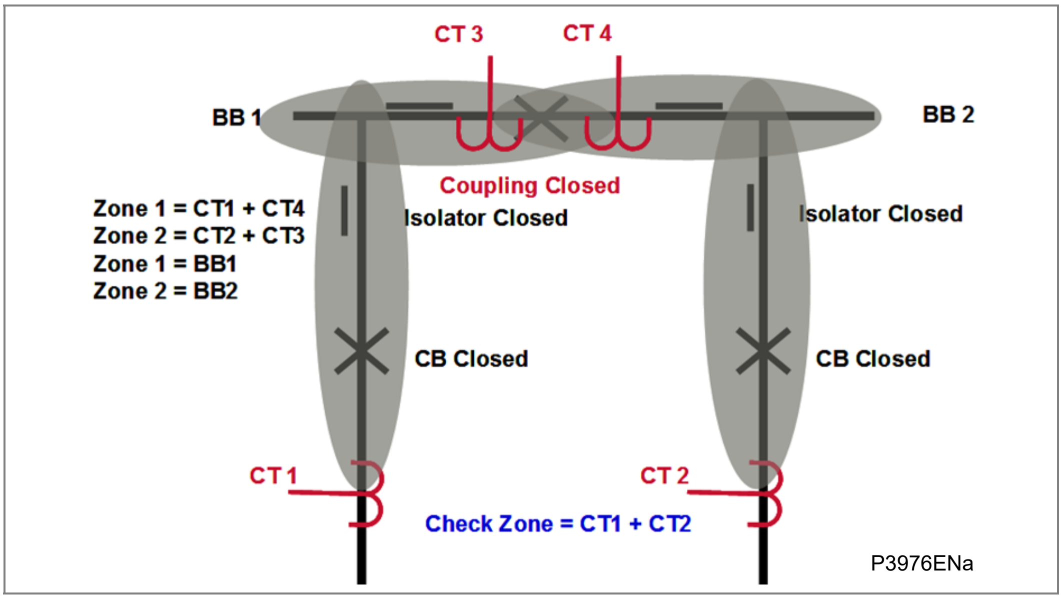


Figure 34 - Bus coupler closed

A zone is defined from a CT to an other CT or an open electrical element (coupler CB or isolator).
When 2 CTs are used in the coupling and the coupler CB is closed, a zone is created from each bar feeder CT to the opposite coupler CT.
The zone between the 2 coupler CTs belongs to both zones.
There is one zone for BB1 to CT4 and one zone for BB2 to CT3.

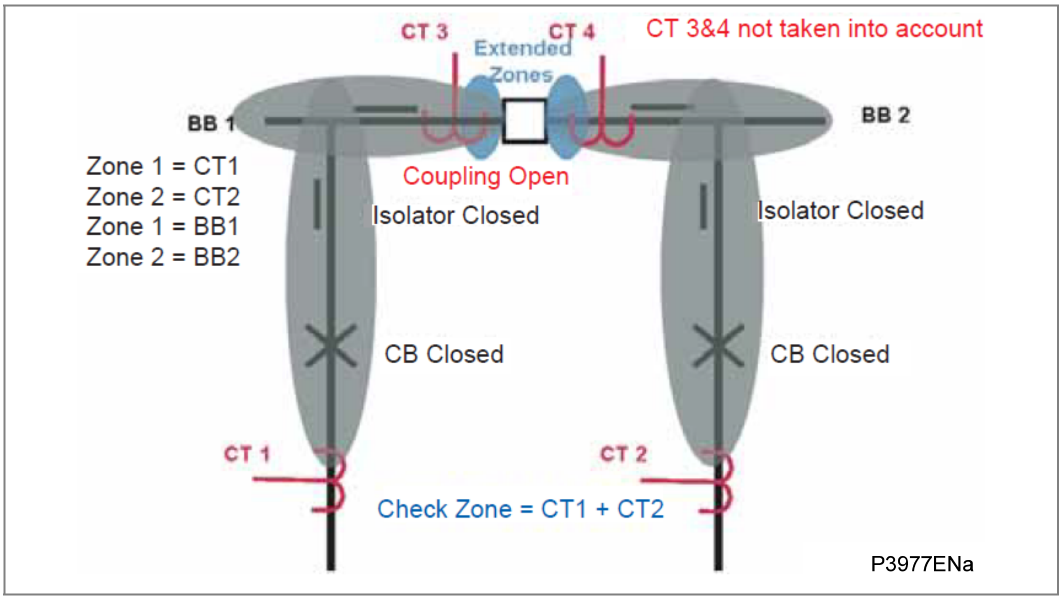


Figure 35 - Bus coupler open

A zone is defined from a CT to an other CT or an open electrical element (coupler CB or isolator).

When 2 CTs are used in the coupling and the coupler CB is open, the coupler CTs measurements are not taken into account and a zone is created from each bar feeder CT to that open coupler CB.

There is one zone for BB1 and one zone for BB2.

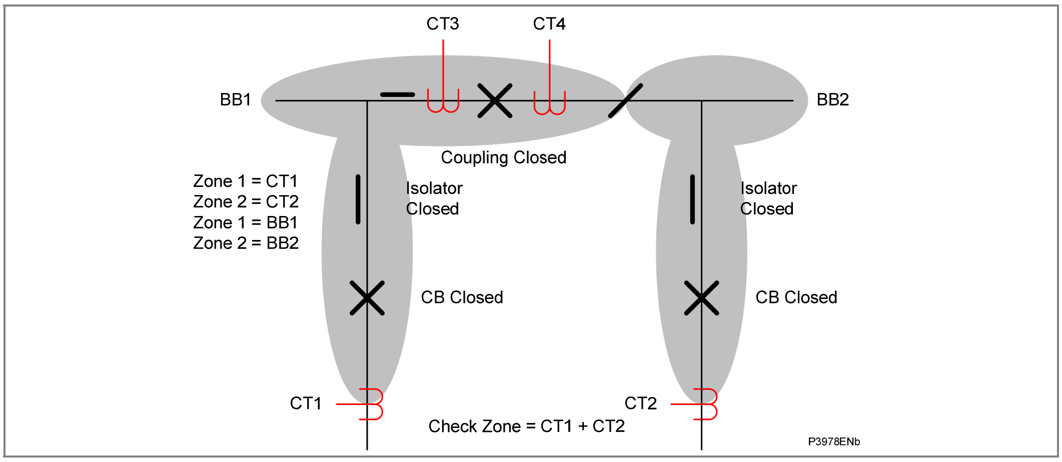


Figure 36 - Bus coupler closed and one isolator open

A zone is defined from a CT to an other CT or an open electrical element (coupler CB or isolator).

When 2 CTs are used in the coupling and the coupler CB is closed but a coupler isolator is open, the coupler CTs measurements are not taken into account and a zone is created from each bar feeder CT to that open coupler isolator.

The zone between the 2 coupler CTs belongs to the closed isolator zone.

There is one zone for BB1 to the open isolator and one zone for BB2 to the open isolator.

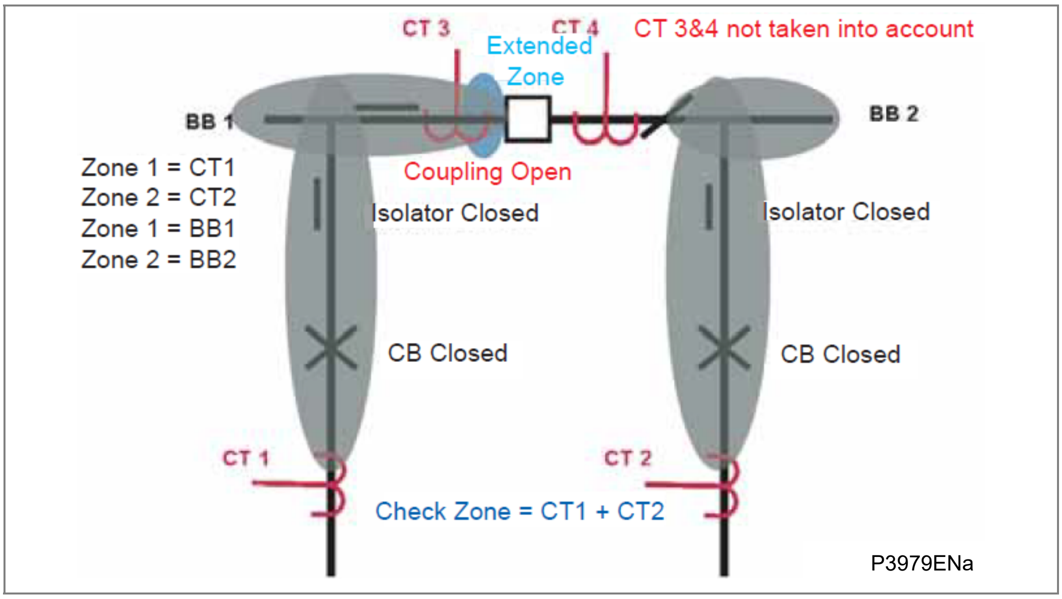


Figure 37 - Bus coupler and one isolator open

A zone is defined from a CT to an other CT or an open electrical element (coupler CB or isolator).

When 2 CTs are used in the coupling and the coupler CB is open and a coupler isolator is open, the coupler CTs measurements are not taken into account and a zone is created from each bar feeder CT to the open CB coupler and to the open coupler isolator.

The zone between the 2 coupler CTs belongs to the closed isolator zone.

There is one zone for BB1 to the open breaker and one zone for BB2 to the open isolator.

6.3.4 CTs on One Side of Bus Coupler

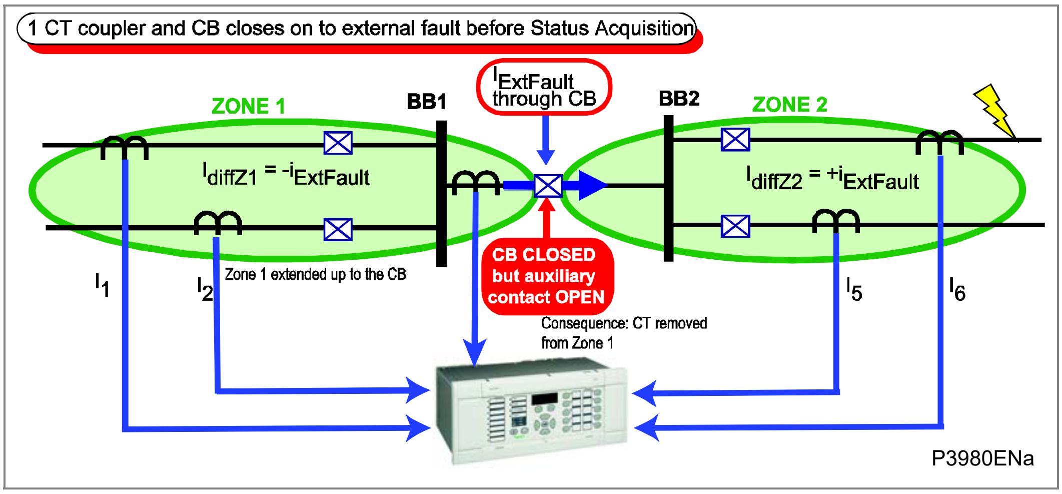


Figure 38 - CTs on one side of bus coupler, CB closes before status acquisition

As the CB has closed but the status has not yet been refreshed the topology still believes the CB to be open.

Treating this as an open bus coupler circuit breaker the topology algorithm will have extended Zone 1(with the area located between the CT and the circuit breaker). This then fully replicates the scheme up to the open bus coupler CB on both sides.

If the circuit breaker was open no load current would flow through the circuit breaker. The differential current in the two main zones would equal zero, as the current flowing into the zones would still equal the current flowing out.

However, if the circuit breaker is actually closed, the external fault current will flow through the circuit breaker. The differential current in main zone 1 and in main zone 2 will be equal in magnitude but opposite in sign. ($\pm_{fault}$)

When the check zone element is calculated, the differential currents seen in zone 1 and 2, which result from the discrepancy in the plant status, can be seen to be cancelled out.

Zone 1 $I_{diff} = I_1 + I_2 = i_{diff}Z1 = -i_{fault} > (I_D\text{>}2 \text{ and } k2 \times I_{Bias})$

Zone 2 $I_{diff} = I_5 + I_6 = i_{diff}Z2 = +i_{fault} > (I_D\text{>}2 \text{ and } k2 \times I_{Bias})$

Check Zone $I_{diff} = I_1 + I_2 + I_5 + I_6 = (-i_{fault}) + (+i_{fault}) = 0$

Again the system retains its stability for discrepancies in plant status (even when switching onto through faults).

Zone Pickups can be avoided by also connecting a CB close signal from the coupler to the BBxx CB Closed status input. This changes the topology before the breaker is closed which will provide discrimination even when closing onto a busbar fault.

6.3.5 CTs on Both Sides of Bus Coupler, CB Closes Before Status Acquisition

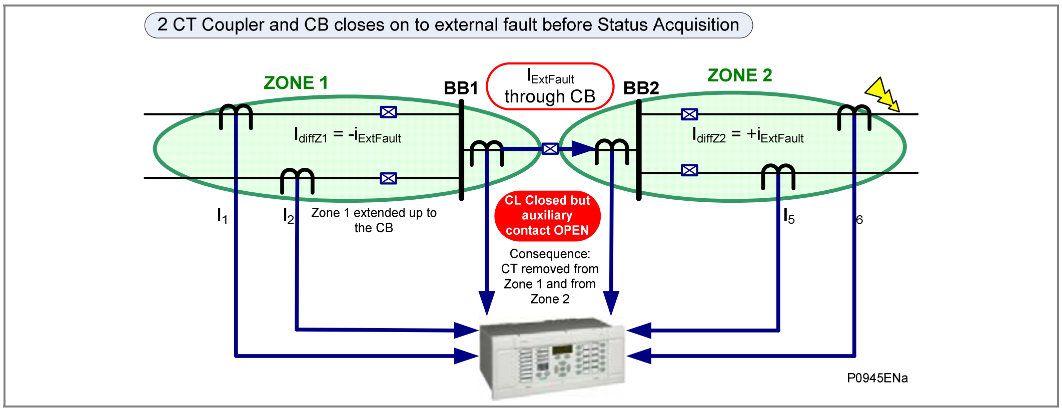


Figure 39 - CTS on both sides of bus coupler, CB closes before status acquisition

As the CB has closed but the status has not yet been refreshed the topology still believes the CB to be open.

Treating this as an open bus coupler the topology algorithm will have extended the two zones with the areas located between the CTs and the circuit breaker. These then fully replicate the scheme up to the open bus coupler CB on both sides.

If the circuit breaker was open no load current would flow through the circuit breaker. The differential current in the two main zones would equal zero, as the current flowing into the zones would still equal the current flowing out.

However, if the circuit breaker is actually closed, the external fault current will flow through the circuit breaker. The differential current in the two main zones will be equal in magnitude but opposite in sign. ($\pm i_{fault}$).

When the check zone element is calculated, the differential currents seen in the two main zones, which result from the discrepancy in the plant status and which are taken into account for the check zone calculation, can be seen to be cancelled out.

Zone 1 $I_{diff} = I_1 + I_2 = i_{diff}Z1 = -i_{fault} > (I_D>2$ and $k2 \times I_{Bias})$

Zone 2 $I_{diff} = I_5 + I_6 = i_{diff}Z2 = +i_{fault} > (I_D>2$ and $k2 \times I_{Bias})$

Check Zone $I_{diff} = I_1 + I_2 + I_5 + I_6 = (-i_{fault}) + (+i_{fault}) = 0$

Hence, the system retains its stability even when there are discrepancies in plant status.

6.3.6 CTs on One Side of Bus Coupler, CB Closed and Fault Evolves Between CT and CB (Even for Switch Onto Fault)

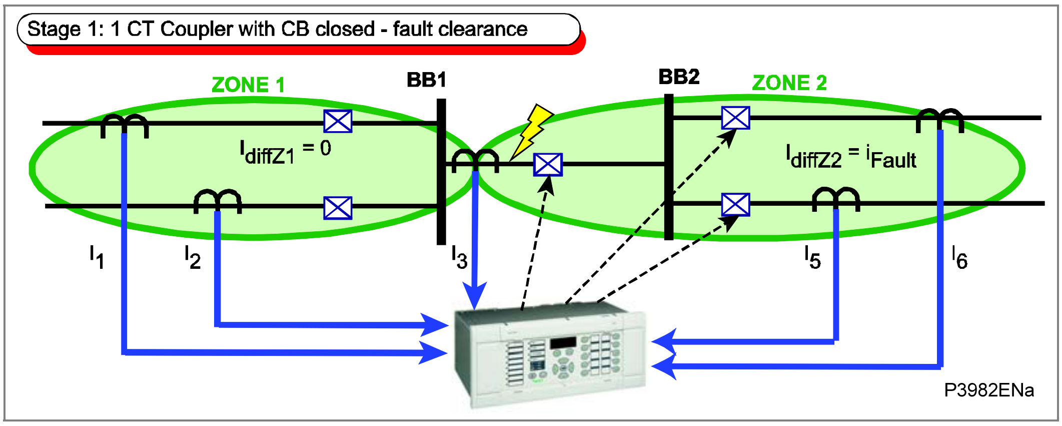


Figure 40 - CTs on one side of bus coupler, CB closed and fault occurs between the CB and the CT

Treating this as a closed bus section circuit breaker the topology algorithm will have extended the limits of the main zones to the bus coupler CT. This then fully replicates the scheme.

Under normal operating conditions when the circuit breaker is closed load current would flow through the circuit breaker and differential current in the two main zones would equal zero, as the current flowing into the zones would still equal the current flowing out.

However, if a fault occurs between the CT and the circuit breaker, the current will flow from zone 1 into zone 2 which feeds the fault. The differential current in main zone 1 will still equal zero, as the current flowing into the zone 1 will still equal the current flowing out, but the differential current measured in zone 2 will be equal to that of the fault current.

In this case, zone 2 would operate as will the check zone element.

Zone 1 $I_{diff} = I_1 + I_2 + I_3 = i_{diff}Z1 = 0$

Zone 2 $I_{diff} = I_3 + I_5 + I_6 = i_{diff}Z2 = i_{fault} > (I_D>2$ and $k2 \times I_{Bias})$

Check zone $I_{diff} = I_1 + I_2 + I_5 + I_6 = i_{diff}Z2 = i_{fault} > (I_DCZ>2$ and $kCZ \times I_{Bias})$

However, when zone 2 trips the fault will still be present. The topology then analyses the remainder of the system as follows.

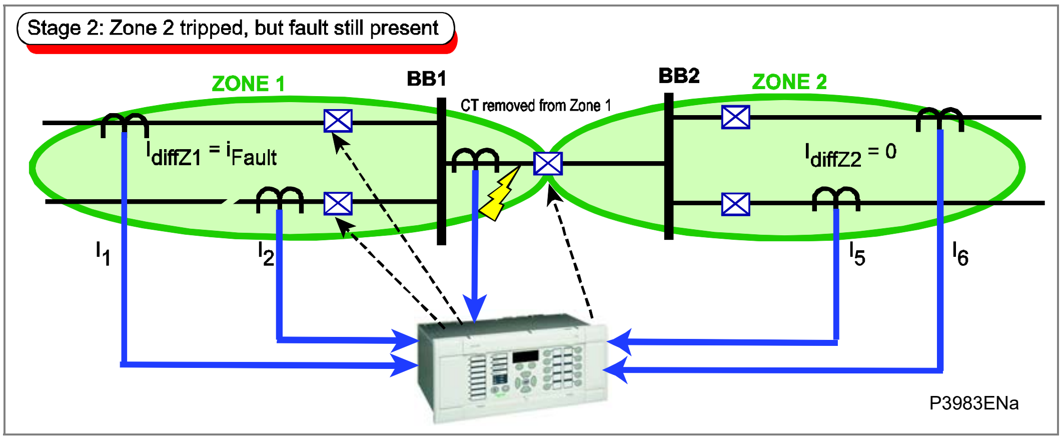


Figure 41 - Zone 2 tripped, fault still present

Treating this as an open bus coupler circuit breaker as before the topology algorithm will have extended zone 1 with the area located between the CT and the circuit breaker. This then fully replicates the scheme up to the open bus coupler CB. Remember that in this example zone 2's limit extended up to the circuit breaker but this zone has been tripped already.

The circuit breaker is now open and the fault current would flow to feed the fault. The differential current in the main zone 2 would equal zero, as the current is flowing into zone 1 whereas the current measured will be equal to the fault current i_{fault}.

Zone 2 $I_{diff} = I_5 + I_6 = i_{diff}Z2 = 0$

Zone 1 $I_{diff} = I_1 + I_2 = i_{diff}Z1 = i_{fault} > (I_D{>}2$ and $k2 \times I_{Bias})$

Check zone $I_{diff} = I_1 + I_2 + I_5 + I_6 = i_{diff}Z1 = i_{fault} > (I_DCZ{>}2$ and $kCZ \times I_{Bias})$

Hence, the system reacts to the continuing presence of the fault and trips the zone 1 as the check zone $I_{diff} > (I_DCZ{>}2$ and $kCZ \times I_{Bias})$ and the zone $I_{diff} > (I_D{>}2$ and $k2 \times I_{Bias})$.

In this example it can be seen that the opposite zone is tripped first but the dynamic topology reacts to the changed scheme and subsequently trips the adjacent main zone.

6.3.7 CTs on both Sides of Coupler, CB Closed and Fault evolves between CT and CB

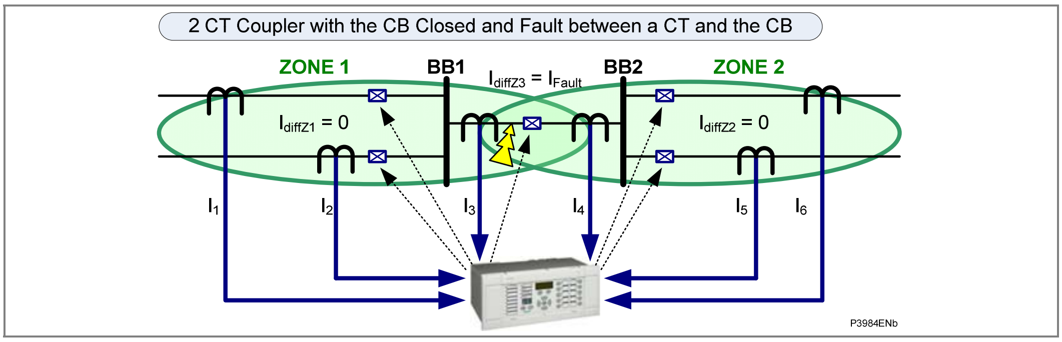


Figure 42 - CTs on both sides of bus coupler, CB closed fault occurs between a CT and the CB

Treating this as a closed bus section circuit breaker the topology algorithm will have created an overlapped zone that surrounds the circuit breaker with the bus coupler CTs as its limits made by zone 1 and 2. This then fully replicates the scheme.

Under normal operating conditions when the circuit breaker is closed load current would flow through the circuit breaker and hence both zones. The differential current in the two main zones would equal zero, as the current flowing into the zones would still equal the current flowing out.

However, if a fault was to occur in the overlapped zone, current would flow into both zones and feed the fault. The differential current in the two main zones will be equal to that of the fault current.

The main zones would operate. When the check zone element is calculated, the differential current which results from the presence of the fault in the coupler, will confirm the presence of a fault and initiate a simultaneous trip of both main.

Zone 1 $I_{diff} = I_1 + I_2 + I_4 = i_{diff}Z1 = i_{fault} > (I_D{>}2$ and $k2 \times I_{Bias})$

Zone 2 $I_{diff} = I_3 + I_5 + I_6 = i_{diff}Z2 = i_{fault} > (I_D{>}2$ and $k2 \times I_{Bias})$

Check zone $I_{diff} = I_1 + I_2 + I_5 + I_6 = i_{diff}Zx = i_{fault}$

Hence, the system reacts to a fault occurring between the CT and the CB simultaneously tripping both zones.

6.3.8 'CB Coupling by' Breaker with One or Without Isolator

By default, when 'Bus Coupling by' setting is "breaker and isolator", it includes, for example, a coupler CB, a bus CT and two isolators.

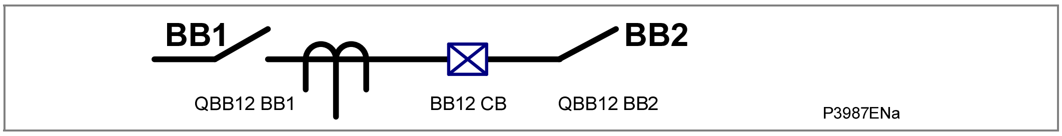


Figure 43 - Example of 'bus coupling by' = breaker

For other configurations (for example, Figure 44), unused isolator DDBs should be mapped to ensure the topology is correct.

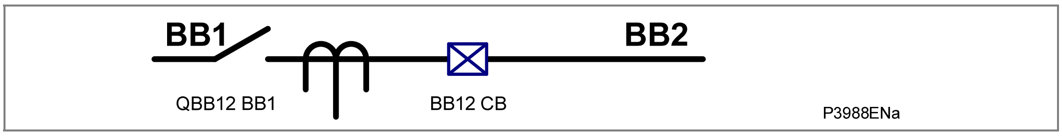


Figure 44 - Example of 'bus coupling by' with one isolator

In this case, the DDB could be changed as follows (the status of 'Q Bus Z2 Closed' is the same as 'Bus CB Closed'):

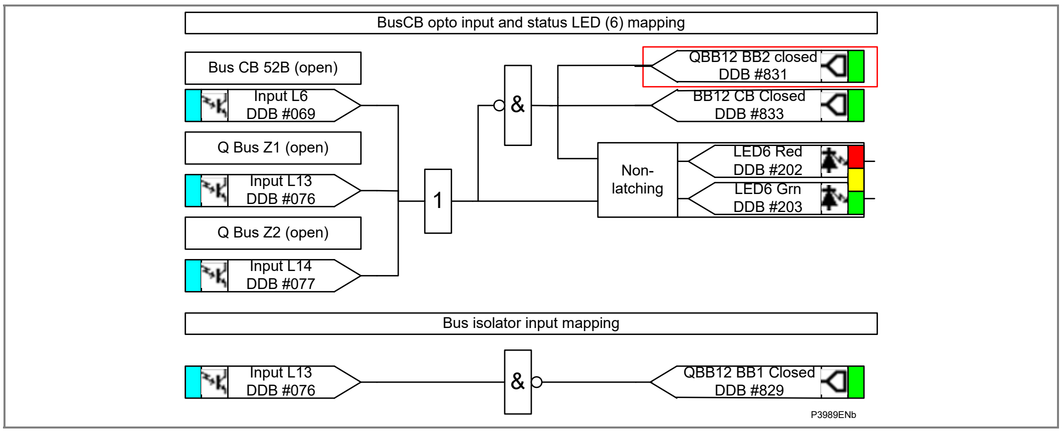


Figure 45 - Example of DDB configuration 'bus coupling by' with one isolator

6.3.9 CB Coupling with Open Isolator

The P746 will detect which busbar the coupler CB is connected to according to the status of the coupler isolators.

The coupler CB is not tripped when one coupler isolator is open while a fault is in the disconnected busbar.

If a fault happens in the un-linked busbar, the coupler CB won't be tripped.

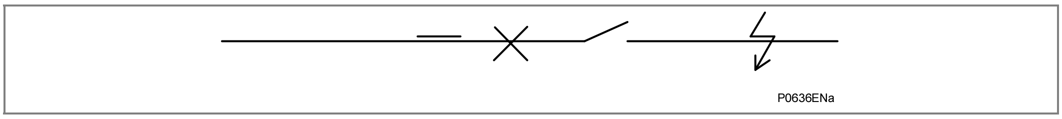


Figure 46 - CB Coupling with Open Isolator

The coupler CB is tripped (even if it is open) when one coupler isolator is open while a fault is in the connected busbar.

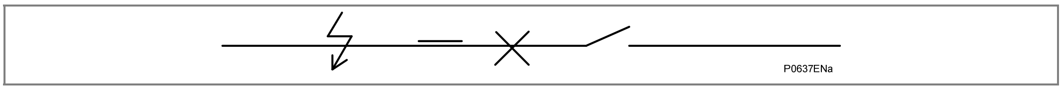


Figure 47 - CB Coupling with Open Isolator

If the coupler CB fails to open, the P746 won't backtrip the un-linked busbar.

If the coupler CB is not ready, the coupler CB won't be tripped as long as the logic given in the default PSL is not removed.

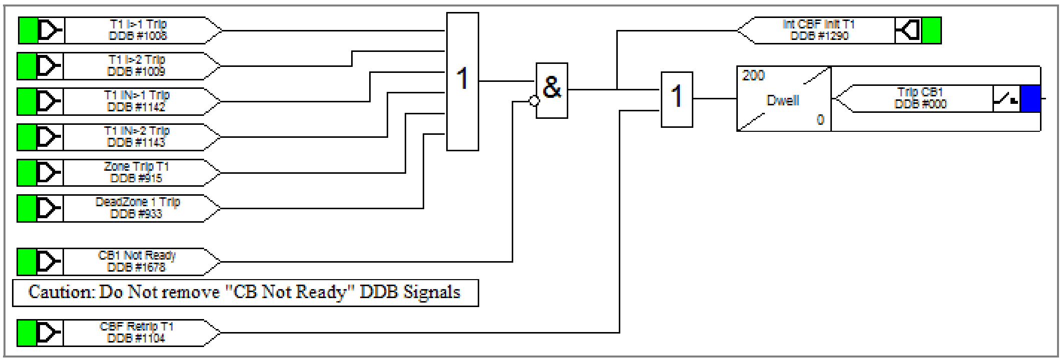


Figure 48 - PSL diagram

7 UNDERTAKING A NUMERICAL DIFFERENTIAL BUSBAR PROTECTION PROJECT

This light Engineering can be done by anyone.
The substation construction will influence the protection scheme installed. It is advisable that a scheme evaluation is conducted as soon as possible, preferably at the same time as the definition of the equipment specification.

7.1 One or Three Box Mode Selection

A P746 embeds 18/21 current inputs and can be connected to 6/7 three phase CTs or 18/21 single phase CTs.
A P746_1 embeds 3 voltage inputs.

7.1.1 P746 Mode Selection

7.1.1.1 1 Zone

Set of CTS	Up to 6/7	Up to 18/21
Set of VTS	0 or 1	0 or 3
Mode	One box mode	Three box mode
Note	1 set of	1 set of

7.1.1.2 2 Zones

Set of CTS	Up to 6/7	Up to 12/14	Up to 18/21	Up to 36/42
Set of VTS	0 or 1	0 to 2	0 or 3	0 or 6
Mode	One box mode		Three box mode	
Note	1 set of	2 set of	1 set of	2 set of

7.1.1.3 3 Zones

Set of CTS	Up to 6/7	Up to 12/14	Up to 18/21	Up to 18/21	Up to 36/42	Up to 54/63
Set of VTS	0 or 1	0 to 2	0 to 3	0 or 3	0 or 6	0 to 9
Mode	One box mode			Three box mode		
Note	1 set of	2 set of	3 set of	1 set of	2 set of	3 set of

7.1.1.4 4 Zones

Set of CTS	Up to 6/7	Up to 12/14	Up to 18/21	Up to 24/28	Up to 18/21	Up to 36/42	Up to 54/63	Up to 72/84
Set of VTS	0 or 1	0 to 2	0 to 3	0 to 4	0 or 3	0 or 6	0 to 9	0 to 12
Mode	One box mode				Three box mode			
Note	1 set of	2 set of	3 set of	4 set of	1 set of	2 set of	3 set of	4 set of

7.2 Application Solutions

7.2.1 1 Box Mode:

All analogue inputs, all digital inputs and all relay outputs are connected to one P746:

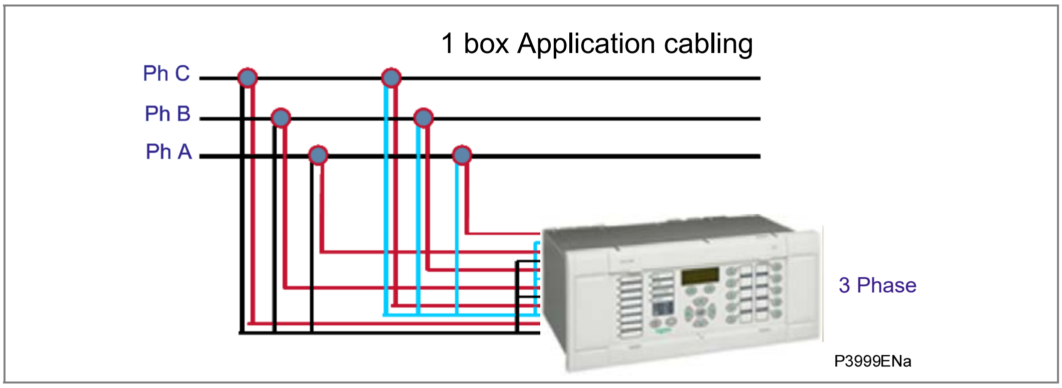


Figure 49 - 1 box application cabling

7.2.2 3 Boxes Mode:

Per phase CT inputs, all digital inputs and all relay outputs are connected to each P746:

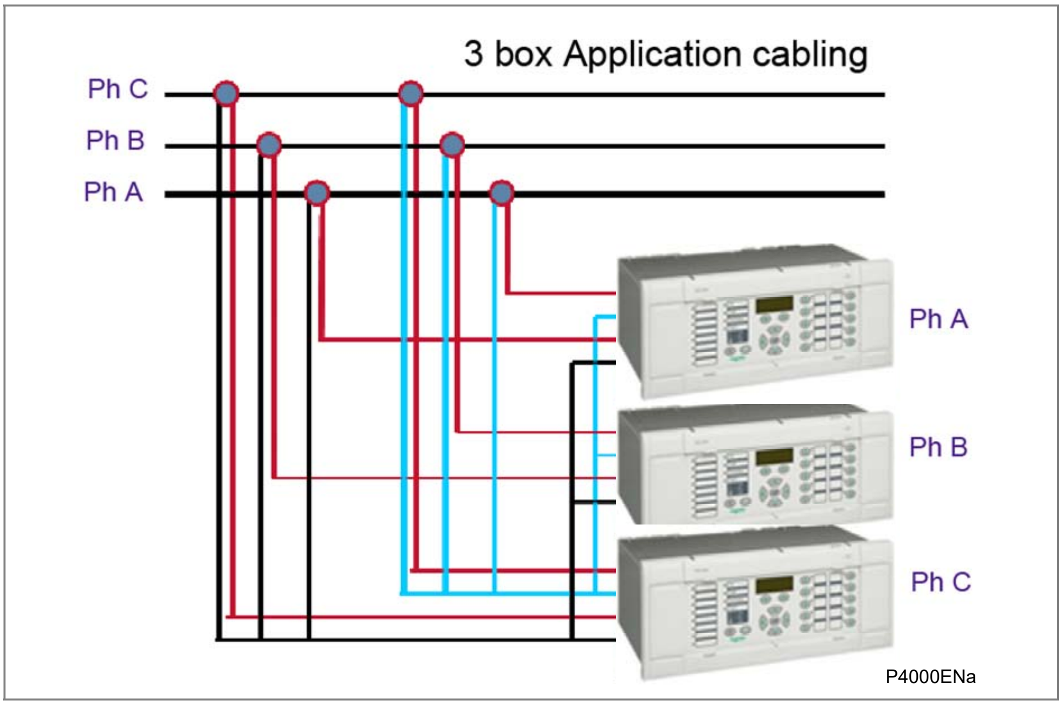


Figure 50 - 3 box application cabling

7.2.3 Voltage Information (P746 with VT only)

When the 3 boxes mode is set, voltage information (based on set criteria) must be shared among the 3 set VT. Hence there can be a maximum of three zones which have voltage information.

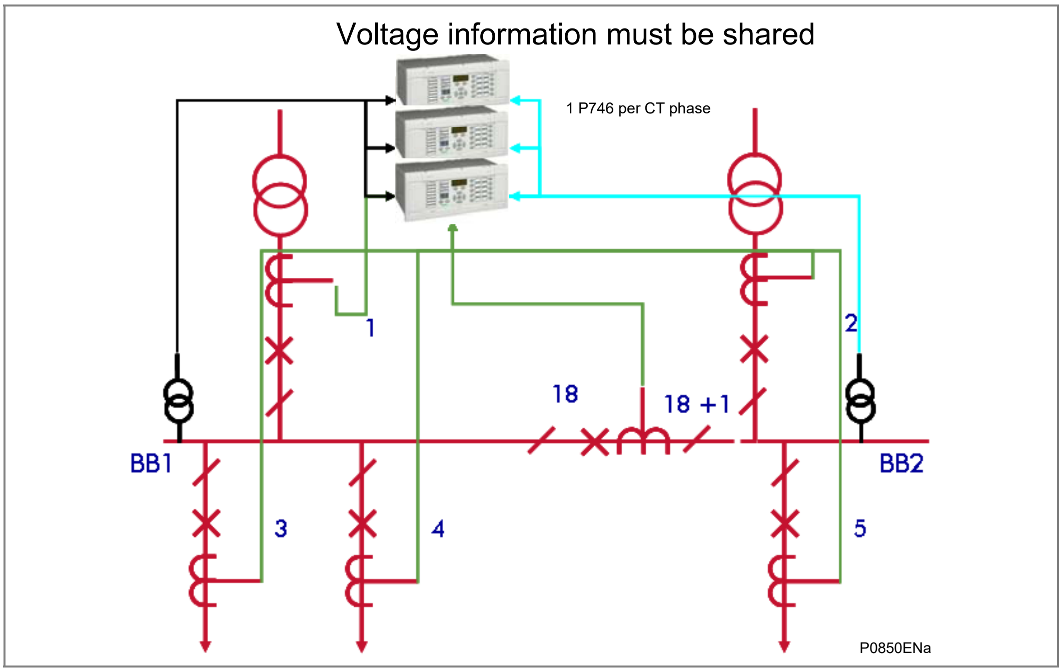


Figure 51 - Voltage information

The information to be shared is the voltage algorithm output that allows the trip.

There are up to four DDB outputs:

- VT Check Allow Zone 1
- VT Check Allow Zone 2
- VT Check Allow Zone 3
- VT Check Allow Zone 4

To be linked (inverted) to up to four DDB inputs:

- Block Bus Diff Zone 1
- Block Bus Diff Zone 2
- Block Bus Diff Zone 3
- Block Bus Diff Zone 4

To do so, the blocking information has to be sent from the connected P746 to the other ones with the following methods:

7.2.3.1 GOOSE Messages with IEC 61850 (Recommended):

This is an example for Figure 51:

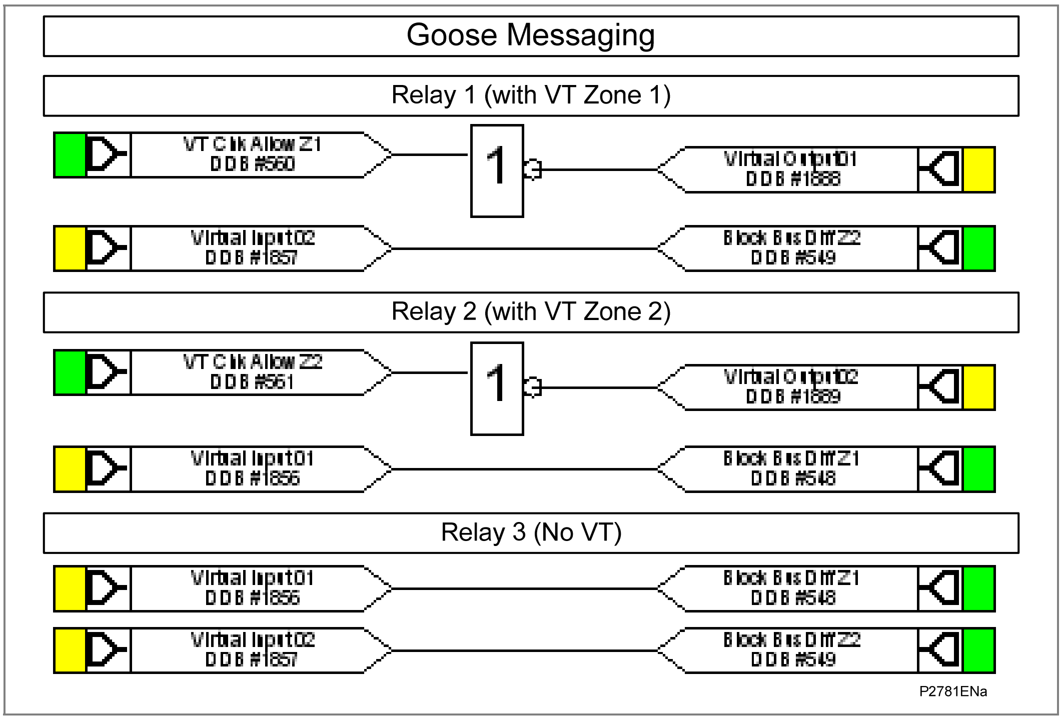
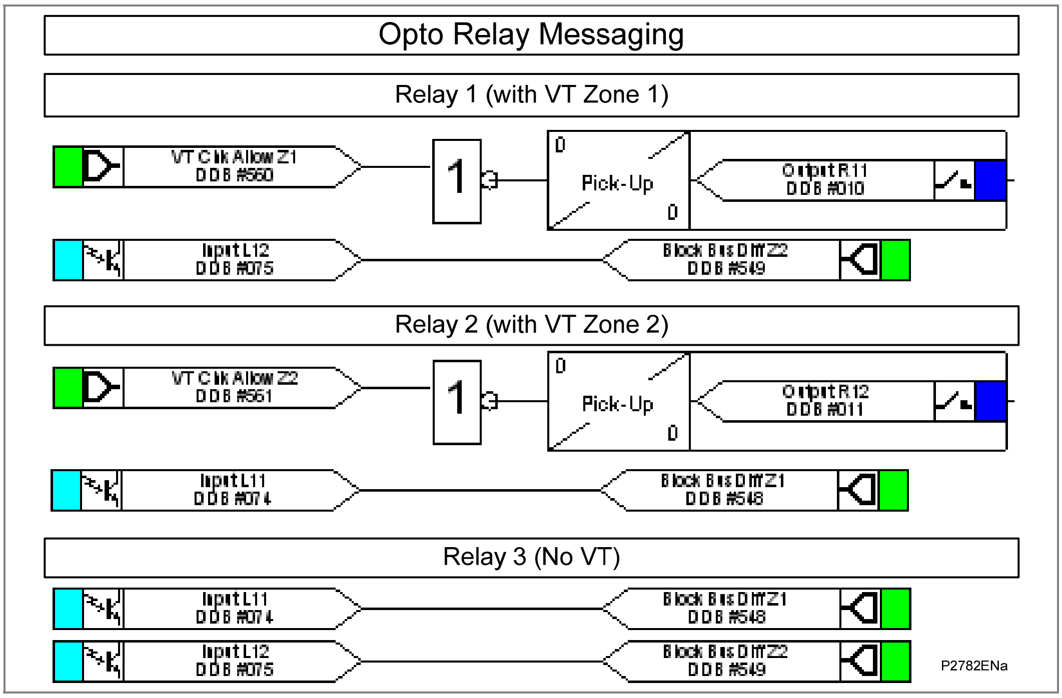


Figure 52 - GOOSE messaging

7.2.3.2 High-Speed Contact to Filtered Optos:

This is an example for Figure 51:

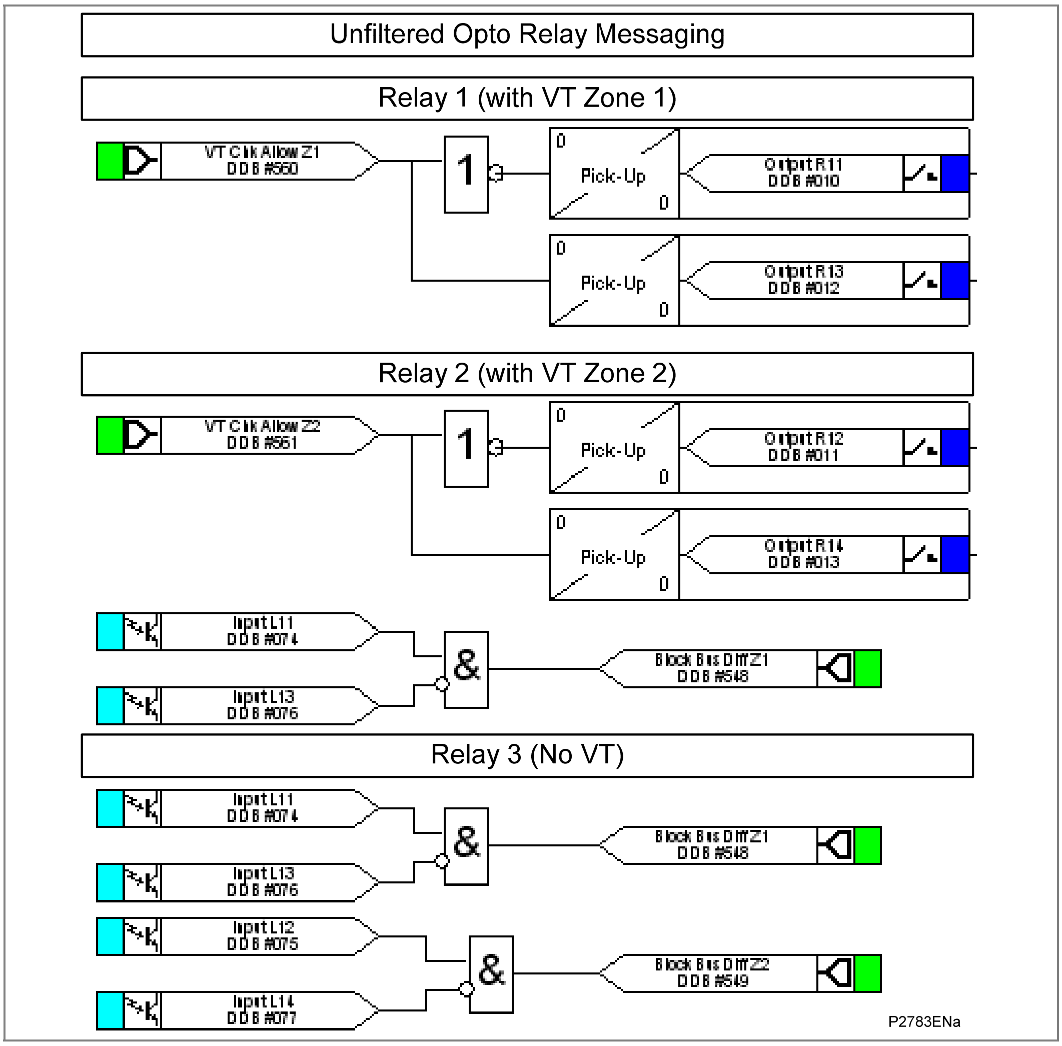


Note	*The tripping time is delayed by around.* *Standard relay: 5ms + opto filtering: 12.5ms = 17.5ms* *High break/high speed relay: 7.5ms + opto filtering: 12.5ms = 20ms*

Figure 53 - Opto relay messaging

7.2.3.3 **High-Speed Contact to Unfiltered Optos:**

This is an example for Figure 51:



Note	*The tripping time is delayed by around 5ms for Standard relay.*

Figure 54 - Unfiltered opto relay messaging

7.2.4 Three Boxes Mode and Simple Redundancy:

When redundancy is needed, an alternative solution of doubling the number of P746 (i.e. 6 P746) is to add a forth one measuring the neutral path.

Any phase to ground fault will be seen by a phase P746 and the neutral P746 and any phase to phase fault will be seen by two phase P746.

By wiring the trip outputs in parallel, any fault would be cleared even if one P746 fails.

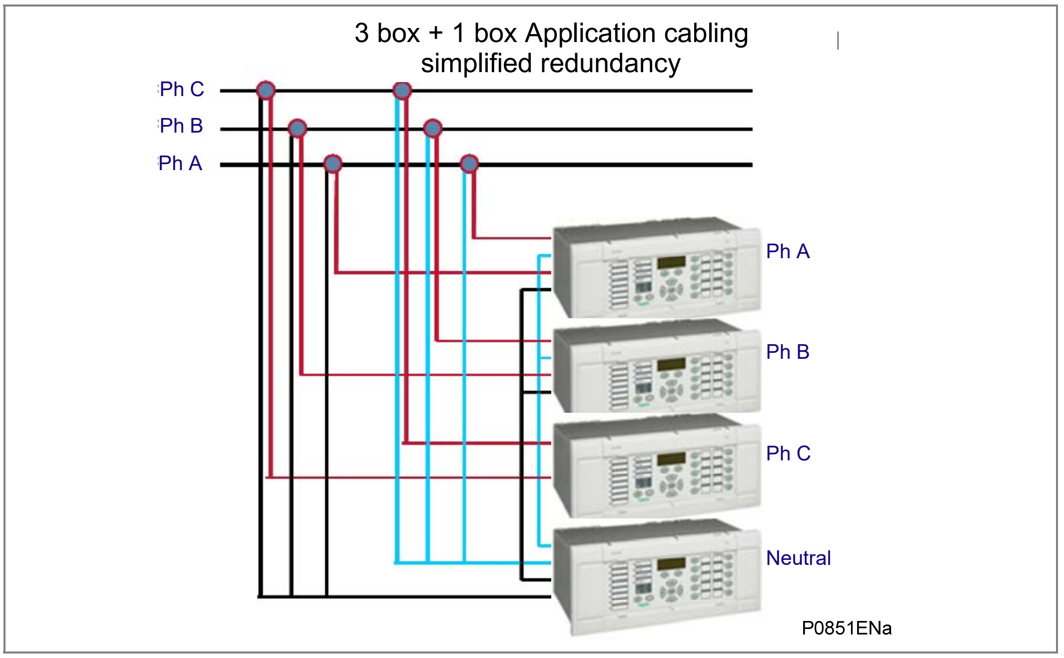


Figure 55 - 3 box + 1 box application cabling simplified redundancy

7.2.5 2 Out of 2 Solution:

Using the same principle, to have the 2 out of 2 solution, the following cabling can be done:

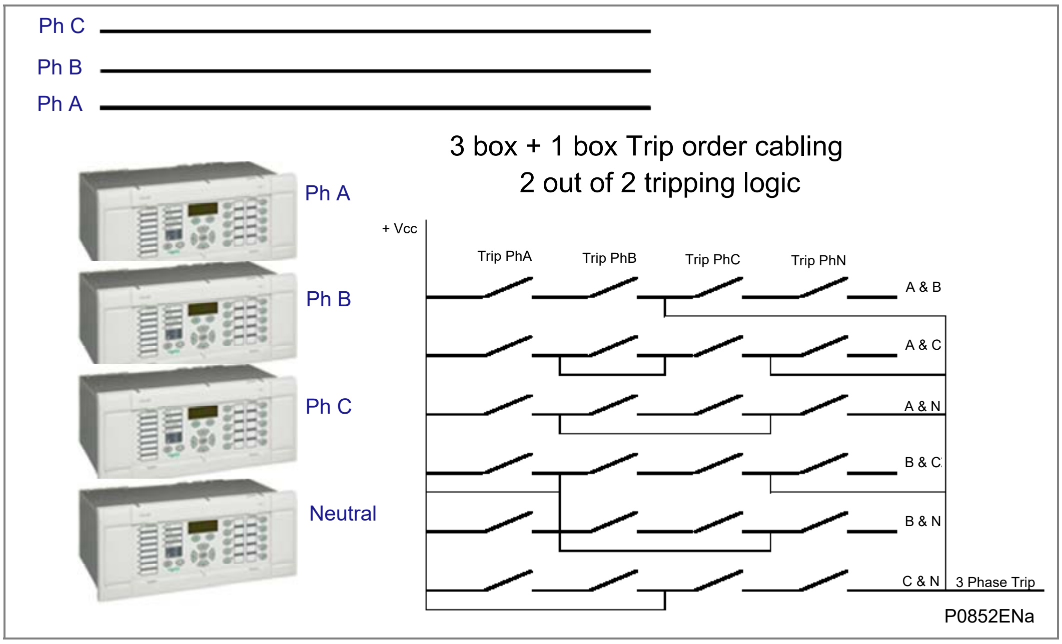


Figure 56 - 2 out of 2 solution

7.2.6 Trip in Two Steps:

7.2.6.1 Trip in Two Steps for Coupler without CT:

When the bus coupling is made with a breaker and without CT, by default, any busbar fault will lead to the trip of both bars:

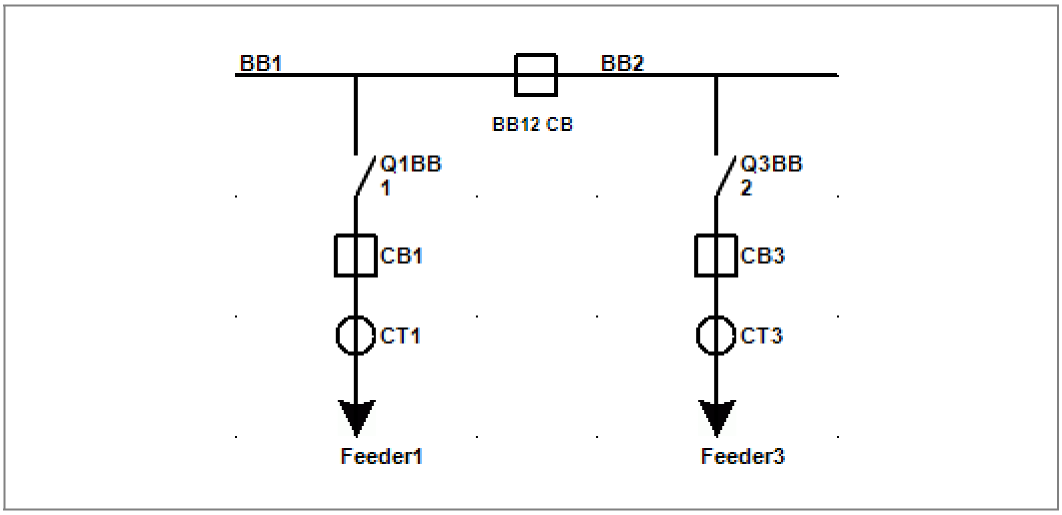


Figure 57 - Busbars, CBs, BBs and feeders

There is the option, upon detection of a busbar fault, to trip first the coupler then after a set timer to trip the faulty bar.

This is to be engineered via the PSL by adding a time delay for the feeder breakers when the coupler is closed as for example:

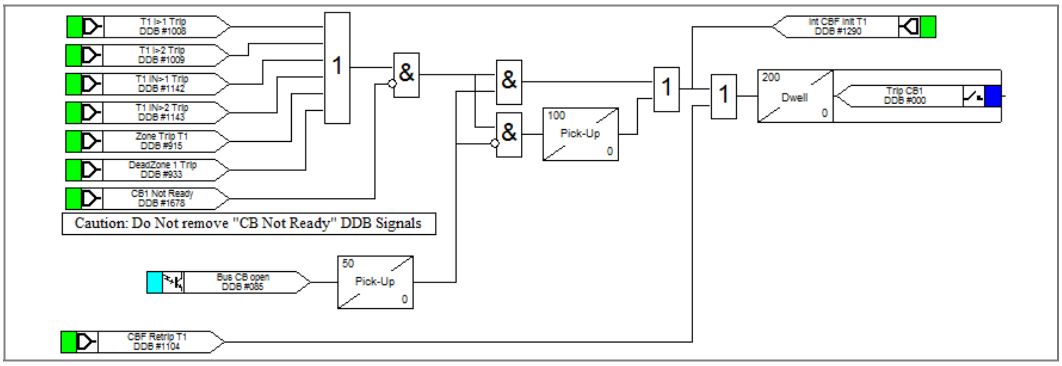


Figure 58 - PSL diagram

Note	*The first pickup timer (here above "50") is set to not trip zone 1 after the opening of the coupler CB and allows the reset of the Diff Zone 1 (20ms is the minimum).* *The second pickup timer (here above "100") shall be longer than the maximum opening time of the coupling breaker plus 20ms and equal to the Backtrip timer of the breaker failure if used.*

7.2.6.2 Trip in Two Steps for Coupler with One CT on Each Side:

When the bus coupling is made with 2 CTs, by default, any fault between these 2 CTs will lead to the trip of both bars:

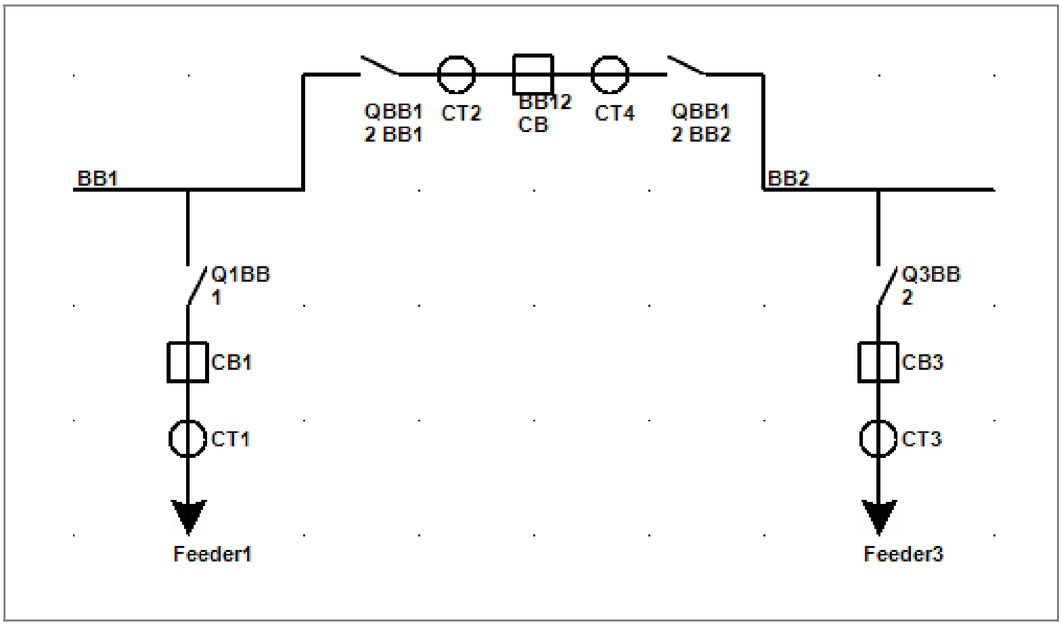


Figure 59 - Real topology

When it is required to first trip the coupler breaker then to trip the faulty bar, the following topology shall be created in the setting:

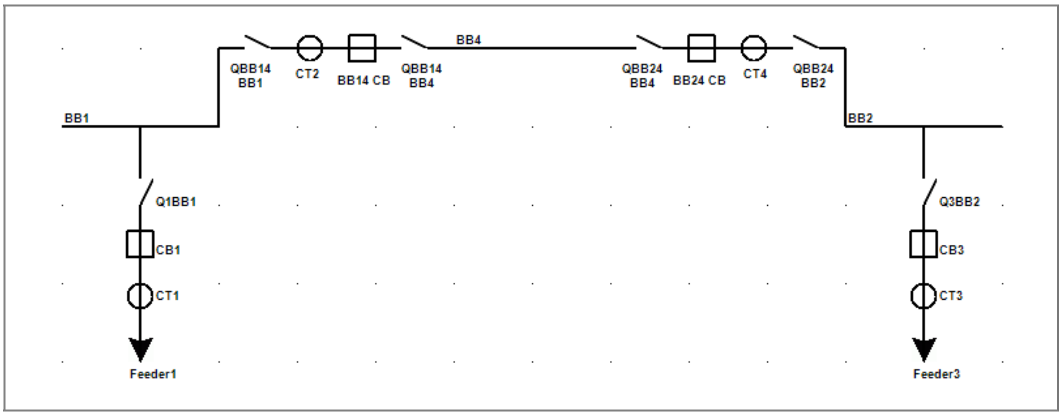


Figure 60 - Engineered topology

Group 1		
GROUP 1 SYSTEM CONFIG		
Phase Sequence	Standard ABC	30.32
Feeder Numbers	7	30.33
Busbar Numbers	4	30.34
BB1 Terminals	0000001	30.35
BB2 Terminals	0000100	30.36
BB3 Terminals	0000000	30.37
BB4 Terminals	0000000	30.38
ChZONE Terminal	0000101	30.39
BB12 coupling by	None	30.3F
BB13 coupling by	None	30.48
BB23 coupling by	None	30.51
BB14 coupling by	Breaker&Isolator	30.5A
BB14 Bus CT/BB1	CT2	30.5B
BB14:BB1 CT Pol	Standard	30.5C
BB14 Bus CT/BB4	NO CT	30.5D
BB14:BB4 CT Pol	Standard	30.5E
BB24 coupling by	Breaker&Isolator	30.63
BB24 Bus CT/BB2	CT4	30.64
BB24:BB2 CT Pol	Standard	30.65
BB24 Bus CT/BB4	NO CT	30.66
BB24:BB4 CT Pol	Standard	30.67
BB34 coupling by	None	30.6C

Figure 61 - Group 1: system config

In the PSL:

- The position of QBB14BB4 and QBB24BB4 shall be fixed to close
- The real position of QBB12B1 shall be linked to QBB14BB1
- The real position of QBB12B2 shall be linked to QBB24BB2
- The real position of BB12 CB shall be linked to both BB14CB and BB24CB

Any fault between the 2 coupling CTs will be seen as in the virtual busbar 4 that will lead to the trip of the virtual BB14 and BB24 breakers that are in fact the real BB12 coupler breaker, then to the faulty bar.

7.3 Check List

The following steps must be performed:

Engineering Phase:

1. Check the CT compliances (using P746VkTest.xls & Rct_Approx.xls)
2. Design the Junction schemes (using AUTOCAD (or equivalent))
3. Create the material definition and the wiring plans
   (distributed or centralised version)
4. Label the relay Inputs & Outputs (using MiCOM S1 Studio Setting (per Group))
5. Calculate the P746 87BB settings (using Idiff_Ibias.xls & P746 setting guide)
6. Calculate the different other P746 settings (transformer, coupler, line, etc…)
7. Draw the topology line diagram (optional but to use the P746 remote HMI)
   (using P746 Remote HMI Tips)
8. Create the P746 PSL file (using MiCOM S1 Studio & Tips)
9. Print out the front panel Labels (using P74x_Stickers.xls)

Testing Phase:

1. Stick the labels on the front of the P746
2. Download the complete setting files into the relay(s) (using MiCOM S1 Studio)
3. Download the PSL file into the relay(s) (using MiCOM S1 Studio)
4. Test the PSLs & Analogue inputs
   (using a Inputs / Outputs and current generator)
5. Test the relay (using MiCOM S1 Studio)

Commissioning Phase:

1. Check the inputs / outputs
2. Check CT connections
3. Check the measurements and the tripping slopes (see documentation)

7.4 General Substation Information

Only a few system parameters are required and it is vital that these are included.

- Number of feeders, bus couplers, bus sections
- Positions of bus sections
- Positions of switchgear plant i.e. circuit breakers, isolators
- Positions of CTs (including the polarity (P1/P2 – S1/S2))
- Planned future extensions with circuit breaker, isolator and current transformer (CT)
- Type of electrical network earthing (Solid or impedance)

7.5 Short Circuit Levels

Maximum external fault current (phase to phase and phase to ground faults):

- Solid:
    - Minimum two phase busbar fault current
    - Minimum load current on the smallest feeder
    - Maximum load current on the biggest feeder or coupler
    - Optional: Maximum three phase busbar fault current
- With impedance:
    - Minimum two phase busbar fault current
    - Minimum single phase to earth busbar fault current
    - Minimum load current on the smallest feeder
    - Maximum load current on the biggest feeder
    - Optional: Maximum three phase busbar fault current
    - Maximum substation short-circuit withstand time

7.6 Switchgear

- Nominal CT ratio

7.7 Substation Architecture

Due to the flexibility of the differential busbar protection there is a number of busbar configurations that can be accommodated via the topology. Each may have very different architecture and, therefore, vary in complexity.

You will find in the following pages topology examples of layouts most frequently encountered. For each example, the number of P746 necessary to protect the busbars is specified.

Generally, the elements of the protection architecture will be identified in a similar manner to the principal parts of the substation e.g. by the letters A and B.

8 STANDARD CONFIGURATIONS

The following information relates only to the more common standard schemes. For further information on the accommodation of other busbar configurations consult your Schneider Electric representative.
Here after is summarised the solution identification:

8.1 P746 Mode Selection

8.1.1.1 1 Zone

Set of CTS	Up to 6/7	Up to 18/21
Set of VTS	0 or 1	0 or 3
Mode	One box mode	Three box mode
Note	1 set of	1 set of

8.1.1.2 2 Zones

Set of CTS	Up to 6/7	Up to 12/14	Up to 18/21	Up to 36/42
Set of VTS	0 or 1	0 to 2	0 or 3	0 or 6
Mode	One box mode		Three box mode	
Note	1 set of	2 set of	1 set of	2 set of

8.1.1.3 3 Zones

Set of CTS	Up to 6/7	Up to 12/14	Up to 18/21	Up to 18/21	Up to 36/42	Up to 54/63
Set of VTS	0 or 1	0 to 2	0 to 3	0 or 3	0 or 6	0 to 9
Mode	One box mode			Three box mode		
Note	1 set of	2 set of	3 set of	1 set of	2 set of	3 set of

8.1.1.4 4 Zones

Set of CTS	Up to 6/7	Up to 12/14	Up to 18/21	Up to 24/28	Up to 18/21	Up to 36/42	Up to 54/63	Up to 72/84
Set of VTS	0 or 1	0 to 2	0 to 3	0 to 4	0 or 3	0 or 6	0 to 9	0 to 12
Mode	One box mode				Three box mode			
Note	1 set of	2 set of	3 set of	4 set of	1 set of	2 set of	3 set of	4 set of

8.2 General Rule to Calculate Number of P746s to Use

The general rule to calculate the number of P746 to use is:

- 1 off P746 from 1 to 6/7 sets of CTs or 6/7 breakers and 2 sets of 1 P746 up to 12/14 sets of CTs when possible.
- 3 off P746 from 7/8 to.18/21 sets of CTs or 18/21 breakers and 2 sets of 3 P746 up to 36/42 sets of CTs when possible.

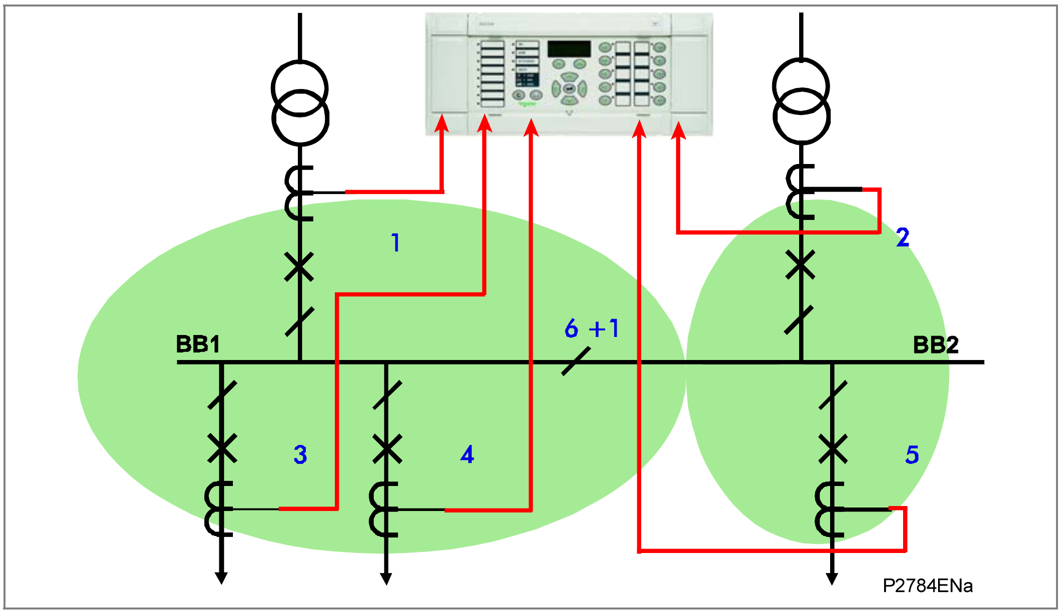


Figure 62 - Single busbar application with bus section isolator

The above example shows a single busbar with a bus section isolator. It is split into two zones.

There are up to 6/7 feeders connected to the busbar. This configuration requires 1 P746.

If it was up to 18/21 feeders connected to the busbar. This configuration would require 3 P746.

There is no solution for more feeders.

The type of P746 used will depend on the I/O requirements of the scheme in question.

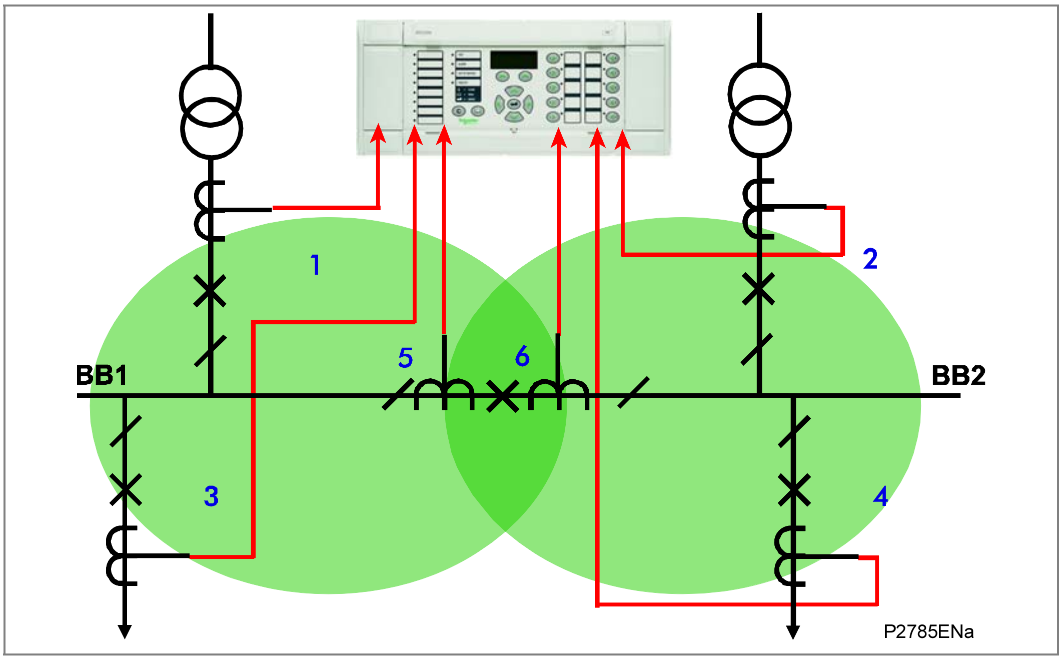


Figure 63 - Single busbar application with bus section circuit breaker

The above example shows a single busbar with a bus section circuit breaker. It is split into two zones.

There are 4 feeders connected to the busbar. The bus section circuit breaker has CTs on either side. This configuration requires 1 P746.

If it was up to 10/12 feeders connected to the busbar. This configuration would require 2 sets of 1 P746 or 3 P746.

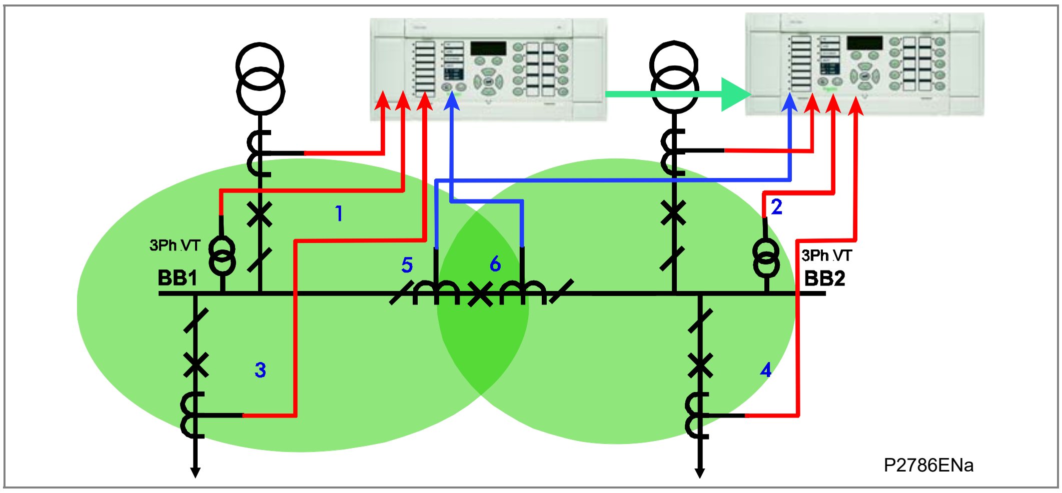


Figure 64 - Multiple feeders

If it was up to 16/19 feeders connected to the busbar. This configuration would require 3 P746.

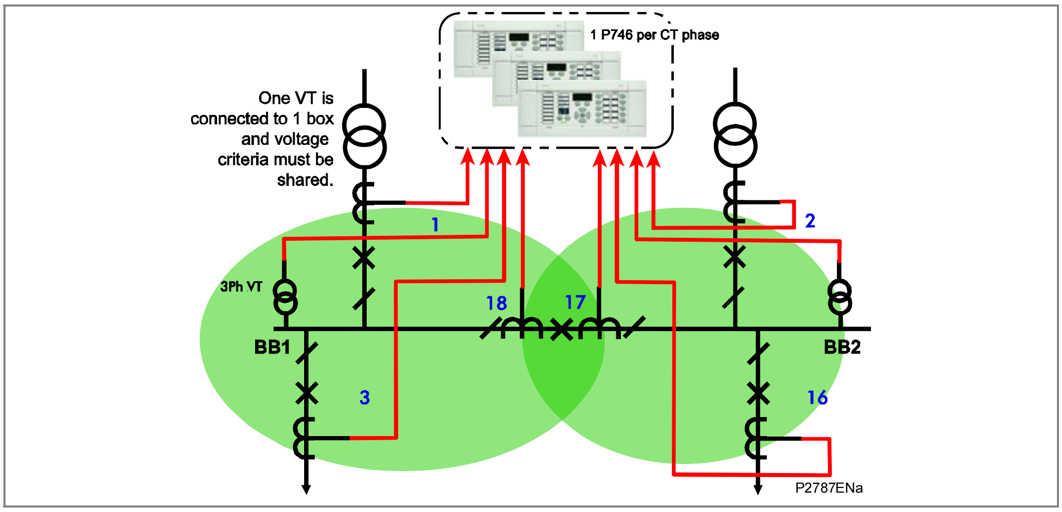


Figure 65 - Multiple feeders

If it was up to 34/41 feeders connected to the busbar. This configuration would require 2 sets of 3 P746.

The type of P746 used will depend on the I/O requirements of the scheme in question.

It is recommended that the CTs for feeder protection are sited such as to overlap with the CTs defining the limits of each busbar protection zone.

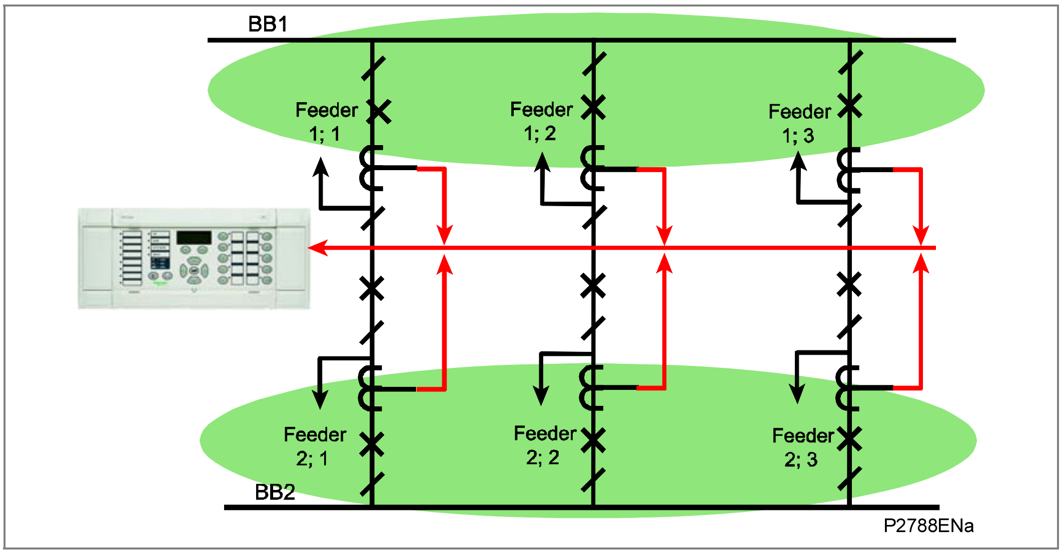


Figure 66 - Breaker and a half scheme

The above example shows a breaker and a half scheme. There are 3 feeders connected to each busbar. This configuration requires 1 P746

- If it was up to 12/14 feeders connected to the busbars, the scheme would require 2 sets of 1 P746 (recommended) or 3 P746.
- If it was up to 18/21 feeders connected to the busbars, the scheme would require 3 P746.
- If it was up to 36/42 feeders connected to the busbars. Each scheme would require 3 P746.

The type of P746 used will depend on the I/O requirements of the scheme in question.

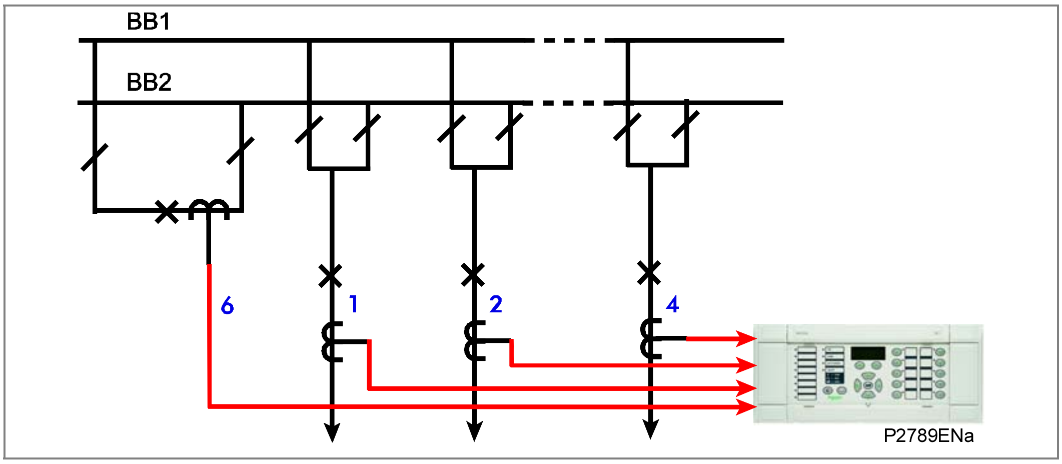


Figure 67 - Double busbar application with bus coupler

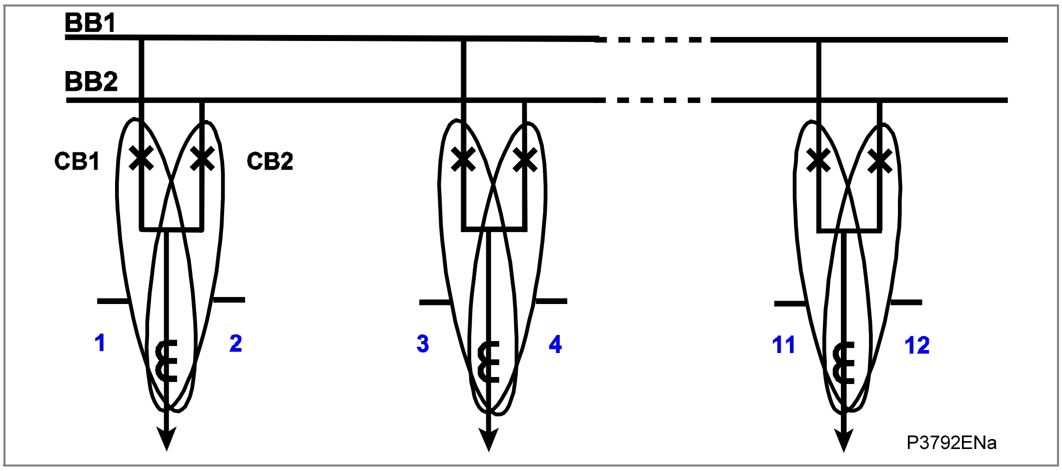


Figure 68 - Double bus bar with two circuit breakers per feeder

When the above situation is met (usually after the addition of a bar on an “old” substation), the below equivalent topology shall be engineered:

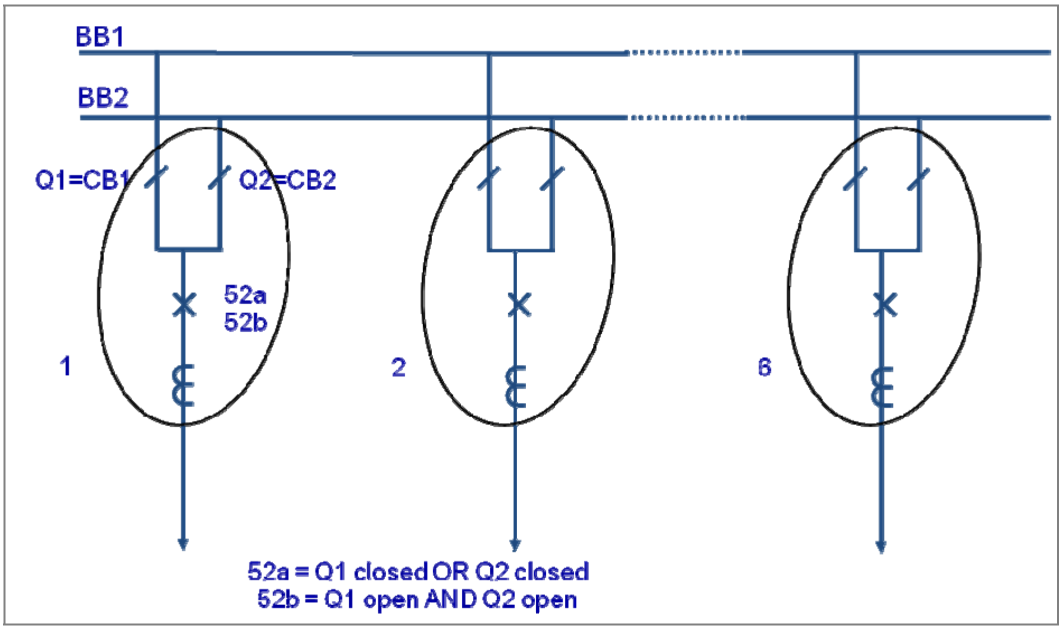


Figure 69 - Busbars and CBs

9 APPLICATION OF NON-PROTECTION FUNCTIONS

The non-protection features for the scheme are summarised below:

- Local, zone and scheme measurements – various measurements are available locally via the relay LCD or remotely via the serial communication link.
- Event, fault and disturbance recording – Comprehensive post fault analysis available via event lists, disturbance records and fault records which can be accessed locally via the relay LCD or remotely via the serial communication link.
- Real time clock/time synchronisation – Time synchronisation available via IRIG-B input.
- Four settings groups – Independent remotely selectable setting groups to allow for customer specific applications.
- CB and isolator state monitoring – indication of the circuit breaker/isolator position via the auxiliary contacts, scheme acts accordingly should discrepancy conditions be detected.
- Commissioning test facilities.
- Continuous self monitoring – extensive self checking routines to ensure maximum reliability.
- Graphical programmable scheme logic – allowing user defined protection and control logic to be tailored to the specific application.

9.1 Function Keys

The following default PSL logic illustrates the programming of function keys to enable/disable the commissioning mode functionality.

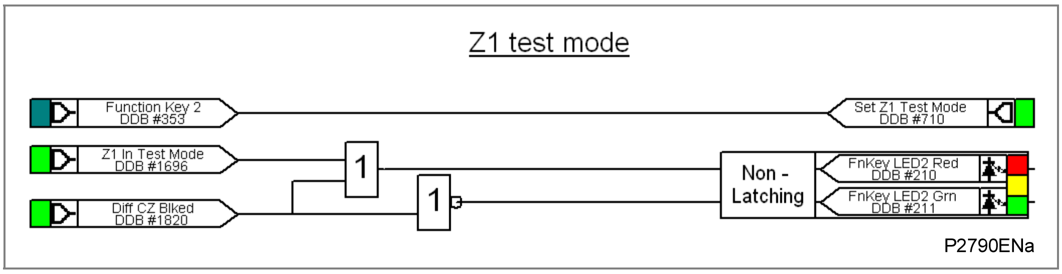


Figure 70 - Commissioning mode default PSL

Note	*Energizing two inputs to an LED conditioner creates a YELLOW illumination.*

Function Key 2 is set to 'Toggle' mode and on activation of the key, the commissioning mode will be in service as long as the function has been enabled in the "Configuration" menu. The associated LED will indicate the state of the protection function in service as GREEN and RED for the Overhaul mode.

10 CT REQUIREMENTS

10.1 Notation

Abbreviation	Meaning
I_F max fault	maximum fault current (same for all feeders) in A
I_F max int cont	maximum contribution from a feeder to an internal fault (depends on the feeder) in A
I_{np}	CT primary rated current
I_n	nominal secondary current (1A or 5A)
R_{CT}	CT secondary winding Resistance in Ohms
R_B	Total external load resistance in Ohms
V_k	CT knee point voltage in Volts
S_{VA}	Nominal output in VA
K_{SSC}	Short-circuit current coefficient (generally 20)

General recommendations for the specification of protection CTs use common rules of engineering which are not directly related to a particular protection.

10.2 87BB Phase CT Requirements

10.2.1 Feeders Connected to Sources of Significant Power (i.e. Lines and Generators)

The primary rated current is specified above a 1/20th of the maximum contribution of the feeder to internal faults.

i.e. $I_{np} = I_F$ max int/20

e.g. A power line likely to import electricity at 20 kA gives rated primary current I_{np} as 1000 A.

In any case the maximum peak current shall be less than 90 In (90A for 1A input and 450A for 5A Input) i.e. 32 In RMS fully offset.

This recommendation is used for the majority of line or transformer protection applications.

The CT must be sized so as not to saturate during internal faults:

For each CT, $I_{FeederMax}$ = maximum contribution of the feeder to an internal fault (could be different for each feeder):

$V_k > I_{FeederMax} * (R_{CT} + R_B)$

Note	*This specification is valid for internal faults.*

10.2.2 CT Specification according to IEC 185, 44-6, BS 3938 (British Standard) and IEC 61869

Note	*IEC 60034 has been partly replaced by IEC 61869*

1. Class X according to British Standard: Minimum knee point voltage for saturation
   V_k min = secondary I_F max x (R_{CT} + R_B)
   With secondary I_F max not less than 20 (if I_F max < 20 In then I_F max = 20)
   Note: This specification is valid for external faults.
   This provides a sufficient margin of security for CT saturation immunity.
   Examples:
   CT = 1000/1; Rct = 2.5 Ohms and Rb = 0.5 Ohms
   For a maximum external fault of 30 kA (30 Ir), Vk > 30 x 3 = 90 V
   For a maximum external fault of 20 kA (20 Ir), Vk > 20 x 3 = 60
   For a maximum external fault of 10 kA (10 Ir), Vk > 20 x 3 = 60 (not 10)
   CT = 1000/5; Rct = 0.4 Ohms and Rb = 0.6 Ohms
   For a maximum external fault of 30 kA (30 Ir), Vk > 30 x 1 = 30 V
2. Class 5P to IEC 185. Conversion of class X (BS) with the 5P equivalent (IEC)
3. Class TPX and TPY according to IEC 44-6. IEC defines a composite error as a percentage of a multiple of the rated current (I_N) on a definite load SVA.
   e.g. CT 1000/5 A – 50VA 5P 20 [CT I_{np} / I_nA – SVA Accuracy P Kscc]
   Vk=0.8 X [(SVA x Kssc)/In + (RCT x Kssc x In)]
   SVA = (I_n x V_k/0.8 K_{ssc}) - R_{CT} x I_n^2

In particular cases, calculation could reveal values too low to correspond to industrial standards. In this case the minima will be: SVA min = 10 VA 5P 20 which correspond to a knee point voltage of approximately V_{kmin} = 70 V at 5A or 350V at 1A. Class TPY would permit lower values of power, (demagnetisation air-gap). Taking into account the weak requirements of class X or TPX one can keep specifications common.

For accuracy, class X or class 5P current transformers (CTs) are strongly recommended. The knee point voltage of the CTs should comply with the minimum requirements of the formulae shown below.

$V_k \geq k (R_{CT} + R_B)$

Where:

V_k	=	Required knee point voltage
k	=	Dimensioning factor
R_{CT}	=	CT secondary resistance
R_L	=	Circuit resistance from CT to relay
R_B	=	Burden resistance

k is a constant depending on:

If	=	Maximum value of through fault current for stability (multiple of In)
X/R	=	Primary system X/R ratio (for the P746 system, X/R up to 120)

The following CT requirement can be developed for the P746 scheme

$V_k \geq$ secondary If max x (R_{CT} + R_B)

With R_B = 2 R_L

10.3 Support of IEEE C Class CTs

MiCOM Px40 series protection is compatible with ANSI/IEEE current transformers as specified in the IEEE C57.13 standard. The applicable class for protection is class "C", which specifies a non air-gapped core. The CT design is identical to IEC class P, or British Standard class X, but the rating is specified differently. The following table allows C57.13 ratings to be translated into an IEC/BS knee point voltage

IEC/BS Knee Point Voltage VK offered BY "C" class CTS						
		IEEE C57.13 – "C" Classification (volts)				
		C50	C100	C200	C400	C800
CT Ratio	RCT (ohm)	V_k	V_k	V_k	V_k	V_k
100/5	0.04	56.5	109	214	424	844
200/5	0.8	60.5	113	218	428	848
400/5	0.16	68.5	121	226	436	856
800/5	0.32	84.5	137	242	452	872
1000/5	0.4	92.5	145	250	460	880
1500/5	0.6	112.5	165	270	480	900
2000/5	0.8	132.5	185	290	500	920
3000/5	1.2	172.5	225	330	540	960

Assumptions:

1. For 5A CTs, the typical resistance is 0.0004 ohm secondary per primary turn (for 1A CTs, the typical resistance is 0.0025 ohm secondary per primary turn)
2. IEC/BS knee is typically 5% higher than ANSI/IEEE knee

Given:

3. IEC/BS knee is specified as an internal EMF, whereas the "C" class voltage is specified at the CT output terminals. To convert from ANSI/IEEE to IEC/BS requires the voltage drop across the CTs secondary winding resistance to be added.
4. IEEE CTs are always rated at 5A secondary
5. The rated dynamic current output of a "C" class CT (Kssc) is always 20 x I_n

V_k = $(C \times 1.05) + (I_n . R_{CT} . K_{ssc})$

Where:
V_k = Equivalent IEC or BS knee point voltage
C = C Rating
I_n = 5A
R_{CT} = CT secondary winding resistance
K_{ssc} = 20 times

11 AUXILIARY SUPPLY FUSE RATING

In the Safety Information part of this manual, the maximum allowable fuse rating of 16A is quoted. To allow time grading with fuses upstream, a lower fuselink current rating is often preferable. Use of standard ratings of between 6A and 16A is recommended. Low voltage fuselinks, rated at 250V minimum and compliant with IEC60269-2 general application type gG are acceptable, with high rupturing capacity. This gives equivalent characteristics to HRC "red spot" fuses type NIT/TIA often specified historically.

The table below recommends advisory limits on relays connected per fused spur. This applies to MiCOM Px40 series devices with hardware suffix C and higher, as these have inrush current limitation on switch-on, to conserve the fuse-link.

Maximum Number of MiCOM Px40 Relays Recommended Per Fuse				
Battery Nominal Voltage	**6A**	**10A Fuse**	**15 or 16A Fuse**	**Fuse Rating > 16A**
24 to 54V	2	4	6	Not permitted
60 to 125V	4	8	12	Not permitted
138 to 250V	6	10	16	Not permitted
Alternatively, Miniature Circuit Breakers (MCBs) may be used to protect the auxiliary supply circuits.				

Table 5 - Recommended advisory limits on relays connected per fused spur

Notes:

USING THE PSL EDITOR

CHAPTER 7

Date:	08/2017	
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.	
Hardware Suffix:	All MiCOM Px4x products	
Software Version:	All MiCOM Px4x products	
Connection Diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P341: 10P341xx (xx = 01 to 12) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P445: 10P445xx (xx = 01 to 04) P44x: 10P44101 (SH 1 & 2) 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)	P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 01 to 10) 10P643xx (xx = 01 to 06) 10P645xx (xx = 01 to 09) P74x: 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)

CONTENTS

FIGURES

TABLES

Notes:

1 OVERVIEW

The purpose of the Programmable Scheme Logic (PSL) is to allow the relay user to configure an individual protection scheme to suit their own particular application. This is achieved through the use of programmable logic gates and delay timers.

The input to the PSL is any combination of the status of opto inputs. It is also used to assign the mapping of functions to the opto inputs and output contacts, the outputs of the protection elements, e.g. protection starts and trips, and the outputs of the fixed protection scheme logic. The fixed scheme logic provides the relay's standard protection schemes.

The PSL itself consists of software logic gates and timers. The logic gates can be programmed to perform a range of different logic functions and can accept any number of inputs. The timers are used either to create a programmable delay, and/or to condition the logic outputs, e.g. to create a pulse of fixed duration on the output regardless of the length of the pulse on the input. The outputs of the PSL are the LEDs on the front panel of the relay and the output contacts at the rear.

The execution of the PSL logic is event driven; the logic is processed whenever any of its inputs change, for example as a result of a change in one of the digital input signals or a trip output from a protection element. Also, only the part of the PSL logic that is affected by the particular input change that has occurred is processed. This reduces the amount of processing time that is used by the PSL; even with large, complex PSL schemes the relay trip time will not lengthen.

This system provides flexibility for the user to create their own scheme logic design. However, it also means that the PSL can be configured into a very complex system; hence setting of the PSL is implemented through the PC support package Easergy Studio.

Note	*MiCOM S1 Studio has been renamed as Easergy Studio.*

2 EASERGY STUDIO PSL EDITOR

Note *MiCOM S1 Studio has been renamed as Easergy Studio.*

The PSL Editor can be used inside Easergy Studio or directly.
This chapter assumes that you are using the PSL Editor from within Easergy Studio.
If you use it from Easergy Studio, the Studio software will be locked whilst you are using the PSL editor software. The Studio software will be unlocked when you close the PSL Editor software.
The Easergy Studio product is updated periodically. These updates provide support for new features (such as allowing you to manage new MiCOM products, as well as using new software releases and hardware suffixes). The updates may also include fixes.
Accordingly, we strongly advise customers to use the latest Schneider Electric version of Easergy Studio.
If you need more information regarding bug fixes, please contact your **Schneider Electric** local support.

2.1 How to Obtain Easergy Studio Software

Easergy Studio is available from the Schneider Electric website:

- www.schneider-electric.com

2.2 To Start Easergy Studio

To Start the Easergy Studio software, click the **Start** > **All apps** > **Schneider Electric** > **Easergy Studio** menu option.

2.3 To Open a Pre-Existing System

Within Easergy Studio, click the **File** + **Open System** menu option.
Navigate to where the scheme is stored, then double-click to open the scheme.

2.4 To Start the PSL Editor

The PSL editor lets you connect to any MiCOM device front port, retrieve and edit its PSL files and send the modified file back to a suitable MiCOM device.
Px30 and Px40 products are edited using different versions of the PSL Editor. There is one link to the Px30 editor and one link to the Px40 editor.
To start the PSL editor for Px40 products:

Highlight the PSL file you wish to edit, and then either:

Double-click the highlighted PSL file,

Click the open icon or

In the Easergy Studio main menu, select Tools > PSL PSL editor (Px40) menu.

The PSL Editor will then start, and show you the relevant PSL Diagram(s) for the file you have opened. An example of such a PSL diagram is shown in the *Example of a PSL editor module* diagram.

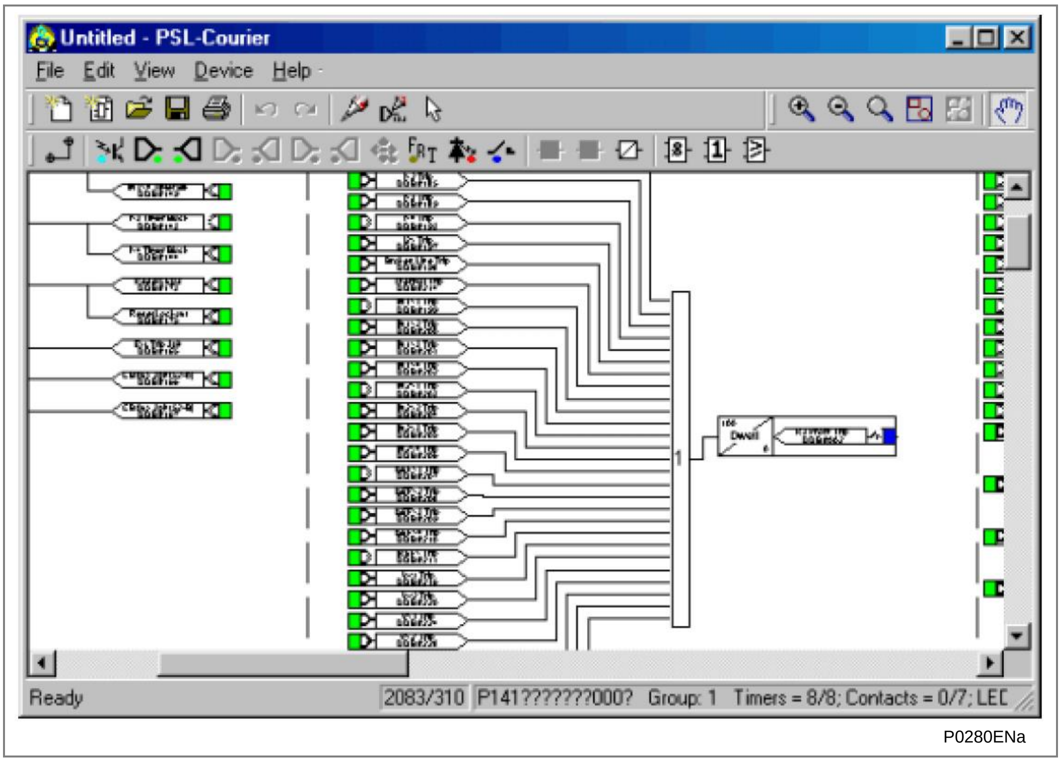


Figure 1 - Example of a PSL editor module

2.5 How to use MiCOM PSL Editor

The MiCOM PSL editor lets you:

- Start a new PSL diagram
- Extract a PSL file from a MiCOM Px40 IED
- Open a diagram from a PSL file
- Add logic components to a PSL file
- Move components in a PSL file
- Edit link of a PSL file
- Add link to a PSL file
- Highlight path in a PSL file
- Use a conditioner output to control logic
- Download PSL file to a MiCOM Px40 IED
- Print PSL files

For a detailed discussion on how to use these functions, please refer to the Easergy Studio online help.

2.6 Warnings

Before the scheme is sent to the relay checks are done. Various warning messages may be displayed as a result of these checks.

The Editor first reads in the model number of the connected relay, then compares it with the stored model number. A "wildcard" comparison is used. If a model mismatch occurs, a warning is generated before sending starts. Both the stored model number and the number read from the relay are displayed with the warning. However, the user must decide if the settings to be sent are compatible with the relay that is connected. Ignoring the warning could lead to undesired behavior of the relay.

If there are any potential problems of an obvious nature then a list will be generated. The types of potential problems that the program attempts to detect are:

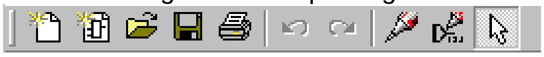
- One or more gates, LED signals, contact signals, and/or timers have their outputs linked directly back to their inputs. An erroneous link of this sort could lock up the relay, or cause other more subtle problems to arise.
- Inputs to Trigger (ITT) exceeds the number of inputs. If a programmable gate has its ITT value set to greater than the number of actual inputs; the gate can never activate. There is no lower ITT value check. A 0-value does not generate a warning.
- Too many gates. There is a theoretical upper limit of 256 gates in a scheme, but the practical limit is determined by the complexity of the logic. In practice the scheme would have to be very complex, and this error is unlikely to occur.
- Too many links. There is no fixed upper limit to the number of links in a scheme. However, as with the maximum number of gates, the practical limit is determined by the complexity of the logic. In practice the scheme would have to be very complex, and this error is unlikely to occur.

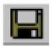
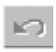
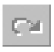
3 TOOLBAR AND COMMANDS

There are a number of toolbars available for easy navigation and editing of PSL.

3.1 Standard Tools

For file management and printing.

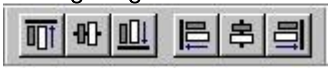


	Blank Scheme	Create a blank scheme based on a relay model.
	Default Configuration	Create a default scheme based on a relay model.
	Open	Open an existing diagram.
	Save	Save the active diagram.
	Print	Display the Windows Print dialog, enabling you to print the current diagram.
	Undo	Undo the last action.
	Redo	Redo the previously undone action.
	Redraw	Redraw the diagram.
	No of DDBs	Display the DDB numbers of the links.
	Calculate CRC	Calculate unique number based on both the function and layout of the logic.
	Compare Files	Compare current file with another stored on disk.
	Select	Enable the select function. While this button is active, the mouse pointer is displayed as an arrow. This is the default mouse pointer. It is sometimes referred to as the selection pointer.

Point to a component and click the left mouse button to select it. Several components may be selected by clicking the left mouse button on the diagram and dragging the pointer to create a rectangular selection area.

3.2 Alignment Tools

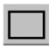
To align logic elements horizontally or vertically into groups.



	Align Top	Align all selected components so the top of each is level with the others.
	Align Middle	Align all selected components so the middle of each is level with the others.
	Align Bottom	Align all selected components so the bottom of each is level with the others.
	Align Left	Align all selected components so the leftmost point of each is level with the others.
	Align Centre	Align all selected components so the centre of each is level with the others.
	Align Right	Align all selected components so the rightmost point of each is level with the others.

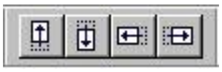
3.3 Drawing Tools

To add text comments and other annotations, for easier reading of PSL schemes.

	Rectangle	When selected, move the mouse pointer to where you want one of the corners to be hold down the left mouse button and move it to where you want the diagonally opposite corner to be. Release the button. To draw a square hold down the SHIFT key to ensure height and width remain the same.
	Ellipse	When selected, move the mouse pointer to where you want one of the corners to be hold down the left mouse button and move until the ellipse is the size you want it to be. Release the button. To draw a circle hold down the SHIFT key to ensure height and width remain the same.
	Line	When selected, move the mouse pointer to where you want the line to start, hold down left mouse, move to the position of the end of the line and release button. To draw horizontal or vertical lines only hold down the SHIFT key.
	Polyline	When selected, move the mouse pointer to where you want the polyline to start and click the left mouse button. Now move to the next point on the line and click the left button. Double click to indicate the final point in the polyline.
	Curve	When selected, move the mouse pointer to where you want the polycurve to start and click the left mouse button. Each time you click the button after this a line will be drawn, each line bisects its associated curve. Double click to end. The straight lines will disappear leaving the polycurve. Note: whilst drawing the lines associated with the polycurve, a curve will not be displayed until either three lines in succession have been drawn or the polycurve line is complete.
	Text	When selected, move the mouse pointer to where you want the text to begin and click the left mouse button. To change the font, size or colour, or text attributes select Properties from the right mouse button menu.
	Image	When selected, the Open dialog is displayed, enabling you to select a bitmap or icon file. Click Open, position the mouse pointer where you want the image to be and click the left mouse button.

3.4 Nudge Tools

To move logic elements.

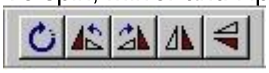


The nudge tool buttons enable you to shift a selected component a single unit in the selected direction, or five pixels if the SHIFT key is held down.
As well as using the tool buttons, single unit nudge actions on the selected components can be achieved using the arrow keys on the keyboard.

	Nudge Up	Shift the selected component(s) upwards by one unit. Holding down the SHIFT key while clicking on this button will shift the component five units upwards.
	Nudge Down	Shift the selected component(s) downwards by one unit. Holding down the SHIFT key while clicking on this button will shift the component five units downwards.
	Nudge Left	Shift the selected component(s) to the left by one unit. Holding down the SHIFT key while clicking on this button will shift the component five units to the left.
	Nudge Right	Shift the selected component(s) to the right by one unit. Holding down the SHIFT key while clicking on this button will shift the component five units to the right.

3.5 Rotation Tools

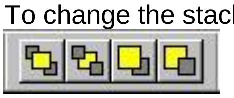
To spin, mirror and flip.



	Free Rotate	Enable the rotation function. While rotation is active components may be rotated as required. Press the ESC key or click on the diagram to disable the function.
	Rotate Left	Rotate the selected component 90 degrees to the left.
	Rotate Right	Rotate the selected component 90 degrees to the right.
	Flip Horizontal	Flip the component horizontally.
	Flip Vertical	Flip the component vertically.

3.6 Structure Tools

To change the stacking order of logic components.



	Bring to Front	Bring the selected components in front of all other components.
	Send to Back	Bring the selected components behind all other components.
	Bring Forward	Bring the selected component forward one layer.
	Send Backward	Send the selected component backwards one layer.

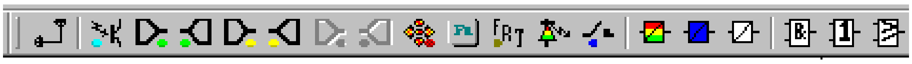
3.7 Zoom and Pan Tools

For scaling the displayed screen size, viewing the entire PSL, or zooming to a selection.

Zoom In	Increases the Zoom magnification by 25%.
Zoom Out	Decreases the Zoom magnification by 25%.
Zoom	Enable the zoom function. While this button is active, the mouse pointer is displayed as a magnifying glass. Right-clicking will zoom out and left-clicking will zoom in. Press the ESC key to return to the selection pointer. Click and drag to zoom in to an area.
Zoom to Fit	Display at the highest magnification that will show all the diagram's components.
Zoom to Selection	Display at the highest magnification that will show the selected component(s).
Pan	Enable the pan function. While this button is active, the mouse pointer is displayed as a hand. Hold down the left mouse button and drag the pointer across the diagram to pan. Press the ESC key to return to the selection pointer.

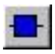
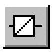
3.8 Logic Symbols

This toolbar provides icons to place each type of logic element into the scheme diagram. Not all elements are available in all devices. Icons will only be displayed for those elements available in the selected device. Depending on the device, the toolbar may not include Function key or coloured LED conditioner/signal or Contact conditioner or SR Gate icons.



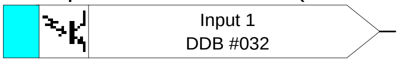
P2718ENa

Link Create a link between two logic symbols.	
Opto Signal Create an opto signal.	
Input Signal Create an input signal.	
Output Signal Create an output signal.	
GOOSE In Create an input signal to logic to receive a UCA2.0 or IEC 61850 GOOSE message transmitted from another IED.	
GOOSE Out Create an output signal from logic to transmit a UCA2.0 or IEC 61850 GOOSE message to another IED.	
Control In Create an input signal to logic that can be operated from an external command.	
Integral Intertripping In/InterMiCOM In Create an input signal to logic to receive a MiCOM command transmitted from another IED. InterMiCOM is not available for all products.	
Integral Intertripping Out/InterMiCOM OutCreate an output signal from logic to transmit a MiCOM command to another IED. InterMiCOM is not available for all products.	

Function Key Create a function key input signal.	
Trigger Signal Create a fault record trigger.	
LED Signal Create an LED input signal that repeats the status of the LED. The icon colour shows whether the product uses mono-colour or tri-color LEDs.	
Contact Signal Create a contact signal.	
LED Conditioner Create a LED conditioner. The icon colour shows whether the product uses mono-colour or tri-color LEDs.	
Contact Conditioner Create a contact conditioner. Contact conditioning is not available for all products.	
Timer Create a timer.	
AND Gate Create an AND Gate.	
OR Gate Create an OR Gate.	
Programmable Gate Create a programmable gate.	
SR gate Create an SR gate.	

4 PSL LOGIC SIGNALS PROPERTIES

The logic signal toolbar is used for the selection of logic signals.
This allows you to link signals together to program the PSL. A number of different properties are associated with each signal. In the following sections, these are characterized by the use of an icon from the toolbar; together with a signal name and a DDB number. The name and DDB number are shown in a pointed rectangular block, which includes a colour code, the icon, the name, DDB No and a directional pointer. One example of such a block (for P54x for Opto Signal 1 DDB No #032) is shown below:



More examples of these are shown in the following properties sections.

Important	**The DDB Numbers vary according to the particular product and the particular name, so that Opto Signal 1 may not be DDB No #032 for all products. The various names and DDB numbers illustrated below are provided as an example. You need to look up the DDB numbers for the signal and the specific MiCOM product you are working on in the relevant DDB table for your chosen product. Available functions will depend on model/firmware version.**

4.1 Signal Properties Menu

The logic signal toolbar is used for the selection of logic signals. To use this:

- Use the logic toolbar to select logic signals.
  This is enabled by default but to hide or show it, select **View** > **Logic Toolbar**.
- Zoom in or out of a logic diagram using the toolbar icon or select **View** > **Zoom Percent**.
- Right-click any logic signal and a context-sensitive menu appears.
- Certain logic elements show the **Properties…** option. Select this and a **Component Properties** window appears. The Component Properties window and the signals listed vary depending on the logic symbol selected.

The following subsections describe each of the available logic symbols.

4.2 Link Properties

Links form the logical link between the output of a signal, gate or condition and the input to any element.
Any link that is connected to the input of a gate can be inverted. Right-click the input and select **Properties…**. The **Link Properties** window appears.

Figure 2 - Link properties

4.2.1 Rules for Linking Symbols

An inverted link is shown with a small circle on the input to a gate. A link must be connected to the input of a gate to be inverted.
Links can only be started from the output of a signal, gate, or conditioner, and can only be ended at an input to any element.

Signals can only be an input or an output. To follow the convention for gates and conditioners, input signals are connected from the left and output signals to the right. The Editor automatically enforces this convention.

A link is refused for the following reasons:

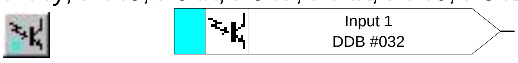
- An attempt to connect to a signal that is already driven. The reason for the refusal may not be obvious because the signal symbol may appear elsewhere in the diagram.

  Right-click the link and select Highlight to find the other signal. Click anywhere on the diagram to disable the highlight.
- An attempt is made to repeat a link between two symbols. The reason for the refusal may not be obvious because the existing link may be represented elsewhere in the diagram.

4.3 Opto Signal Properties

Each opto input can be selected and used for programming in PSL. Activation of the opto input drives an associated DDB signal.

For example, activating opto Input L1 asserts DDB 032 in the PSL for the P14x, P34x, P44y, P445, P54x, P547, P74x, P746, P841, P849 products.

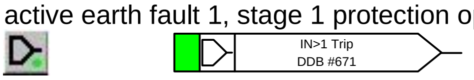


DDB Nos	*"Input 1 DDB #064" applies to: P24x, P64x.* *"Opto Label DDB #064" applies to: P44x.*

4.4 Input Signal Properties

Relay logic functions provide logic output signals that can be used for programming in PSL. Depending on the relay functionality, operation of an active relay function drives an associated DDB signal in PSL.

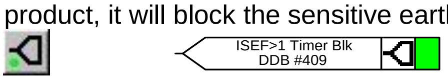
For example, DDB 671 is asserted in the PSL for the P44y, P547 & P841 product if the active earth fault 1, stage 1 protection operate/trip.



4.5 Output Signal Properties

Relay logic functions provide logic input signals that can be used for programming in PSL. Depending on the relay functionality, activation of the output signal will drive an associated DDB signal in PSL and cause an associated response to the relay function.

For example, if DDB 409 is asserted in the PSL for the P44y, P54x, P547 and P841 product, it will block the sensitive earth function stage 1 timer.

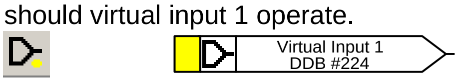


4.6 GOOSE Input Signal Properties

The PSL interfaces with the GOOSE Scheme Logic using virtual inputs. The Virtual Inputs can be used in much the same way as the Opto Input signals.

The logic that drives each of the Virtual Inputs is contained within the relay's GOOSE Scheme Logic file. It is possible to map any number of bit-pairs, from any enrolled device, using logic gates onto a Virtual Input (see Easergy Studio (MiCOM S1 Studio) User Manual for more details). The number of available GOOSE virtual inputs is shown in the *Programmable Logic* chapter.

For example DDB 224 will be asserted in PSL for the P44y, P54x, P547 & P841 product should virtual input 1 operate.



4.7 GOOSE Output Signal Properties

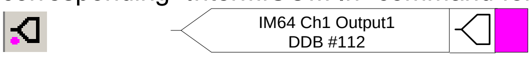
The PSL interfaces with the GOOSE Scheme Logic using 32 virtual outputs. Virtual outputs can be mapped to bit-pairs for transmitting to any enrolled devices.
For example if DDB 256 is asserted in PSL for the P44y, P54x, P547 and P841 product, Virtual Output 32 and its associated mappings will operate.

4.8 Control In Signal Properties

There are 32 control inputs which can be activated via the relay menu, ‘hotkeys’ or via rear communications. Depending on the programmed setting i.e. latched or pulsed, an associated DDB signal will be activated in PSL when a control input is operated
For example, when operated control input 1 will assert DDB 192 in the PSL for the P44y, P54x, P547 and P841 products.

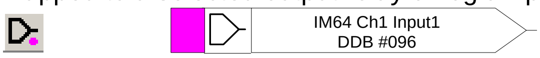
4.9 InterMiCOM Output Commands Properties

There are 16 InterMiCOM outputs that could be selected and use for teleprotection, remote commands, etc. “InterMiCOM Out” is a send command to a remote end that could be mapped to any logic output or opto input. This will be transmitted to the remote end as corresponding “InterMiCOM In” command for the P14x, P44y, P445 & P54x products.



4.10 InterMiCOM Input Commands Properties

There are 16 InterMiCOM inputs that could be selected and use for teleprotection, remote commands, etc. “InterMiCOM In” is a received signal from remote end that could be mapped to a selected output relay or logic input.

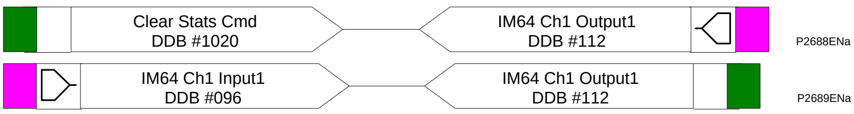


Example:

Relay End A — At end A, InterMiCOM Output 1 is mapped to the command indication “Clear Statistics” (issued at end A).

Relay End B — At end B, InterMiCOM Input 1 is mapped to the command “Clear Statistics”.

Upon receive of IM64 1 from relay at end A, the relay at end B will reset its statistics.



4.11 Function Key Properties

Each function key can be selected and used for programming in PSL. Activation of the function key will drive an associated DDB signal and the DDB signal will remain active depending on the programmed setting i.e. toggled or normal. Toggled mode means the DDB signal will remain latched or unlatched on key press and normal means the DDB will only be active for the duration of the key press.

For example, operate function key 1 to assert DDB 1096 in the PSL for the P44y, P54x, P547 or P841 products.

4.12 Fault Recorder Trigger Properties

The fault recording facility can be activated by driving the fault recorder trigger DDB signal.
For example assert DDB 702 to activate the fault recording in the PSL for the P44y, P54x, P547 or P841 product.


4.13 LED Signal Properties

All programmable LEDs will drive associated DDB signal when the LED is activated.
For example DDB 1036 will be asserted when LED 7 is activated for the P44y, P54x, P547 or P841 product.


4.14 Contact Signal Properties

All relay output contacts will drive associated DDB signal when the output contact is activated.
For example, DDB 009 will be asserted when output R10 is activated for all products.


4.15 LED Conditioner Properties

1. Select the **LED name** from the list (only shown when inserting a new symbol).
2. Configure the LED output to be Red, Yellow or Green.

   Configure a Green LED by driving the Green DDB input.
   Configure a RED LED by driving the RED DDB input.
   Configure a Yellow LED by driving the RED and GREEN DDB inputs simultaneously.

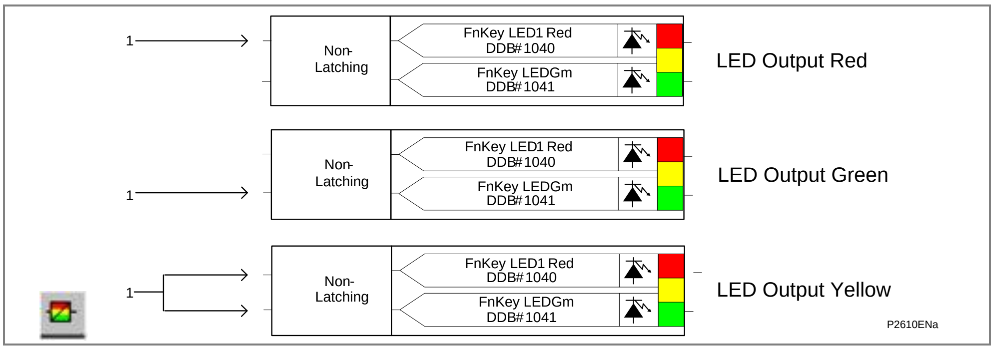


Figure 3 - Red, green and yellow LED outputs

3. Configure the LED output to be latching or non-latching.

DDB #642 and DDB #643 applies to these products: P14x, P44x, P74x, P746 and P849.
DDB #1040 and DDB #1041 applies to these products: P24x, P34x, P44y, P54x, P547, P64x and P841.

4.16 Contact Conditioner Properties

Each contact can be conditioned with an associated timer that can be selected for pick up, drop off, dwell, pulse, pick-up/drop-off, straight-through, or latching operation. **Straight-through** means it is not conditioned in any way whereas **Latching** is used to create a sealed-in or lockout type function.

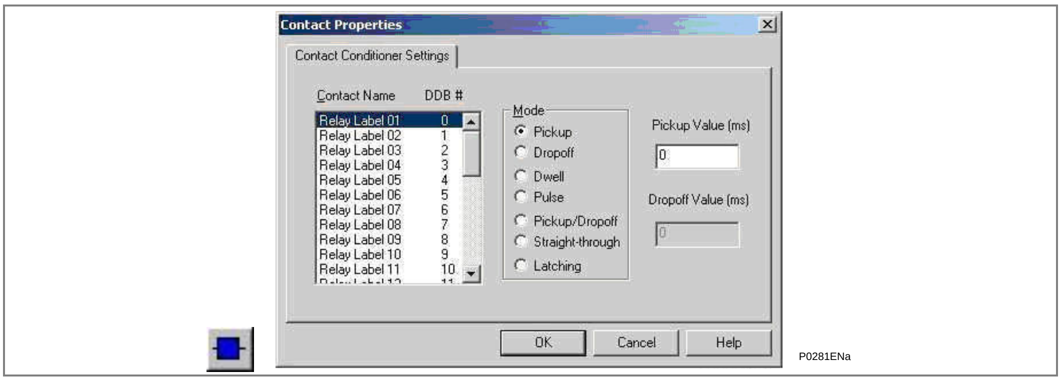


Figure 4 - Contact conditioner settings

1. Select the contact **name** from the **Contact Name** list (only shown when inserting a new symbol).
2. Choose the conditioner type required in the **Mode** tick list.
3. Set the **Pick-up** Time (in milliseconds), if required.
4. Set the **Drop-off** Time (in milliseconds), if required.

4.17 Timer Properties

Each timer can be selected for pick up, drop off, dwell, pulse or pick-up/drop-off operation.

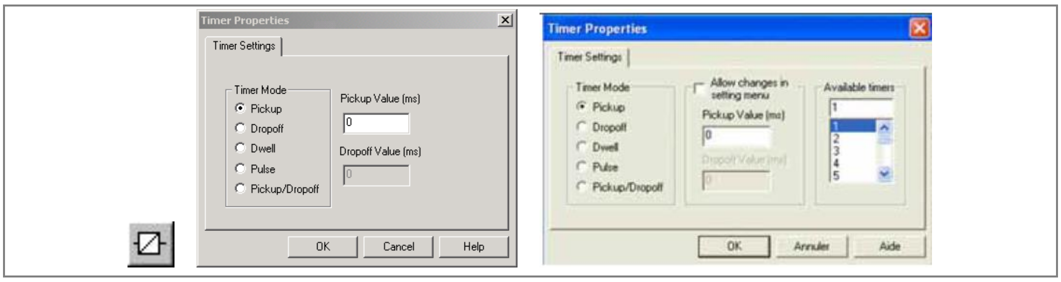


Figure 5 - Timer settings

1. Choose the operation mode from the **Timer Mode** tick list.
2. Set the Pick-up Time (in milliseconds), if required.
3. Set the Drop-off Time (in milliseconds), if required.

4.18 Gate Properties

A Gate may be an AND, OR, or programmable gate.

	An **AND** gate requires that all inputs are TRUE for the output to be TRUE.
	An **OR** gate requires that one or more input is TRUE for the output to be TRUE.
	A **Programmable** gate requires that the number of inputs that are TRUE is equal to or greater than its ‘Inputs to Trigger’ setting for the output to be TRUE.

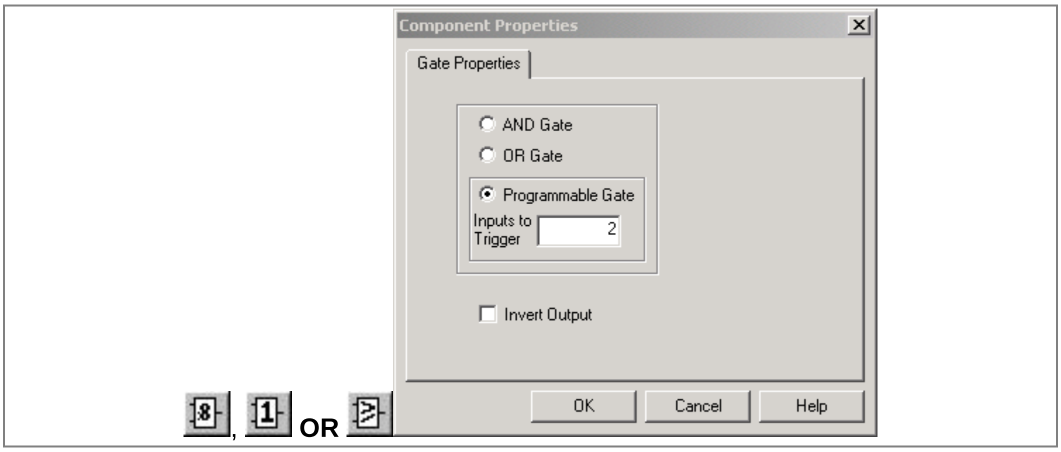


Figure 6 - Gate properties

1. Select the Gate type AND, OR, or Programmable.
2. Set the number of inputs to trigger when Programmable is selected.
3. Select if the output of the gate should be inverted using the Invert Output check box. An inverted output is indicated with a "bubble" on the gate output.

4.19 SR Programmable Gate Properties

For many products a number of programmable SR Latches are added. They are configured by an appropriate version of PSL Editor (S1v2.14 version 5.0.0 or greater) where an SRQ icon features on the toolbar.

Each SR latch has a Q output. The Q output may be inverted in the PSL Editor under the SR Latch component properties window. The SR Latches may be configured as Standard (no input dominant), Set Dominant or Reset Dominant in the PSL Editor under the SR Latch component properties window. The truth table for the SR Latches is given below.

A **Programmable** SR gate can be selected to operate with these latch properties:

S input	R input	O - Standard	O – Set input dominant	O – Reset input dominant
0	0	0	0	0
0	1	0	0	0
1	0	1	1	1
1	1	0	1	0

Table 1 - SR programmable gate properties

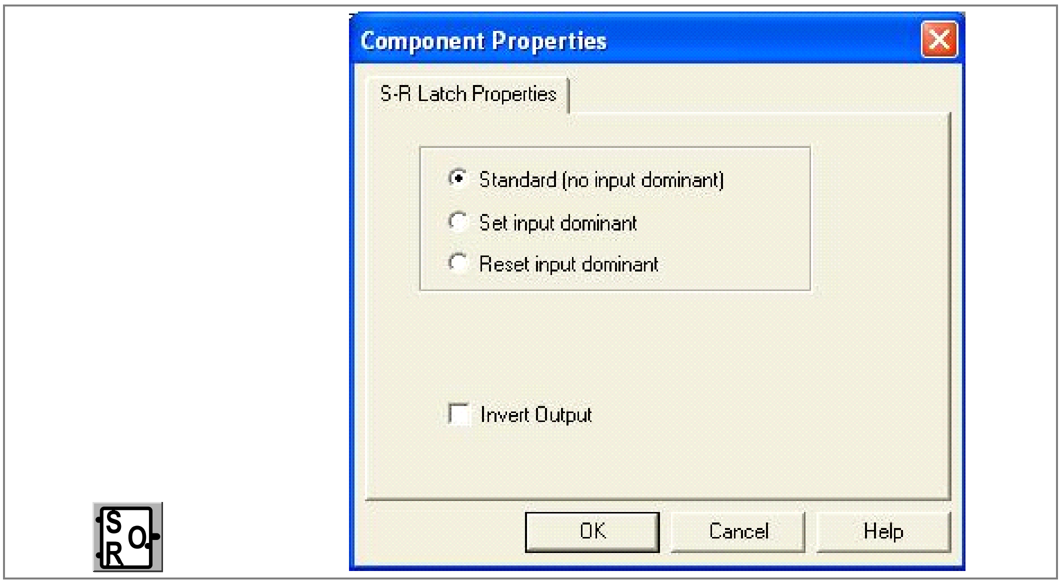


Figure 7 - SR latch component properties

Select if the output of the gate should be inverted using the Invert Output check box. An inverted output is indicated with a "bubble" on the gate output.

4.20 PSL Signal Grouping Modes

PSL Signal Grouping Nodes

For Software Version D1a and later, these DDB “Group” Nodes can be mapped to individual or multiple DDBs in the PSL:

PSL Group Sig 1
PSL Group Sig 2
PSL Group Sig 3
PSL Group Sig 4

There are now four additional ***DDB Group Sig x*** Nodes that can be mapped to individual or multiple DDBs in the PSL. These can then be set to trigger the DR via the DISTURBANCE RECORD menu.

These "Nodes" are general and can also be used to group signals together in the PSL for any other reason. These four nodes are available in each of the four PSL setting groups.

Number	PSL Group Sig
992	PSL Group Sig 1
993	PSL Group Sig 2
994	PSL Group Sig 3
995	PSL Group Sig 4

1. For a control input, the DR can be triggered directly by triggering directly from the Individual Control Input (e.g. Low to High (L to H) change)
2. For an input that cannot be triggered directly, or where any one of a number of DDBs are required to trigger a DR, map the DDBs to the new PSL Group sig n and then trigger the DR on this.

e.g. in the PSL:

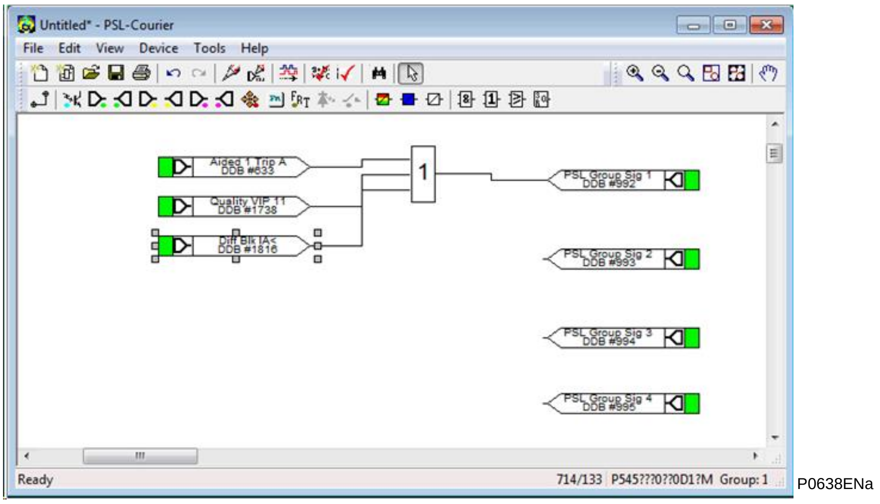


Figure 8 - PSL diagram

In the DR Settings:

- Digital Input 1 is triggered by the PSL Group Sig 1 (L to H)
- Digital Input 2 is triggered by Control Input 1 (L to H)

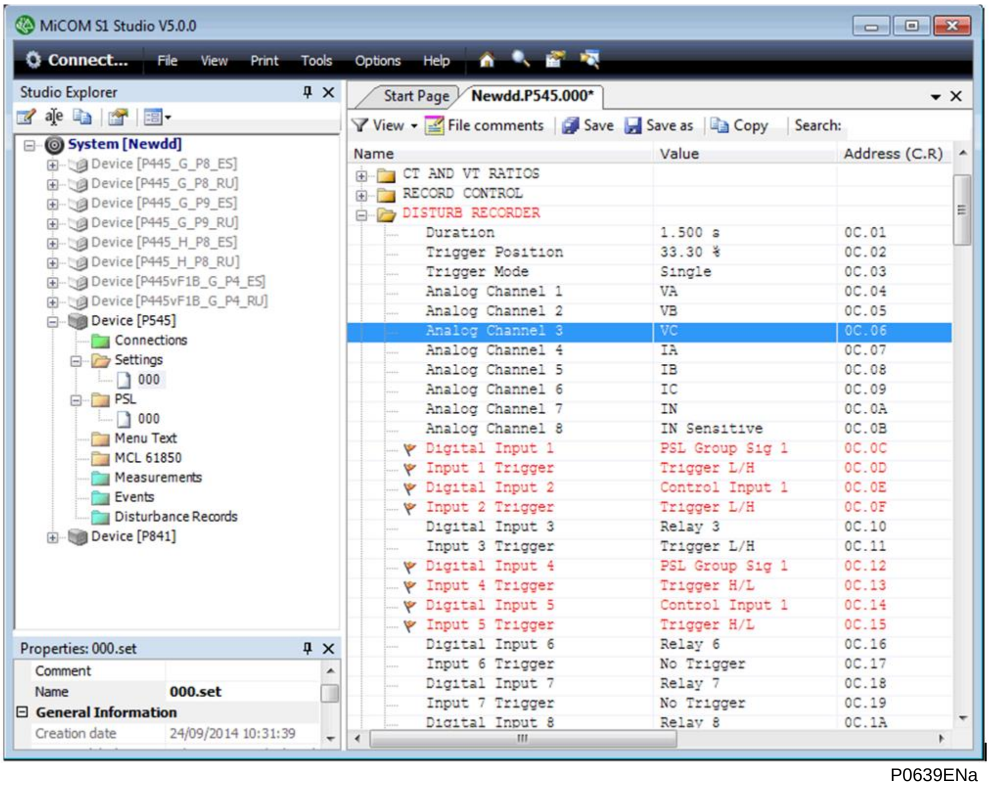


Figure 9 – Easergy Studio (MiCOM S1 Studio) Disturb Recorder table diagram

If triggering on both edges is required map another DR channel to the H/L as well

Digital Input 4 is triggered by the PSL Group Sig 1 (H to L)

Digital Input 5 is triggered by Control Input 1 (H to L)

5 SPECIFIC TASKS

Note	*MiCOM S1 Studio has been renamed as Easergy Studio.*

5.1 DR Digital Input Label Operation (P44y, P54x, P445 & P841 only)

The digital input labels can be modified via the MiCOM Px40 user interface or Easergy Studio (MiCOM S1 Studio). The following example is using S1 Studio Version 5.0.0. The digital input labels are available in the “DR CHAN LABELS” folder in the settings file as shown below:

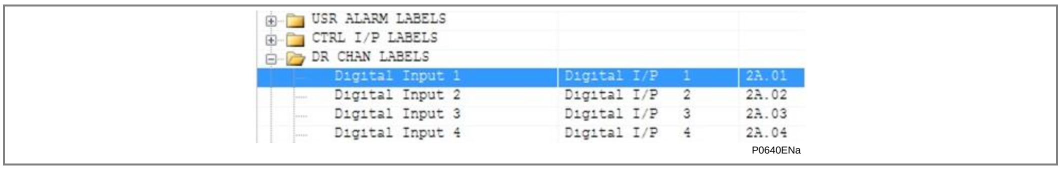


Figure 10 - DR Chan Labels tree

Easergy Studio (MiCOM S1 Studio) removes leading spaces from the value field so making the ‘D’ look as if it’s the 1st character in the label. The default values above in fact have a leading space which is used to switch off the use of the label as show below in the change settings view.

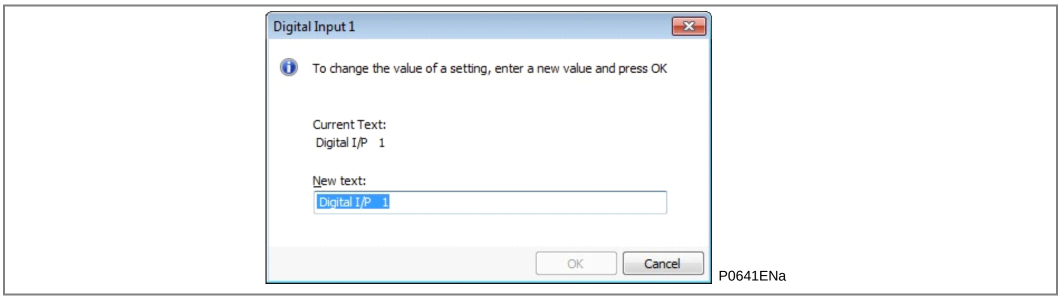


Figure 11 - Digital Input 1 dialog box

Pressing OK will save the setting and return to the settings page as follows:

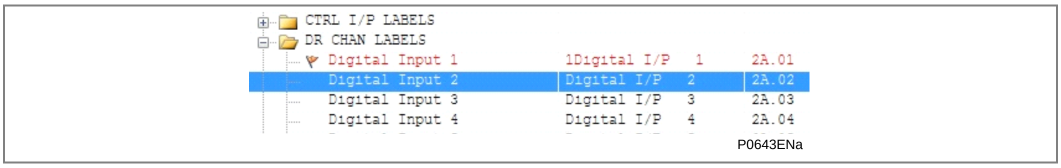


Figure 12 - DR Chan Labels tree

Digital Input 1 label will now be used in the Disturbance Record when the settings file is downloaded to the relay.

5.2 Virtual Input Label Operation

The Virtual Input labels can be modified via the MiCOM Px40 user interface or Easergy Studio.

The default labels are available in the “VIR I/P LABELS” (or “VIRT I/P LABELS”) folder in the settings file as shown below:

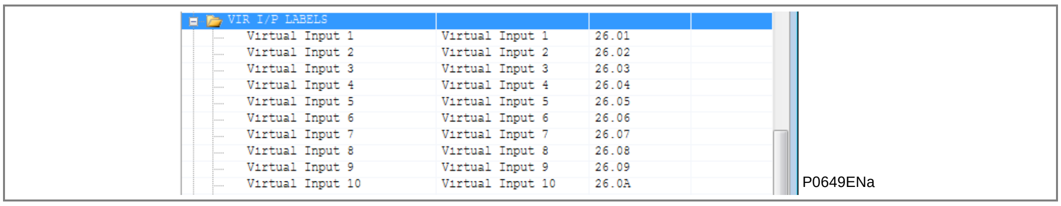


Figure 13 - Easergy Studio VIR I/P Labels Tree

The default “Virtual Input” labels can be changed to customer requirements. For example, to change default text from “Virtual Input 1” to “Customer Func 1” open the ***Virtual Input 1*** box, and change “Virtual Input 1” in the ***New Text:*** box to “Customer Func 1”:

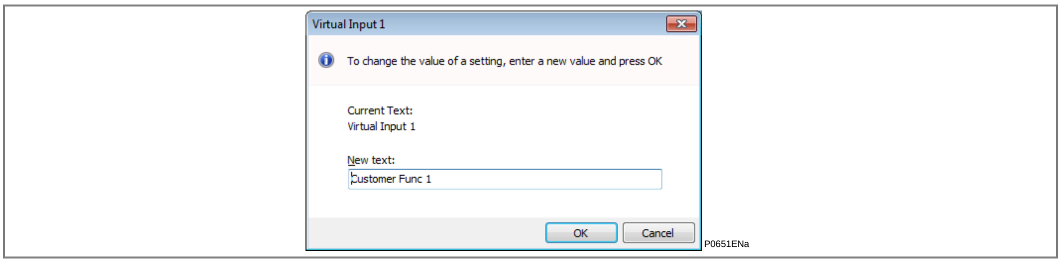


Figure 14 - Virtual Input 1 dialog box

Pressing OK will save the setting and return to the settings page as follows:

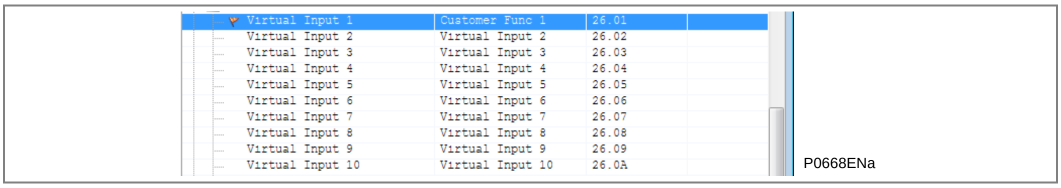


Figure 15 - Easergy Studio VIR I/P Labels Tree

The above “Customer Func 1” label text will now be used in place of “Virtual Input 1” in the Disturbance / Event Records after the settings file is downloaded to the relay.

5.3 Virtual Output Label Operation

The Virtual Output labels can be modified via the relay user interface or Easergy Studio.

The virtual Output labels are available in the “VIR O/P LABELS” ” (or “VIRT O/P LABELS”) folder in the settings file as shown below:

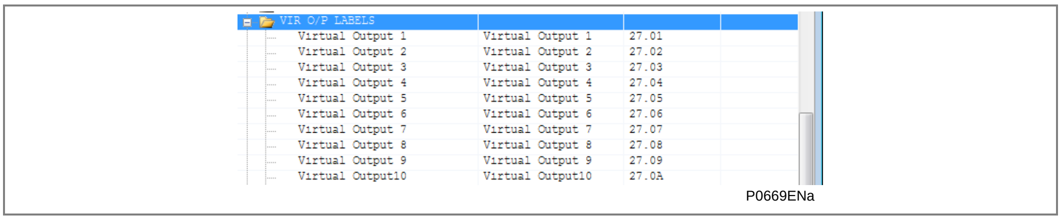


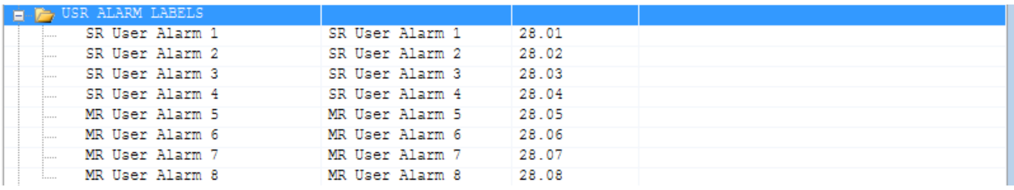
Figure 16 - Easergy Studio VIR O/P Labels Tree

The default “Virtual Output Labels” can be changed to suit the customer requirements. The process is identical to the previously described procedure for the Virtual Input Labels.

5.4 SR/MR User Alarm Label Operation

The SR/MR User Alarm input labels can be modified via the MiCOM Px40 user interface or Easergy Studio.

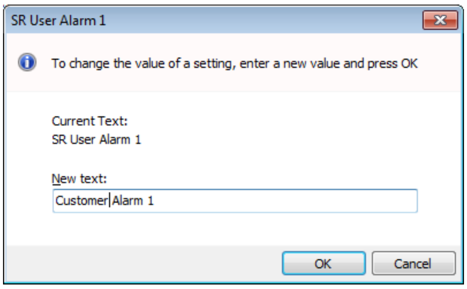
The default labels are available in the “USR ALARM LABELS” folder in the settings file as shown below:



P0670ENa

Figure 17 - Easergy Studio USR Labels Tree

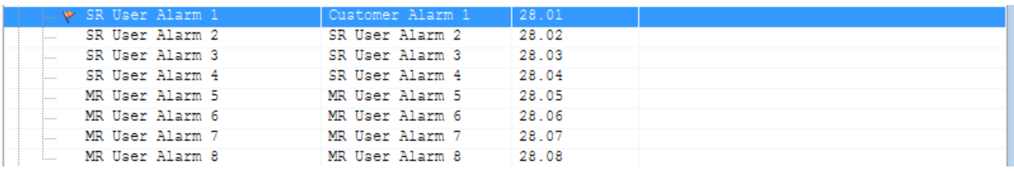
The default “SR User Alarm” and “MR User Alarm” labels can be changed to suit the customer requirements. For example, to change default text from “SR User Alarm 1” to “Customer Alarm 1” open the ***SR User Alarm 1*** dialog box and change “SR User Alarm 1” in the ***New Text:*** Text box to be “Customer Alarm 1”.



P0672ENa

Figure 18 – User Alarm dialog box

Pressing OK will save the setting and return to the settings page as follows:



P0673ENa

Figure 19 - Virtual Input 1 settings

The above “Customer Alarm 1” label text will now be used in place of “SR User Alarm 1” in the Disturbance / Event Records after the settings file is downloaded to the relay.

5.5 Settable Control Input Operation (P14x, P44y, P54x, P445 & P841 only)

The settings should be applied to all relays in the current differential protection scheme. As from Software Versions C1/D1/F1/G4/H4/J4, there are now 32 Standard Control Inputs and 16 additional Settable Control Inputs available. These are settable via the "CONTROL INPUTS" folder and are located after the standard "Control Input" labels in the relevant settings file.

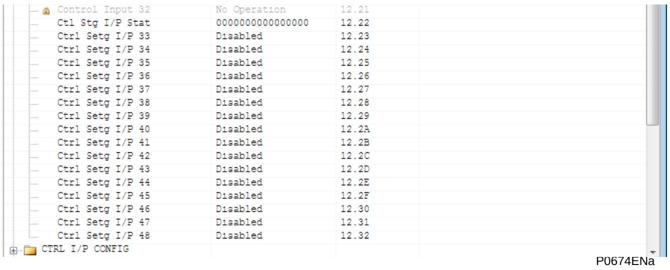


Figure 20 - Easergy Studio Control Inputs tree

Each Settable control Input "Ctrl Setg I/P xx" can be controlled using Enable / Disable settings. To change from (the default) Disabled to Enabled, open the ***Ctrl Setg I/P xx*** dialog box, then change Disabled to Enabled in the ***New Setting*** drop-down list box:

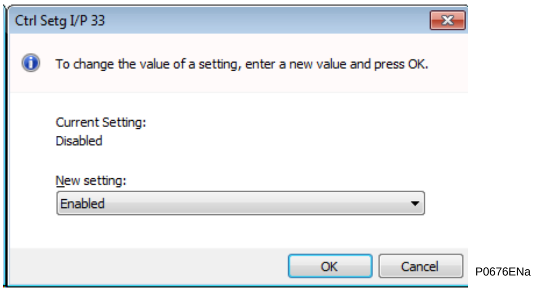


Figure 21 – Ctrl Setg I/P 33 dialog box

Pressing OK will save the setting and return to the settings page as follows:

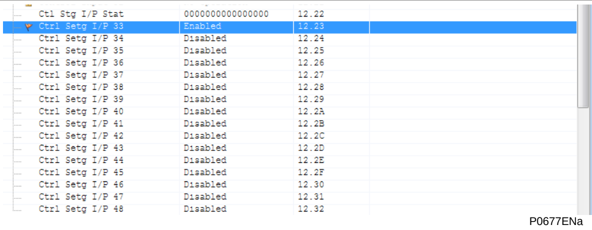


Figure 22 - Easergy Studio Control Inputs (Ctl Setg I/P 33) tree

The setting "Ctl Stg I/P Stat" can be used to control multiple "Ctrl Setg I/P" at the same time, e.g. clear Ctrl Setg I/P 33 and set Ctrl Setg I/P 34 to 38, but please note that the status will not be reflected in the individual inputs settings or vice versa.
This cell may be hidden in the Easergy Studio files.

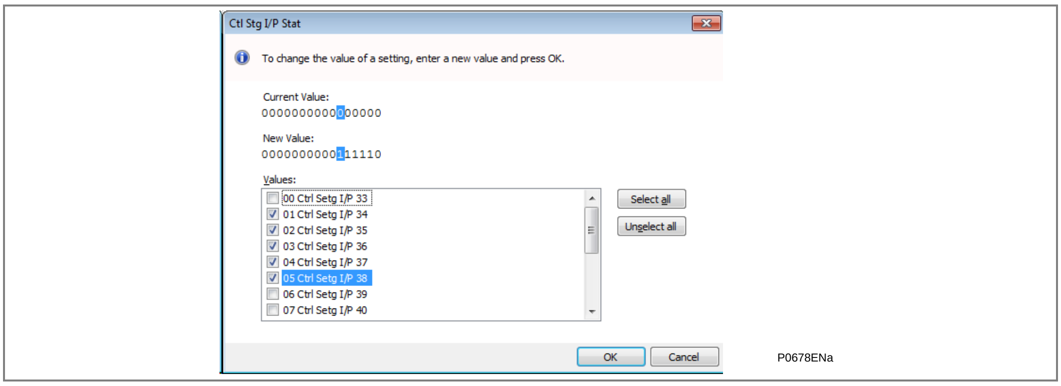


Figure 23 – Ctrl Stg I/P Stat dialog box

5.6 Settable Control Setg I/P Label Operation (P14x, P44y, P54x, P445 & P841 only)

The default labels are available in the “CTRL I/P LABELS” folder and are located after the standard “Control Input” labels in the settings file as shown below:

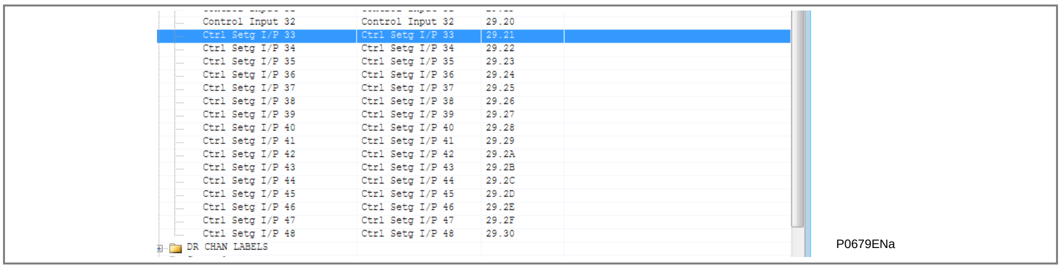


Figure 24 - Easergy Studio Control I/P Labels (Ctl Setg I/P 33) tree

The default “Ctrl Setg I/P” labels can be changed to suit the customer requirements using the same procedure as for the standard “Control Inputs”. For example to change the default text from “Ctrl Setg I/P 33” to “Custom Ctrl Sg 1” open the ***Ctrl Setg I/P 33*** dialog box, then change “Ctrl Setg I/P 33” in the ***New Text:*** box to be “Custom Ctrl Sg 1”.

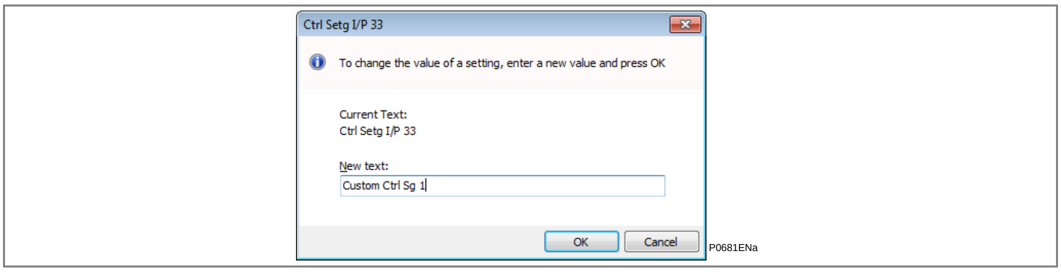


Figure 25 – Ctrl Setg I/P 33 dialog box

Pressing OK will save the setting and return to the settings page as follows:

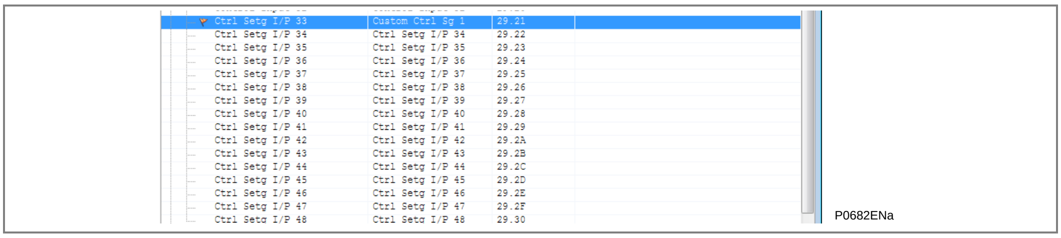


Figure 26 - Easergy Studio Control I/P Labels (Ctl Setg I/P 33) tree

The above “Custom Ctrl Sg 1” label text will now be used in place of “Ctrl Setg I/P 33” in the Disturbance / Event Records after the settings file is downloaded to the relay.

6 MAKING A RECORD OF MICOM PX40 DEVICE SETTINGS

6.1 Using Easergy Studio to Manage Device Settings

An engineer often needs to create a record of what settings have been applied to a device. In the past, they could have used paper printouts of all the available settings, and mark up the ones they had used. Keeping such a paper-based Settings Records could be time-consuming and prone to error (e.g. due to being settings written down incorrectly).
The Easergy Studio software lets you read from or write to MiCOM devices.

- **Extract** lets you download all the settings from a MiCOM Px40 device. A summary is given in the ***Extract Settings from a MiCOM Px40 Device*** section.
- **Send** lets you send the settings you currently have open in Easergy Studio. A summary is given in the ***Send Settings to a MiCOM Px40 Device*** section.

In most cases, it will be quicker and less error prone to extract settings electronically and store them in a settings file on a memory stick. In this way, there will be a digital record which is certain to be accurate. It is also possible to archive these settings files in a repository; so they can be used again or adapted for another use.
Full details of how to do this is provided in the Easergy Studio help.
A quick summary of the main steps is here. In each case, you need to make sure that:

- Your computer includes the Easergy Studio software.
- Your computer and the MiCOM device are powered on.
- You have used a suitable cable to connect your computer to the MiCOM device (Front Port, Rear Port, Ethernet port or Modem as available).

6.2 Extract Settings from a MiCOM Px40 Device

Full details of how to do this is provided in the Easergy Studio help.
As a quick guide, you need to do the following:

1. In Easergy Studio, click the Quick Connect… button.
2. Select the relevant Device Type in the Quick Connect dialog box.
3. Click the relevant port in the Port Selection dialog box.
4. Enter the relevant connection parameters in the Connection Parameters dialog box and click the Finish button
5. Studio will try to communicate with the Px40 device. It will display a connected message if the connection attempt is successful.
6. The device will appear in the Studio Explorer pane on the top-left hand side of the interface.
7. Click the + button to expand the options for the device, then click on the Settings folder.
8. Right-click on Settings and select the Extract Settings link to read the settings on the device and store them on your computer or a memory stick attached to your computer.
9. After retrieving the settings file, close the dialog box by clicking the Close button.

6.3 Send Settings to a MiCOM Px40 Device

Full details of how to do this is provided in the Easergy Studio help.

As a quick guide, you need to do the following:

1. In Easergy Studio, click the Quick Connect… button.
2. Select the relevant Device Type in the Quick Connect dialog box.
3. Click the relevant port in the Port Selection dialog box.
4. Enter the relevant connection parameters in the Connection Parameters dialog box and click the Finish button
5. Studio will try to communicate with the Px40 device. It will display a connected message if the connection attempt is successful.
6. The device will appear in the Studio Explorer pane on the top-left hand side of the interface.
7. Click the + button to expand the options for the device, then click on the Settings link.
8. Right-click on the device name and select the Send link.

Note	*When you send settings to a MiCOM Px40 device, the data is stored in a temporary location at first. This temporary data is tested to make sure it is complete. If the temporary data is complete, it will be programmed into the MiCOM Px40 device. This avoids the risk of a device being programmed with incomplete or corrupt settings.*

9. In the Send To dialog box, select the settings file(s) you wish to send, then click the Send button.
10. Close the Send To dialog box by clicking the Close button.

PROGRAMMABLE LOGIC

CHAPTER 8

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Hardware Suffix:	M
Software Version:	B4 (P746_1) / C4 (P746_2)
Connection Diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

TABLES

FIGURES

1 PROGRAMMABLE LOGIC

1.1 Overview

The purpose of the Programmable Scheme Logic (PSL) is to allow the user to configure an individual protection scheme to suit their own particular application. This is achieved through the use of programmable logic gates and delay timers.

The input to the PSL is any combination of the status of opto inputs. It is also used to assign the mapping of functions to the opto inputs and output contacts, the outputs of the protection elements, e.g. protection starts and trips, and the outputs of the fixed protection scheme logic. The fixed scheme logic provides the relay's standard protection schemes.

The PSL itself consists of software logic gates and timers. The logic gates can be programmed to perform a range of different logic functions and can accept any number of inputs. The timers are used either to create a programmable delay, and/or to condition the logic outputs, e.g. to create a pulse of fixed duration on the output regardless of the length of the pulse on the input. The outputs of the PSL are the LEDs on the front panel of the relay and the output contacts at the rear.

The execution of the PSL logic is event driven; the logic is processed whenever any of its inputs change, for example as a result of a change in one of the digital input signals. Also, only the part of the PSL logic that is affected by the particular input change that has occurred is processed. This reduces the amount of processing time that is used by the PSL. This means that even with large, complex PSL schemes the device trip time will not lengthen.

This system provides flexibility for the user to create their own scheme logic design. It also means that the PSL can be configured into a very complex system, hence setting of the PSL is implemented through the PC support package MiCOM S1 Studio.

How to edit the PSL schemes is described in the "Using the PSL Editor" chapter.

This chapter contains details of the logic nodes which are specific to this product, together with any PSL diagrams which we have published for this product.

2 DESCRIPTION OF P746 LOGIC NODES

The following table shows the available DDB Numbers, a Description of what they are and which product (or products) they apply to. If a DDB Number is not shown, it is not used in this range of products.

DDB	Element Name	Source	Description
0	DDB_OUTPUT_RELAY_1	SW	Output Relay 1
1	DDB_OUTPUT_RELAY_2	SW	Output Relay 2
2	DDB_OUTPUT_RELAY_3	SW	Output Relay 3
3	DDB_OUTPUT_RELAY_4	SW	Output Relay 4
4	DDB_OUTPUT_RELAY_5	SW	Output Relay 5
5	DDB_OUTPUT_RELAY_6	SW	Output Relay 6
6	DDB_OUTPUT_RELAY_7	SW	Output Relay 7
7	DDB_OUTPUT_RELAY_8	SW	Output Relay 8
8	DDB_OUTPUT_RELAY_9	SW	Output Relay 9
9	DDB_OUTPUT_RELAY_10	SW	Output Relay 10
10	DDB_OUTPUT_RELAY_11	SW	Output Relay 11
11	DDB_OUTPUT_RELAY_12	SW	Output Relay 12
12	DDB_OUTPUT_RELAY_13	SW	Output Relay 13
13	DDB_OUTPUT_RELAY_14	SW	Output Relay 14
14	DDB_OUTPUT_RELAY_15	SW	Output Relay 15
15	DDB_OUTPUT_RELAY_16	SW	Output Relay 16
16	DDB_OUTPUT_RELAY_17	SW	Output Relay 17
17	DDB_OUTPUT_RELAY_18	SW	Output Relay 18
18	DDB_OUTPUT_RELAY_19	SW	Output Relay 19
19	DDB_OUTPUT_RELAY_20	SW	Output Relay 20
20	DDB_OUTPUT_RELAY_21	SW	Output Relay 21
21	DDB_OUTPUT_RELAY_22	SW	Output Relay 22
22	DDB_OUTPUT_RELAY_23	SW	Output Relay 23
23	DDB_OUTPUT_RELAY_24	SW	Output Relay 24
24	DDB_OUTPUT_RELAY_25	SW	Output Relay 25
25	DDB_OUTPUT_RELAY_26	SW	Output Relay 26
26	DDB_OUTPUT_RELAY_27	SW	Output Relay 27
27	DDB_OUTPUT_RELAY_28	SW	Output Relay 28
28	DDB_OUTPUT_RELAY_29	SW	Output Relay 29
29	DDB_OUTPUT_RELAY_30	SW	Output Relay 30
30	DDB_OUTPUT_RELAY_31	SW	Output Relay 31
31	DDB_OUTPUT_RELAY_32	SW	Output Relay 32
64	DDB_OPTO_ISOLATOR_1	SW	Opto Isolator Input 1
65	DDB_OPTO_ISOLATOR_2	SW	Opto Isolator Input 2
66	DDB_OPTO_ISOLATOR_3	SW	Opto Isolator Input 3
67	DDB_OPTO_ISOLATOR_4	SW	Opto Isolator Input 4
68	DDB_OPTO_ISOLATOR_5	SW	Opto Isolator Input 5
69	DDB_OPTO_ISOLATOR_6	SW	Opto Isolator Input 6
70	DDB_OPTO_ISOLATOR_7	SW	Opto Isolator Input 7
71	DDB_OPTO_ISOLATOR_8	SW	Opto Isolator Input 8
72	DDB_OPTO_ISOLATOR_9	SW	Opto Isolator Input 9

DDB	Element Name	Source	Description
73	DDB_OPTO_ISOLATOR_10	SW	Opto Isolator Input 10
74	DDB_OPTO_ISOLATOR_11	SW	Opto Isolator Input 11
75	DDB_OPTO_ISOLATOR_12	SW	Opto Isolator Input 12
76	DDB_OPTO_ISOLATOR_13	SW	Opto Isolator Input 13
77	DDB_OPTO_ISOLATOR_14	SW	Opto Isolator Input 14
78	DDB_OPTO_ISOLATOR_15	SW	Opto Isolator Input 15
79	DDB_OPTO_ISOLATOR_16	SW	Opto Isolator Input 16
80	DDB_OPTO_ISOLATOR_17	SW	Opto Isolator Input 17
81	DDB_OPTO_ISOLATOR_18	SW	Opto Isolator Input 18
82	DDB_OPTO_ISOLATOR_19	SW	Opto Isolator Input 19
83	DDB_OPTO_ISOLATOR_20	SW	Opto Isolator Input 20
84	DDB_OPTO_ISOLATOR_21	SW	Opto Isolator Input 21
85	DDB_OPTO_ISOLATOR_22	SW	Opto Isolator Input 22
86	DDB_OPTO_ISOLATOR_23	SW	Opto Isolator Input 23
87	DDB_OPTO_ISOLATOR_24	SW	Opto Isolator Input 24
88	DDB_OPTO_ISOLATOR_25	SW	Opto Isolator Input 25
89	DDB_OPTO_ISOLATOR_26	SW	Opto Isolator Input 26
90	DDB_OPTO_ISOLATOR_27	SW	Opto Isolator Input 27
91	DDB_OPTO_ISOLATOR_28	SW	Opto Isolator Input 28
92	DDB_OPTO_ISOLATOR_29	SW	Opto Isolator Input 29
93	DDB_OPTO_ISOLATOR_30	SW	Opto Isolator Input 30
94	DDB_OPTO_ISOLATOR_31	SW	Opto Isolator Input 31
95	DDB_OPTO_ISOLATOR_32	SW	Opto Isolator Input 32
96	DDB_OPTO_ISOLATOR_33	SW	Opto Isolator Input 33
97	DDB_OPTO_ISOLATOR_34	SW	Opto Isolator Input 34
98	DDB_OPTO_ISOLATOR_35	SW	Opto Isolator Input 35
99	DDB_OPTO_ISOLATOR_36	SW	Opto Isolator Input 36
100	DDB_OPTO_ISOLATOR_37	SW	Opto Isolator Input 37
101	DDB_OPTO_ISOLATOR_38	SW	Opto Isolator Input 38
102	DDB_OPTO_ISOLATOR_39	SW	Opto Isolator Input 39
103	DDB_OPTO_ISOLATOR_40	SW	Opto Isolator Input 40
128	DDB_OUTPUT_CON_1	PSL	Relay Conditioner 1
129	DDB_OUTPUT_CON_2	PSL	Relay Conditioner 2
130	DDB_OUTPUT_CON_3	PSL	Relay Conditioner 3
131	DDB_OUTPUT_CON_4	PSL	Relay Conditioner 4
132	DDB_OUTPUT_CON_5	PSL	Relay Conditioner 5
133	DDB_OUTPUT_CON_6	PSL	Relay Conditioner 6
134	DDB_OUTPUT_CON_7	PSL	Relay Conditioner 7
135	DDB_OUTPUT_CON_8	PSL	Relay Conditioner 8
136	DDB_OUTPUT_CON_9	PSL	Relay Conditioner 9
137	DDB_OUTPUT_CON_10	PSL	Relay Conditioner 10
138	DDB_OUTPUT_CON_11	PSL	Relay Conditioner 11
139	DDB_OUTPUT_CON_12	PSL	Relay Conditioner 12
140	DDB_OUTPUT_CON_13	PSL	Relay Conditioner 13

DDB	Element Name	Source	Description
141	DDB_OUTPUT_CON_14	PSL	Relay Conditioner 14
142	DDB_OUTPUT_CON_15	PSL	Relay Conditioner 15
143	DDB_OUTPUT_CON_16	PSL	Relay Conditioner 16
144	DDB_OUTPUT_CON_17	PSL	Relay Conditioner 17
145	DDB_OUTPUT_CON_18	PSL	Relay Conditioner 18
146	DDB_OUTPUT_CON_19	PSL	Relay Conditioner 19
147	DDB_OUTPUT_CON_20	PSL	Relay Conditioner 20
148	DDB_OUTPUT_CON_21	PSL	Relay Conditioner 21
149	DDB_OUTPUT_CON_22	PSL	Relay Conditioner 22
150	DDB_OUTPUT_CON_23	PSL	Relay Conditioner 23
151	DDB_OUTPUT_CON_24	PSL	Relay Conditioner 24
152	DDB_OUTPUT_CON_25	PSL	Relay Conditioner 25
153	DDB_OUTPUT_CON_26	PSL	Relay Conditioner 26
154	DDB_OUTPUT_CON_27	PSL	Relay Conditioner 27
155	DDB_OUTPUT_CON_28	PSL	Relay Conditioner 28
156	DDB_OUTPUT_CON_29	PSL	Relay Conditioner 29
157	DDB_OUTPUT_CON_30	PSL	Relay Conditioner 30
158	DDB_OUTPUT_CON_31	PSL	Relay Conditioner 31
159	DDB_OUTPUT_CON_32	PSL	Relay Conditioner 32
192	DDB_OUTPUT_TRI_LED_1_RED	SW	Programmable Tri-LED 1 Red energized
193	DDB_OUTPUT_TRI_LED_1_GRN	SW	Programmable Tri-LED 1 Green energized
194	DDB_OUTPUT_TRI_LED_2_RED	SW	Programmable Tri-LED 2 Red energized
195	DDB_OUTPUT_TRI_LED_2_GRN	SW	Programmable Tri-LED 2 Green energized
196	DDB_OUTPUT_TRI_LED_3_RED	SW	Programmable Tri-LED 3 Red energized
197	DDB_OUTPUT_TRI_LED_3_GRN	SW	Programmable Tri-LED 3 Green energized
198	DDB_OUTPUT_TRI_LED_4_RED	SW	Programmable Tri-LED 4 Red energized
199	DDB_OUTPUT_TRI_LED_4_GRN	SW	Programmable Tri-LED 4 Green energized
200	DDB_OUTPUT_TRI_LED_5_RED	SW	Programmable Tri-LED 5 Red energized
201	DDB_OUTPUT_TRI_LED_5_GRN	SW	Programmable Tri-LED 5 Green energized
202	DDB_OUTPUT_TRI_LED_6_RED	SW	Programmable Tri-LED 6 Red energized
203	DDB_OUTPUT_TRI_LED_6_GRN	SW	Programmable Tri-LED 6 Green energized
204	DDB_OUTPUT_TRI_LED_7_RED	SW	Programmable Tri-LED 7 Red energized
205	DDB_OUTPUT_TRI_LED_7_GRN	SW	Programmable Tri-LED 7 Green energized
206	DDB_OUTPUT_TRI_LED_8_RED	SW	Programmable Tri-LED 8 Red energized
207	DDB_OUTPUT_TRI_LED_8_GRN	SW	Programmable Tri-LED 8 Green energized
208	DDB_OUTPUT_TRI_LED_9_RED	SW	Programmable function key Tri-LED 1 Red energized
209	DDB_OUTPUT_TRI_LED_9_GRN	SW	Programmable function key Tri-LED 1 Green energized
210	DDB_OUTPUT_TRI_LED_10_RED	SW	Programmable function key Tri-LED 2 Red energized
211	DDB_OUTPUT_TRI_LED_10_GRN	SW	Programmable function key Tri-LED 2 Green energized
212	DDB_OUTPUT_TRI_LED_11_RED	SW	Programmable function key Tri-LED 3 Red energized
213	DDB_OUTPUT_TRI_LED_11_GRN	SW	Programmable function key Tri-LED 3 Green energized
214	DDB_OUTPUT_TRI_LED_12_RED	SW	Programmable function key Tri-LED 4 Red energized
215	DDB_OUTPUT_TRI_LED_12_GRN	SW	Programmable function key Tri-LED 4 Green energized
216	DDB_OUTPUT_TRI_LED_13_RED	SW	Programmable function key Tri-LED 5 Red energized

DDB	Element Name	Source	Description
217	DDB_OUTPUT_TRI_LED_13_GRN	SW	Programmable function key Tri-LED 5 Green energized
218	DDB_OUTPUT_TRI_LED_14_RED	SW	Programmable function key Tri-LED 6 Red energized
219	DDB_OUTPUT_TRI_LED_14_GRN	SW	Programmable function key Tri-LED 6 Green energized
220	DDB_OUTPUT_TRI_LED_15_RED	SW	Programmable function key Tri-LED 7 Red energized
221	DDB_OUTPUT_TRI_LED_15_GRN	SW	Programmable function key Tri-LED 7 Green energized
222	DDB_OUTPUT_TRI_LED_16_RED	SW	Programmable function key Tri-LED 8 Red energized
223	DDB_OUTPUT_TRI_LED_16_GRN	SW	Programmable function key Tri-LED 8 Green energized
224	DDB_OUTPUT_TRI_LED_17_RED	SW	Programmable function key Tri-LED 9 Red energized
225	DDB_OUTPUT_TRI_LED_17_GRN	SW	Programmable function key Tri-LED 9 Green energized
226	DDB_OUTPUT_TRI_LED_18_RED	SW	Programmable function key Tri-LED 10 Red energized
227	DDB_OUTPUT_TRI_LED_18_GRN	SW	Programmable function key Tri-LED 10 Green energized
228	DDB_DST_STATUS	SW	If this location DST is in effect now
256	DDB_TRI_LED_RED_CON_1	PSL	Assignment of signal to drive output Tri-LED 1 Red
257	DDB_TRI_LED_GRN_CON_1	PSL	Assignment of signal to drive output Tri-LED 1 Green
258	DDB_TRI_LED_RED_CON_2	PSL	Assignment of signal to drive output Tri-LED 2 Red
259	DDB_TRI_LED_GRN_CON_2	PSL	Assignment of signal to drive output Tri-LED 2 Green
260	DDB_TRI_LED_RED_CON_3	PSL	Assignment of signal to drive output Tri-LED 3 Red
261	DDB_TRI_LED_GRN_CON_3	PSL	Assignment of signal to drive output Tri-LED 3 Green
262	DDB_TRI_LED_RED_CON_4	PSL	Assignment of signal to drive output Tri-LED 4 Red
263	DDB_TRI_LED_GRN_CON_4	PSL	Assignment of signal to drive output Tri-LED 4 Green
264	DDB_TRI_LED_RED_CON_5	PSL	Assignment of signal to drive output Tri-LED 5 Red
265	DDB_TRI_LED_GRN_CON_5	PSL	Assignment of signal to drive output Tri-LED 5 Green
266	DDB_TRI_LED_RED_CON_6	PSL	Assignment of signal to drive output Tri-LED 6 Red
267	DDB_TRI_LED_GRN_CON_6	PSL	Assignment of signal to drive output Tri-LED 6 Green
268	DDB_TRI_LED_RED_CON_7	PSL	Assignment of signal to drive output Tri-LED 7 Red
269	DDB_TRI_LED_GRN_CON_7	PSL	Assignment of signal to drive output Tri-LED 7 Green
270	DDB_TRI_LED_RED_CON_8	PSL	Assignment of signal to drive output Tri-LED 8 Red
271	DDB_TRI_LED_GRN_CON_8	PSL	Assignment of signal to drive output Tri-LED 8 Green
272	DDB_TRI_LED_RED_CON_9	PSL	Function key Tri-LED Conditioner 1 Red
273	DDB_TRI_LED_GRN_CON_9	PSL	Function key Tri-LED Conditioner 1 Green
274	DDB_TRI_LED_RED_CON_10	PSL	Function key Tri-LED Conditioner 2 Red
275	DDB_TRI_LED_GRN_CON_10	PSL	Function key Tri-LED Conditioner 2 Green
276	DDB_TRI_LED_RED_CON_11	PSL	Function key Tri-LED Conditioner 3 Red
277	DDB_TRI_LED_GRN_CON_11	PSL	Function key Tri-LED Conditioner 3 Green
278	DDB_TRI_LED_RED_CON_12	PSL	Function key Tri-LED Conditioner 4 Red
279	DDB_TRI_LED_GRN_CON_12	PSL	Function key Tri-LED Conditioner 4 Green
280	DDB_TRI_LED_RED_CON_13	PSL	Function key Tri-LED Conditioner 5 Red
281	DDB_TRI_LED_GRN_CON_13	PSL	Function key Tri-LED Conditioner 5 Green
282	DDB_TRI_LED_RED_CON_14	PSL	Function key Tri-LED Conditioner 6 Red
283	DDB_TRI_LED_GRN_CON_14	PSL	Function key Tri-LED Conditioner 6 Green
284	DDB_TRI_LED_RED_CON_15	PSL	Function key Tri-LED Conditioner 7 Red
285	DDB_TRI_LED_GRN_CON_15	PSL	Function key Tri-LED Conditioner 7 Green
286	DDB_TRI_LED_RED_CON_16	PSL	Function key Tri-LED Conditioner 8 Red
287	DDB_TRI_LED_GRN_CON_16	PSL	Function key Tri-LED Conditioner 8 Green

DDB	Element Name	Source	Description
288	DDB_TRI_LED_RED_CON_17	PSL	Function key Tri-LED Conditioner 9 Red
289	DDB_TRI_LED_GRN_CON_17	PSL	Function key Tri-LED Conditioner 9 Green
290	DDB_TRI_LED_RED_CON_18	PSL	Function key Tri-LED Conditioner 10 Red
291	DDB_TRI_LED_GRN_CON_18	PSL	Function key Tri-LED Conditioner 10 Green
292	DDB_Q1_BB3_ALARM	PSL	Isolator Q1 connected to BB3 alarm
293	DDB_Q1_BB3_CLOSED	PSL	Isolator Q1 connected to BB3 Closed
294	DDB_Q1_BB4_ALARM	PSL	Isolator Q1 connected to BB4 alarm
295	DDB_Q1_BB4_CLOSED	PSL	Isolator Q1 connected to BB4 Closed
296	DDB_Q2_BB3_ALARM	PSL	Isolator Q2 connected to BB3 alarm
297	DDB_Q2_BB3_CLOSED	PSL	Isolator Q2 connected to BB3 Closed
298	DDB_Q2_BB4_ALARM	PSL	Isolator Q2 connected to BB4 alarm
299	DDB_Q2_BB4_CLOSED	PSL	Isolator Q2 connected to BB4 Closed
300	DDB_Q3_BB3_ALARM	PSL	Isolator Q3 connected to BB3 alarm
301	DDB_Q3_BB3_CLOSED	PSL	Isolator Q3 connected to BB3 Closed
302	DDB_Q3_BB4_ALARM	PSL	Isolator Q3 connected to BB4 alarm
303	DDB_Q3_BB4_CLOSED	PSL	Isolator Q3 connected to BB4 Closed
304	DDB_Q4_BB3_ALARM	PSL	Isolator Q4 connected to BB3 alarm
305	DDB_Q4_BB3_CLOSED	PSL	Isolator Q4 connected to BB3 Closed
306	DDB_Q4_BB4_ALARM	PSL	Isolator Q4 connected to BB4 alarm
307	DDB_Q4_BB4_CLOSED	PSL	Isolator Q4 connected to BB4 Closed
308	DDB_Q5_BB3_ALARM	PSL	Isolator Q5 connected to BB3 alarm
309	DDB_Q5_BB3_CLOSED	PSL	Isolator Q5 connected to BB3 Closed
310	DDB_Q5_BB4_ALARM	PSL	Isolator Q5 connected to BB4 alarm
311	DDB_Q5_BB4_CLOSED	PSL	Isolator Q5 connected to BB4 Closed
312	DDB_Q6_BB3_ALARM	PSL	Isolator Q6 connected to BB3 alarm
313	DDB_Q6_BB3_CLOSED	PSL	Isolator Q6 connected to BB3 Closed
314	DDB_Q6_BB4_ALARM	PSL	Isolator Q6 connected to BB4 alarm
315	DDB_Q6_BB4_CLOSED	PSL	Isolator Q6 connected to BB4 Closed
316	DDB_Q7_BB3_ALARM	PSL	Isolator Q7 connected to BB3 alarm
317	DDB_Q7_BB3_CLOSED	PSL	Isolator Q7 connected to BB3 Closed
318	DDB_Q7_BB4_ALARM	PSL	Isolator Q7 connected to BB4 alarm
319	DDB_Q7_BB4_CLOSED	PSL	Isolator Q7 connected to BB4 Closed
320	DDB_Q8_BB3_ALARM	PSL	Isolator Q8 connected to BB3 alarm
321	DDB_Q8_BB3_CLOSED	PSL	Isolator Q8 connected to BB3 Closed
322	DDB_Q8_BB4_ALARM	PSL	Isolator Q8 connected to BB4 alarm
323	DDB_Q8_BB4_CLOSED	PSL	Isolator Q8 connected to BB4 Closed
324	DDB_Q9_BB3_ALARM	PSL	Isolator Q9 connected to BB3 alarm
325	DDB_Q9_BB3_CLOSED	PSL	Isolator Q9 connected to BB3 Closed
326	DDB_Q9_BB4_ALARM	PSL	Isolator Q9 connected to BB4 alarm
327	DDB_Q9_BB4_CLOSED	PSL	Isolator Q9 connected to BB4 Closed
328	DDB_Q10_BB3_ALARM	PSL	Isolator Q10 connected to BB3 alarm
329	DDB_Q10_BB3_CLOSED	PSL	Isolator Q10 connected to BB3 Closed
330	DDB_Q10_BB4_ALARM	PSL	Isolator Q10 connected to BB4 alarm
331	DDB_Q10_BB4_CLOSED	PSL	Isolator Q10 connected to BB4 Closed

DDB	Element Name	Source	Description
332	DDB_Q11_BB3_ALARM	PSL	Isolator Q11 connected to BB3 alarm
333	DDB_Q11_BB3_CLOSED	PSL	Isolator Q11 connected to BB3 Closed
334	DDB_Q11_BB4_ALARM	PSL	Isolator Q11 connected to BB4 alarm
335	DDB_Q11_BB4_CLOSED	PSL	Isolator Q11 connected to BB4 Closed
336	DDB_Q12_BB3_ALARM	PSL	Isolator Q12 connected to BB3 alarm
337	DDB_Q12_BB3_CLOSED	PSL	Isolator Q12 connected to BB3 Closed
338	DDB_Q12_BB4_ALARM	PSL	Isolator Q12 connected to BB4 alarm
339	DDB_Q12_BB4_CLOSED	PSL	Isolator Q12 connected to BB4 Closed
340	DDB_Q13_BB3_ALARM	PSL	Isolator Q13 connected to BB3 alarm
341	DDB_Q13_BB3_CLOSED	PSL	Isolator Q13 connected to BB3 Closed
342	DDB_Q13_BB4_ALARM	PSL	Isolator Q13 connected to BB4 alarm
343	DDB_Q13_BB4_CLOSED	PSL	Isolator Q13 connected to BB4 Closed
344	DDB_Q14_BB3_ALARM	PSL	Isolator Q14 connected to BB3 alarm
345	DDB_Q14_BB3_CLOSED	PSL	Isolator Q14 connected to BB3 Closed
346	DDB_Q14_BB4_ALARM	PSL	Isolator Q14 connected to BB4 alarm
347	DDB_Q14_BB4_CLOSED	PSL	Isolator Q14 connected to BB4 Closed
348	DDB_Q15_BB3_ALARM	PSL	Isolator Q15 connected to BB3 alarm
349	DDB_Q15_BB3_CLOSED	PSL	Isolator Q15 connected to BB3 Closed
350	DDB_Q15_BB4_ALARM	PSL	Isolator Q15 connected to BB4 alarm
351	DDB_Q15_BB4_CLOSED	PSL	Isolator Q15 connected to BB4 Closed
352	DDB_FN_KEY_1	SW	Function Key 1
353	DDB_FN_KEY_2	SW	Function Key 2
354	DDB_FN_KEY_3	SW	Function Key 3
355	DDB_FN_KEY_4	SW	Function Key 4
356	DDB_FN_KEY_5	SW	Function Key 5
357	DDB_FN_KEY_6	SW	Function Key 6
358	DDB_FN_KEY_7	SW	Function Key 7
359	DDB_FN_KEY_8	SW	Function Key 8
360	DDB_FN_KEY_9	SW	Function Key 9
361	DDB_FN_KEY_10	SW	Function Key 10
362	DDB_Q16_BB3_ALARM	PSL	Isolator Q16 connected to BB3 alarm
363	DDB_Q16_BB3_CLOSED	PSL	Isolator Q16 connected to BB3 Closed
364	DDB_Q16_BB4_ALARM	PSL	Isolator Q16 connected to BB4 alarm
365	DDB_Q16_BB4_CLOSED	PSL	Isolator Q16 connected to BB4 Closed
366	DDB_Q17_BB3_ALARM	PSL	Isolator Q17 connected to BB3 alarm
367	DDB_Q17_BB3_CLOSED	PSL	Isolator Q17 connected to BB3 Closed
368	DDB_Q17_BB4_ALARM	PSL	Isolator Q17 connected to BB4 alarm
369	DDB_Q17_BB4_CLOSED	PSL	Isolator Q17 connected to BB4 Closed
370	DDB_Q18_BB3_ALARM	PSL	Isolator Q18 connected to BB3 alarm
371	DDB_Q18_BB3_CLOSED	PSL	Isolator Q18 connected to BB3 Closed
372	DDB_Q18_BB4_ALARM	PSL	Isolator Q18 connected to BB4 alarm
373	DDB_Q18_BB4_CLOSED	PSL	Isolator Q18 connected to BB4 Closed
374	DDB_Q19_BB1_ALARM	PSL	Isolator Q19 connected to BB1 alarm
375	DDB_Q19_BB1_CLOSED	PSL	Isolator Q19 connected to BB1 Closed

DDB	Element Name	Source	Description
376	DDB_Q19_BB2_ALARM	PSL	Isolator Q19 connected to BB2 alarm
377	DDB_Q19_BB2_CLOSED	PSL	Isolator Q19 connected to BB2 Closed
378	DDB_Q19_BB3_ALARM	PSL	Isolator Q19 connected to BB3 alarm
379	DDB_Q19_BB3_CLOSED	PSL	Isolator Q19 connected to BB3 Closed
380	DDB_Q19_BB4_ALARM	PSL	Isolator Q19 connected to BB4 alarm
381	DDB_Q19_BB4_CLOSED	PSL	Isolator Q19 connected to BB4 Closed
382	DDB_Q20_BB1_ALARM	PSL	Isolator Q20 connected to BB1 alarm
383	DDB_Q20_BB1_CLOSED	PSL	Isolator Q20 connected to BB1 Closed
384	DDB_TIMEROUT_1	SW	Auxiliary Timer out 1
385	DDB_TIMEROUT_2	SW	Auxiliary Timer out 2
386	DDB_TIMEROUT_3	SW	Auxiliary Timer out 3
387	DDB_TIMEROUT_4	SW	Auxiliary Timer out 4
388	DDB_TIMEROUT_5	SW	Auxiliary Timer out 5
389	DDB_TIMEROUT_6	SW	Auxiliary Timer out 6
390	DDB_TIMEROUT_7	SW	Auxiliary Timer out 7
391	DDB_TIMEROUT_8	SW	Auxiliary Timer out 8
392	DDB_TIMEROUT_9	SW	Auxiliary Timer out 9
393	DDB_TIMEROUT_10	SW	Auxiliary Timer out 10
394	DDB_TIMEROUT_11	SW	Auxiliary Timer out 11
395	DDB_TIMEROUT_12	SW	Auxiliary Timer out 12
396	DDB_TIMEROUT_13	SW	Auxiliary Timer out 13
397	DDB_TIMEROUT_14	SW	Auxiliary Timer out 14
398	DDB_TIMEROUT_15	SW	Auxiliary Timer out 15
399	DDB_TIMEROUT_16	SW	Auxiliary Timer out 16
400	DDB_Q20_BB2_ALARM	PSL	Isolator Q20 connected to BB2 alarm
401	DDB_Q20_BB2_CLOSED	PSL	Isolator Q20 connected to BB2 Closed
402	DDB_Q20_BB3_ALARM	PSL	Isolator Q20 connected to BB3 alarm
403	DDB_Q20_BB3_CLOSED	PSL	Isolator Q20 connected to BB3 Closed
404	DDB_Q20_BB4_ALARM	PSL	Isolator Q20 connected to BB4 alarm
405	DDB_Q20_BB4_CLOSED	PSL	Isolator Q20 connected to BB4 Closed
406	DDB_Q21_BB1_ALARM	PSL	Isolator Q21 connected to BB1 alarm
407	DDB_Q21_BB1_CLOSED	PSL	Isolator Q21 connected to BB1 Closed
408	DDB_Q21_BB2_ALARM	PSL	Isolator Q21 connected to BB2 alarm
409	DDB_Q21_BB2_CLOSED	PSL	Isolator Q21 connected to BB2 Closed
410	DDB_Q21_BB3_ALARM	PSL	Isolator Q21 connected to BB3 alarm
411	DDB_Q21_BB3_CLOSED	PSL	Isolator Q21 connected to BB3 Closed
412	DDB_Q21_BB4_ALARM	PSL	Isolator Q21 connected to BB4 alarm
413	DDB_Q21_BB4_CLOSED	PSL	Isolator Q21 connected to BB4 Closed
416	DDB_TIMERIN_1	PSL	Auxiliary Timer in 1
417	DDB_TIMERIN_2	PSL	Auxiliary Timer in 2
418	DDB_TIMERIN_3	PSL	Auxiliary Timer in 3
419	DDB_TIMERIN_4	PSL	Auxiliary Timer in 4
420	DDB_TIMERIN_5	PSL	Auxiliary Timer in 5
421	DDB_TIMERIN_6	PSL	Auxiliary Timer in 6

DDB	Element Name	Source	Description
422	DDB_TIMERIN_7	PSL	Auxiliary Timer in 7
423	DDB_TIMERIN_8	PSL	Auxiliary Timer in 8
424	DDB_TIMERIN_9	PSL	Auxiliary Timer in 9
425	DDB_TIMERIN_10	PSL	Auxiliary Timer in 10
426	DDB_TIMERIN_11	PSL	Auxiliary Timer in 11
427	DDB_TIMERIN_12	PSL	Auxiliary Timer in 12
428	DDB_TIMERIN_13	PSL	Auxiliary Timer in 13
429	DDB_TIMERIN_14	PSL	Auxiliary Timer in 14
430	DDB_TIMERIN_15	PSL	Auxiliary Timer in 15
431	DDB_TIMERIN_16	PSL	Auxiliary Timer in 16
450	DDB_ILLEGAL_OPTO_SETTINGS_GROUP	SW	Setting Group selection by DDB inputs invalid
451	DDB_CB_STATUS_ALARM	SW	CB Status Alarm
451	DDB_CB_STATUS_ALARM	FL	CB Status Alarm
452	DDB_ISO_STATUS_ALARM	FL	Isolator Status Alarm
452	DDB_RTD_ALARM	FL	RTD Thermal Alarm
453	DDB_RTD_OPEN_CCT	SW	RTD Open Circuit Failure
454	DDB_RTD_SHORT_CCT	SW	RTD Short Circuit Failure
455	DDB_RTD_DATA_ERROR	SW	RTD Data Inconsistency Error
456	DDB_RTD_BOARD_FAILURE	SW	RTD Board Failure
457	DDB_CL_INPUT_1_ALARM	SW	Current Loop Input 1 Alarm
458	DDB_CL_INPUT_2_ALARM	SW	Current Loop Input 2 Alarm
459	DDB_CL_INPUT_3_ALARM	SW	Current Loop Input 3 Alarm
460	DDB_CL_INPUT_4_ALARM	SW	Current Loop Input 4 Alarm
461	DDB_CLI_1_UNDERCURRENT_ALARM	SW	Current Loop Input 1 Undercurrent Fail Alarm
462	DDB_CLI_2_UNDERCURRENT_ALARM	SW	Current Loop Input 2 Undercurrent Fail Alarm
463	DDB_CLI_3_UNDERCURRENT_ALARM	SW	Current Loop Input 3 Undercurrent Fail Alarm
464	DDB_CLI_4_UNDERCURRENT_ALARM	SW	Current Loop Input 4 Undercurrent Fail Alarm
465	DDB_OOS_ALARM	SW	Protection Disabled
466	DDB_FREQ_ALARM	FL	Frequency out of range
467	DDB_CIR_FLT_Z1_ALM	SW	Circuilty Fault Z1 Alm
468	DDB_CIR_FLT_Z2_ALM	SW	Circuilty Fault Z2 Alm
469	DDB_CIR_FLT_CZ_ALM	SW	Circuilty Fault CZ Alm
470	DDB_CIR_FLT_Z3_ALM	SW	Circuilty Fault Z3 Alm
471	DDB_CIR_FLT_Z4_ALM	SW	Circuilty Fault Z4 Alm
475	DDB_CTS_INDICATION	SW	CTS Fail Alarm
476	DDB_CIRCUITRY_FLT_ALM	SW	Circuity FLT Alm
477	DDB_VTS_INDICATION	SW	VTS VT Fail Alarm
478	DDB_CB_FAIL_ALM_T19	SW	CB Fail Alarm T19
479	DDB_CB_FAIL_ALM_T20	SW	CB Fail Alarm T20
480	DDB_CB_FAIL_ALM_T21	SW	CB Fail Alarm T21
481	DDB_BREAKER_FAIL_ALARM	SW	Breaker Fail Alarm
482	DDB_CB_FAIL_ALM_T1	SW	CB Fail Alarm T1
483	DDB_CB_FAIL_ALM_T2	SW	CB Fail Alarm T2
484	DDB_CB_FAIL_ALM_T3	SW	CB Fail Alarm T3

DDB	Element Name	Source	Description
485	DDB_CB_FAIL_ALM_T4	SW	CB Fail Alarm T4
486	DDB_CB_FAIL_ALM_T5	SW	CB Fail Alarm T5
487	DDB_CB_FAIL_ALM_T6	SW	CB Fail Alarm T6
488	DDB_CB_FAIL_ALM_T7	SW	CB Fail Alarm T7
489	DDB_CB_FAIL_ALM_T8	SW	CB Fail Alarm T8
490	DDB_CB_FAIL_ALM_T9	SW	CB Fail Alarm T9
491	DDB_CB_FAIL_ALM_T10	SW	CB Fail Alarm T10
492	DDB_CB_FAIL_ALM_T11	SW	CB Fail Alarm T11
493	DDB_CB_FAIL_ALM_T12	SW	CB Fail Alarm T12
494	DDB_CB_FAIL_ALM_T13	SW	CB Fail Alarm T13
495	DDB_CB_FAIL_ALM_T14	SW	CB Fail Alarm T14
496	DDB_CB_FAIL_ALM_T15	SW	CB Fail Alarm T15
497	DDB_CB_FAIL_ALM_T16	SW	CB Fail Alarm T16
498	DDB_CB_FAIL_ALM_T17	SW	CB Fail Alarm T17
499	DDB_CB_FAIL_ALM_T18	SW	CB Fail Alarm T18
500	DDB_CB_FAIL_BB12_CB	SW	CB Fail Alarm Bus12 CB
501	DDB_CB_FAIL_BB13_CB	SW	CB Fail Alarm Bus13 CB
502	DDB_CB_FAIL_BB23_CB	SW	CB Fail Alarm Bus23 CB
503	DDB_CB_FAIL_BB14_CB	SW	CB Fail Alarm Bus14 CB
504	DDB_CB_FAIL_BB24_CB	SW	CB Fail Alarm Bus24 CB
505	DDB_CB_FAIL_BB34_CB	SW	CB Fail Alarm Bus34 CB
507	DDB_FREQ_PROT_ALM	SW	Frequency Protection Alarm
508	DDB_Z4_INTEST_ALARM	SW	Z4 in Test Mode Alarm
509	DDB_Z1_INTEST_ALARM	SW	Z1 in Test Mode Alarm
510	DDB_Z2_INTEST_ALARM	SW	Z2 in Test Mode Alarm
511	DDB_Z3_INTEST_ALARM	SW	Z3 in Test Mode Alarm
512	DDB_BATTERY_FAIL_ALARM	SW	Battery Fail alarm indication
513	DDB_FIELD_VOLTS_FAIL	SW	Field Voltage Failure
515	DDB_GOOSE_MISSING_IED_ALARM	SW	Enrolled GOOSE IED absent alarm indication
516	DDB_ECARD_NOT_FITTED_ALARM	SW	Network Interface Card not fitted/failed alarm
517	DDB_NIC_NOT_RESPONDING_ALARM	SW	Network Interface Card not responding alarm
518	DDB_NIC_FATAL_ERROR_ALARM	SW	Network Interface Card fatal error alarm indication
519	DDB_NIC_SOFTWARE_RELOAD_ALARM	SW	Network Interface Card software reload alarm
520	DDB_INVALID_TCP_IP_CONFIG_ALARM	SW	Bad TCP/IP Configuration Alarm
521	DDB_INVALID_OSI_CONFIG_ALARM	SW	Bad OSI Configuration Alarm
523	DDB_SW_MISMATCH_ALARM	SW	Main card/NIC software mismatch alarm indication
524	DDB_IP_ADDRESS_CONFLICT_ALARM	SW	IP address conflict alarm indication
533	DDB_INVALID_DNPOE_IP_ALARM	SW	Invalid DNPoE IP Configuration Alarm
534	DDB_INVALID_CONFIG_ALARM	SW	Invalid IEC 61850 Configuration Alarm
535	DDB_TEST_MODE_ALARM	SW	Test Mode Activated Alarm
536	DDB_CONT_BLK_ALARM	SW	Contacts Blocked Alarm
537	DDB_HW_MISMATCH_ALARM	SW	Main card/Ethernet card hw option mismatch Alarm
538	DDB_IEC61850_VER_MISMATCH_ALARM	SW	Main card/Ethernet card IEC61850 ver mismatch Alarm
539	DDB_GS_ACEPT_SIMU_ALM	SW	IEC 61850 accept simulation GOOSE alarm

DDB	Element Name	Source	Description
548	DDB_INHIBIT_BUSDIFF_Z1	PSL	Block Z1 Diff
549	DDB_INHIBIT_BUSDIFF_Z2	PSL	Block Z2 Diff
550	DDB_INHIBIT_BUSDIFF_CZ	PSL	Block CZ Diff
551	DDB_INHIBIT_BUSDIFF_Z3	PSL	Block Z3 Diff
552	DDB_INHIBIT_BUSDIFF_Z4	PSL	Block Z4 Diff
553	DDB_2ND_HAR_BLKB	SW	2rd Harmonic B
554	DDB_2ND_HAR_BLKC	SW	2th Harmonic C
555	DDB_5TH_HAR_BLKA	SW	5nd Har Blk A
556	DDB_DEADBUS_ZONE3_DETECTED	SW	Dead Bus Zone 3Detected
557	DDB_DEADBUS_ZONE4_DETECTED	SW	Dead Bus Zone 4Detected
558	DDB_DEADBUS_ZONE1_DETECTED	SW	Dead Bus Zone 1Detected
559	DDB_DEADBUS_ZONE2_DETECTED	SW	Dead Bus Zone 2Detected
560	DDB_VT_CHECK_ALLOW_ZONE1	SW	VT Check Allow Z1 Trip
561	DDB_VT_CHECK_ALLOW_ZONE2	SW	VT Check Allow Z2 Trip
562	DDB_VT_CHECK_ALLOW_ZONE3	SW	VT Check Allow Z3 Trip
563	DDB_VT_CHECK_ALLOW_ZONE4	SW	VT Check Allow Z4 Trip
571	DDB_INHIBIT_CTS	PSL	Inhibit CTS
572	DDB_CTS_BLK	SW	CTS BLK
573	DDB_CTS_CT1	SW	CTS CT1
574	DDB_CTS_CT2	SW	CTS CT2
575	DDB_CTS_CT3	SW	CTS CT3
576	DDB_CTS_Z3	SW	Z3 Block By CTS
577	DDB_CTS_Z4	SW	Z4 Block By CTS
578	DDB_CTS_Z1	SW	Z1 Block By CTS
579	DDB_CTS_Z2	SW	Z2 Block By CTS
580	DDB_CTS_TERMINAL_1	SW	CTS T1
581	DDB_CTS_TERMINAL_2	SW	CTS T2
582	DDB_CTS_TERMINAL_3	SW	CTS T3
583	DDB_CTS_TERMINAL_4	SW	CTS T4
584	DDB_CTS_TERMINAL_5	SW	CTS T5
585	DDB_CTS_TERMINAL_6	SW	CTS T6
586	DDB_CTS_TERMINAL_7	SW	CTS T7
587	DDB_IRIGB_SIGNAL_VALID	SW	IRIG-B Status Signal Valid
588	DDB_BLK_TOL	PSL	Blk TOL
589	DDB_CTS_HV	SW	CTS HV
590	DDB_CTS_LV	SW	CTS LV
591	DDB_CTS_TV	SW	CTS TV
592	DDB_INHIBIT_VTS	PSL	Inhibit VTS
593	DDB_VTS_BLK_Z1	SW	VTS Block Z1
594	DDB_VTS_BLK_Z3	SW	VTS Block Z3
595	DDB_VTS_BLK_Z4	SW	VTS Block Z4
596	DDB_BLK_REF_TV	PSL	Blk REF TV
597	DDB_VTS_BLK_Z2	SW	VTS Block Z2
598	DDB_HV_POC_1_TIMER_BLOCK	PSL	HV I>1 Timer Block

DDB	Element Name	Source	Description
598	DDB_T1_POC_1_TIMER_BLOCK	PSL	T1 I>1 Timer Block
599	DDB_HV_POC_2_TIMER_BLOCK	PSL	HV I>2 Timer Block
599	DDB_T1_POC_2_TIMER_BLOCK	PSL	T1 I>2 Timer Block
601	DDB_HV_POC_4_TIMER_BLOCK	PSL	HV I>4 Timer Block
601	DDB_T2_POC_1_TIMER_BLOCK	PSL	T2 I>1 Timer Block
602	DDB_T2_POC_2_TIMER_BLOCK	PSL	T2 I>2 Timer Block
603	DDB_LV_POC_1_TIMER_BLOCK	PSL	LV I>1 Timer Block
604	DDB_LV_POC_2_TIMER_BLOCK	PSL	LV I>2 Timer Block
604	DDB_T3_POC_1_TIMER_BLOCK	PSL	T3 I>1 Timer Block
605	DDB_LV_POC_3_TIMER_BLOCK	PSL	LV I>3 Timer Block
605	DDB_T3_POC_2_TIMER_BLOCK	PSL	T3 I>2 Timer Block
606	DDB_LV_POC_4_TIMER_BLOCK	PSL	LV I>4 Timer Block
607	DDB_T4_POC_1_TIMER_BLOCK	PSL	T4 I>1 Timer Block
608	DDB_TV_POC_1_TIMER_BLOCK	PSL	TV I>1 Timer Block
608	DDB_T4_POC_2_TIMER_BLOCK	PSL	T4 I>2 Timer Block
609	DDB_TV_POC_2_TIMER_BLOCK	PSL	TV I>2 Timer Block
610	DDB_TV_POC_3_TIMER_BLOCK	PSL	TV I>3 Timer Block
610	DDB_T5_POC_1_TIMER_BLOCK	PSL	T5 I>1 Timer Block
611	DDB_TV_POC_4_TIMER_BLOCK	PSL	TV I>4 Timer Block
611	DDB_T5_POC_2_TIMER_BLOCK	PSL	T5 I>2 Timer Block
612	DDB_T6_POC_1_TIMER_BLOCK	PSL	T6 I>1 Timer Block
613	DDB_T6_POC_2_TIMER_BLOCK	PSL	T6 I>2 Timer Block
614	DDB_T7_POC_1_TIMER_BLOCK	PSL	T7 I>1 Timer Block
615	DDB_T7_POC_2_TIMER_BLOCK	PSL	T7 I>2 Timer Block
616	DDB_T8_POC_1_TIMER_BLOCK	PSL	T8 I>1 Timer Block
617	DDB_T8_POC_2_TIMER_BLOCK	PSL	T8 I>2 Timer Block
618	DDB_T9_POC_1_TIMER_BLOCK	PSL	T9 I>1 Timer Block
619	DDB_T9_POC_2_TIMER_BLOCK	PSL	T9 I>2 Timer Block
620	DDB_T10_POC_1_TIMER_BLOCK	PSL	T10 I>1 Timer Block
621	DDB_T10_POC_2_TIMER_BLOCK	PSL	T10 I>2 Timer Block
622	DDB_T11_POC_1_TIMER_BLOCK	PSL	T11 I>1 Timer Block
623	DDB_T11_POC_2_TIMER_BLOCK	PSL	T11 I>2 Timer Block
624	DDB_T12_POC_1_TIMER_BLOCK	PSL	T12 I>1 Timer Block
625	DDB_T12_POC_2_TIMER_BLOCK	PSL	T12 I>2 Timer Block
626	DDB_T13_POC_1_TIMER_BLOCK	PSL	T13 I>1 Timer Block
627	DDB_T13_POC_2_TIMER_BLOCK	PSL	T13 I>2 Timer Block
628	DDB_T14_POC_1_TIMER_BLOCK	PSL	T14 I>1 Timer Block
629	DDB_T14_POC_2_TIMER_BLOCK	PSL	T14 I>2 Timer Block
630	DDB_T15_POC_1_TIMER_BLOCK	PSL	T15 I>1 Timer Block
631	DDB_T15_POC_2_TIMER_BLOCK	PSL	T15 I>2 Timer Block
632	DDB_T16_POC_1_TIMER_BLOCK	PSL	T16 I>1 Timer Block
633	DDB_T16_POC_2_TIMER_BLOCK	PSL	T16 I>2 Timer Block
634	DDB_T17_POC_1_TIMER_BLOCK	PSL	T17 I>1 Timer Block
635	DDB_T17_POC_2_TIMER_BLOCK	PSL	T17 I>2 Timer Block

DDB	Element Name	Source	Description
636	DDB_T18_POC_1_TIMER_BLOCK	PSL	T18 I>1 Timer Block
637	DDB_T18_POC_2_TIMER_BLOCK	PSL	T18 I>2 Timer Block
638	DDB_T19_POC_1_TIMER_BLOCK	PSL	T19 I>1 Timer Block
639	DDB_T19_POC_2_TIMER_BLOCK	PSL	T19 I>2 Timer Block
640	DDB_T20_POC_1_TIMER_BLOCK	PSL	T20 I>1 Timer Block
641	DDB_T20_POC_2_TIMER_BLOCK	PSL	T20 I>2 Timer Block
642	DDB_T21_POC_1_TIMER_BLOCK	PSL	T21 I>1 Timer Block
643	DDB_T21_POC_2_TIMER_BLOCK	PSL	T21 I>2 Timer Block
644	DDB_STUB_BUS_HV_ENABLED	PSL	HV StubBus Enabled
645	DDB_STUB_BUS_LV_ENABLED	PSL	LV StubBus Enabled
646	DDB_STUB_BUS_TV_ENABLED	PSL	TV StubBus Enabled
647	DDB_STUB_BUS_HV_ACTIVED	PSL	HV StubBus Actived
648	DDB_STUB_BUS_LV_ACTIVED	PSL	LV StubBus Actived
649	DDB_STUB_BUS_TV_ACTIVED	PSL	TV StubBus Actived
650	DDB_FREQ_STOP_TRACK	PSL	Stop Freq Track
651	DDB_HV_EF_1_TIMER_BLOCK	PSL	HV IN>1 TimeBlk
651	DDB_T1_EF_1_TIMER_BLOCK	PSL	T1 IN>1 TimeBlk
652	DDB_HV_EF_2_TIMER_BLOCK	PSL	HV IN>2 TimeBlk
652	DDB_T1_EF_2_TIMER_BLOCK	PSL	T1 IN>2 TimeBlk
653	DDB_HV_EF_3_TIMER_BLOCK	PSL	HV IN>3 TimeBlk
653	DDB_T2_EF_1_TIMER_BLOCK	PSL	T2 IN>1 TimeBlk
654	DDB_HV_EF_4_TIMER_BLOCK	PSL	HV IN>4 TimeBlk
654	DDB_T2_EF_2_TIMER_BLOCK	PSL	T2 IN>2 TimeBlk
655	DDB_LV_EF_1_TIMER_BLOCK	PSL	LV IN>1 TimeBlk
655	DDB_T3_EF_1_TIMER_BLOCK	PSL	T3 IN>1 TimeBlk
656	DDB_LV_EF_2_TIMER_BLOCK	PSL	LV IN>2 TimeBlk
656	DDB_T3_EF_2_TIMER_BLOCK	PSL	T3 IN>2 TimeBlk
657	DDB_LV_EF_3_TIMER_BLOCK	PSL	LV IN>3 TimeBlk
657	DDB_T4_EF_1_TIMER_BLOCK	PSL	T4 IN>1 TimeBlk
658	DDB_LV_EF_4_TIMER_BLOCK	PSL	LV IN>4 TimeBlk
658	DDB_T4_EF_2_TIMER_BLOCK	PSL	T4 IN>2 TimeBlk
659	DDB_TV_EF_1_TIMER_BLOCK	PSL	TV IN>1 TimeBlk
659	DDB_T5_EF_1_TIMER_BLOCK	PSL	T5 IN>1 TimeBlk
660	DDB_TV_EF_2_TIMER_BLOCK	PSL	TV IN>2 TimeBlk
660	DDB_T5_EF_2_TIMER_BLOCK	PSL	T5 IN>2 TimeBlk
661	DDB_TV_EF_3_TIMER_BLOCK	PSL	TV IN>3 TimeBlk
661	DDB_T6_EF_1_TIMER_BLOCK	PSL	T6 IN>1 TimeBlk
662	DDB_TV_EF_4_TIMER_BLOCK	PSL	TV IN>4 TimeBlk
662	DDB_T6_EF_2_TIMER_BLOCK	PSL	T6 IN>2 TimeBlk
663	DDB_T7_EF_1_TIMER_BLOCK	PSL	T7 IN>1 TimeBlk
664	DDB_T7_EF_2_TIMER_BLOCK	PSL	T7 IN>2 TimeBlk
665	DDB_Q_BB13_ALARM	PSL	QBB13 alarm
666	DDB_Q_BB13_CLOSED	PSL	QBB13 Closed
667	DDB_Q_BB13_BB1_ALARM	PSL	QBB13 BB1 alarm

DDB	Element Name	Source	Description
668	DDB_Q_BB13_BB1_CLOSED	PSL	QBB13 BB1 Closed
669	DDB_Q_BB13_BB3_ALARM	PSL	QBB13 BB3 alarm
670	DDB_Q_BB13_BB3_CLOSED	PSL	QBB13 BB3 Closed
671	DDB_Q_BB14_ALARM	PSL	QBB14 alarm
672	DDB_Q_BB14_CLOSED	PSL	QBB14 Closed
673	DDB_Q_BB14_BB1_ALARM	PSL	QBB14 BB1 alarm
674	DDB_Q_BB14_BB1_CLOSED	PSL	QBB14 BB1 Closed
675	DDB_Q_BB14_BB4_ALARM	PSL	QBB14 BB4 alarm
676	DDB_Q_BB14_BB4_CLOSED	PSL	QBB14 BB4 Closed
677	DDB_Q_BB23_ALARM	PSL	QBB23 alarm
678	DDB_Q_BB23_CLOSED	PSL	QBB23 Closed
679	DDB_Q_BB23_BB2_ALARM	PSL	QBB23 BB2 alarm
680	DDB_Q_BB23_BB2_CLOSED	PSL	QBB23 BB2 Closed
681	DDB_Q_BB23_BB3_ALARM	PSL	QBB23 BB3 alarm
682	DDB_Q_BB23_BB3_CLOSED	PSL	QBB23 BB3 Closed
683	DDB_Q_BB24_ALARM	PSL	QBB24 alarm
684	DDB_Q_BB24_CLOSED	PSL	QBB24 Closed
685	DDB_Q_BB24_BB2_ALARM	PSL	QBB24 BB2 alarm
686	DDB_Q_BB24_BB2_CLOSED	PSL	QBB24 BB2 Closed
687	DDB_Q_BB24_BB4_ALARM	PSL	QBB24 BB4 alarm
688	DDB_Q_BB24_BB4_CLOSED	PSL	QBB24 BB4 Closed
689	DDB_Q_BB34_ALARM	PSL	QBB34 alarm
690	DDB_Q_BB34_CLOSED	PSL	QBB34 Closed
691	DDB_Q_BB34_BB3_ALARM	PSL	QBB34 BB3 alarm
692	DDB_Q_BB34_BB3_CLOSED	PSL	QBB34 BB3 Closed
693	DDB_Q_BB34_BB4_ALARM	PSL	QBB34 BB4 alarm
694	DDB_Q_BB34_BB4_CLOSED	PSL	QBB34 BB4 Closed
695	DDB_CB_BUS13_COUPLER_ALARM	PSL	BB13 CB Alarm
696	DDB_CB_BUS13_COUPLER_CLOSED	PSL	BB13 CB Closed
697	DDB_CB_BUS23_COUPLER_ALARM	PSL	BB23 CB Alarm
698	DDB_CB_BUS23_COUPLER_CLOSED	PSL	BB23 CB Closed
699	DDB_CB_BUS14_COUPLER_ALARM	PSL	BB14 CB Alarm
700	DDB_CB_BUS14_COUPLER_CLOSED	PSL	BB14 CB Closed
701	DDB_CB_BUS24_COUPLER_ALARM	PSL	BB24 CB Alarm
702	DDB_CB_BUS24_COUPLER_CLOSED	PSL	BB24 CB Closed
703	DDB_CB_BUS34_COUPLER_ALARM	PSL	BB34 CB Alarm
704	DDB_CB_BUS34_COUPLER_CLOSED	PSL	BB34 CB Closed
705	DDB_LOGIC_0	SW	Logic 0 for use in PSL (Never changes state!)
706	DDB_RESOV_1_TIMER_BLOCK	PSL	Block Residual Over Voltage Stage 1 time delay
707	DDB_RESOV_2_TIMER_BLOCK	PSL	Block Residual Over Voltage Stage 2 time delay
708	DDB_SET_Z3_TEST_MODE	PSL	Enable Z3 Test Mode
709	DDB_SET_Z4_TEST_MODE	PSL	Enable Z4 Test Mode
710	DDB_SET_Z1_TEST_MODE	PSL	Enable Z1 Test Mode
711	DDB_SET_Z2_TEST_MODE	PSL	Enable Z2 Test Mode

DDB	Element Name	Source	Description
712	DDB_CB19_AUX_3PH_ALARM	PSL	CB19 Alarm
713	DDB_CB19_AUX_3PH_CLOSED	PSL	CB19 Closed
714	DDB_CB20_AUX_3PH_ALARM	PSL	CB20 Alarm
715	DDB_CB20_AUX_3PH_CLOSED	PSL	CB20 Closed
716	DDB_CB21_AUX_3PH_ALARM	PSL	CB21 Alarm
717	DDB_CB21_AUX_3PH_CLOSED	PSL	CB21 Closed
718	DDB_CB1_AUX_3PH_ALARM	PSL	CB1 Alarm
719	DDB_CB1_AUX_3PH_CLOSED	PSL	CB1 Closed
720	DDB_CB2_AUX_3PH_ALARM	PSL	CB2 Alarm
721	DDB_CB2_AUX_3PH_CLOSED	PSL	CB2 Closed
722	DDB_CB3_AUX_3PH_ALARM	PSL	CB3 Alarm
723	DDB_CB3_AUX_3PH_CLOSED	PSL	CB3 Closed
724	DDB_CB4_AUX_3PH_ALARM	PSL	CB4 Alarm
725	DDB_CB4_AUX_3PH_CLOSED	PSL	CB4 Closed
726	DDB_CB5_AUX_3PH_ALARM	PSL	CB5 Alarm
727	DDB_CB5_AUX_3PH_CLOSED	PSL	CB5 Closed
728	DDB_CB6_AUX_3PH_ALARM	PSL	CB6 Alarm
729	DDB_CB6_AUX_3PH_CLOSED	PSL	CB6 Closed
730	DDB_CB7_AUX_3PH_ALARM	PSL	CB7 Alarm
731	DDB_CB7_AUX_3PH_CLOSED	PSL	CB7 Closed
732	DDB_CB8_AUX_3PH_ALARM	PSL	CB8 Alarm
733	DDB_CB8_AUX_3PH_CLOSED	PSL	CB8 Closed
734	DDB_CB9_AUX_3PH_ALARM	PSL	CB9 Alarm
735	DDB_CB9_AUX_3PH_CLOSED	PSL	CB9 Closed
736	DDB_CB10_AUX_3PH_ALARM	PSL	CB10 Alarm
737	DDB_CB10_AUX_3PH_CLOSED	PSL	CB10 Closed
738	DDB_CB11_AUX_3PH_ALARM	PSL	CB11 Alarm
739	DDB_CB11_AUX_3PH_CLOSED	PSL	CB11 Closed
740	DDB_CB12_AUX_3PH_ALARM	PSL	CB12 Alarm
741	DDB_CB12_AUX_3PH_CLOSED	PSL	CB12 Closed
742	DDB_CB13_AUX_3PH_ALARM	PSL	CB13 Alarm
743	DDB_CB13_AUX_3PH_CLOSED	PSL	CB13 Closed
744	DDB_CB14_AUX_3PH_ALARM	PSL	CB14 Alarm
745	DDB_CB14_AUX_3PH_CLOSED	PSL	CB14 Closed
746	DDB_CB15_AUX_3PH_ALARM	PSL	CB15 Alarm
747	DDB_CB15_AUX_3PH_CLOSED	PSL	CB15 Closed
748	DDB_CB16_AUX_3PH_ALARM	PSL	CB16 Alarm
749	DDB_CB16_AUX_3PH_CLOSED	PSL	CB16 Closed
750	DDB_CB17_AUX_3PH_ALARM	PSL	CB17 Alarm
751	DDB_CB17_AUX_3PH_CLOSED	PSL	CB17 Closed
752	DDB_CB18_AUX_3PH_ALARM	PSL	CB18 Alarm
753	DDB_CB18_AUX_3PH_CLOSED	PSL	CB18 Closed
754	DDB_Q1_BB1_ALARM	PSL	Q1 BB1 alarm
755	DDB_Q1_BB1_CLOSED	PSL	Q1 BB1 Closed

DDB	Element Name	Source	Description
756	DDB_Q1_BB2_ALARM	PSL	Q1 BB2 alarm
757	DDB_Q1_BB2_CLOSED	PSL	Q1 BB2 Closed
758	DDB_Q2_BB1_ALARM	PSL	Q2 BB1 alarm
759	DDB_Q2_BB1_CLOSED	PSL	Q2 BB1 Closed
760	DDB_Q2_BB2_ALARM	PSL	Q2 BB2 alarm
761	DDB_Q2_BB2_CLOSED	PSL	Q2 BB2 Closed
762	DDB_Q3_BB1_ALARM	PSL	Q3 BB1 alarm
763	DDB_Q3_BB1_CLOSED	PSL	Q3 BB1 Closed
764	DDB_Q3_BB2_ALARM	PSL	Q3 BB2 alarm
765	DDB_Q3_BB2_CLOSED	PSL	Q3 BB2 Closed
766	DDB_Q4_BB1_ALARM	PSL	Q4 BB1 alarm
767	DDB_Q4_BB1_CLOSED	PSL	Q4 BB1 Closed
768	DDB_Q4_BB2_ALARM	PSL	Q4 BB2 alarm
769	DDB_Q4_BB2_CLOSED	PSL	Q4 BB2 Closed
770	DDB_Q5_BB1_ALARM	PSL	Q5 BB1 alarm
771	DDB_Q5_BB1_CLOSED	PSL	Q5 BB1 Closed
772	DDB_Q5_BB2_ALARM	PSL	Q5 BB2 alarm
773	DDB_Q5_BB2_CLOSED	PSL	Q5 BB2 Closed
774	DDB_Q6_BB1_ALARM	PSL	Q6 BB1 alarm
775	DDB_Q6_BB1_CLOSED	PSL	Q6 BB1 Closed
776	DDB_Q6_BB2_ALARM	PSL	Q6 BB2 alarm
777	DDB_Q6_BB2_CLOSED	PSL	Q6 BB2 Closed
778	DDB_Q7_BB1_ALARM	PSL	Q7 BB1 alarm
779	DDB_Q7_BB1_CLOSED	PSL	Q7 BB1 Closed
780	DDB_Q7_BB2_ALARM	PSL	Q7 BB2 alarm
781	DDB_Q7_BB2_CLOSED	PSL	Q7 BB2 Closed
782	DDB_Q8_BB1_ALARM	PSL	Q8 BB1 alarm
783	DDB_Q8_BB1_CLOSED	PSL	Q8 BB1 Closed
784	DDB_Q8_BB2_ALARM	PSL	Q8 BB2 alarm
785	DDB_Q8_BB2_CLOSED	PSL	Q8 BB2 Closed
786	DDB_Q9_BB1_ALARM	PSL	Q9 BB1 alarm
787	DDB_Q9_BB1_CLOSED	PSL	Q9 BB1 Closed
788	DDB_Q9_BB2_ALARM	PSL	Q9 BB2 alarm
789	DDB_Q9_BB2_CLOSED	PSL	Q9 BB2 Closed
790	DDB_Q10_BB1_ALARM	PSL	Q10 BB1 alarm
791	DDB_Q10_BB1_CLOSED	PSL	Q10 BB1 Closed
792	DDB_Q10_BB2_ALARM	PSL	Q10 BB2 alarm
793	DDB_Q10_BB2_CLOSED	PSL	Q10 BB2 Closed
794	DDB_Q11_BB1_ALARM	PSL	Q11 BB1 alarm
795	DDB_Q11_BB1_CLOSED	PSL	Q11 BB1 Closed
796	DDB_Q11_BB2_ALARM	PSL	Q11 BB2 alarm
797	DDB_Q11_BB2_CLOSED	PSL	Q11 BB2 Closed
798	DDB_Q12_BB1_ALARM	PSL	Q12 BB1 alarm
799	DDB_Q12_BB1_CLOSED	PSL	Q12 BB1 Closed

DDB	Element Name	Source	Description
800	DDB_Q12_BB2_ALARM	PSL	Q12 BB2 alarm
801	DDB_Q12_BB2_CLOSED	PSL	Q12 BB2 Closed
802	DDB_Q13_BB1_ALARM	PSL	Q13 BB1 alarm
803	DDB_Q13_BB1_CLOSED	PSL	Q13 BB1 Closed
804	DDB_Q13_BB2_ALARM	PSL	Q13 BB2 alarm
805	DDB_Q13_BB2_CLOSED	PSL	Q13 BB2 Closed
806	DDB_Q14_BB1_ALARM	PSL	Q14 BB1 alarm
807	DDB_Q14_BB1_CLOSED	PSL	Q14 BB1 Closed
808	DDB_Q14_BB2_ALARM	PSL	Q14 BB2 alarm
809	DDB_Q14_BB2_CLOSED	PSL	Q14 BB2 Closed
810	DDB_Q15_BB1_ALARM	PSL	Q15 BB1 alarm
811	DDB_Q15_BB1_CLOSED	PSL	Q15 BB1 Closed
812	DDB_Q15_BB2_ALARM	PSL	Q15 BB2 alarm
813	DDB_Q15_BB2_CLOSED	PSL	Q15 BB2 Closed
814	DDB_Q16_BB1_ALARM	PSL	Q16 BB1 alarm
815	DDB_Q16_BB1_CLOSED	PSL	Q16 BB1 Closed
816	DDB_Q16_BB2_ALARM	PSL	Q16 BB2 alarm
817	DDB_Q16_BB2_CLOSED	PSL	Q16 BB2 Closed
818	DDB_Q17_BB1_ALARM	PSL	Q17 BB1 alarm
819	DDB_Q17_BB1_CLOSED	PSL	Q17 BB1 Closed
820	DDB_Q17_BB2_ALARM	PSL	Q17 BB2 alarm
821	DDB_Q17_BB2_CLOSED	PSL	Q17 BB2 Closed
822	DDB_Q18_BB1_ALARM	PSL	Q18 BB1 alarm
823	DDB_Q18_BB1_CLOSED	PSL	Q18 BB1 Closed
824	DDB_Q18_BB2_ALARM	PSL	Q18 BB2 alarm
825	DDB_Q18_BB2_CLOSED	PSL	Q18 BB2 Closed
826	DDB_Q_BB12_ALARM	PSL	QBB12 alarm
827	DDB_Q_BB12_CLOSED	PSL	QBB12 Closed
828	DDB_Q_BB12_BB1_ALARM	PSL	QBB12 BB1 alarm
829	DDB_Q_BB12_BB1_CLOSED	PSL	QBB12 BB1 Closed
830	DDB_Q_BB12_BB2_ALARM	PSL	QBB12 BB2 alarm
831	DDB_Q_BB12_BB2_CLOSED	PSL	QBB12 BB2 Closed
832	DDB_CB_BUS12_COUPLER_ALARM	PSL	BB12 CB Alarm
833	DDB_CB_BUS12_COUPLER_CLOSED	PSL	BB12 CB Closed
834	DDB_CIR_FLT_A_Z1	SW	Z1 Phase A Circuity Flt
835	DDB_CIR_FLT_B_Z1	SW	Z1 Phase B Circuity Flt
836	DDB_CIR_FLT_C_Z1	SW	Z1 Phase C Circuity Flt
837	DDB_CIR_FLT_A_Z2	SW	Z2 Phase A Circuity Flt
838	DDB_CIR_FLT_B_Z2	SW	Z2 Phase B Circuity Flt
839	DDB_CIR_FLT_C_Z2	SW	Z2 Phase C Circuity Flt
840	DDB_CIR_FLT_A_CZ	SW	CZ Phase A Circuity Flt
841	DDB_CIR_FLT_B_CZ	SW	CZ Phase B Circuity Flt
842	DDB_CIR_FLT_C_CZ	SW	CZ Phase C Circuity Flt
843	DDB_CIR_FLT_Z1	SW	Z1 Circuity Flt

DDB	Element Name	Source	Description
844	DDB_CIR_FLT_Z2	SW	Z2 Circuity Flt
845	DDB_CIR_FLT_A	SW	Phase A Circuity Flt
846	DDB_CIR_FLT_B	SW	Phase B Circuity Flt
847	DDB_CIR_FLT_C	SW	Phase C Circuity Flt
848	DDB_CIR_FLT_CZ	SW	CZ Circuity Flt
849	DDB_BUS12_CB_NOT_READY	PSL	BB12 Bus CB Not Ready
850	DDB_BUS12_CB_NOT_READY_IN	FL	BB12 Bus CB Not Ready
855	DDB_CIR_FLT_A_Z3	SW	Z3 Phase A Circuity Flt
856	DDB_CIR_FLT_B_Z3	SW	Z3 Phase B Circuity Flt
857	DDB_CIR_FLT_C_Z3	SW	Z3 Phase C Circuity Flt
858	DDB_CIR_FLT_Z3	SW	Z3 Circuity Flt
859	DDB_RP1_READ_ONLY	PSL	Remote Read Only 1 DDB
860	DDB_RP2_READ_ONLY	PSL	Remote Read Only 2 DDB
861	DDB_NIC_READ_ONLY	PSL	Remote Read Only NIC DDB
862	DDB_MONITOR_BLOCKING	PSL	Monitor Block
863	DDB_COMMAND_BLOCKING	PSL	Command Block
864	DDB_MONITOR_PORT_1	SW	Monitor Port 1
865	DDB_MONITOR_PORT_2	SW	Monitor Port 2
866	DDB_MONITOR_PORT_3	SW	Monitor Port 3
867	DDB_MONITOR_PORT_4	SW	Monitor Port 4
868	DDB_MONITOR_PORT_5	SW	Monitor Port 5
869	DDB_MONITOR_PORT_6	SW	Monitor Port 6
870	DDB_MONITOR_PORT_7	SW	Monitor Port 7
871	DDB_MONITOR_PORT_8	SW	Monitor Port 8
872	DDB_CIR_FLT_A_Z4	SW	Z4 Phase A Circuity Flt
873	DDB_CIR_FLT_B_Z4	SW	Z4 Phase B Circuity Flt
874	DDB_CIR_FLT_C_Z4	SW	Z4 Phase C Circuity Flt
875	DDB_CIR_FLT_Z4	SW	Z4 Circuity Flt
876	DDB_RESET_RELAYS_LEDS	PSL	Reset Latched Relays & LED’s
877	DDB_UNUSED_DR	PSL	DDB_UNUSED
878	DDB_BUS_IDIFF_TRIPC_Z4	SW	Z4 Diff Phase C Trip
879	DDB_CS103_BLOCK	PSL	IEC60870-5-103 Monitor Blocking
880	DDB_CS103_CMD_BLOCK	PSL	IEC60870-5-103 Command Blocking
881	DDB_TIME_SYNCH	PSL	Time synchronise to nearest minute on 0-1 change
882	DDB_TEST_MODE	PSL	Initiate Test Mode
883	DDB_FAULT_RECORDER_START	PSL	Fault Record Trigger Input
884	DDB_SG_SELECTOR_X1	PSL	Setting Group Selector x1 (bit 0)
885	DDB_SG_SELECTOR_1X	PSL	Setting Group Selector 1x (bit 1)
886	DDB_ANY_TRIP	PSL	Any Trip
886	DDB_ANY_TRIP	FL	Any Trip
887	DDB_BUS_IDIFF_TRIPA_Z3	SW	Z3 Diff Phase A Trip
888	DDB_BUS_IDIFF_TRIPB_Z3	SW	Z3 Diff Phase B Trip
889	DDB_BUS_IDIFF_TRIPC_Z3	SW	Z3 Diff Phase C Trip
890	DDB_BUS_IDIFF_TRIPA_Z4	SW	Z4 Diff Phase A Trip

DDB	Element Name	Source	Description
891	DDB_TRIP_INITIAL	FL	Trip Initial (same as Any trip)
892	DDB_RESET_CIR_FLT	PSL	Reset Circuitry fault
893	DDB_FAULT_A	FL	Phase A Fault
894	DDB_FAULT_B	FL	Phase B Fault
895	DDB_FAULT_C	FL	Phase C Fault
896	DDB_FAULT_N	FL	Earth Fault
897	DDB_BUS_IDIFF_TRIPB_Z4	SW	Z4 Diff Phase B Trip
899	DDB_IDIFF_TRIPA	SW	Idiff Trip A
900	DDB_IDIFF_TRIPB	SW	Idiff Trip B
901	DDB_IDIFF_TRIPC	SW	Idiff Trip C
902	DDB_IDIFF_TRIP	SW	Idiff Trip
903	DDB_IDIFF_HS1_TRIPA	SW	Idiff HS1 Trip A
903	DDB_BUS_IDIFF_TRIPA_Z1	SW	Z1 Diff Phase A Trip
904	DDB_IDIFF_HS1_TRIPB	SW	Idiff HS1 Trip B
904	DDB_BUS_IDIFF_TRIPB_Z1	SW	Z1 Diff Phase B Trip
905	DDB_IDIFF_HS1_TRIPC	SW	Idiff HS1 Trip C
905	DDB_BUS_IDIFF_TRIPC_Z1	SW	Z1 Diff Phase C Trip
906	DDB_IDIFF_HS2_TRIPA	SW	Idiff HS2 Trip A
906	DDB_BUS_IDIFF_TRIPA_Z2	SW	Z2 Diff Phase A Trip
907	DDB_IDIFF_HS2_TRIPB	SW	Idiff HS2 Trip B
907	DDB_BUS_IDIFF_TRIPB_Z2	SW	Z2 Diff Phase B Trip
908	DDB_IDIFF_HS2_TRIPC	SW	Idiff HS2 Trip C
908	DDB_BUS_IDIFF_TRIPC_Z2	SW	Z2 Diff Phase C Trip
909	DDB_IDIFF_BIAS_TRIPA	SW	Id Bias Trip A
909	DDB_BUS_ZONE_TRIP_BB12	SW	BB12 CB Tripped
910	DDB_BUS_ZONE_TRIP_BB13	SW	BB13 CB Tripped
911	DDB_BUS_IDIFF_TRIP_Z4	SW	Z4 Diff Trip
912	DDB_BUS_IDIFF_TRIP_Z1	SW	Z1 Diff Trip
913	DDB_BUS_IDIFF_TRIP_Z2	SW	Z2 Diff Trip
914	DDB_BUS_IDIFF_TRIP_Z3	SW	Z3 Diff Trip
915	DDB_BUS_ZONE_TRIP_T1	SW	Zone Trip T1 by Diff Trip or CBF Back Zone Trip or External Zone Trip
916	DDB_BUS_ZONE_TRIP_T2	SW	Zone Trip T2 by Diff Trip or CBF Back Zone Trip or External Zone Trip
917	DDB_BUS_ZONE_TRIP_T3	SW	Zone Trip T3 by Diff Trip or CBF Back Zone Trip or External Zone Trip
918	DDB_BUS_ZONE_TRIP_T4	SW	Zone Trip T4 by Diff Trip or CBF Back Zone Trip or External Zone Trip
919	DDB_BUS_ZONE_TRIP_T5	SW	Zone Trip T5 by Diff Trip or CBF Back Zone Trip or External Zone Trip
920	DDB_BUS_ZONE_TRIP_T6	SW	Zone Trip T6 by Diff Trip or CBF Back Zone Trip or External Zone Trip
921	DDB_BUS_ZONE_TRIP_T7	SW	Zone Trip T7 by Diff Trip or CBF Back Zone Trip or External Zone Trip
922	DDB_BUS_ZONE_TRIP_T8	SW	Zone Trip T8 by Diff Trip or CBF Back Zone Trip or External Zone Trip
923	DDB_BUS_ZONE_TRIP_T9	SW	Zone Trip T9 by Diff Trip or CBF Back Zone Trip or External Zone Trip
924	DDB_BUS_ZONE_TRIP_T10	SW	Zone Trip T10 by Diff Trip or CBF Back Zone Trip or External Zone Trip
925	DDB_BUS_ZONE_TRIP_T11	SW	Zone Trip T11 by Diff Trip or CBF Back Zone Trip or External Zone Trip
926	DDB_BUS_ZONE_TRIP_T12	SW	Zone Trip T12 by Diff Trip or CBF Back Zone Trip or External Zone Trip
927	DDB_BUS_ZONE_TRIP_T13	SW	Zone Trip T13 by Diff Trip or CBF Back Zone Trip or External Zone Trip
928	DDB_BUS_ZONE_TRIP_T14	SW	Zone Trip T14 by Diff Trip or CBF Back Zone Trip or External Zone Trip

DDB	Element Name	Source	Description
929	DDB_BUS_ZONE_TRIP_T15	SW	Zone Trip T15 by Diff Trip or CBF Back Zone Trip or External Zone Trip
930	DDB_BUS_ZONE_TRIP_T16	SW	Zone Trip T16 by Diff Trip or CBF Back Zone Trip or External Zone Trip
931	DDB_BUS_ZONE_TRIP_T17	SW	Zone Trip T17 by Diff Trip or CBF Back Zone Trip or External Zone Trip
932	DDB_BUS_ZONE_TRIP_T18	SW	Zone Trip T18 by Diff Trip or CBF Back Zone Trip or External Zone Trip
933	DDB_DZ1_OC_3PH_TRIP	SW	T1 DeadZone Trip
934	DDB_DZ2_OC_3PH_TRIP	SW	T2 DeadZone Trip
935	DDB_DZ3_OC_3PH_TRIP	SW	T3 DeadZone Trip
936	DDB_DZ4_OC_3PH_TRIP	SW	T4 DeadZone Trip
937	DDB_DZ5_OC_3PH_TRIP	SW	T5 DeadZone Trip
938	DDB_DZ6_OC_3PH_TRIP	SW	T6 DeadZone Trip
939	DDB_DZ7_OC_3PH_TRIP	SW	T7 DeadZone Trip
940	DDB_DZ8_OC_3PH_TRIP	SW	T8 DeadZone Trip
941	DDB_DZ9_OC_3PH_TRIP	SW	T9 DeadZone Trip
942	DDB_DZ10_OC_3PH_TRIP	SW	T10 DeadZone Trip
943	DDB_DZ11_OC_3PH_TRIP	SW	T11 DeadZone Trip
944	DDB_DZ12_OC_3PH_TRIP	SW	T12 DeadZone Trip
945	DDB_DZ13_OC_3PH_TRIP	SW	T13 DeadZone Trip
946	DDB_DZ14_OC_3PH_TRIP	SW	T14 DeadZone Trip
947	DDB_DZ15_OC_3PH_TRIP	SW	T15 DeadZone Trip
948	DDB_DZ16_OC_3PH_TRIP	SW	T16 DeadZone Trip
949	DDB_DZ17_OC_3PH_TRIP	SW	T17 DeadZone Trip
950	DDB_DZ18_OC_3PH_TRIP	SW	T18 DeadZone Trip
951	DDB_DZ19_OC_3PH_TRIP	SW	T19 DeadZone Trip
952	DDB_DZ20_OC_3PH_TRIP	SW	T20 DeadZone Trip
953	DDB_DZ21_OC_3PH_TRIP	SW	T21 DeadZone Trip
954	DDB_UI_LOGGEDIN	SW	User logged into UI
955	DDB_FCUR_LOGGEDIN	SW	User logged into front port courier
956	DDB_RP1_LOGGEDIN	SW	User logged into Rear Port1 courier
957	DDB_RP2_LOGGEDIN	SW	User logged into Rear Port2 courier
958	DDB_TNL_LOGGEDIN	SW	User logged into turnneled courier
959	DDB_CPR_LOGGEDIN	SW	User logged into co-processor courier
975	DDB_BUS_ZONE_TRIP_T19	SW	Zone Trip T19 by Diff Trip or CBF Back Zone Trip or External Zone Trip
976	DDB_BUS_ZONE_TRIP_T20	SW	Zone Trip T20 by Diff Trip or CBF Back Zone Trip or External Zone Trip
977	DDB_BUS_ZONE_TRIP_T21	SW	Zone Trip T21 by Diff Trip or CBF Back Zone Trip or External Zone Trip
978	DDB_BUS_ZONE_TRIP_BB23	SW	BB23 CB Tripped
979	DDB_BUS_ZONE_TRIP_BB14	SW	BB14 CB Tripped
980	DDB_BUS_ZONE_TRIP_BB24	SW	BB24 CB Tripped
981	DDB_BUS_ZONE_TRIP_BB34	SW	BB34 CB Tripped
982	DDB_LV_POC_2_PH_B_TRIP	SW	LV I>2 Trip B
983	DDB_LV_POC_2_PH_C_TRIP	SW	LV I>2 Trip C
984	DDB_LV_POC_3_3PH_TRIP	SW	LV I>3 Trip
985	DDB_LV_POC_3_PH_A_TRIP	SW	LV I>3 Trip A
986	DDB_LV_POC_3_PH_B_TRIP	SW	LV I>3 Trip B
987	DDB_LV_POC_3_PH_C_TRIP	SW	LV I>3 Trip C

DDB	Element Name	Source	Description
988	DDB_LV_POC_4_3PH_TRIP	SW	LV I>4 Trip
989	DDB_LV_POC_4_PH_A_TRIP	SW	LV I>4 Trip A
990	DDB_LV_POC_4_PH_B_TRIP	SW	LV I>4 Trip B
991	DDB_LV_POC_4_PH_C_TRIP	SW	LV I>4 Trip C
992	DDB_TV_POC_1_3PH_TRIP	SW	TV I>1 Trip
993	DDB_TV_POC_1_PH_A_TRIP	SW	TV I>1 Trip A
994	DDB_TV_POC_1_PH_B_TRIP	SW	TV I>1 Trip B
995	DDB_TV_POC_1_PH_C_TRIP	SW	TV I>1 Trip C
996	DDB_TV_POC_2_3PH_TRIP	SW	TV I>2 Trip
997	DDB_TV_POC_2_PH_A_TRIP	SW	TV I>2 Trip A
998	DDB_TV_POC_2_PH_B_TRIP	SW	TV I>2 Trip B
999	DDB_TV_POC_2_PH_C_TRIP	SW	TV I>2 Trip C
1000	DDB_TV_POC_3_3PH_TRIP	SW	TV I>3 Trip
1001	DDB_TV_POC_3_PH_A_TRIP	SW	TV I>3 Trip A
1002	DDB_TV_POC_3_PH_B_TRIP	SW	TV I>3 Trip B
1003	DDB_TV_POC_3_PH_C_TRIP	SW	TV I>3 Trip C
1004	DDB_TV_POC_4_3PH_TRIP	SW	TV I>4 Trip
1005	DDB_TV_POC_4_PH_A_TRIP	SW	TV I>4 Trip A
1006	DDB_TV_POC_4_PH_B_TRIP	SW	TV I>4 Trip B
1007	DDB_TV_POC_4_PH_C_TRIP	SW	TV I>4 Trip C
1008	DDB_T1_POC_1_3PH_TRIP	SW	T1 I>1 Trip
1009	DDB_T1_POC_2_3PH_TRIP	SW	T1 I>2 Trip
1010	DDB_T2_POC_1_3PH_TRIP	SW	T2 I>1 Trip
1011	DDB_T2_POC_2_3PH_TRIP	SW	T2 I>2 Trip
1012	DDB_T3_POC_1_3PH_TRIP	SW	T3 I>1 Trip
1013	DDB_T3_POC_2_3PH_TRIP	SW	T3 I>2 Trip
1014	DDB_T4_POC_1_3PH_TRIP	SW	T4 I>1 Trip
1015	DDB_T4_POC_2_3PH_TRIP	SW	T4 I>2 Trip
1016	DDB_T5_POC_1_3PH_TRIP	SW	T5 I>1 Trip
1017	DDB_T5_POC_2_3PH_TRIP	SW	T5 I>2 Trip
1018	DDB_T6_POC_1_3PH_TRIP	SW	T6 I>1 Trip
1019	DDB_T6_POC_2_3PH_TRIP	SW	T6 I>2 Trip
1020	DDB_T7_POC_1_3PH_TRIP	SW	T7 I>1 Trip
1021	DDB_T7_POC_2_3PH_TRIP	SW	T7 I>2 Trip
1022	DDB_T8_POC_1_3PH_TRIP	SW	T8 I>1 Trip
1023	DDB_T8_POC_2_3PH_TRIP	SW	T8 I>2 Trip
1024	DDB_T9_POC_1_3PH_TRIP	SW	T9 I>1 Trip
1025	DDB_T9_POC_2_3PH_TRIP	SW	T9 I>2 Trip
1026	DDB_T10_POC_1_3PH_TRIP	SW	T10 I>1 Trip
1027	DDB_T10_POC_2_3PH_TRIP	SW	T10 I>2 Trip
1028	DDB_T11_POC_1_3PH_TRIP	SW	T11 I>1 Trip
1029	DDB_T11_POC_2_3PH_TRIP	SW	T11 I>2 Trip
1030	DDB_T12_POC_1_3PH_TRIP	SW	T12 I>1 Trip
1031	DDB_T12_POC_2_3PH_TRIP	SW	T12 I>2 Trip

DDB	Element Name	Source	Description
1032	DDB_T13_POC_1_3PH_TRIP	SW	T13 I>1 Trip
1033	DDB_T13_POC_2_3PH_TRIP	SW	T13 I>2 Trip
1034	DDB_T14_POC_1_3PH_TRIP	SW	T14 I>1 Trip
1035	DDB_T14_POC_2_3PH_TRIP	SW	T14 I>2 Trip
1036	DDB_T15_POC_1_3PH_TRIP	SW	T15 I>1 Trip
1037	DDB_T15_POC_2_3PH_TRIP	SW	T15 I>2 Trip
1038	DDB_T16_POC_1_3PH_TRIP	SW	T16 I>1 Trip
1039	DDB_T16_POC_2_3PH_TRIP	SW	T16 I>2 Trip
1040	DDB_T17_POC_1_3PH_TRIP	SW	T17 I>1 Trip
1041	DDB_T17_POC_2_3PH_TRIP	SW	T17 I>2 Trip
1042	DDB_T18_POC_1_3PH_TRIP	SW	T18 I>1 Trip
1043	DDB_T18_POC_2_3PH_TRIP	SW	T18 I>2 Trip
1044	DDB_T19_POC_1_3PH_TRIP	SW	T19 I>1 Trip
1045	DDB_T19_POC_2_3PH_TRIP	SW	T19 I>2 Trip
1046	DDB_T20_POC_1_3PH_TRIP	SW	T20 I>1 Trip
1047	DDB_T20_POC_2_3PH_TRIP	SW	T20 I>2 Trip
1048	DDB_T21_POC_1_3PH_TRIP	SW	T21 I>1 Trip
1049	DDB_T21_POC_2_3PH_TRIP	SW	T21 I>2 Trip
1050	DDB_BUS13_CB_NOT_READY	PSL	BB13 Bus CB Not Ready
1051	DDB_BUS23_CB_NOT_READY	PSL	BB23 Bus CB Not Ready
1052	DDB_BUS14_CB_NOT_READY	PSL	BB14 Bus CB Not Ready
1053	DDB_BUS24_CB_NOT_READY	PSL	BB24 Bus CB Not Ready
1054	DDB_BUS34_CB_NOT_READY	PSL	BB34 Bus CB Not Ready
1055	DDB_BUS13_CB_NOT_READY_IN	FL	BB13 Bus CB Not Ready
1056	DDB_BUS23_CB_NOT_READY_IN	FL	BB23 Bus CB Not Ready
1057	DDB_BUS14_CB_NOT_READY_IN	FL	BB14 Bus CB Not Ready
1058	DDB_BUS24_CB_NOT_READY_IN	FL	BB24 Bus CB Not Ready
1059	DDB_BUS34_CB_NOT_READY_IN	FL	BB34 Bus CB Not Ready
1062	DDB_USER_ALARM_1	PSL	User definable Self Reset Alarm 1
1063	DDB_USER_ALARM_2	PSL	User definable Self Reset Alarm 2
1064	DDB_USER_ALARM_3	PSL	User definable Self Reset Alarm 3
1065	DDB_USER_ALARM_4	PSL	User definable Self Reset Alarm 4
1066	DDB_USER_ALARM_5	PSL	User definable Self Reset Alarm 5
1067	DDB_USER_ALARM_6	PSL	User definable Self Reset Alarm 6
1068	DDB_USER_ALARM_7	PSL	User definable Self Reset Alarm 7
1069	DDB_USER_ALARM_8	PSL	User definable Self Reset Alarm 8
1070	DDB_USER_ALARM_9	PSL	User definable Self Reset Alarm 9
1071	DDB_USER_ALARM_10	PSL	User definable Self Reset Alarm 10
1072	DDB_USER_ALARM_11	PSL	User definable Self Reset Alarm 11
1073	DDB_USER_ALARM_12	PSL	User definable Self Reset Alarm 12
1074	DDB_USER_ALARM_13	PSL	User definable Self Reset Alarm 13
1075	DDB_USER_ALARM_14	PSL	User definable Self Reset Alarm 14
1076	DDB_USER_ALARM_15	PSL	User definable Self Reset Alarm 15
1077	DDB_USER_ALARM_16	PSL	User definable Self Reset Alarm 16

DDB	Element Name	Source	Description
1078	DDB_USER_ALARM_17	PSL	User definable Manual Reset Alarm 17
1079	DDB_USER_ALARM_18	PSL	User definable Manual Reset Alarm 18
1080	DDB_USER_ALARM_19	PSL	User definable Manual Reset Alarm 19
1081	DDB_USER_ALARM_20	PSL	User definable Manual Reset Alarm 20
1082	DDB_USER_ALARM_21	PSL	User definable Manual Reset Alarm 21
1083	DDB_USER_ALARM_22	PSL	User definable Manual Reset Alarm 22
1084	DDB_USER_ALARM_23	PSL	User definable Manual Reset Alarm 23
1085	DDB_USER_ALARM_24	PSL	User definable Manual Reset Alarm 24
1086	DDB_USER_ALARM_25	PSL	User definable Manual Reset Alarm 25
1087	DDB_USER_ALARM_26	PSL	User definable Manual Reset Alarm 26
1088	DDB_USER_ALARM_27	PSL	User definable Manual Reset Alarm 27
1089	DDB_USER_ALARM_28	PSL	User definable Manual Reset Alarm 28
1090	DDB_USER_ALARM_29	PSL	User definable Manual Reset Alarm 29
1091	DDB_USER_ALARM_30	PSL	User definable Manual Reset Alarm 30
1092	DDB_USER_ALARM_31	PSL	User definable Manual Reset Alarm 31
1093	DDB_USER_ALARM_32	PSL	User definable Manual Reset Alarm 32
1104	DDB_CB1_3PH_RETRIP	SW	CB1 ReTrip 3ph
1104	DDB_CBF_RETRIP_T1	SW	CBF Retrip T1
1105	DDB_CB1_3PH_BKTRIP	SW	CB1 BkTrip 3ph
1105	DDB_CBF_RETRIP_T2	SW	CBF Retrip T2
1106	DDB_CB2_3PH_RETRIP	SW	CB2 ReTrip 3ph
1106	DDB_CBF_RETRIP_T3	SW	CBF Retrip T3
1107	DDB_CB2_3PH_BKTRIP	SW	CB2 BkTrip 3ph
1107	DDB_CBF_RETRIP_T4	SW	CBF Retrip T4
1108	DDB_CB3_3PH_RETRIP	SW	CB3 ReTrip 3ph
1108	DDB_CBF_RETRIP_T5	SW	CBF Retrip T5
1109	DDB_CB3_3PH_BKTRIP	SW	CB3 BkTrip 3ph
1109	DDB_CBF_RETRIP_T6	SW	CBF Retrip T6
1110	DDB_CB4_3PH_RETRIP	SW	CB4 ReTrip 3ph
1110	DDB_CBF_RETRIP_T7	SW	CBF Retrip T7
1111	DDB_CB4_3PH_BKTRIP	SW	CB4 BkTrip 3ph
1111	DDB_CBF_RETRIP_T8	SW	CBF Retrip T8
1112	DDB_CB5_3PH_RETRIP	SW	CB5 ReTrip 3ph
1112	DDB_CBF_RETRIP_T9	SW	CBF Retrip T9
1113	DDB_CB5_3PH_BKTRIP	SW	CB5 BkTrip 3ph
1113	DDB_CBF_RETRIP_T10	SW	CBF Retrip T10
1114	DDB_CBF_RETRIP_T11	SW	CBF Retrip T11
1115	DDB_CBF_RETRIP_T12	SW	CBF Retrip T12
1116	DDB_CBF_RETRIP_T13	SW	CBF Retrip T13
1117	DDB_CBF_RETRIP_T14	SW	CBF Retrip T14
1118	DDB_CBF_RETRIP_T15	SW	CBF Retrip T15
1119	DDB_CBF_RETRIP_T16	SW	CBF Retrip T16
1120	DDB_CBF_RETRIP_T17	SW	CBF Retrip T17
1121	DDB_CBF_RETRIP_T18	SW	CBF Retrip T18

DDB	Element Name	Source	Description
1122	DDB_CBF_BKTRIP_Z1	SW	Z1 CBF Back Trip
1123	DDB_CBF_BKTRIP_Z2	SW	Z2 CBF Back Trip
1124	DDB_REMOTE_TRIP_T1	SW	T1 Remote Trip By Diff or CBF
1125	DDB_REMOTE_TRIP_T2	SW	T2 Remote Trip By Diff or CBF
1126	DDB_REMOTE_TRIP_T3	SW	T3 Remote Trip By Diff or CBF
1127	DDB_REMOTE_TRIP_T4	SW	T4 Remote Trip By Diff or CBF
1128	DDB_REMOTE_TRIP_T5	SW	T5 Remote Trip By Diff or CBF
1129	DDB_REMOTE_TRIP_T6	SW	T6 Remote Trip By Diff or CBF
1130	DDB_REMOTE_TRIP_T7	SW	T7 Remote Trip By Diff or CBF
1131	DDB_REMOTE_TRIP_T8	SW	T8 Remote Trip By Diff or CBF
1132	DDB_REMOTE_TRIP_T9	SW	T9 Remote Trip By Diff or CBF
1133	DDB_REMOTE_TRIP_T10	SW	T10 Remote Trip By Diff or CBF
1134	DDB_REMOTE_TRIP_T11	SW	T11 Remote Trip By Diff or CBF
1135	DDB_REMOTE_TRIP_T12	SW	T12 Remote Trip By Diff or CBF
1136	DDB_REMOTE_TRIP_T13	SW	T13 Remote Trip By Diff or CBF
1137	DDB_REMOTE_TRIP_T14	SW	T14 Remote Trip By Diff or CBF
1138	DDB_REMOTE_TRIP_T15	SW	T15 Remote Trip By Diff or CBF
1139	DDB_REMOTE_TRIP_T16	SW	T16 Remote Trip By Diff or CBF
1140	DDB_REMOTE_TRIP_T17	SW	T17 Remote Trip By Diff or CBF
1141	DDB_REMOTE_TRIP_T18	SW	T18 Remote Trip By Diff or CBF
1142	DDB_HV_EF_1_TRIP	SW	HV IN>1 Trip
1142	DDB_T1_EF_1_TRIP	SW	T1 IN>1 Trip
1143	DDB_HV_EF_2_TRIP	SW	HV IN>2 Trip
1143	DDB_T1_EF_2_TRIP	SW	T1 IN>2 Trip
1144	DDB_HV_EF_3_TRIP	SW	HV IN>3 Trip
1144	DDB_T2_EF_1_TRIP	SW	T2 IN>1 Trip
1145	DDB_HV_EF_4_TRIP	SW	HV IN>4 Trip
1145	DDB_T2_EF_2_TRIP	SW	T2 IN>2 Trip
1146	DDB_LV_EF_1_TRIP	SW	LV IN>1 Trip
1146	DDB_T3_EF_1_TRIP	SW	T3 IN>1 Trip
1147	DDB_LV_EF_2_TRIP	SW	LV IN>2 Trip
1147	DDB_T3_EF_2_TRIP	SW	T3 IN>2 Trip
1148	DDB_LV_EF_3_TRIP	SW	LV IN>3 Trip
1148	DDB_T4_EF_1_TRIP	SW	T4 IN>1 Trip
1149	DDB_LV_EF_4_TRIP	SW	LV IN>4 Trip
1149	DDB_T4_EF_2_TRIP	SW	T4 IN>2 Trip
1150	DDB_TV_EF_1_TRIP	SW	TV IN>1 Trip
1150	DDB_T5_EF_1_TRIP	SW	T5 IN>1 Trip
1151	DDB_TV_EF_2_TRIP	SW	TV IN>2 Trip
1151	DDB_T5_EF_2_TRIP	SW	T5 IN>2 Trip
1152	DDB_TV_EF_3_TRIP	SW	TV IN>3 Trip
1152	DDB_T6_EF_1_TRIP	SW	T6 IN>1 Trip
1153	DDB_TV_EF_4_TRIP	SW	TV IN>4 Trip
1153	DDB_T6_EF_2_TRIP	SW	T6 IN>2 Trip

DDB	Element Name	Source	Description
1154	DDB_T7_EF_1_TRIP	SW	T7 IN>1 Trip
1155	DDB_T7_EF_2_TRIP	SW	T7 IN>2 Trip
1156	DDB_T19_POC_1_3PH_START	SW	T19 I>1 Start
1157	DDB_T19_POC_1_PH_A_START	SW	T19 I>1 Start A
1158	DDB_T19_POC_1_PH_B_START	SW	T19 I>1 Start B
1159	DDB_T19_POC_1_PH_C_START	SW	T19 I>1 Start C
1160	DDB_T19_POC_2_3PH_START	SW	T19 I>2 Start
1161	DDB_T19_POC_2_PH_A_START	SW	T19 I>2 Start A
1162	DDB_T19_POC_2_PH_B_START	SW	T19 I>2 Start B
1163	DDB_T19_POC_2_PH_C_START	SW	T19 I>2 Start C
1164	DDB_T20_POC_1_3PH_START	SW	T20 I>1 Start
1165	DDB_T20_POC_1_PH_A_START	SW	T20 I>1 Start A
1166	DDB_T20_POC_1_PH_B_START	SW	T20 I>1 Start B
1167	DDB_T20_POC_1_PH_C_START	SW	T20 I>1 Start C
1168	DDB_T20_POC_2_3PH_START	SW	T20 I>2 Start
1169	DDB_T20_POC_2_PH_A_START	SW	T20 I>2 Start A
1170	DDB_T20_POC_2_PH_B_START	SW	T20 I>2 Start B
1171	DDB_T20_POC_2_PH_C_START	SW	T20 I>2 Start C
1172	DDB_T21_POC_1_3PH_START	SW	T21 I>1 Start
1173	DDB_T21_POC_1_PH_A_START	SW	T21 I>1 Start A
1174	DDB_T21_POC_1_PH_B_START	SW	T21 I>1 Start B
1175	DDB_T21_POC_1_PH_C_START	SW	T21 I>1 Start C
1176	DDB_T21_POC_2_3PH_START	SW	T21 I>2 Start
1177	DDB_T21_POC_2_PH_A_START	SW	T21 I>2 Start A
1178	DDB_T21_POC_2_PH_B_START	SW	T21 I>2 Start B
1179	DDB_T21_POC_2_PH_C_START	SW	T21 I>2 Start C
1180	DDB_CBF_RETRIP_T19	SW	CBF Retrip T19
1181	DDB_CBF_RETRIP_T20	SW	CBF Retrip T20
1182	DDB_CBF_RETRIP_T21	SW	CBF Retrip T21
1183	DDB_CBF_BKTRIP_Z3	SW	Z3 CBF Back Trip
1184	DDB_VIP_PUB_PRES_1	SW	GOOSE Virtual input 1 publisher bit
1185	DDB_VIP_PUB_PRES_2	SW	GOOSE Virtual input 2 publisher bit
1186	DDB_VIP_PUB_PRES_3	SW	GOOSE Virtual input 3 publisher bit
1187	DDB_VIP_PUB_PRES_4	SW	GOOSE Virtual input 4 publisher bit
1188	DDB_VIP_PUB_PRES_5	SW	GOOSE Virtual input 5 publisher bit
1189	DDB_VIP_PUB_PRES_6	SW	GOOSE Virtual input 6 publisher bit
1190	DDB_VIP_PUB_PRES_7	SW	GOOSE Virtual input 7 publisher bit
1191	DDB_VIP_PUB_PRES_8	SW	GOOSE Virtual input 8 publisher bit
1192	DDB_VIP_PUB_PRES_9	SW	GOOSE Virtual input 9 publisher bit
1193	DDB_VIP_PUB_PRES_10	SW	GOOSE Virtual input 10 publisher bit
1194	DDB_VIP_PUB_PRES_11	SW	GOOSE Virtual input 11 publisher bit
1195	DDB_VIP_PUB_PRES_12	SW	GOOSE Virtual input 12 publisher bit
1196	DDB_VIP_PUB_PRES_13	SW	GOOSE Virtual input 13 publisher bit
1197	DDB_VIP_PUB_PRES_14	SW	GOOSE Virtual input 14 publisher bit

DDB	Element Name	Source	Description
1198	DDB_VIP_PUB_PRES_15	SW	GOOSE Virtual input 15 publisher bit
1199	DDB_VIP_PUB_PRES_16	SW	GOOSE Virtual input 16 publisher bit
1200	DDB_VIP_PUB_PRES_17	SW	GOOSE Virtual input 17 publisher bit
1201	DDB_VIP_PUB_PRES_18	SW	GOOSE Virtual input 18 publisher bit
1202	DDB_VIP_PUB_PRES_19	SW	GOOSE Virtual input 19 publisher bit
1203	DDB_VIP_PUB_PRES_20	SW	GOOSE Virtual input 20 publisher bit
1204	DDB_VIP_PUB_PRES_21	SW	GOOSE Virtual input 21 publisher bit
1205	DDB_VIP_PUB_PRES_22	SW	GOOSE Virtual input 22 publisher bit
1206	DDB_VIP_PUB_PRES_23	SW	GOOSE Virtual input 23 publisher bit
1207	DDB_VIP_PUB_PRES_24	SW	GOOSE Virtual input 24 publisher bit
1208	DDB_VIP_PUB_PRES_25	SW	GOOSE Virtual input 25 publisher bit
1209	DDB_VIP_PUB_PRES_26	SW	GOOSE Virtual input 26 publisher bit
1210	DDB_VIP_PUB_PRES_27	SW	GOOSE Virtual input 27 publisher bit
1211	DDB_VIP_PUB_PRES_28	SW	GOOSE Virtual input 28 publisher bit
1212	DDB_VIP_PUB_PRES_29	SW	GOOSE Virtual input 29 publisher bit
1213	DDB_VIP_PUB_PRES_30	SW	GOOSE Virtual input 30 publisher bit
1214	DDB_VIP_PUB_PRES_31	SW	GOOSE Virtual input 31 publisher bit
1215	DDB_VIP_PUB_PRES_32	SW	GOOSE Virtual input 32 publisher bit
1216	DDB_VIP_PUB_PRES_33	SW	GOOSE Virtual input 33 publisher bit
1217	DDB_VIP_PUB_PRES_34	SW	GOOSE Virtual input 34 publisher bit
1218	DDB_VIP_PUB_PRES_35	SW	GOOSE Virtual input 35 publisher bit
1219	DDB_VIP_PUB_PRES_36	SW	GOOSE Virtual input 36 publisher bit
1220	DDB_VIP_PUB_PRES_37	SW	GOOSE Virtual input 37 publisher bit
1221	DDB_VIP_PUB_PRES_38	SW	GOOSE Virtual input 38 publisher bit
1222	DDB_VIP_PUB_PRES_39	SW	GOOSE Virtual input 39 publisher bit
1223	DDB_VIP_PUB_PRES_40	SW	GOOSE Virtual input 40 publisher bit
1224	DDB_VIP_PUB_PRES_41	SW	GOOSE Virtual input 41 publisher bit
1225	DDB_VIP_PUB_PRES_42	SW	GOOSE Virtual input 42 publisher bit
1226	DDB_VIP_PUB_PRES_43	SW	GOOSE Virtual input 43 publisher bit
1227	DDB_VIP_PUB_PRES_44	SW	GOOSE Virtual input 44 publisher bit
1228	DDB_VIP_PUB_PRES_45	SW	GOOSE Virtual input 45 publisher bit
1229	DDB_VIP_PUB_PRES_46	SW	GOOSE Virtual input 46 publisher bit
1230	DDB_VIP_PUB_PRES_47	SW	GOOSE Virtual input 47 publisher bit
1231	DDB_VIP_PUB_PRES_48	SW	GOOSE Virtual input 48 publisher bit
1232	DDB_VIP_PUB_PRES_49	SW	GOOSE Virtual input 49 publisher bit
1233	DDB_VIP_PUB_PRES_50	SW	GOOSE Virtual input 50 publisher bit
1234	DDB_VIP_PUB_PRES_51	SW	GOOSE Virtual input 51 publisher bit
1235	DDB_VIP_PUB_PRES_52	SW	GOOSE Virtual input 52 publisher bit
1236	DDB_VIP_PUB_PRES_53	SW	GOOSE Virtual input 53 publisher bit
1237	DDB_VIP_PUB_PRES_54	SW	GOOSE Virtual input 54 publisher bit
1238	DDB_VIP_PUB_PRES_55	SW	GOOSE Virtual input 55 publisher bit
1239	DDB_VIP_PUB_PRES_56	SW	GOOSE Virtual input 56 publisher bit
1240	DDB_VIP_PUB_PRES_57	SW	GOOSE Virtual input 57 publisher bit
1241	DDB_VIP_PUB_PRES_58	SW	GOOSE Virtual input 58 publisher bit

DDB	Element Name	Source	Description
1242	DDB_VIP_PUB_PRES_59	SW	GOOSE Virtual input 59 publisher bit
1243	DDB_VIP_PUB_PRES_60	SW	GOOSE Virtual input 60 publisher bit
1244	DDB_VIP_PUB_PRES_61	SW	GOOSE Virtual input 61 publisher bit
1245	DDB_VIP_PUB_PRES_62	SW	GOOSE Virtual input 62 publisher bit
1246	DDB_VIP_PUB_PRES_63	SW	GOOSE Virtual input 63 publisher bit
1247	DDB_VIP_PUB_PRES_64	SW	GOOSE Virtual input 64 publisher bit
1248	DDB_CBF_BKTRIP_Z4	SW	Z3 CBF Back Trip
1249	DDB_REMOTE_TRIP_T19	SW	T19 Remote Trip By Diff or CBF
1250	DDB_REMOTE_TRIP_T20	SW	T20 Remote Trip By Diff or CBF
1251	DDB_REMOTE_TRIP_T21	SW	T21 Remote Trip By Diff or CBF
1252	DDB_EXT_TRIP_Z3	PSL	Z3 External CBF Trip
1253	DDB_EXT_TRIP_Z4	PSL	Z4 External CBF Trip
1254	DDB_EXT_CBF_INIT_BUS13_CB	PSL	External CBF Init Bus13 CB
1255	DDB_EXT_CBF_INIT_BUS23_CB	PSL	External CBF Init Bus23 CB
1256	DDB_EXT_CBF_INIT_BUS14_CB	PSL	External CBF Init Bus14 CB
1257	DDB_EXT_CBF_INIT_BUS24_CB	PSL	External CBF Init Bus24 CB
1258	DDB_EXT_CBF_INIT_BUS34_CB	PSL	External CBF Init Bus34 CB
1259	DDB_EXT_CBF_INIT_T19	PSL	External CBF Init T19
1260	DDB_EXT_CBF_INIT_T20	PSL	External CBF Init T20
1261	DDB_EXT_CBF_INIT_T21	PSL	External CBF Init T21
1262	DDB_EXT_CBF_INIT_T1	PSL	External CBF Init T1
1263	DDB_EXT_CBF_INIT_T2	PSL	External CBF Init T2
1264	DDB_EXT_CBF_INIT_T3	PSL	External CBF Init T3
1265	DDB_EXT_CBF_INIT_T4	PSL	External CBF Init T4
1266	DDB_EXT_CBF_INIT_T5	PSL	External CBF Init T5
1267	DDB_EXT_CBF_INIT_T6	PSL	External CBF Init T6
1268	DDB_EXT_CBF_INIT_T7	PSL	External CBF Init T7
1269	DDB_EXT_CBF_INIT_T8	PSL	External CBF Init T8
1270	DDB_EXT_CBF_INIT_T9	PSL	External CBF Init T9
1271	DDB_EXT_CBF_INIT_T10	PSL	External CBF Init T10
1272	DDB_EXT_CBF_INIT_T11	PSL	External CBF Init T11
1273	DDB_EXT_CBF_INIT_T12	PSL	External CBF Init T12
1274	DDB_EXT_CBF_INIT_T13	PSL	External CBF Init T13
1275	DDB_EXT_CBF_INIT_T14	PSL	External CBF Init T14
1276	DDB_EXT_CBF_INIT_T15	PSL	External CBF Init T15
1277	DDB_EXT_CBF_INIT_T16	PSL	External CBF Init T16
1278	DDB_EXT_CBF_INIT_T17	PSL	External CBF Init T17
1279	DDB_EXT_CBF_INIT_T18	PSL	External CBF Init T18
1280	DDB_EXT_CBF_INIT_BUS12_CB	PSL	External CBF Init Bus12 CB
1281	DDB_EXT_TRIP_Z1	PSL	Z1 External CBF Trip
1282	DDB_EXT_TRIP_Z2	PSL	Z2 External CBF Trip
1283	DDB_CBF_RETRIP_BUS12_CB	SW	Bus CB12 CBF Retrip
1284	DDB_CBF_RETRIP_BUS13_CB	SW	Bus CB13 CBF Retrip
1285	DDB_CBF_RETRIP_BUS23_CB	SW	Bus CB23 CBF Retrip

DDB	Element Name	Source	Description
1286	DDB_CBF_RETRIP_BUS14_CB	SW	Bus CB14 CBF Retrip
1287	DDB_CBF_RETRIP_BUS24_CB	SW	Bus CB24 CBF Retrip
1288	DDB_CBF_RETRIP_BUS34_CB	SW	Bus CB34 CBF Retrip
1290	DDB_INT_CBF_INIT_T1	PSL	Internal signal init CBF T1
1291	DDB_INT_CBF_INIT_T2	PSL	Internal signal init CBF T2
1292	DDB_INT_CBF_INIT_T3	PSL	Internal signal init CBF T3
1293	DDB_INT_CBF_INIT_T4	PSL	Internal signal init CBF T4
1294	DDB_INT_CBF_INIT_T5	PSL	Internal signal init CBF T5
1295	DDB_INT_CBF_INIT_T6	PSL	Internal signal init CBF T6
1296	DDB_INT_CBF_INIT_T7	PSL	Internal signal init CBF T7
1297	DDB_INT_CBF_INIT_T8	PSL	Internal signal init CBF T8
1298	DDB_INT_CBF_INIT_T9	PSL	Internal signal init CBF T9
1299	DDB_INT_CBF_INIT_T10	PSL	Internal signal init CBF T10
1300	DDB_INT_CBF_INIT_T11	PSL	Internal signal init CBF T11
1301	DDB_INT_CBF_INIT_T12	PSL	Internal signal init CBF T12
1302	DDB_INT_CBF_INIT_T13	PSL	Internal signal init CBF T13
1303	DDB_INT_CBF_INIT_T14	PSL	Internal signal init CBF T14
1304	DDB_INT_CBF_INIT_T15	PSL	Internal signal init CBF T15
1305	DDB_INT_CBF_INIT_T16	PSL	Internal signal init CBF T16
1306	DDB_INT_CBF_INIT_T17	PSL	Internal signal init CBF T17
1307	DDB_INT_CBF_INIT_T18	PSL	Internal signal init CBF T18
1308	DDB_INT_CBF_INIT_BUS12_CB	PSL	Internal signal init CBF Bus CB12
1309	DDB_INT_CBF_INIT_T19	PSL	Internal signal init CBF T19
1310	DDB_INT_CBF_INIT_T20	PSL	Internal signal init CBF T20
1311	DDB_INT_CBF_INIT_T21	PSL	Internal signal init CBF T21
1312	DDB_ANY_START	FL	Any Start
1313	DDB_IDIFF_BIAS_STARTA	SW	Diff Phase A Start
1314	DDB_IDIFF_BIAS_STARTB	SW	Diff Phase B Start
1315	DDB_IDIFF_BIAS_STARTC	SW	Diff Phase C Start
1316	DDB_DZ1_OC_3PH_START	SW	T1 DeadZone Over Current Start
1317	DDB_DZ2_OC_3PH_START	SW	T2 DeadZone Over Current Start
1318	DDB_DZ3_OC_3PH_START	SW	T3 DeadZone Over Current Start
1319	DDB_DZ4_OC_3PH_START	SW	T4 DeadZone Over Current Start
1320	DDB_DZ5_OC_3PH_START	SW	T5 DeadZone Over Current Start
1321	DDB_DZ6_OC_3PH_START	SW	T6 DeadZone Over Current Start
1322	DDB_DZ7_OC_3PH_START	SW	T7 DeadZone Over Current Start
1323	DDB_DZ8_OC_3PH_START	SW	T8 DeadZone Over Current Start
1324	DDB_DZ9_OC_3PH_START	SW	T9 DeadZone Over Current Start
1325	DDB_DZ10_OC_3PH_START	SW	T10 DeadZone Over Current Start
1326	DDB_DZ11_OC_3PH_START	SW	T11 DeadZone Over Current Start
1327	DDB_DZ12_OC_3PH_START	SW	T12 DeadZone Over Current Start
1328	DDB_DZ13_OC_3PH_START	SW	T13 DeadZone Over Current Start
1329	DDB_DZ14_OC_3PH_START	SW	T14 DeadZone Over Current Start
1330	DDB_DZ15_OC_3PH_START	SW	T15 DeadZone Over Current Start

DDB	Element Name	Source	Description
1331	DDB_DZ16_OC_3PH_START	SW	T16 DeadZone Over Current Start
1332	DDB_DZ17_OC_3PH_START	SW	T17 DeadZone Over Current Start
1333	DDB_DZ18_OC_3PH_START	SW	T18 DeadZone Over Current Start
1334	DDB_DZ19_OC_3PH_START	SW	T19 DeadZone Over Current Start
1335	DDB_DZ20_OC_3PH_START	SW	T20 DeadZone Over Current Start
1336	DDB_DZ21_OC_3PH_START	SW	T21 DeadZone Over Current Start
1337	DDB_TOP_OIL_1_START	SW	Top Oil >1 start
1338	DDB_TOP_OIL_2_START	SW	Top Oil >2 start
1339	DDB_TOP_OIL_3_START	SW	Top Oil >3 start
1340	DDB_HV_POC_1_3PH_START	SW	HV I>1 Start
1340	DDB_T1_POC_1_3PH_START	SW	T1 I>1 Start
1341	DDB_HV_POC_1_PH_A_START	SW	HV I>1 Start A
1341	DDB_T1_POC_1_PH_A_START	SW	T1 I>1 Start A
1342	DDB_HV_POC_1_PH_B_START	SW	HV I>1 Start B
1342	DDB_T1_POC_1_PH_B_START	SW	T1 I>1 Start B
1343	DDB_HV_POC_1_PH_C_START	SW	HV I>1 Start C
1343	DDB_T1_POC_1_PH_C_START	SW	T1 I>1 Start C
1344	DDB_HV_POC_2_3PH_START	SW	HV I>2 Start
1344	DDB_T1_POC_2_3PH_START	SW	T1 I>2 Start
1345	DDB_HV_POC_2_PH_A_START	SW	HV I>2 Start A
1345	DDB_T1_POC_2_PH_A_START	SW	T1 I>2 Start A
1346	DDB_HV_POC_2_PH_B_START	SW	HV I>2 Start B
1346	DDB_T1_POC_2_PH_B_START	SW	T1 I>2 Start B
1347	DDB_HV_POC_2_PH_C_START	SW	HV I>2 Start C
1347	DDB_T1_POC_2_PH_C_START	SW	T1 I>2 Start C
1348	DDB_HV_POC_3_3PH_START	SW	HV I>3 Start
1348	DDB_T2_POC_1_3PH_START	SW	T2 I>1 Start
1349	DDB_HV_POC_3_PH_A_START	SW	HV I>3 Start A
1349	DDB_T2_POC_1_PH_A_START	SW	T2 I>1 Start A
1350	DDB_HV_POC_3_PH_B_START	SW	HV I>3 Start B
1350	DDB_T2_POC_1_PH_B_START	SW	T2 I>1 Start B
1351	DDB_HV_POC_3_PH_C_START	SW	HV I>3 Start C
1351	DDB_T2_POC_1_PH_C_START	SW	T2 I>1 Start C
1352	DDB_HV_POC_4_3PH_START	SW	HV I>4 Start
1352	DDB_T2_POC_2_3PH_START	SW	T2 I>2 Start
1353	DDB_HV_POC_4_PH_A_START	SW	HV I>4 Start A
1353	DDB_T2_POC_2_PH_A_START	SW	T2 I>2 Start A
1354	DDB_HV_POC_4_PH_B_START	SW	HV I>4 Start B
1354	DDB_T2_POC_2_PH_B_START	SW	T2 I>2 Start B
1355	DDB_HV_POC_4_PH_C_START	SW	HV I>4 Start C
1355	DDB_T2_POC_2_PH_C_START	SW	T2 I>2 Start C
1356	DDB_LV_POC_1_3PH_START	SW	LV I>1 Start
1356	DDB_T3_POC_1_3PH_START	SW	T3 I>1 Start
1357	DDB_LV_POC_1_PH_A_START	SW	LV I>1 Start A

DDB	Element Name	Source	Description
1357	DDB_T3_POC_1_PH_A_START	SW	T3 I>1 Start A
1358	DDB_LV_POC_1_PH_B_START	SW	LV I>1 Start B
1358	DDB_T3_POC_1_PH_B_START	SW	T3 I>1 Start B
1359	DDB_LV_POC_1_PH_C_START	SW	LV I>1 Start C
1359	DDB_T3_POC_1_PH_C_START	SW	T3 I>1 Start C
1360	DDB_LV_POC_2_3PH_START	SW	LV I>2 Start
1360	DDB_T3_POC_2_3PH_START	SW	T3 I>2 Start
1361	DDB_LV_POC_2_PH_A_START	SW	LV I>2 Start A
1361	DDB_T3_POC_2_PH_A_START	SW	T3 I>2 Start A
1362	DDB_LV_POC_2_PH_B_START	SW	LV I>2 Start B
1362	DDB_T3_POC_2_PH_B_START	SW	T3 I>2 Start B
1363	DDB_LV_POC_2_PH_C_START	SW	LV I>2 Start C
1363	DDB_T3_POC_2_PH_C_START	SW	T3 I>2 Start C
1364	DDB_LV_POC_3_3PH_START	SW	LV I>3 Start
1364	DDB_T4_POC_1_3PH_START	SW	T4 I>1 Start
1365	DDB_LV_POC_3_PH_A_START	SW	LV I>3 Start A
1365	DDB_T4_POC_1_PH_A_START	SW	T4 I>1 Start A
1366	DDB_LV_POC_3_PH_B_START	SW	LV I>3 Start B
1366	DDB_T4_POC_1_PH_B_START	SW	T4 I>1 Start B
1367	DDB_LV_POC_3_PH_C_START	SW	LV I>3 Start C
1367	DDB_T4_POC_1_PH_C_START	SW	T4 I>1 Start C
1368	DDB_LV_POC_4_3PH_START	SW	LV I>4 Start
1368	DDB_T4_POC_2_3PH_START	SW	T4 I>2 Start
1369	DDB_LV_POC_4_PH_A_START	SW	LV I>4 Start A
1369	DDB_T4_POC_2_PH_A_START	SW	T4 I>2 Start A
1370	DDB_LV_POC_4_PH_B_START	SW	LV I>4 Start B
1370	DDB_T4_POC_2_PH_B_START	SW	T4 I>2 Start B
1371	DDB_LV_POC_4_PH_C_START	SW	LV I>4 Start C
1371	DDB_T4_POC_2_PH_C_START	SW	T4 I>2 Start C
1372	DDB_TV_POC_1_3PH_START	SW	TV I>1 Start
1372	DDB_T5_POC_1_3PH_START	SW	T5 I>1 Start
1373	DDB_TV_POC_1_PH_A_START	SW	TV I>1 Start A
1373	DDB_T5_POC_1_PH_A_START	SW	T5 I>1 Start A
1374	DDB_TV_POC_1_PH_B_START	SW	TV I>1 Start B
1374	DDB_T5_POC_1_PH_B_START	SW	T5 I>1 Start B
1375	DDB_TV_POC_1_PH_C_START	SW	TV I>1 Start C
1375	DDB_T5_POC_1_PH_C_START	SW	T5 I>1 Start C
1376	DDB_TV_POC_2_3PH_START	SW	TV I>2 Start
1376	DDB_T5_POC_2_3PH_START	SW	T5 I>2 Start
1377	DDB_TV_POC_2_PH_A_START	SW	TV I>2 Start A
1377	DDB_T5_POC_2_PH_A_START	SW	T5 I>2 Start A
1378	DDB_TV_POC_2_PH_B_START	SW	TV I>2 Start B
1378	DDB_T5_POC_2_PH_B_START	SW	T5 I>2 Start B
1379	DDB_TV_POC_2_PH_C_START	SW	TV I>2 Start C

DDB	Element Name	Source	Description
1379	DDB_T5_POC_2_PH_C_START	SW	T5 I>2 Start C
1380	DDB_TV_POC_3_3PH_START	SW	TV I>3 Start
1380	DDB_T6_POC_1_3PH_START	SW	T6 I>1 Start
1381	DDB_TV_POC_3_PH_A_START	SW	TV I>3 Start A
1381	DDB_T6_POC_1_PH_A_START	SW	T6 I>1 Start A
1382	DDB_TV_POC_3_PH_B_START	SW	TV I>3 Start B
1382	DDB_T6_POC_1_PH_B_START	SW	T6 I>1 Start B
1383	DDB_TV_POC_3_PH_C_START	SW	TV I>3 Start C
1383	DDB_T6_POC_1_PH_C_START	SW	T6 I>1 Start C
1384	DDB_TV_POC_4_3PH_START	SW	TV I>4 Start
1384	DDB_T6_POC_2_3PH_START	SW	T6 I>2 Start
1385	DDB_TV_POC_4_PH_A_START	SW	TV I>4 Start A
1385	DDB_T6_POC_2_PH_A_START	SW	T6 I>2 Start A
1386	DDB_TV_POC_4_PH_B_START	SW	TV I>4 Start B
1386	DDB_T6_POC_2_PH_B_START	SW	T6 I>2 Start B
1387	DDB_TV_POC_4_PH_C_START	SW	TV I>4 Start C
1387	DDB_T6_POC_2_PH_C_START	SW	T6 I>2 Start C
1388	DDB_T7_POC_1_3PH_START	SW	T7 I>1 Start
1389	DDB_T7_POC_1_PH_A_START	SW	T7 I>1 Start A
1390	DDB_T7_POC_1_PH_B_START	SW	T7 I>1 Start B
1391	DDB_T7_POC_1_PH_C_START	SW	T7 I>1 Start C
1392	DDB_T7_POC_2_3PH_START	SW	T7 I>2 Start
1393	DDB_T7_POC_2_PH_A_START	SW	T7 I>2 Start A
1394	DDB_T7_POC_2_PH_B_START	SW	T7 I>2 Start B
1395	DDB_T7_POC_2_PH_C_START	SW	T7 I>2 Start C
1396	DDB_T8_POC_1_3PH_START	SW	T8 I>1 Start
1397	DDB_T8_POC_1_PH_A_START	SW	T8 I>1 Start A
1398	DDB_T8_POC_1_PH_B_START	SW	T8 I>1 Start B
1399	DDB_T8_POC_1_PH_C_START	SW	T8 I>1 Start C
1400	DDB_T8_POC_2_3PH_START	SW	T8 I>2 Start
1401	DDB_T8_POC_2_PH_A_START	SW	T8 I>2 Start A
1402	DDB_T8_POC_2_PH_B_START	SW	T8 I>2 Start B
1403	DDB_T8_POC_2_PH_C_START	SW	T8 I>2 Start C
1404	DDB_T9_POC_1_3PH_START	SW	T9 I>1 Start
1405	DDB_T9_POC_1_PH_A_START	SW	T9 I>1 Start A
1406	DDB_T9_POC_1_PH_B_START	SW	T9 I>1 Start B
1407	DDB_T9_POC_1_PH_C_START	SW	T9 I>1 Start C
1408	DDB_T9_POC_2_3PH_START	SW	T9 I>2 Start
1409	DDB_T9_POC_2_PH_A_START	SW	T9 I>2 Start A
1410	DDB_T9_POC_2_PH_B_START	SW	T9 I>2 Start B
1411	DDB_T9_POC_2_PH_C_START	SW	T9 I>2 Start C
1412	DDB_T10_POC_1_3PH_START	SW	T10 I>1 Start
1413	DDB_T10_POC_1_PH_A_START	SW	T10 I>1 Start A
1414	DDB_T10_POC_1_PH_B_START	SW	T10 I>1 Start B

DDB	Element Name	Source	Description
1415	DDB_T10_POC_1_PH_C_START	SW	T10 I>1 Start C
1416	DDB_T10_POC_2_3PH_START	SW	T10 I>2 Start
1417	DDB_T10_POC_2_PH_A_START	SW	T10 I>2 Start A
1418	DDB_T10_POC_2_PH_B_START	SW	T10 I>2 Start B
1419	DDB_T10_POC_2_PH_C_START	SW	T10 I>2 Start C
1420	DDB_T11_POC_1_3PH_START	SW	T11 I>1 Start
1421	DDB_T11_POC_1_PH_A_START	SW	T11 I>1 Start A
1422	DDB_T11_POC_1_PH_B_START	SW	T11 I>1 Start B
1423	DDB_T11_POC_1_PH_C_START	SW	T11 I>1 Start C
1424	DDB_T11_POC_2_3PH_START	SW	T11 I>2 Start
1425	DDB_T11_POC_2_PH_A_START	SW	T11 I>2 Start A
1426	DDB_T11_POC_2_PH_B_START	SW	T11 I>2 Start B
1427	DDB_T11_POC_2_PH_C_START	SW	T11 I>2 Start C
1428	DDB_T12_POC_1_3PH_START	SW	T12 I>1 Start
1429	DDB_T12_POC_1_PH_A_START	SW	T12 I>1 Start A
1430	DDB_T12_POC_1_PH_B_START	SW	T12 I>1 Start B
1431	DDB_T12_POC_1_PH_C_START	SW	T12 I>1 Start C
1432	DDB_T12_POC_2_3PH_START	SW	T12 I>2 Start
1433	DDB_T12_POC_2_PH_A_START	SW	T12 I>2 Start A
1434	DDB_T12_POC_2_PH_B_START	SW	T12 I>2 Start B
1435	DDB_T12_POC_2_PH_C_START	SW	T12 I>2 Start C
1436	DDB_T13_POC_1_3PH_START	SW	T13 I>1 Start
1437	DDB_T13_POC_1_PH_A_START	SW	T13 I>1 Start A
1438	DDB_T13_POC_1_PH_B_START	SW	T13 I>1 Start B
1439	DDB_T13_POC_1_PH_C_START	SW	T13 I>1 Start C
1440	DDB_T13_POC_2_3PH_START	SW	T13 I>2 Start
1441	DDB_T13_POC_2_PH_A_START	SW	T13 I>2 Start A
1442	DDB_T13_POC_2_PH_B_START	SW	T13 I>2 Start B
1443	DDB_T13_POC_2_PH_C_START	SW	T13 I>2 Start C
1444	DDB_T14_POC_1_3PH_START	SW	T14 I>1 Start
1445	DDB_T14_POC_1_PH_A_START	SW	T14 I>1 Start A
1446	DDB_T14_POC_1_PH_B_START	SW	T14 I>1 Start B
1447	DDB_T14_POC_1_PH_C_START	SW	T14 I>1 Start C
1448	DDB_T14_POC_2_3PH_START	SW	T14 I>2 Start
1449	DDB_T14_POC_2_PH_A_START	SW	T14 I>2 Start A
1450	DDB_T14_POC_2_PH_B_START	SW	T14 I>2 Start B
1451	DDB_T14_POC_2_PH_C_START	SW	T14 I>2 Start C
1452	DDB_T15_POC_1_3PH_START	SW	T15 I>1 Start
1453	DDB_T15_POC_1_PH_A_START	SW	T15 I>1 Start A
1454	DDB_T15_POC_1_PH_B_START	SW	T15 I>1 Start B
1455	DDB_T15_POC_1_PH_C_START	SW	T15 I>1 Start C
1456	DDB_T15_POC_2_3PH_START	SW	T15 I>2 Start
1457	DDB_T15_POC_2_PH_A_START	SW	T15 I>2 Start A
1458	DDB_T15_POC_2_PH_B_START	SW	T15 I>2 Start B

DDB	Element Name	Source	Description
1459	DDB_T15_POC_2_PH_C_START	SW	T15 I>2 Start C
1460	DDB_T16_POC_1_3PH_START	SW	T16 I>1 Start
1461	DDB_T16_POC_1_PH_A_START	SW	T16 I>1 Start A
1462	DDB_T16_POC_1_PH_B_START	SW	T16 I>1 Start B
1463	DDB_T16_POC_1_PH_C_START	SW	T16 I>1 Start C
1464	DDB_T16_POC_2_3PH_START	SW	T16 I>2 Start
1465	DDB_T16_POC_2_PH_A_START	SW	T16 I>2 Start A
1466	DDB_T16_POC_2_PH_B_START	SW	T16 I>2 Start B
1467	DDB_T16_POC_2_PH_C_START	SW	T16 I>2 Start C
1468	DDB_T17_POC_1_3PH_START	SW	T17 I>1 Start
1469	DDB_T17_POC_1_PH_A_START	SW	T17 I>1 Start A
1470	DDB_T17_POC_1_PH_B_START	SW	T17 I>1 Start B
1471	DDB_T17_POC_1_PH_C_START	SW	T17 I>1 Start C
1472	DDB_T17_POC_2_3PH_START	SW	T17 I>2 Start
1473	DDB_T17_POC_2_PH_A_START	SW	T17 I>2 Start A
1474	DDB_T17_POC_2_PH_B_START	SW	T17 I>2 Start B
1475	DDB_T17_POC_2_PH_C_START	SW	T17 I>2 Start C
1476	DDB_T18_POC_1_3PH_START	SW	T18 I>1 Start
1477	DDB_T18_POC_1_PH_A_START	SW	T18 I>1 Start A
1478	DDB_T18_POC_1_PH_B_START	SW	T18 I>1 Start B
1479	DDB_T18_POC_1_PH_C_START	SW	T18 I>1 Start C
1480	DDB_T18_POC_2_3PH_START	SW	T18 I>2 Start
1481	DDB_T18_POC_2_PH_A_START	SW	T18 I>2 Start A
1482	DDB_T18_POC_2_PH_B_START	SW	T18 I>2 Start B
1483	DDB_T18_POC_2_PH_C_START	SW	T18 I>2 Start C
1484	DDB_INT_CBF_INIT_BUS13_CB	PSL	Internal signal init CBF Bus CB13
1485	DDB_INT_CBF_INIT_BUS23_CB	PSL	Internal signal init CBF Bus CB23
1486	DDB_INT_CBF_INIT_BUS14_CB	PSL	Internal signal init CBF Bus CB14
1487	DDB_INT_CBF_INIT_BUS24_CB	PSL	Internal signal init CBF Bus CB24
1488	DDB_INT_CBF_INIT_BUS34_CB	PSL	Internal signal init CBF Bus CB34
1489	DDB_LV_EF_2_START	SW	LV IN>2 Start
1490	DDB_LV_EF_3_START	SW	LV IN>3 Start
1491	DDB_LV_EF_4_START	SW	LV IN>4 Start
1492	DDB_TV_EF_1_START	SW	TV IN>1 Start
1493	DDB_TV_EF_2_START	SW	TV IN>2 Start
1494	DDB_T7_EF_1_START	SW	T7 IN>1 Start
1495	DDB_T7_EF_2_START	SW	T7 IN>2 Start
1496	DDB_T1_EF_1_START	SW	T1 IN>1 Start
1497	DDB_T1_EF_2_START	SW	T1 IN>2 Start
1498	DDB_T2_EF_1_START	SW	T2 IN>1 Start
1499	DDB_T2_EF_2_START	SW	T2 IN>2 Start
1500	DDB_T3_EF_1_START	SW	T3 IN>1 Start
1501	DDB_T3_EF_2_START	SW	T3 IN>2 Start
1502	DDB_T4_EF_1_START	SW	T4 IN>1 Start

DDB	Element Name	Source	Description
1503	DDB_T4_EF_2_START	SW	T4 IN>2 Start
1504	DDB_T5_EF_1_START	SW	T5 IN>1 Start
1505	DDB_T5_EF_2_START	SW	T5 IN>2 Start
1506	DDB_T6_EF_1_START	SW	T6 IN>1 Start
1507	DDB_T6_EF_2_START	SW	T6 IN>2 Start
1508	DDB_BUS_IDIFF_STARTA_Z3	SW	Idiff Z3 StartA
1509	DDB_BUS_IDIFF_STARTB_Z3	SW	Idiff Z3 StartB
1510	DDB_BUS_IDIFF_STARTC_Z3	SW	Idiff Z3 StartC
1511	DDB_BUS_IDIFF_STARTA_Z4	SW	Idiff Z4 StartA
1512	DDB_BUS_IDIFF_STARTB_Z4	SW	Idiff Z4 StartB
1513	DDB_BUS_IDIFF_STARTC_Z4	SW	Idiff Z4 StartC
1514	DDB_BUS_IDIFF_START_Z3	SW	Z3 Diff Start
1515	DDB_BUS_IDIFF_START_Z4	SW	Z4 Diff Start
1516	DDB_BUS_IDIFF_STARTA_Z1	SW	Idiff Z1 StartA
1517	DDB_BUS_IDIFF_STARTB_Z1	SW	Idiff Z1 StartB
1518	DDB_BUS_IDIFF_STARTC_Z1	SW	Idiff Z1 StartC
1519	DDB_BUS_IDIFF_STARTA_Z2	SW	Idiff Z2 StartA
1520	DDB_BUS_IDIFF_STARTB_Z2	SW	Idiff Z2 StartB
1521	DDB_BUS_IDIFF_STARTC_Z2	SW	Idiff Z2 StartC
1522	DDB_BUS_IDIFF_START_Z1	SW	Z1 Diff Start
1523	DDB_BUS_IDIFF_START_Z2	SW	Z2 Diff Start
1524	DDB_BUS_IDIFF_STARTA_CZ	SW	CZ Phase A Diff Start
1525	DDB_BUS_IDIFF_STARTB_CZ	SW	CZ Phase B Diff Start
1526	DDB_BUS_IDIFF_STARTC_CZ	SW	CZ Phase C Diff Start
1527	DDB_BUS_IDIFF_START_CZ	SW	CZ Diff Start
1528	DDB_VIP_QUALITY_1	SW	GOOSE Virtual input 1 Quality bit
1529	DDB_VIP_QUALITY_2	SW	GOOSE Virtual input 2 Quality bit
1530	DDB_VIP_QUALITY_3	SW	GOOSE Virtual input 3 Quality bit
1531	DDB_VIP_QUALITY_4	SW	GOOSE Virtual input 4 Quality bit
1532	DDB_VIP_QUALITY_5	SW	GOOSE Virtual input 5 Quality bit
1533	DDB_VIP_QUALITY_6	SW	GOOSE Virtual input 6 Quality bit
1534	DDB_VIP_QUALITY_7	SW	GOOSE Virtual input 7 Quality bit
1535	DDB_VIP_QUALITY_8	SW	GOOSE Virtual input 8 Quality bit
1536	DDB_VIP_QUALITY_9	SW	GOOSE Virtual input 9 Quality bit
1537	DDB_VIP_QUALITY_10	SW	GOOSE Virtual input 10 Quality bit
1538	DDB_VIP_QUALITY_11	SW	GOOSE Virtual input 11 Quality bit
1539	DDB_VIP_QUALITY_12	SW	GOOSE Virtual input 12 Quality bit
1540	DDB_VIP_QUALITY_13	SW	GOOSE Virtual input 13 Quality bit
1541	DDB_VIP_QUALITY_14	SW	GOOSE Virtual input 14 Quality bit
1542	DDB_VIP_QUALITY_15	SW	GOOSE Virtual input 15 Quality bit
1543	DDB_VIP_QUALITY_16	SW	GOOSE Virtual input 16 Quality bit
1544	DDB_VIP_QUALITY_17	SW	GOOSE Virtual input 17 Quality bit
1545	DDB_VIP_QUALITY_18	SW	GOOSE Virtual input 18 Quality bit
1546	DDB_VIP_QUALITY_19	SW	GOOSE Virtual input 19 Quality bit

DDB	Element Name	Source	Description
1547	DDB_VIP_QUALITY_20	SW	GOOSE Virtual input 20 Quality bit
1548	DDB_VIP_QUALITY_21	SW	GOOSE Virtual input 21 Quality bit
1549	DDB_VIP_QUALITY_22	SW	GOOSE Virtual input 22 Quality bit
1550	DDB_VIP_QUALITY_23	SW	GOOSE Virtual input 23 Quality bit
1551	DDB_VIP_QUALITY_24	SW	GOOSE Virtual input 24 Quality bit
1552	DDB_VIP_QUALITY_25	SW	GOOSE Virtual input 25 Quality bit
1553	DDB_VIP_QUALITY_26	SW	GOOSE Virtual input 26 Quality bit
1554	DDB_VIP_QUALITY_27	SW	GOOSE Virtual input 27 Quality bit
1555	DDB_VIP_QUALITY_28	SW	GOOSE Virtual input 28 Quality bit
1556	DDB_VIP_QUALITY_29	SW	GOOSE Virtual input 29 Quality bit
1557	DDB_VIP_QUALITY_30	SW	GOOSE Virtual input 30 Quality bit
1558	DDB_VIP_QUALITY_31	SW	GOOSE Virtual input 31 Quality bit
1559	DDB_VIP_QUALITY_32	SW	GOOSE Virtual input 32 Quality bit
1560	DDB_VIP_QUALITY_33	SW	GOOSE Virtual input 33 Quality bit
1561	DDB_VIP_QUALITY_34	SW	GOOSE Virtual input 34 Quality bit
1562	DDB_VIP_QUALITY_35	SW	GOOSE Virtual input 35 Quality bit
1563	DDB_VIP_QUALITY_36	SW	GOOSE Virtual input 36 Quality bit
1564	DDB_VIP_QUALITY_37	SW	GOOSE Virtual input 37 Quality bit
1565	DDB_VIP_QUALITY_38	SW	GOOSE Virtual input 38 Quality bit
1566	DDB_VIP_QUALITY_39	SW	GOOSE Virtual input 39 Quality bit
1567	DDB_VIP_QUALITY_40	SW	GOOSE Virtual input 40 Quality bit
1568	DDB_VIP_QUALITY_41	SW	GOOSE Virtual input 41 Quality bit
1569	DDB_VIP_QUALITY_42	SW	GOOSE Virtual input 42 Quality bit
1570	DDB_VIP_QUALITY_43	SW	GOOSE Virtual input 43 Quality bit
1571	DDB_VIP_QUALITY_44	SW	GOOSE Virtual input 44 Quality bit
1572	DDB_VIP_QUALITY_45	SW	GOOSE Virtual input 45 Quality bit
1573	DDB_VIP_QUALITY_46	SW	GOOSE Virtual input 46 Quality bit
1574	DDB_VIP_QUALITY_47	SW	GOOSE Virtual input 47 Quality bit
1575	DDB_VIP_QUALITY_48	SW	GOOSE Virtual input 48 Quality bit
1576	DDB_VIP_QUALITY_49	SW	GOOSE Virtual input 49 Quality bit
1577	DDB_VIP_QUALITY_50	SW	GOOSE Virtual input 50 Quality bit
1578	DDB_VIP_QUALITY_51	SW	GOOSE Virtual input 51 Quality bit
1579	DDB_VIP_QUALITY_52	SW	GOOSE Virtual input 52 Quality bit
1580	DDB_VIP_QUALITY_53	SW	GOOSE Virtual input 53 Quality bit
1581	DDB_VIP_QUALITY_54	SW	GOOSE Virtual input 54 Quality bit
1582	DDB_VIP_QUALITY_55	SW	GOOSE Virtual input 55 Quality bit
1583	DDB_VIP_QUALITY_56	SW	GOOSE Virtual input 56 Quality bit
1584	DDB_VIP_QUALITY_57	SW	GOOSE Virtual input 57 Quality bit
1585	DDB_VIP_QUALITY_58	SW	GOOSE Virtual input 58 Quality bit
1586	DDB_VIP_QUALITY_59	SW	GOOSE Virtual input 59 Quality bit
1587	DDB_VIP_QUALITY_60	SW	GOOSE Virtual input 60 Quality bit
1588	DDB_VIP_QUALITY_61	SW	GOOSE Virtual input 61 Quality bit
1589	DDB_VIP_QUALITY_62	SW	GOOSE Virtual input 62 Quality bit
1590	DDB_VIP_QUALITY_63	SW	GOOSE Virtual input 63 Quality bit

DDB	Element Name	Source	Description
1591	DDB_VIP_QUALITY_64	SW	GOOSE Virtual input 64 Quality bit
1592	DDB_GOOSEOUT_1	PSL	Virtual Output 01
1593	DDB_GOOSEOUT_2	PSL	Virtual Output 02
1594	DDB_GOOSEOUT_3	PSL	Virtual Output 03
1595	DDB_GOOSEOUT_4	PSL	Virtual Output 04
1596	DDB_GOOSEOUT_5	PSL	Virtual Output 05
1597	DDB_GOOSEOUT_6	PSL	Virtual Output 06
1598	DDB_GOOSEOUT_7	PSL	Virtual Output 07
1599	DDB_GOOSEOUT_8	PSL	Virtual Output 08
1600	DDB_GOOSEOUT_9	PSL	Virtual Output 09
1601	DDB_GOOSEOUT_10	PSL	Virtual Output 10
1602	DDB_GOOSEOUT_11	PSL	Virtual Output 11
1603	DDB_GOOSEOUT_12	PSL	Virtual Output 12
1604	DDB_GOOSEOUT_13	PSL	Virtual Output 13
1605	DDB_GOOSEOUT_14	PSL	Virtual Output 14
1606	DDB_GOOSEOUT_15	PSL	Virtual Output 15
1607	DDB_GOOSEOUT_16	PSL	Virtual Output 16
1608	DDB_GOOSEOUT_17	PSL	Virtual Output 17
1609	DDB_GOOSEOUT_18	PSL	Virtual Output 18
1610	DDB_GOOSEOUT_19	PSL	Virtual Output 19
1611	DDB_GOOSEOUT_20	PSL	Virtual Output 20
1612	DDB_GOOSEOUT_21	PSL	Virtual Output 21
1613	DDB_GOOSEOUT_22	PSL	Virtual Output 22
1614	DDB_GOOSEOUT_23	PSL	Virtual Output 23
1615	DDB_GOOSEOUT_24	PSL	Virtual Output 24
1616	DDB_GOOSEOUT_25	PSL	Virtual Output 25
1617	DDB_GOOSEOUT_26	PSL	Virtual Output 26
1618	DDB_GOOSEOUT_27	PSL	Virtual Output 27
1619	DDB_GOOSEOUT_28	PSL	Virtual Output 28
1620	DDB_GOOSEOUT_29	PSL	Virtual Output 29
1621	DDB_GOOSEOUT_30	PSL	Virtual Output 30
1622	DDB_GOOSEOUT_31	PSL	Virtual Output 31
1623	DDB_GOOSEOUT_32	PSL	Virtual Output 32
1624	DDB_DZ1_OC_PH_A_START	SW	T1 Phase A DeadZone Over Current start
1625	DDB_DZ2_OC_PH_A_START	SW	T2 Phase A DeadZone Over Current start
1626	DDB_DZ3_OC_PH_A_START	SW	T3 Phase A DeadZone Over Current start
1627	DDB_DZ4_OC_PH_A_START	SW	T4 Phase A DeadZone Over Current start
1628	DDB_DZ5_OC_PH_A_START	SW	T5 Phase A DeadZone Over Current start
1629	DDB_DZ6_OC_PH_A_START	SW	T6 Phase A DeadZone Over Current start
1630	DDB_DZ7_OC_PH_A_START	SW	T7 Phase A DeadZone Over Current start
1631	DDB_DZ8_OC_PH_A_START	SW	T8 Phase A DeadZone Over Current start
1632	DDB_DZ9_OC_PH_A_START	SW	T9 Phase A DeadZone Over Current start
1633	DDB_DZ10_OC_PH_A_START	SW	T10 Phase A DeadZone Over Current start
1634	DDB_DZ11_OC_PH_A_START	SW	T11 Phase A DeadZone Over Current start

DDB	Element Name	Source	Description
1635	DDB_DZ12_OC_PH_A_START	SW	T12 Phase A DeadZone Over Current start
1636	DDB_DZ13_OC_PH_A_START	SW	T13 Phase A DeadZone Over Current start
1637	DDB_DZ14_OC_PH_A_START	SW	T14 Phase A DeadZone Over Current start
1638	DDB_DZ15_OC_PH_A_START	SW	T15 Phase A DeadZone Over Current start
1639	DDB_DZ16_OC_PH_A_START	SW	T16 Phase A DeadZone Over Current start
1640	DDB_DZ17_OC_PH_A_START	SW	T17 Phase A DeadZone Over Current start
1641	DDB_DZ18_OC_PH_A_START	SW	T18 Phase A DeadZone Over Current start
1642	DDB_DZ1_OC_PH_B_START	SW	T1 Phase B DeadZone Over Current start
1643	DDB_DZ2_OC_PH_B_START	SW	T2 Phase B DeadZone Over Current start
1644	DDB_DZ3_OC_PH_B_START	SW	T3 Phase B DeadZone Over Current start
1645	DDB_DZ4_OC_PH_B_START	SW	T4 Phase B DeadZone Over Current start
1646	DDB_DZ5_OC_PH_B_START	SW	T5 Phase B DeadZone Over Current start
1647	DDB_DZ6_OC_PH_B_START	SW	T6 Phase B DeadZone Over Current start
1648	DDB_DZ7_OC_PH_B_START	SW	T7 Phase B DeadZone Over Current start
1649	DDB_DZ8_OC_PH_B_START	SW	T8 Phase B DeadZone Over Current start
1650	DDB_DZ9_OC_PH_B_START	SW	T9 Phase B DeadZone Over Current start
1651	DDB_DZ10_OC_PH_B_START	SW	T10 Phase B DeadZone Over Current start
1652	DDB_DZ11_OC_PH_B_START	SW	T11 Phase B DeadZone Over Current start
1653	DDB_DZ12_OC_PH_B_START	SW	T12 Phase B DeadZone Over Current start
1654	DDB_DZ13_OC_PH_B_START	SW	T13 Phase B DeadZone Over Current start
1655	DDB_DZ14_OC_PH_B_START	SW	T14 Phase B DeadZone Over Current start
1656	DDB_DZ15_OC_PH_B_START	SW	T15 Phase B DeadZone Over Current start
1657	DDB_DZ16_OC_PH_B_START	SW	T16 Phase B DeadZone Over Current start
1658	DDB_DZ17_OC_PH_B_START	SW	T17 Phase B DeadZone Over Current start
1659	DDB_DZ18_OC_PH_B_START	SW	T18 Phase B DeadZone Over Current start
1660	DDB_DZ1_OC_PH_C_START	SW	T1 Phase C DeadZone Over Current start
1661	DDB_DZ2_OC_PH_C_START	SW	T2 Phase C DeadZone Over Current start
1662	DDB_DZ3_OC_PH_C_START	SW	T3 Phase C DeadZone Over Current start
1663	DDB_DZ4_OC_PH_C_START	SW	T4 Phase C DeadZone Over Current start
1664	DDB_DZ5_OC_PH_C_START	SW	T5 Phase C DeadZone Over Current start
1665	DDB_DZ6_OC_PH_C_START	SW	T6 Phase C DeadZone Over Current start
1666	DDB_DZ7_OC_PH_C_START	SW	T7 Phase C DeadZone Over Current start
1667	DDB_DZ8_OC_PH_C_START	SW	T8 Phase C DeadZone Over Current start
1668	DDB_DZ9_OC_PH_C_START	SW	T9 Phase C DeadZone Over Current start
1669	DDB_DZ10_OC_PH_C_START	SW	T10 Phase C DeadZone Over Current start
1670	DDB_DZ11_OC_PH_C_START	SW	T11 Phase C DeadZone Over Current start
1671	DDB_DZ12_OC_PH_C_START	SW	T12 Phase C DeadZone Over Current start
1672	DDB_DZ13_OC_PH_C_START	SW	T13 Phase C DeadZone Over Current start
1673	DDB_DZ14_OC_PH_C_START	SW	T14 Phase C DeadZone Over Current start
1674	DDB_DZ15_OC_PH_C_START	SW	T15 Phase C DeadZone Over Current start
1675	DDB_DZ16_OC_PH_C_START	SW	T16 Phase C DeadZone Over Current start
1676	DDB_DZ17_OC_PH_C_START	SW	T17 Phase C DeadZone Over Current start
1677	DDB_DZ18_OC_PH_C_START	SW	T18 Phase C DeadZone Over Current start
1678	DDB_CB1_NOT_READY_IN	FL	CB1 Not Ready

DDB	Element Name	Source	Description
1679	DDB_CB2_NOT_READY_IN	FL	CB2 Not Ready
1680	DDB_CB3_NOT_READY_IN	FL	CB3 Not Ready
1681	DDB_CB4_NOT_READY_IN	FL	CB4 Not Ready
1682	DDB_CB5_NOT_READY_IN	FL	CB5 Not Ready
1683	DDB_CB6_NOT_READY_IN	FL	CB6 Not Ready
1684	DDB_CB7_NOT_READY_IN	FL	CB7 Not Ready
1685	DDB_CB8_NOT_READY_IN	FL	CB8 Not Ready
1686	DDB_CB9_NOT_READY_IN	FL	CB9 Not Ready
1687	DDB_CB10_NOT_READY_IN	FL	CB10 Not Ready
1688	DDB_CB11_NOT_READY_IN	FL	CB11 Not Ready
1689	DDB_CB12_NOT_READY_IN	FL	CB12 Not Ready
1690	DDB_CB13_NOT_READY_IN	FL	CB13 Not Ready
1691	DDB_CB14_NOT_READY_IN	FL	CB14 Not Ready
1692	DDB_CB15_NOT_READY_IN	FL	CB15 Not Ready
1693	DDB_CB16_NOT_READY_IN	FL	CB16 Not Ready
1694	DDB_CB17_NOT_READY_IN	FL	CB17 Not Ready
1695	DDB_CB18_NOT_READY_IN	FL	CB18 Not Ready
1696	DDB_Z1_IN_TEST_MODE	SW	Z1 Test Mode
1697	DDB_Z2_IN_TEST_MODE	SW	Z2 Test Mode
1698	DDB_T1_IN_TEST_MODE	SW	T1 In Test Zone
1699	DDB_T2_IN_TEST_MODE	SW	T2 In Test Zone
1700	DDB_T3_IN_TEST_MODE	SW	T3 In Test Zone
1701	DDB_T4_IN_TEST_MODE	SW	T4 In Test Zone
1702	DDB_T5_IN_TEST_MODE	SW	T5 In Test Zone
1703	DDB_T6_IN_TEST_MODE	SW	T6 In Test Zone
1704	DDB_T7_IN_TEST_MODE	SW	T7 In Test Zone
1705	DDB_T8_IN_TEST_MODE	SW	T8 In Test Zone
1706	DDB_T9_IN_TEST_MODE	SW	T9 In Test Zone
1707	DDB_T10_IN_TEST_MODE	SW	T10 In Test Zone
1708	DDB_T11_IN_TEST_MODE	SW	T11 In Test Zone
1709	DDB_T12_IN_TEST_MODE	SW	T12 In Test Zone
1710	DDB_T13_IN_TEST_MODE	SW	T13 In Test Zone
1711	DDB_T14_IN_TEST_MODE	SW	T14 In Test Zone
1712	DDB_T15_IN_TEST_MODE	SW	T15 In Test Zone
1713	DDB_T16_IN_TEST_MODE	SW	T16 In Test Zone
1714	DDB_T17_IN_TEST_MODE	SW	T17 In Test Zone
1715	DDB_T18_IN_TEST_MODE	SW	T18 In Test Zone
1716	DDB_PHASE_COMP_Z1_BLOCK_A	SW	Z1 Phase A Phase Comparision Block
1717	DDB_PHASE_COMP_Z1_BLOCK_B	SW	Z1 Phase B Phase Comparision Block
1718	DDB_PHASE_COMP_Z1_BLOCK_C	SW	Z1 Phase C Phase Comparision Block
1719	DDB_PHASE_COMP_Z2_BLOCK_A	SW	Z2 Phase A Phase Comparision Block
1720	DDB_PHASE_COMP_Z2_BLOCK_B	SW	Z2 Phase B Phase Comparision Block
1721	DDB_PHASE_COMP_Z2_BLOCK_C	SW	Z2 Phase C Phase Comparision Block
1722	DDB_PHASE_COMP_Z3_BLOCK_A	SW	Z3 Phase A Phase Comparision Block

DDB	Element Name	Source	Description
1723	DDB_PHASE_COMP_Z3_BLOCK_B	SW	Z3 Phase B Phase Comparision Block
1724	DDB_PHASE_COMP_Z3_BLOCK_C	SW	Z3 Phase C Phase Comparision Block
1725	DDB_PHASE_COMP_Z4_BLOCK_A	SW	Z4 Phase A Phase Comparision Block
1726	DDB_PHASE_COMP_Z4_BLOCK_B	SW	Z4 Phase B Phase Comparision Block
1727	DDB_PHASE_COMP_Z4_BLOCK_C	SW	Z4 Phase C Phase Comparision Block
1728	DDB_RTD_1_ALARM	SW	RTD 1 Alarm
1728	DDB_CBF_Z1_BLOCKED	FL	Z1 CBF in Block Status
1729	DDB_RTD_2_ALARM	SW	RTD 2 Alarm
1729	DDB_CBF_Z2_BLOCKED	FL	Z2 CBF in Block Status
1730	DDB_RTD_3_ALARM	SW	RTD 3 Alarm
1730	DDB_DIFF_CZ_C_BLOCKED	SW	CZ Diff Phase C in Block Status
1731	DDB_RTD_4_ALARM	SW	RTD 4 Alarm
1731	DDB_PHASE_COMP_Z1_BLOCK	SW	Z1 Phase comparison block (AND gate of PhaseA,B,C)
1732	DDB_RTD_5_ALARM	SW	RTD 5 Alarm
1732	DDB_PHASE_COMP_Z2_BLOCK	SW	Z2 Phase comparison block (AND gate of PhaseA,B,C)
1733	DDB_PHASE_COMP_Z3_BLOCK	SW	Z3 Phase comparison block (AND gate of PhaseA,B,C)
1734	DDB_PHASE_COMP_Z4_BLOCK	SW	Z4 Phase comparison block (AND gate of PhaseA,B,C)
1735	DDB_DIFF_FAULT_Z3	SW	Z3 Diff has Fault
1736	DDB_DIFF_FAULT_Z3_A	SW	Z3 Diff Phase A has Fault
1737	DDB_DIFF_FAULT_Z3_B	SW	Z3 Diff Phase B has Fault
1738	DDB_DIFF_FAULT_Z3_C	SW	Z3 Diff Phase C has Fault
1739	DDB_DIFF_FAULT_Z4	SW	Z4 Diff has Fault
1740	DDB_DIFF_FAULT_Z4_A	SW	Z4 Diff Phase A has Fault
1741	DDB_DIFF_FAULT_Z4_B	SW	Z4 Diff Phase B has Fault
1742	DDB_DIFF_FAULT_Z4_C	SW	Z4 Diff Phase C has Fault
1743	DDB_DIFF_Z3_BLOCKED	SW	Z3 Diff in Block Status
1744	DDB_DIFF_Z3_A_BLOCKED	SW	Z3 Diff Phase A in Block Status
1745	DDB_DIFF_Z3_B_BLOCKED	SW	Z3 Diff Phase B in Block Status
1746	DDB_DIFF_Z3_C_BLOCKED	SW	Z3 Diff Phase C in Block Status
1747	DDB_DIFF_Z4_BLOCKED	SW	Z4 Diff in Block Status
1748	DDB_DIFF_Z4_A_BLOCKED	SW	Z4 Diff Phase A in Block Status
1749	DDB_DIFF_Z4_B_BLOCKED	SW	Z4 Diff Phase B in Block Status
1750	DDB_DIFF_Z4_C_BLOCKED	SW	Z4 Diff Phase C in Block Status
1751	DDB_FREQ_ABOVE_RANGE_LIMIT	SW	Freq High
1752	DDB_FREQ_BELOW_RANGE_LIMIT	SW	Freq Low
1753	DDB_FREQ_NOT_FOUND	SW	Freq Not Found
1754	DDB_CB1_NOT_READY	PSL	CB1 Healthy
1755	DDB_CB2_NOT_READY	PSL	CB2 Healthy
1756	DDB_CB3_NOT_READY	PSL	CB3 Healthy
1757	DDB_CB4_NOT_READY	PSL	CB4 Healthy
1758	DDB_CB5_NOT_READY	PSL	CB5 Healthy
1759	DDB_CB6_NOT_READY	PSL	CB6 Healthy
1760	DDB_CB7_NOT_READY	PSL	CB7 Healthy
1761	DDB_CB8_NOT_READY	PSL	CB8 Healthy

DDB	Element Name	Source	Description
1762	DDB_CB9_NOT_READY	PSL	CB9 Healthy
1763	DDB_CB10_NOT_READY	PSL	CB10 Healthy
1764	DDB_CB11_NOT_READY	PSL	CB11 Healthy
1765	DDB_CB12_NOT_READY	PSL	CB12 Healthy
1766	DDB_CB13_NOT_READY	PSL	CB13 Healthy
1767	DDB_CB14_NOT_READY	PSL	CB14 Healthy
1768	DDB_CB15_NOT_READY	PSL	CB15 Healthy
1769	DDB_CB16_NOT_READY	PSL	CB16 Healthy
1770	DDB_CB17_NOT_READY	PSL	CB17 Healthy
1771	DDB_CB18_NOT_READY	PSL	CB18 Healthy
1772	DDB_CB19_NOT_READY	PSL	CB19 Healthy
1772	DDB_ALL_POLEDEAD	SW	All Poles Dead
1773	DDB_CB20_NOT_READY	PSL	CB20 Healthy
1773	DDB_ANY_POLEDEAD	SW	Any Pole Dead
1774	DDB_CB21_NOT_READY	PSL	CB21 Healthy
1774	DDB_PHASE_A_POLEDEAD	SW	Pole Dead A
1775	DDB_CB19_NOT_READY_IN	FL	CB19 Not Ready
1775	DDB_PHASE_B_POLEDEAD	SW	Pole Dead B
1776	DDB_CB20_NOT_READY_IN	FL	CB20 Not Ready
1776	DDB_PHASE_C_POLEDEAD	SW	Pole Dead C
1777	DDB_CB21_NOT_READY_IN	FL	CB21 Not Ready
1777	DDB_THROUGH_FAULT_OC_START	SW	Through fault START
1778	DDB_THROUGH_FAULT_OC_RESET	SW	Through fault OC END
1779	DDB_THROUGH_FAULT_RECORDER	SW	Through fault TRIGGER
1780	DDB_DZ19_OC_PH_A_START	SW	T19 Phase A DeadZone Over Current start
1781	DDB_DZ19_OC_PH_B_START	SW	T19 Phase B DeadZone Over Current start
1782	DDB_DZ19_OC_PH_C_START	SW	T19 Phase C DeadZone Over Current start
1783	DDB_DZ20_OC_PH_A_START	SW	T20 Phase A DeadZone Over Current start
1784	DDB_DZ20_OC_PH_B_START	SW	T20 Phase B DeadZone Over Current start
1785	DDB_DZ20_OC_PH_C_START	SW	T20 Phase C DeadZone Over Current start
1786	DDB_DZ21_OC_PH_A_START	SW	T21 Phase A DeadZone Over Current start
1787	DDB_DZ21_OC_PH_B_START	SW	T21 Phase B DeadZone Over Current start
1788	DDB_DZ21_OC_PH_C_START	SW	T21 Phase C DeadZone Over Current start
1789	DDB_Z3_IN_TEST_MODE	SW	Z3 Test Mode
1790	DDB_Z4_IN_TEST_MODE	SW	Z4 Test Mode
1791	DDB_T19_IN_TEST_MODE	SW	T19 In Test Zone
1792	DDB_T20_IN_TEST_MODE	SW	T20 In Test Zone
1793	DDB_T21_IN_TEST_MODE	SW	T21 In Test Zone
1796	DDB_CBF_Z3_BLOCKED	FL	Z3 CBF in Block Status
1797	DDB_NIC_LINK_1_FAIL	SW	Network Interface Card link 1 fail indication
1798	DDB_NIC_LINK_2_FAIL	SW	Network Interface Card link 2 fail indication
1799	DDB_NIC_LINK_3_FAIL	SW	Network Interface Card link 3 fail indication
1800	DDB_DIFF_FAULT_Z1	SW	Z1 Diff has Fault
1800	DDB_VTS_FAST_BLOCK	SW	VTS Fast Block

DDB	Element Name	Source	Description
1801	DDB_DIFF_FAULT_Z1_A	SW	Z1 Diff Phase A has Fault
1801	DDB_VTS_SLOW_BLOCK	SW	VTS Slow Block
1802	DDB_DIFF_FAULT_Z1_B	SW	Z1 Diff Phase B has Fault
1803	DDB_DIFF_FAULT_Z1_C	SW	Z1 Diff Phase C has Fault
1804	DDB_DIFF_FAULT_Z2	SW	Z2 Diff has Fault
1805	DDB_DIFF_FAULT_Z2_A	SW	Z2 Diff Phase A has Fault
1806	DDB_DIFF_FAULT_Z2_B	SW	Z2 Diff Phase B has Fault
1807	DDB_DIFF_FAULT_Z2_C	SW	Z2 Diff Phase C has Fault
1808	DDB_DIFF_FAULT_CZ	SW	CZ Diff has Fault
1809	DDB_DIFF_FAULT_CZ_A	SW	CZ Diff Phase A has Fault
1810	DDB_DIFF_FAULT_CZ_B	SW	CZ Diff Phase B has Fault
1811	DDB_DIFF_FAULT_CZ_C	SW	CZ Diff Phase C has Fault
1812	DDB_DIFF_Z1_BLOCKED	SW	Z1 Diff in Block Status
1813	DDB_DIFF_Z1_A_BLOCKED	SW	Z1 Diff Phase A in Block Status
1814	DDB_DIFF_Z1_B_BLOCKED	SW	Z1 Diff Phase B in Block Status
1815	DDB_DIFF_Z1_C_BLOCKED	SW	Z1 Diff Phase C in Block Status
1816	DDB_DIFF_Z2_BLOCKED	SW	Z2 Diff in Block Status
1817	DDB_DIFF_Z2_A_BLOCKED	SW	Z2 Diff Phase A in Block Status
1818	DDB_DIFF_Z2_B_BLOCKED	SW	Z2 Diff Phase B in Block Status
1819	DDB_DIFF_Z2_C_BLOCKED	SW	Z2 Diff Phase C in Block Status
1820	DDB_DIFF_CZ_BLOCKED	SW	CZ Diff in Block Status
1821	DDB_DIFF_CZ_A_BLOCKED	SW	CZ Diff Phase A in Block Status
1822	DDB_DIFF_CZ_B_BLOCKED	SW	CZ Diff Phase B in Block Status
1823	DDB_CBF_Z4_BLOCKED	FL	Z4 CBF in Block Status
1824	DDB_CONTROL_1	SW	Control Input 1
1825	DDB_CONTROL_2	SW	Control Input 2
1826	DDB_CONTROL_3	SW	Control Input 3
1827	DDB_CONTROL_4	SW	Control Input 4
1828	DDB_CONTROL_5	SW	Control Input 5
1829	DDB_CONTROL_6	SW	Control Input 6
1830	DDB_CONTROL_7	SW	Control Input 7
1831	DDB_CONTROL_8	SW	Control Input 8
1832	DDB_CONTROL_9	SW	Control Input 9
1833	DDB_CONTROL_10	SW	Control Input 10
1834	DDB_CONTROL_11	SW	Control Input 11
1835	DDB_CONTROL_12	SW	Control Input 12
1836	DDB_CONTROL_13	SW	Control Input 13
1837	DDB_CONTROL_14	SW	Control Input 14
1838	DDB_CONTROL_15	SW	Control Input 15
1839	DDB_CONTROL_16	SW	Control Input 16
1840	DDB_CONTROL_17	SW	Control Input 17
1841	DDB_CONTROL_18	SW	Control Input 18
1842	DDB_CONTROL_19	SW	Control Input 19
1843	DDB_CONTROL_20	SW	Control Input 20

DDB	Element Name	Source	Description
1844	DDB_CONTROL_21	SW	Control Input 21
1845	DDB_CONTROL_22	SW	Control Input 22
1846	DDB_CONTROL_23	SW	Control Input 23
1847	DDB_CONTROL_24	SW	Control Input 24
1848	DDB_CONTROL_25	SW	Control Input 25
1849	DDB_CONTROL_26	SW	Control Input 26
1850	DDB_CONTROL_27	SW	Control Input 27
1851	DDB_CONTROL_28	SW	Control Input 28
1852	DDB_CONTROL_29	SW	Control Input 29
1853	DDB_CONTROL_30	SW	Control Input 30
1854	DDB_CONTROL_31	SW	Control Input 31
1855	DDB_CONTROL_32	SW	Control Input 32
1856	DDB_GOOSEIN_1	SW	Virtual Input 01
1857	DDB_GOOSEIN_2	SW	Virtual Input 02
1858	DDB_GOOSEIN_3	SW	Virtual Input 03
1859	DDB_GOOSEIN_4	SW	Virtual Input 04
1860	DDB_GOOSEIN_5	SW	Virtual Input 05
1861	DDB_GOOSEIN_6	SW	Virtual Input 06
1862	DDB_GOOSEIN_7	SW	Virtual Input 07
1863	DDB_GOOSEIN_8	SW	Virtual Input 08
1864	DDB_GOOSEIN_9	SW	Virtual Input 09
1865	DDB_GOOSEIN_10	SW	Virtual Input 10
1866	DDB_GOOSEIN_11	SW	Virtual Input 11
1867	DDB_GOOSEIN_12	SW	Virtual Input 12
1868	DDB_GOOSEIN_13	SW	Virtual Input 13
1869	DDB_GOOSEIN_14	SW	Virtual Input 14
1870	DDB_GOOSEIN_15	SW	Virtual Input 15
1871	DDB_GOOSEIN_16	SW	Virtual Input 16
1872	DDB_GOOSEIN_17	SW	Virtual Input 17
1873	DDB_GOOSEIN_18	SW	Virtual Input 18
1874	DDB_GOOSEIN_19	SW	Virtual Input 19
1875	DDB_GOOSEIN_20	SW	Virtual Input 20
1876	DDB_GOOSEIN_21	SW	Virtual Input 21
1877	DDB_GOOSEIN_22	SW	Virtual Input 22
1878	DDB_GOOSEIN_23	SW	Virtual Input 23
1879	DDB_GOOSEIN_24	SW	Virtual Input 24
1880	DDB_GOOSEIN_25	SW	Virtual Input 25
1881	DDB_GOOSEIN_26	SW	Virtual Input 26
1882	DDB_GOOSEIN_27	SW	Virtual Input 27
1883	DDB_GOOSEIN_28	SW	Virtual Input 28
1884	DDB_GOOSEIN_29	SW	Virtual Input 29
1885	DDB_GOOSEIN_30	SW	Virtual Input 30
1886	DDB_GOOSEIN_31	SW	Virtual Input 31
1887	DDB_GOOSEIN_32	SW	Virtual Input 32

DDB	Element Name	Source	Description
1888	DDB_GOOSEIN_33	SW	Virtual Intput 33
1889	DDB_GOOSEIN_34	SW	Virtual Intput 34
1890	DDB_GOOSEIN_35	SW	Virtual Intput 35
1891	DDB_GOOSEIN_36	SW	Virtual Intput 36
1892	DDB_GOOSEIN_37	SW	Virtual Intput 37
1893	DDB_GOOSEIN_38	SW	Virtual Intput 38
1894	DDB_GOOSEIN_39	SW	Virtual Intput 39
1895	DDB_GOOSEIN_40	SW	Virtual Intput 40
1896	DDB_GOOSEIN_41	SW	Virtual Intput 41
1897	DDB_GOOSEIN_42	SW	Virtual Intput 42
1898	DDB_GOOSEIN_43	SW	Virtual Intput 43
1899	DDB_GOOSEIN_44	SW	Virtual Intput 44
1900	DDB_GOOSEIN_45	SW	Virtual Intput 45
1901	DDB_GOOSEIN_46	SW	Virtual Intput 46
1902	DDB_GOOSEIN_47	SW	Virtual Intput 47
1903	DDB_GOOSEIN_48	SW	Virtual Intput 48
1904	DDB_GOOSEIN_49	SW	Virtual Intput 49
1905	DDB_GOOSEIN_50	SW	Virtual Intput 50
1906	DDB_GOOSEIN_51	SW	Virtual Intput 51
1907	DDB_GOOSEIN_52	SW	Virtual Intput 52
1908	DDB_GOOSEIN_53	SW	Virtual Intput 53
1909	DDB_GOOSEIN_54	SW	Virtual Intput 54
1910	DDB_GOOSEIN_55	SW	Virtual Intput 55
1911	DDB_GOOSEIN_56	SW	Virtual Intput 56
1912	DDB_GOOSEIN_57	SW	Virtual Intput 57
1913	DDB_GOOSEIN_58	SW	Virtual Intput 58
1914	DDB_GOOSEIN_59	SW	Virtual Intput 59
1915	DDB_GOOSEIN_60	SW	Virtual Intput 60
1916	DDB_GOOSEIN_61	SW	Virtual Intput 61
1917	DDB_GOOSEIN_62	SW	Virtual Intput 62
1918	DDB_GOOSEIN_63	SW	Virtual Intput 63
1919	DDB_GOOSEIN_64	SW	Virtual Intput 64
1920	DDB_PSLINT_1	PSL	PSL Internal connection
1921	DDB_PSLINT_2	PSL	PSL Internal connection
1922	DDB_PSLINT_3	PSL	PSL Internal connection
1923	DDB_PSLINT_4	PSL	PSL Internal connection
1924	DDB_PSLINT_5	PSL	PSL Internal connection
1925	DDB_PSLINT_6	PSL	PSL Internal connection
1926	DDB_PSLINT_7	PSL	PSL Internal connection
1927	DDB_PSLINT_8	PSL	PSL Internal connection
1928	DDB_PSLINT_9	PSL	PSL Internal connection
1929	DDB_PSLINT_10	PSL	PSL Internal connection
1930	DDB_PSLINT_11	PSL	PSL Internal connection
1931	DDB_PSLINT_12	PSL	PSL Internal connection

DDB	Element Name	Source	Description
1932	DDB_PSLINT_13	PSL	PSL Internal connection
1933	DDB_PSLINT_14	PSL	PSL Internal connection
1934	DDB_PSLINT_15	PSL	PSL Internal connection
1935	DDB_PSLINT_16	PSL	PSL Internal connection
1936	DDB_PSLINT_17	PSL	PSL Internal connection
1937	DDB_PSLINT_18	PSL	PSL Internal connection
1938	DDB_PSLINT_19	PSL	PSL Internal connection
1939	DDB_PSLINT_20	PSL	PSL Internal connection
1940	DDB_PSLINT_21	PSL	PSL Internal connection
1941	DDB_PSLINT_22	PSL	PSL Internal connection
1942	DDB_PSLINT_23	PSL	PSL Internal connection
1943	DDB_PSLINT_24	PSL	PSL Internal connection
1944	DDB_PSLINT_25	PSL	PSL Internal connection
1945	DDB_PSLINT_26	PSL	PSL Internal connection
1946	DDB_PSLINT_27	PSL	PSL Internal connection
1947	DDB_PSLINT_28	PSL	PSL Internal connection
1948	DDB_PSLINT_29	PSL	PSL Internal connection
1949	DDB_PSLINT_30	PSL	PSL Internal connection
1950	DDB_PSLINT_31	PSL	PSL Internal connection
1951	DDB_PSLINT_32	PSL	PSL Internal connection
1952	DDB_PSLINT_33	PSL	PSL Internal connection
1953	DDB_PSLINT_34	PSL	PSL Internal connection
1954	DDB_PSLINT_35	PSL	PSL Internal connection
1955	DDB_PSLINT_36	PSL	PSL Internal connection
1956	DDB_PSLINT_37	PSL	PSL Internal connection
1957	DDB_PSLINT_38	PSL	PSL Internal connection
1958	DDB_PSLINT_39	PSL	PSL Internal connection
1959	DDB_PSLINT_40	PSL	PSL Internal connection
1960	DDB_PSLINT_41	PSL	PSL Internal connection
1961	DDB_PSLINT_42	PSL	PSL Internal connection
1962	DDB_PSLINT_43	PSL	PSL Internal connection
1963	DDB_PSLINT_44	PSL	PSL Internal connection
1964	DDB_PSLINT_45	PSL	PSL Internal connection
1965	DDB_PSLINT_46	PSL	PSL Internal connection
1966	DDB_PSLINT_47	PSL	PSL Internal connection
1967	DDB_PSLINT_48	PSL	PSL Internal connection
1968	DDB_PSLINT_49	PSL	PSL Internal connection
1969	DDB_PSLINT_50	PSL	PSL Internal connection
1970	DDB_PSLINT_51	PSL	PSL Internal connection
1971	DDB_PSLINT_52	PSL	PSL Internal connection
1972	DDB_PSLINT_53	PSL	PSL Internal connection
1973	DDB_PSLINT_54	PSL	PSL Internal connection
1974	DDB_PSLINT_55	PSL	PSL Internal connection
1975	DDB_PSLINT_56	PSL	PSL Internal connection

DDB	Element Name	Source	Description
1976	DDB_PSLINT_57	PSL	PSL Internal connection
1977	DDB_PSLINT_58	PSL	PSL Internal connection
1978	DDB_PSLINT_59	PSL	PSL Internal connection
1979	DDB_PSLINT_60	PSL	PSL Internal connection
1980	DDB_PSLINT_61	PSL	PSL Internal connection
1981	DDB_PSLINT_62	PSL	PSL Internal connection
1982	DDB_PSLINT_63	PSL	PSL Internal connection
1983	DDB_PSLINT_64	PSL	PSL Internal connection
1984	DDB_PSLINT_65	PSL	PSL Internal connection
1985	DDB_PSLINT_66	PSL	PSL Internal connection
1986	DDB_PSLINT_67	PSL	PSL Internal connection
1987	DDB_PSLINT_68	PSL	PSL Internal connection
1988	DDB_PSLINT_69	PSL	PSL Internal connection
1989	DDB_PSLINT_70	PSL	PSL Internal connection
1990	DDB_PSLINT_71	PSL	PSL Internal connection
1991	DDB_PSLINT_72	PSL	PSL Internal connection
1992	DDB_PSLINT_73	PSL	PSL Internal connection
1993	DDB_PSLINT_74	PSL	PSL Internal connection
1994	DDB_PSLINT_75	PSL	PSL Internal connection
1995	DDB_PSLINT_76	PSL	PSL Internal connection
1996	DDB_PSLINT_77	PSL	PSL Internal connection
1997	DDB_PSLINT_78	PSL	PSL Internal connection
1998	DDB_PSLINT_79	PSL	PSL Internal connection
1999	DDB_PSLINT_80	PSL	PSL Internal connection
2000	DDB_PSLINT_81	PSL	PSL Internal connection
2001	DDB_PSLINT_82	PSL	PSL Internal connection
2002	DDB_PSLINT_83	PSL	PSL Internal connection
2003	DDB_PSLINT_84	PSL	PSL Internal connection
2004	DDB_PSLINT_85	PSL	PSL Internal connection
2005	DDB_PSLINT_86	PSL	PSL Internal connection
2006	DDB_PSLINT_87	PSL	PSL Internal connection
2007	DDB_PSLINT_88	PSL	PSL Internal connection
2008	DDB_PSLINT_89	PSL	PSL Internal connection
2009	DDB_PSLINT_90	PSL	PSL Internal connection
2010	DDB_PSLINT_91	PSL	PSL Internal connection
2011	DDB_PSLINT_92	PSL	PSL Internal connection
2012	DDB_PSLINT_93	PSL	PSL Internal connection
2013	DDB_PSLINT_94	PSL	PSL Internal connection
2014	DDB_PSLINT_95	PSL	PSL Internal connection
2015	DDB_PSLINT_96	PSL	PSL Internal connection
2016	DDB_PSLINT_97	PSL	PSL Internal connection
2017	DDB_PSLINT_98	PSL	PSL Internal connection
2018	DDB_PSLINT_99	PSL	PSL Internal connection
2019	DDB_PSLINT_100	PSL	PSL Internal connection

DDB	Element Name	Source	Description
2020	DDB_PSLINT_101	PSL	PSL Internal connection
2021	DDB_PSLINT_102	PSL	PSL Internal connection
2022	DDB_PSLINT_103	PSL	PSL Internal connection
2023	DDB_PSLINT_104	PSL	PSL Internal connection
2024	DDB_PSLINT_105	PSL	PSL Internal connection
2025	DDB_PSLINT_106	PSL	PSL Internal connection
2026	DDB_PSLINT_107	PSL	PSL Internal connection
2027	DDB_PSLINT_108	PSL	PSL Internal connection
2028	DDB_PSLINT_109	PSL	PSL Internal connection
2029	DDB_PSLINT_110	PSL	PSL Internal connection
2030	DDB_PSLINT_111	PSL	PSL Internal connection
2031	DDB_PSLINT_112	PSL	PSL Internal connection
2032	DDB_PSLINT_113	PSL	PSL Internal connection
2033	DDB_PSLINT_114	PSL	PSL Internal connection
2034	DDB_PSLINT_115	PSL	PSL Internal connection
2035	DDB_PSLINT_116	PSL	PSL Internal connection
2036	DDB_PSLINT_117	PSL	PSL Internal connection
2037	DDB_PSLINT_118	PSL	PSL Internal connection
2038	DDB_PSLINT_119	PSL	PSL Internal connection
2039	DDB_PSLINT_120	PSL	PSL Internal connection
2040	DDB_PSLINT_121	PSL	PSL Internal connection
2041	DDB_PSLINT_122	PSL	PSL Internal connection
2042	DDB_PSLINT_123	PSL	PSL Internal connection
2043	DDB_PSLINT_124	PSL	PSL Internal connection
2044	DDB_PSLINT_125	PSL	PSL Internal connection
2045	DDB_PSLINT_126	PSL	PSL Internal connection
2046	DDB_PSLINT_127	PSL	PSL Internal connection
2047	DDB_PSLINT_128	PSL	PSL Internal connection

Table 1 - P746 DDB Numbers (sorted by DDB Number)

3 FACTORY DEFAULT PROGRAMMABLE SCHEME LOGIC

This table details the default settings of the PSL. The P746 models are as follows:

Model	Logic Inputs	Relay Outputs		
		Total	Relays	High Break Relays
P746xxxA	16	16	16	--
P746xxxB	16	16	8	8
P746xxxC	16	32	32	--
P746xxxD	16	28	24	4
P746xxxE	24	24	24	--
P746xxxF	24	24	16	8
P746xxxG	24	20	8	12
P746xxxH	32	24	24	--
P746xxxJ	32	24	16	8
P746xxxK	40	24	24	--
P746xxxL	32	32	32	--

Table 2 - Factory Default Logic Inputs and Relay Outputs

4 LOGIC INPUT MAPPING

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

Opto-Input No	P746 Relay Text	Function	Opto-Input No	P746 Relay Text	Function
1	Input L1	CB1 Closed	21	Input L21	Not mapped
2	Input L2	CB2 Closed	22	Input L22	Not mapped
3	Input L3	CB3 Closed	23	Input L23	Not mapped
4	Input L4	CB4 Closed	24	Input L24	Not mapped
5	Input L5	CB5 Closed	25	Input L25	Not mapped
6	Input L6	BB12 CB Closed	26	Input L26	Not mapped
7	Input L7	Q1 BB1 Closed	27	Input L27	Not mapped
8	Input L8	Q2 BB1 Closed	28	Input L28	Not mapped
9	Input L9	Q3 BB2 Closed	29	Input L29	Not mapped
10	Input L10	Q4 BB2 Closed	30	Input L30	Not mapped
11	Input L11	Q5 BB1 Closed	31	Input L31	Not mapped
12	Input L12	Q5 BB2 Closed	32	Input L32	Not mapped
13	Input L13	QBB12 BB1 Closed	33	Input L33	Not mapped
14	Input L14	QBB12 BB2 Closed	34	Input L34	Not mapped
15	Input L15	Block CZ	35	Input L35	Not mapped
16	Input L16	CB6 Closed (P746_2)	36	Input L36	Not mapped
17	Input L17	Not mapped	37	Input L37	Not mapped
18	Input L18	Not mapped	38	Input L38	Not mapped
19	Input L19	Not mapped	39	Input L39	Not mapped
20	Input L20	Not mapped	40	Input L40	Not mapped

Table 3 - Logic Input Mapping

5 RELAY OUTPUT CONTACT MAPPING

The default mappings for each of the relay output contacts are as shown in this table:

Relay Contact No	P746 Relay Text	P746 Relay Conditioner	Function
1	Relay R1	Dwell 200/0	Trip CB1
2	Relay R2	Dwell 200/0	Trip CB2
3	Relay R3	Dwell 200/0	Trip CB3
4	Relay R4	Dwell 200/0	Trip CB4
5	Relay R5	Dwell 200/0	Trip CB5
6	Relay R6	Dwell 200/0	Trip BB12 CB
7	Relay R7	Pick-up 0/0	Circuitry fault
8	Relay R8	Pick-up 0/0	Fault Zone 1
9	Relay R9	Pick-up 0/0	Fault Zone 2
10	Relay R10	Pick-up 0/0	CBF trip
11	Relay R11	Pick-up 0/0	87BB Trip
12	Relay R12	Pick-up 0/0	Fault Ph A
13	Relay R13	Pick-up 0/0	Fault Ph B
14	Relay R14	Pick-up 0/0	Fault Ph C
15	Relay R15	Pick-up 0/0	Maintenance
16(P746_1)	Relay R16	Pick-up 0/0	CB Alarm
16(P746_2)	Relay R16	Dwell 200/0	Trip CB6
17	Relay R17		Not mapped
18	Relay R18		Not mapped
19	Relay R19		Not mapped
20	Relay R20		Not mapped
21	Relay R21		Not mapped
22	Relay R22		Not mapped
23	Relay R23		Not mapped
24	Relay R24		Not mapped
25	Relay R25		Not mapped
26	Relay R26		Not mapped
27	Relay R27		Not mapped
28	Relay R28		Not mapped
29	Relay R29		Not mapped
30	Relay R30		Not mapped
31	Relay R31		Not mapped
32	Relay R32		Not mapped

Table 4 - Relay output contact mapping

Caution ***A fault record can be generated by connecting one or a number of contacts to the "Fault Record Trigger" in PSL. It is recommended that the triggering contact be 'self reset' and not a latching. If a latching contact were chosen the fault record would not be generated until the contact had fully reset.***

6 FUNCTION KEY INPUT MAPPING

The default mappings for each of the function key inputs are as shown in this table:

LED Number	Text	Setting	Function
1	Function Key 1	Normal	
2	Function Key 2	Toggled	Set zone 1 in test mode
3	Function Key 3	Normal	
4	Function Key 4	Normal	
5	Function Key 5	Normal	
6	Function Key 6	Normal	
7	Function Key 7	Toggled	Set zone 2 in test mode
8	Function Key 8	Normal	Reset Circuitry fault
9	Function Key 9	Normal	Reset Indications
10	Function Key 10	Normal	Start DR, trigger a fault record

Table 5 - Function key input mapping

7 PROGRAMMABLE LED OUTPUT MAPPING

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

LED No	LED Input Connection/Text	Latched	P746 LED Function Indication
1	LED1 Red LED1 Yellow LED1 Green	No	CB1 closed CB1 Alarm CB1 open
2	LED2 Red LED2 Yellow LED2 Green	No	CB2 closed CB2 Alarm CB2 open
3	LED3 Red LED3 Yellow LED3 Green	No	CB3 closed CB3 alarm CB3 open
4	LED4 Red LED4 Yellow LED4 Green	No	CB4 closed CB4 Alarm CB4 open
5	LED5 Red LED5 Yellow LED5 Green	No	CB5 closed CB5 Alarm CB5 open
6	LED6 Red LED6 Yellow LED6 Green	No	BB12 CB closed BB12 CB Alarm BB12 CB open
7	LED7 Red LED7 Yellow LED7 Green	No	50BF Trip zone 1 87BB & 50 BF trip zone 1 87BB Trip zone 1
8	LED8 Red LED8 Yellow LED8 Green	No	50BF Trip zone 2 87BB & 50 BF trip zone 2 87BB Trip zone 2
9	FnKey LED1 Red FnKey LED1 Yellow FnKey LED1 Green	No	Zone 1: blocked Zone 1: alarm (CZ blocked but not the Zone1) Zone 1: healthy
10	FnKey LED2 Red FnKey LED2 Yellow FnKey LED2 Green	No	CZ blocked Zone 1: Test Mode Zone 1: healthy
11	FnKey LED3 Red FnKey LED3 Yellow FnKey LED3 Green	No	Fault on phase A Not used Not used
12	FnKey LED4 Red FnKey LED4 Yellow FnKey LED4 Green	No	Fault on phase B Not used Not used
13	FnKey LED5 Red FnKey LED5 Yellow FnKey LED5 Green	No	Fault on phase C Not used Not used
14	FnKey LED6 Red FnKey LED6 Yellow FnKey LED6 Green	No	Zone 2: blocked Zone 2: alarm (CZ blocked but not the Zone2) Zone 2: healthy
15	FnKey LED7 Red FnKey LED7 Yellow FnKey LED7 Green	No	CZ blocked Zone 2: Test Mode Zone 2: healthy
16	FnKey LED8 Red FnKey LED8 Yellow FnKey LED8 Green	No	Circuit fault blocked Z1 & Z2 AND CZ alarm Circuit fault Alarm Z1 & Z2 Healthy

LED No	LED Input Connection/Text	Latched	P746 LED Function Indication	
17	FnKey LED9 Red FnKey LED9 Yellow FnKey LED9 Green	No	Applies to P746_1 Not used Not used Indications resetting	Applies to P746_2 CB6 closed CB6 Alarm CB6 open
18	FnKey LED10 Red FnKey LED10 Yellow FnKey LED10 Green	No	Not used Any start or Any trip Trigger Disturbance record & fault record manually	

Table 6 - Programmable LED Input Mapping

8 FAULT RECORDER START MAPPING

8.1 Fault Recorder Start Mapping

The default mapping for the signal which initiates a fault record is as shown in this table:

Initiating Signal	Fault Trigger
Any Trip	Initiate fault recording from any trip
Any Start	Initiate fault recording from any start
Function Key 10	Initiate fault recording Manually

Table 7 - Fault recorder start mapping

8.2 PSL DATA Column

The MiCOM P746 relay contains a PSL DATA column that can be used to track PSL modifications. A total of 12 cells are contained in the PSL DATA column, 3 for each setting group. The function for each cell is shown below:

The relay contains a PSL DATA column that can be used to track PSL modifications. A total of 12 cells are contained in the PSL DATA column, 3 for each setting group. The function for each cell is shown below:

Grp PSL Ref	When downloading a PSL to the relay, the user will be prompted to enter which groups the PSL is for and a reference ID. The first 32 characters of the reference ID will be displayed in this cell. The ◄ and ► keys can be used to scroll through 32 characters as only 16 can be displayed at any one time.
18 Nov 2002 08:59:32.047	This cell displays the date and time when the PSL was down loaded to the relay.
Grp 1 PSL ID - 2062813232	This is a unique number for the PSL that has been entered. Any change in the PSL will result in a different number being displayed.

Note *The above cells are repeated for each setting group.*

Table 8 - PSL Data column

9 VIEWING AND PRINTING DEFAULT PSL DIAGRAMS

9.1 Typical Mappings

It is possible to view and print the default PSL diagrams for the device. Typically, these diagrams allow you to see these mappings:

- Opto Input Mappings
- Output Relay Mappings
- LED Mappings
- Start Indications
- Phase Trip Mappings
- System Check Mapping

Important	***The following PSL diagrams show the DDB numbers for a specific MiCOM product, with a specific software version to run on a specific hardware platform. Descriptions, DDB Numbers, Inputs and Outputs may vary for different products, software or hardware.***

9.2 Download and Print PSL Diagrams

To download and print the default PSL diagrams for the device:

1. Close MiCOM S1 Studio.
2. Select **Programs** > then navigate through to > **MiCOM S1 Studio** > **Data Model Manager**.
3. Click **Add** then **Next**.
4. Click **Internet** then **Next**.
5. Select your language then click **Next**.
6. From the tree view, select the model and software version.
7. Click **Install**. When complete click **OK**.
8. Close the Data Model Manager and start MiCOM S1 Studio.
9. Select Tools > PSL Editor (Px40).
10. In the PSL Editor select **File** > **Open**. The downloaded PSL files are in C:\Program Files\ directory located in the \MiCOM S1\Courier\PSL\Defaults sub-directory.
11. Highlight the required PSL diagram and select **File** > **Print**.

10 P746_1 PROGRAMMABLE SCHEME LOGIC (PSL)

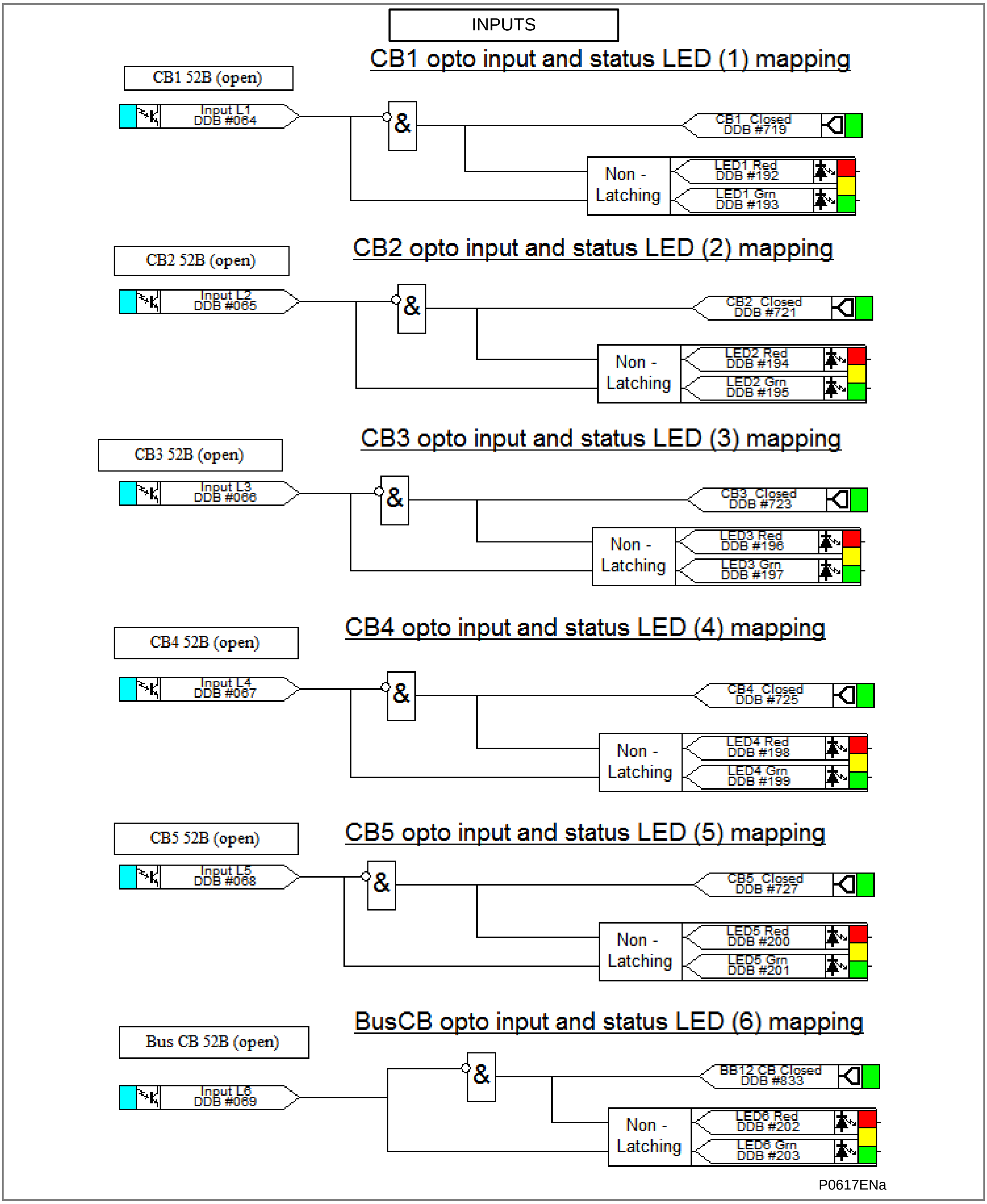


Figure 1 - P746_1 Inputs

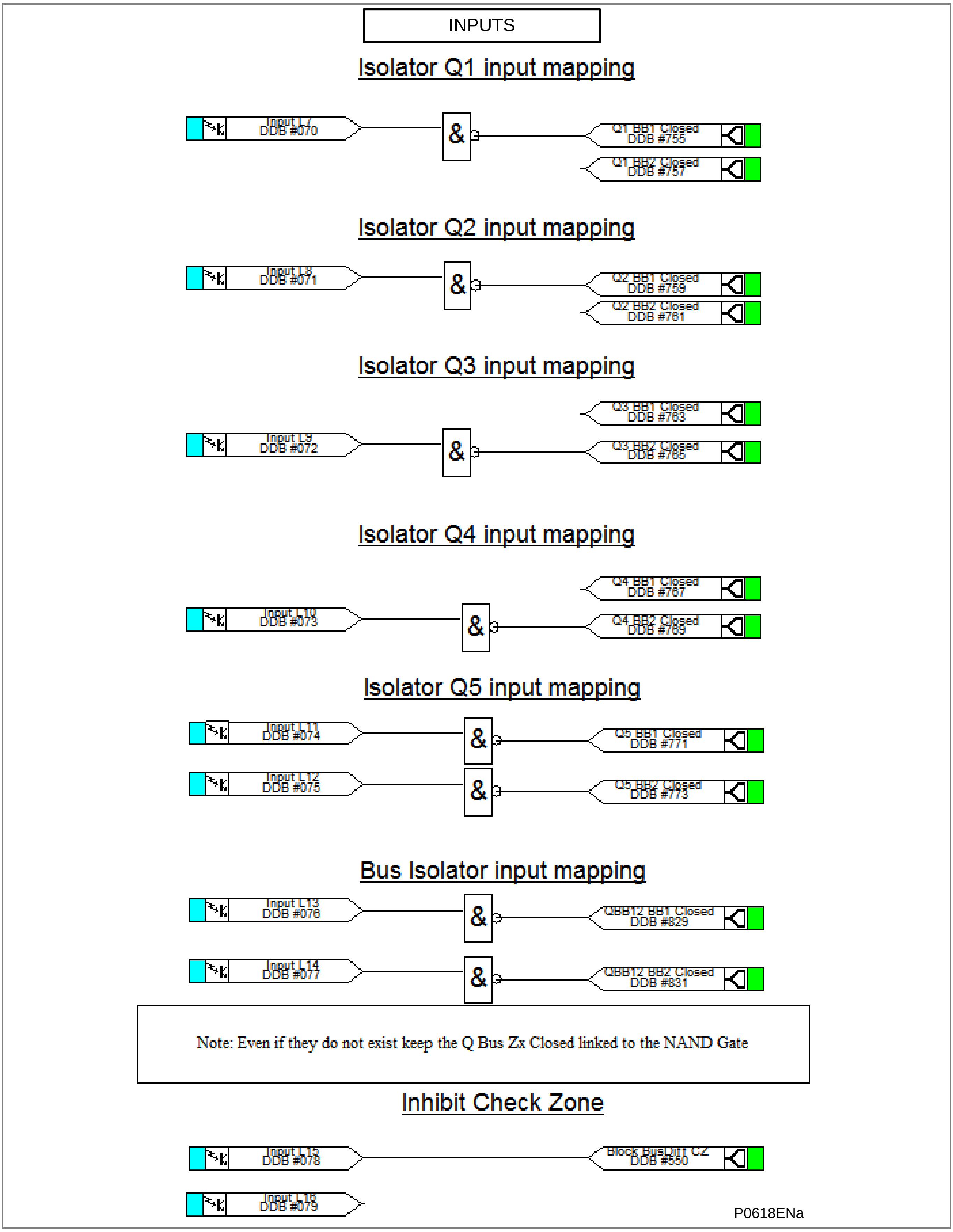


Figure 2 - P746_1 Inputs

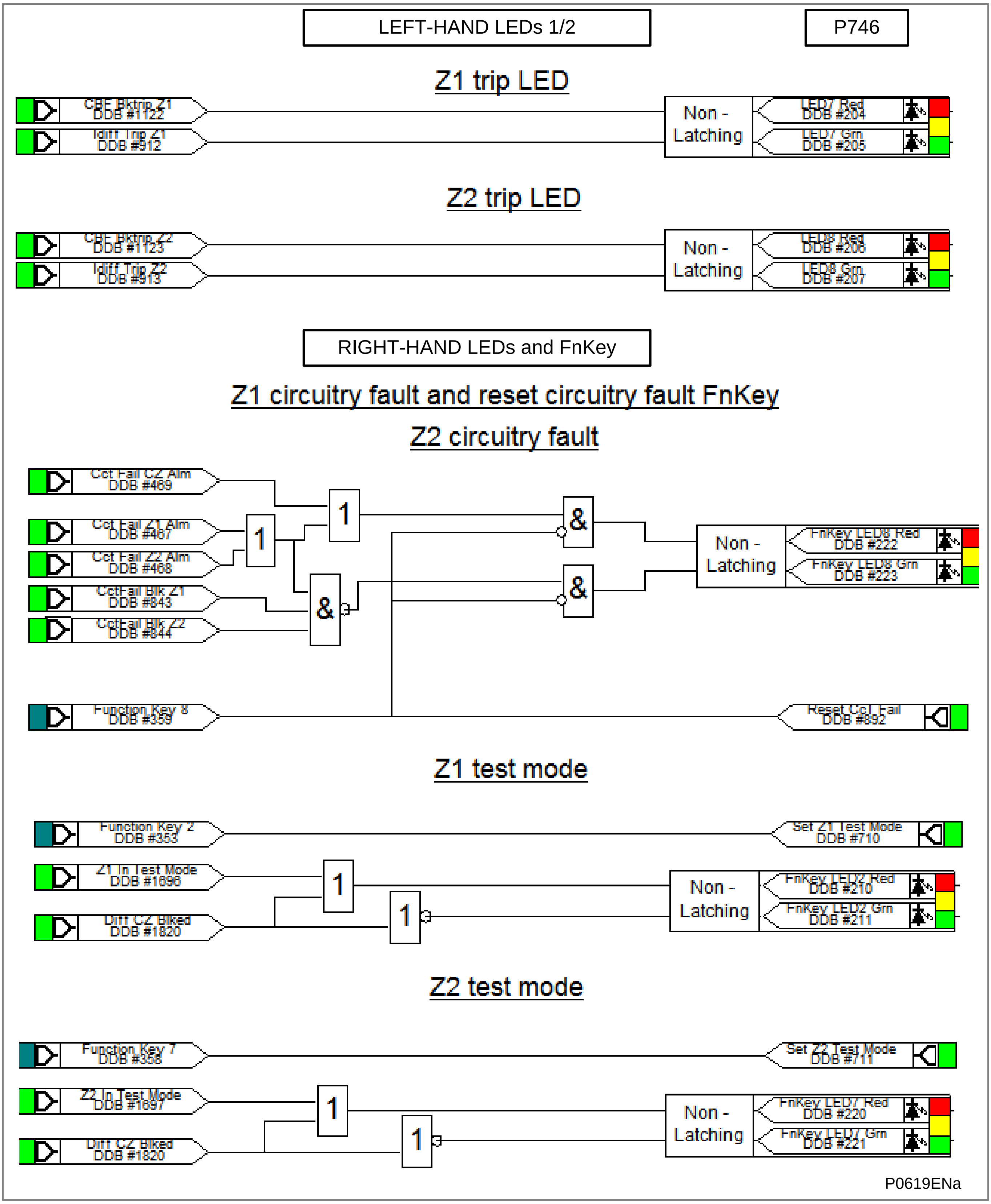


Figure 3 - P746_1 Left-Hand LEDs 1/2

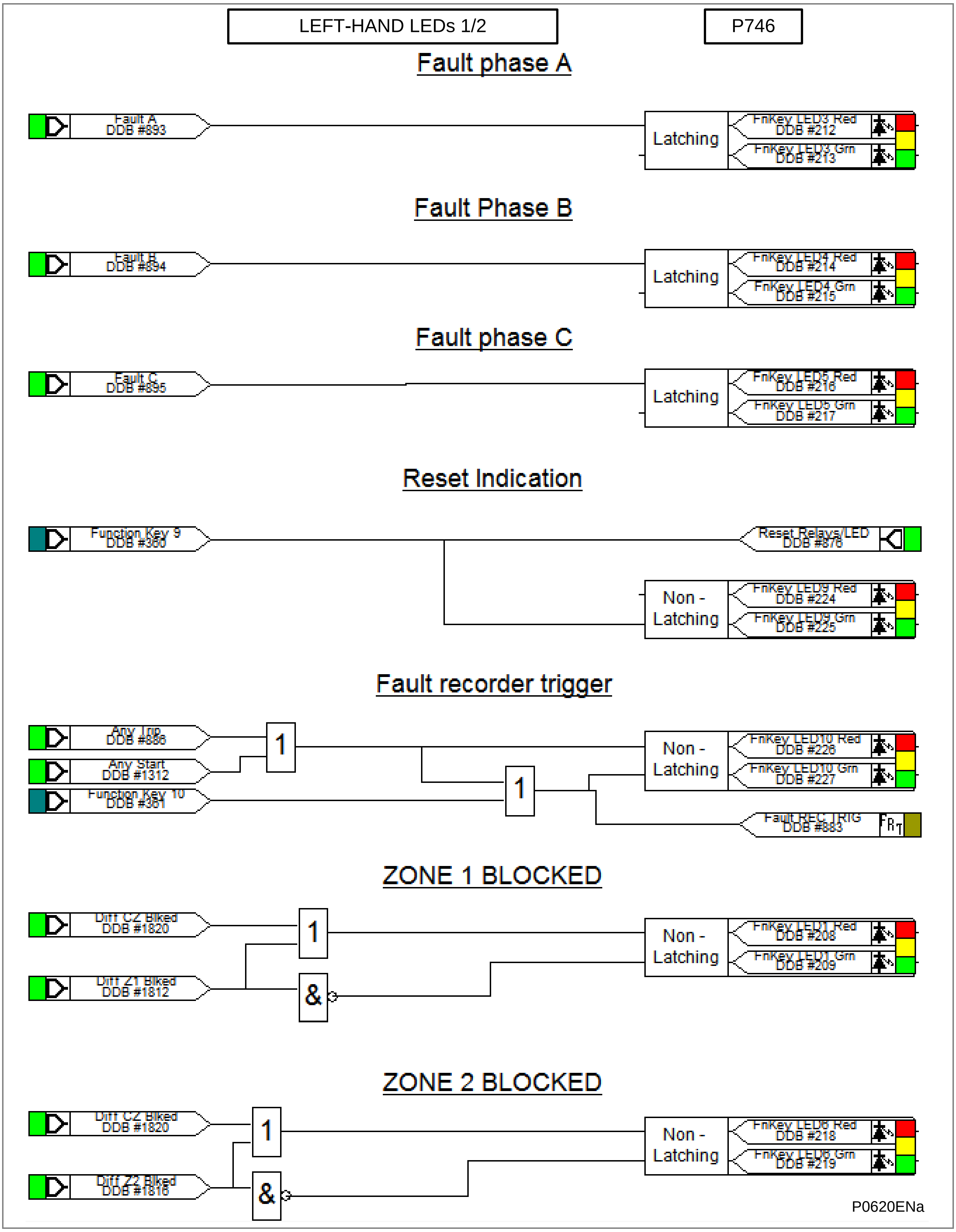


Figure 4 - P746_1 Left-Hand LEDs 2/2

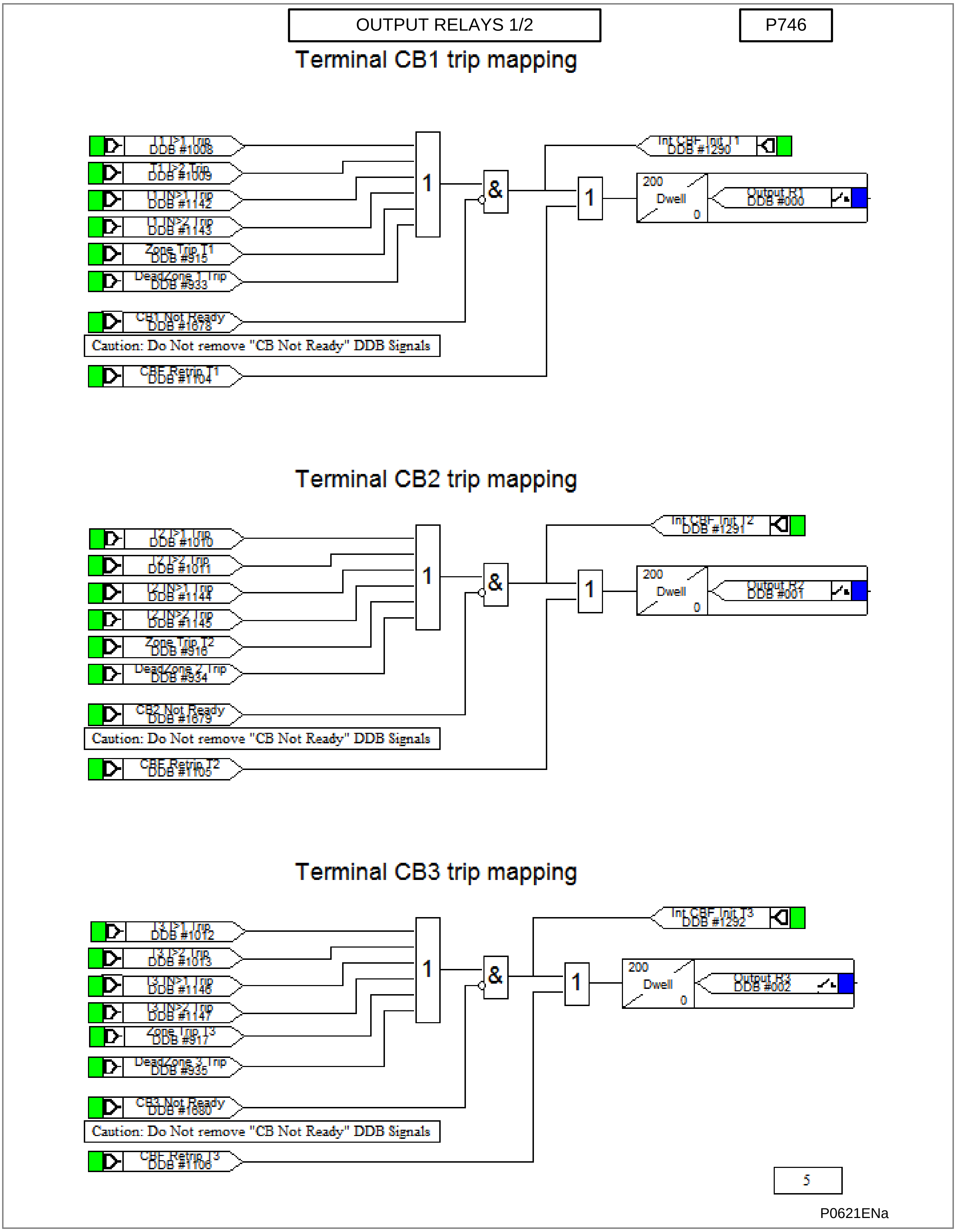


Figure 5 - P746_1 Output Relays 1/2

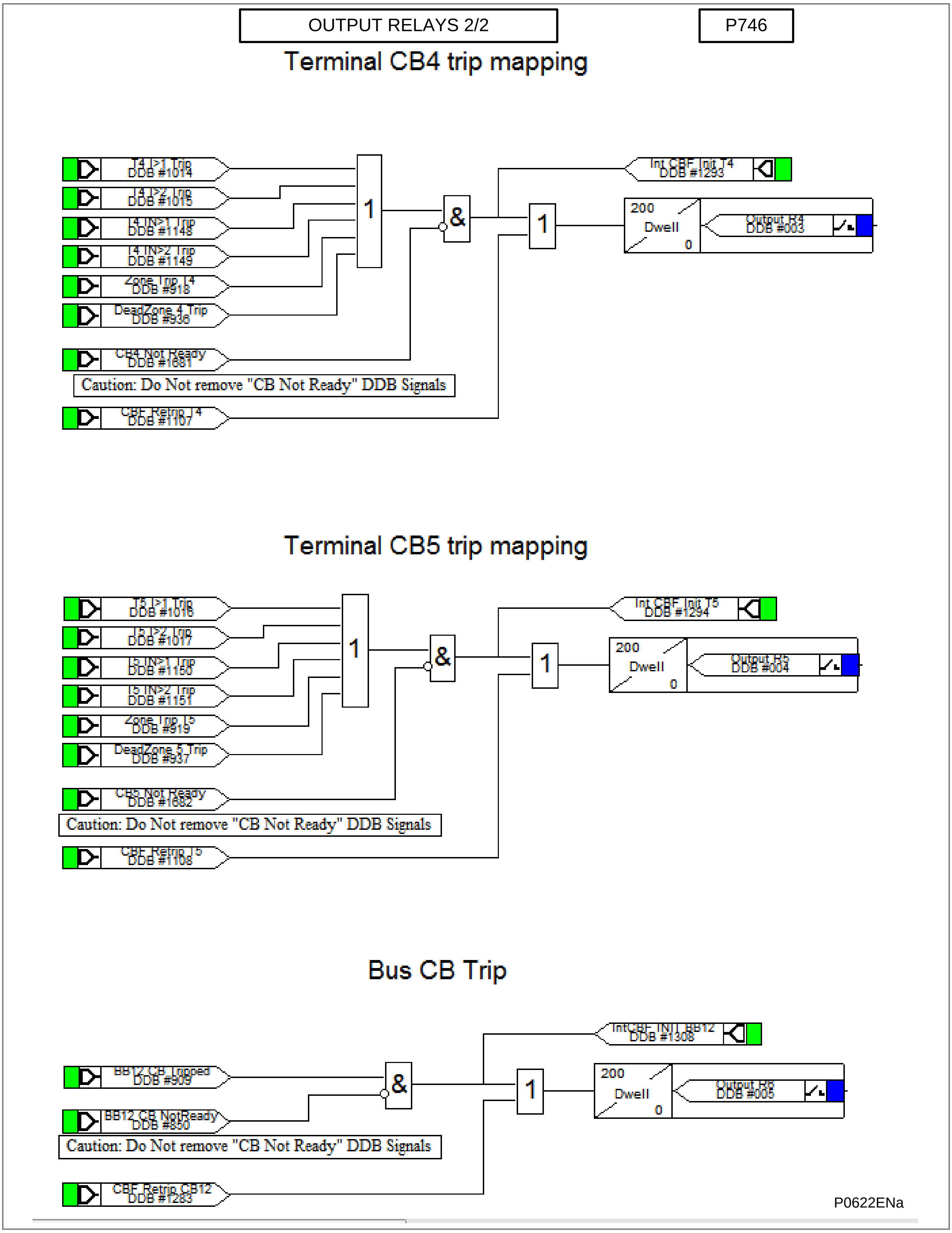


Figure 6 - P746_1 Output Relays 2/2

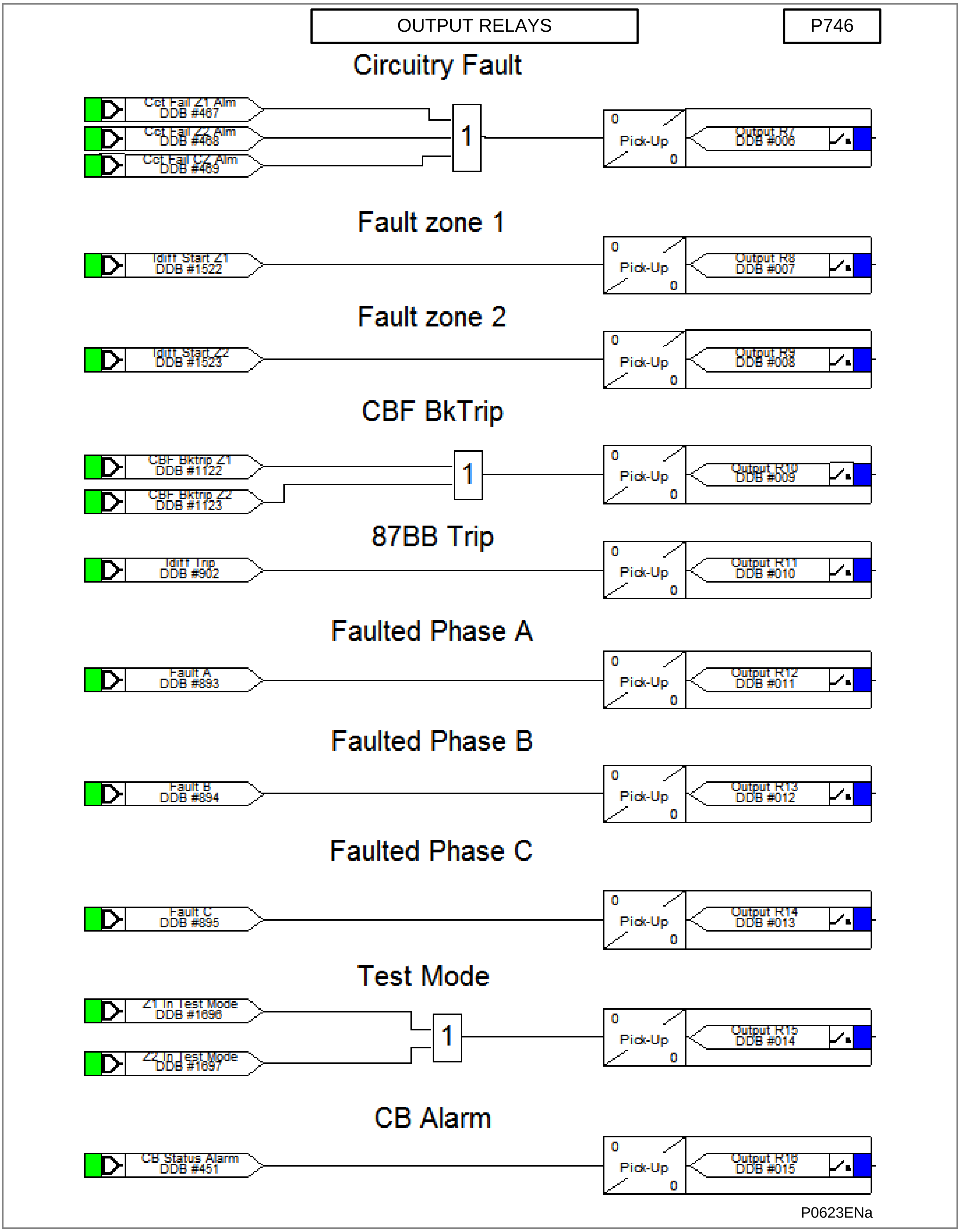


Figure 7 - P746_1 Output Relays

11 P746_2 PROGRAMMABLE SCHEME LOGIC (PSL)

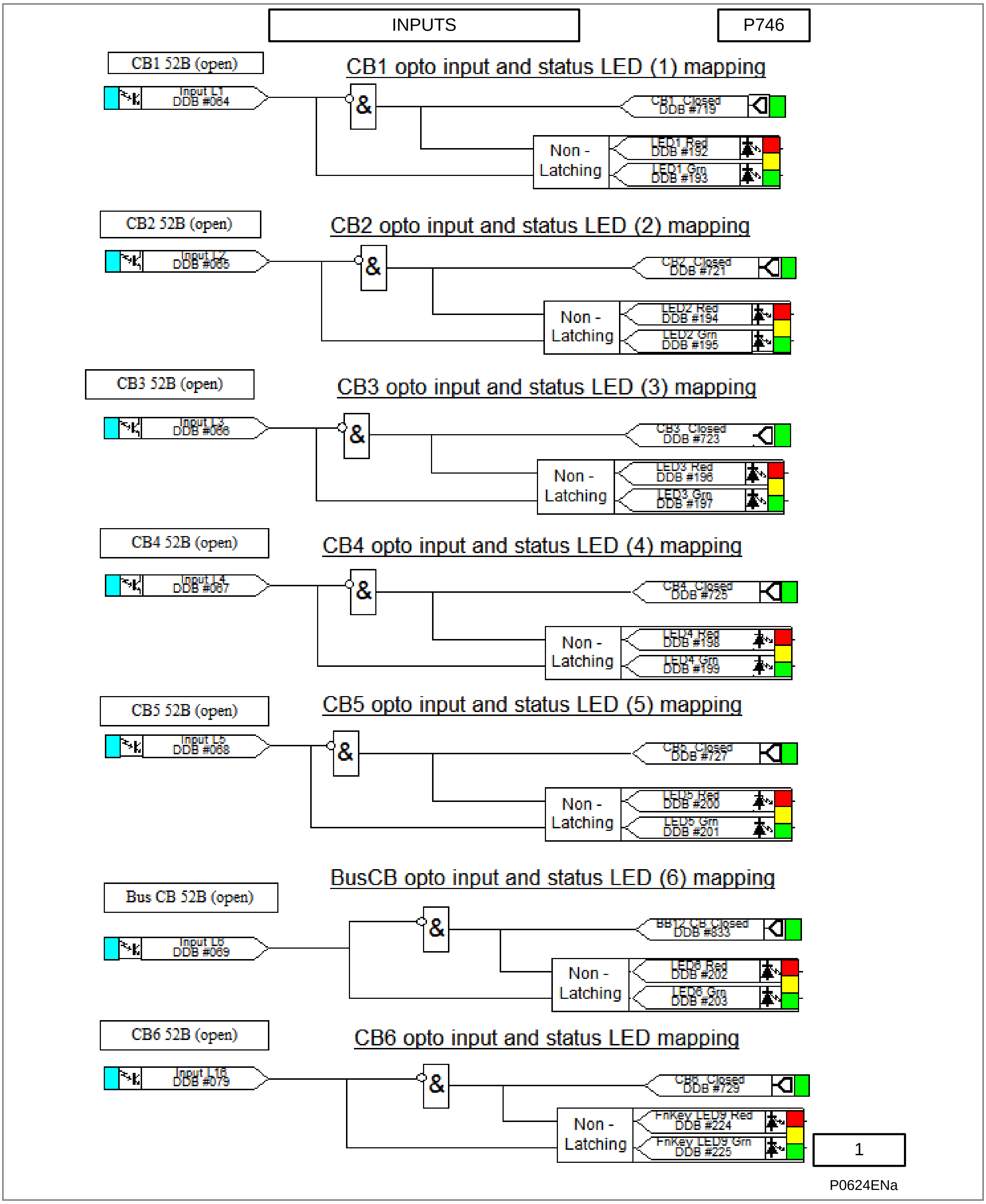


Figure 8 - P746_2 Inputs

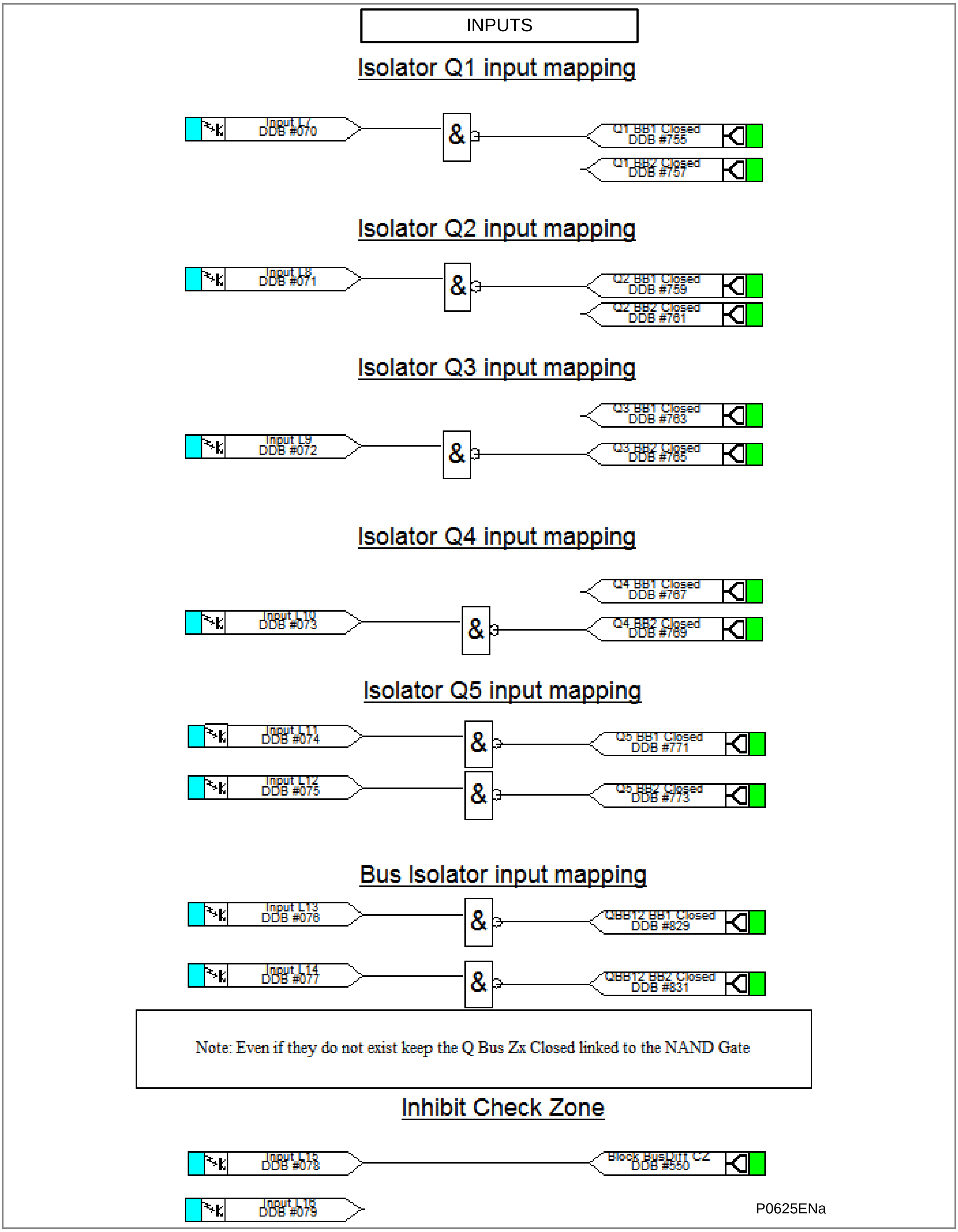


Figure 9 - P746_2 Inputs

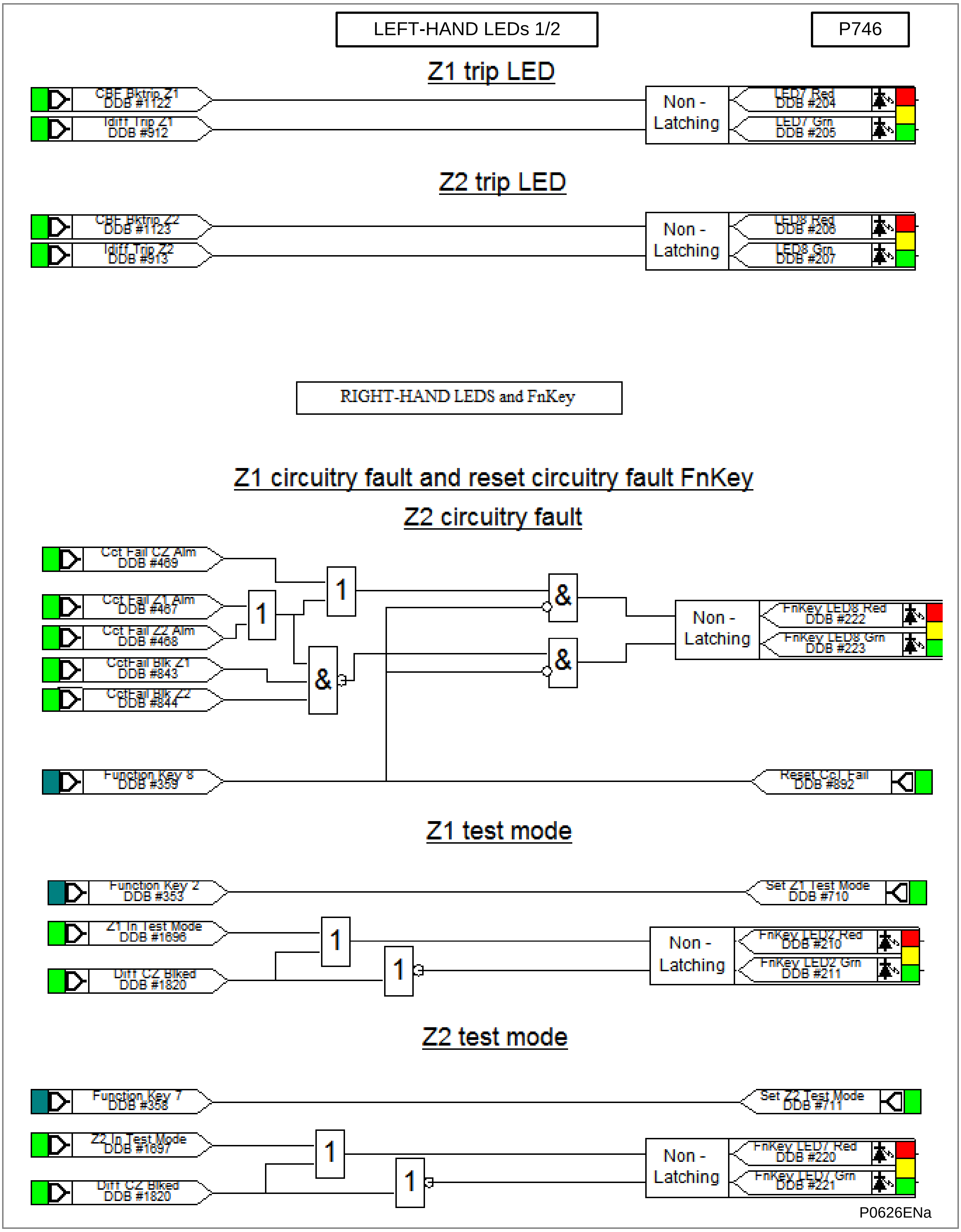


Figure 10 - P746_2 Left-Hand LEDs 1/2

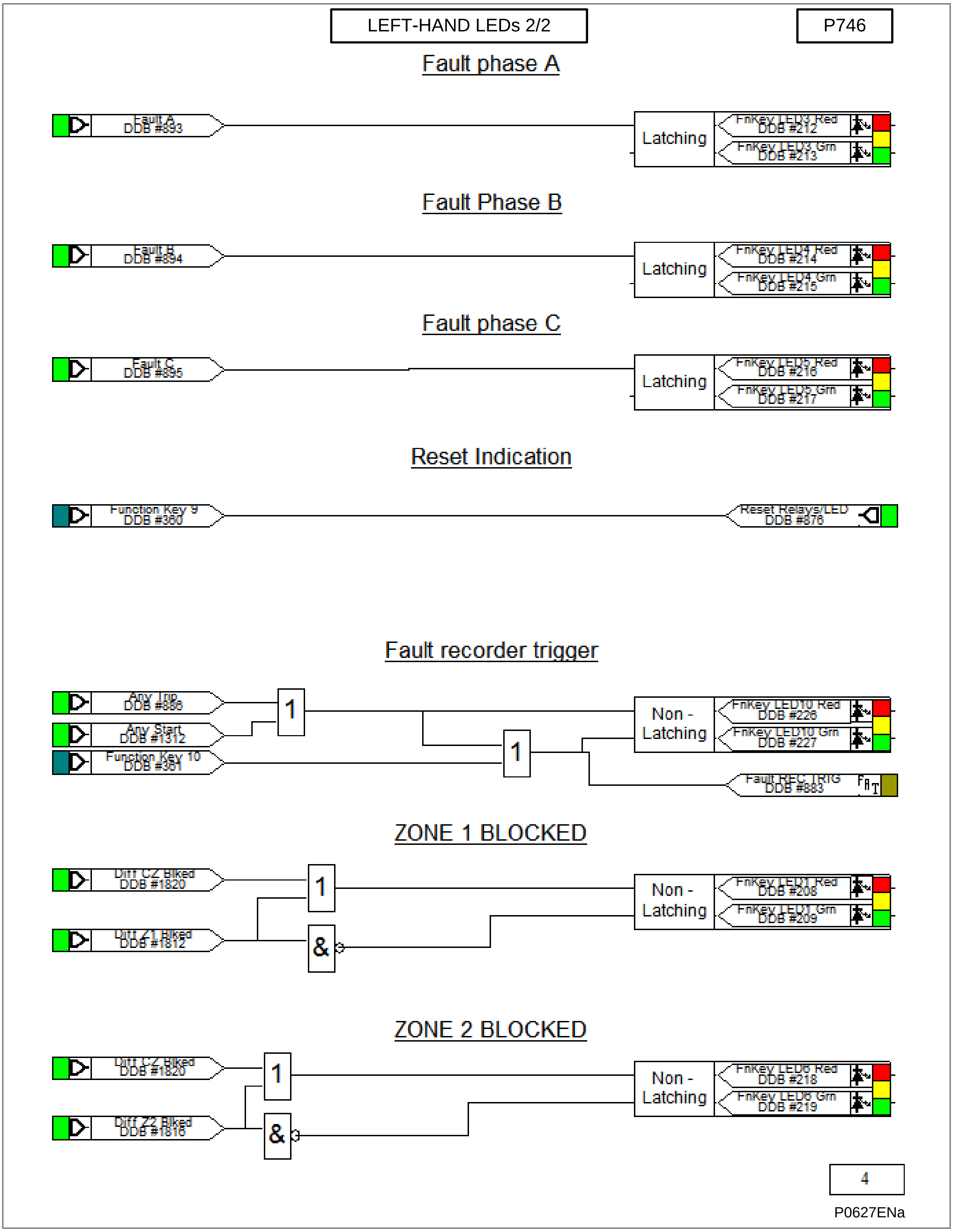


Figure 11 - P746_2 Left-Hand LEDs 2/2

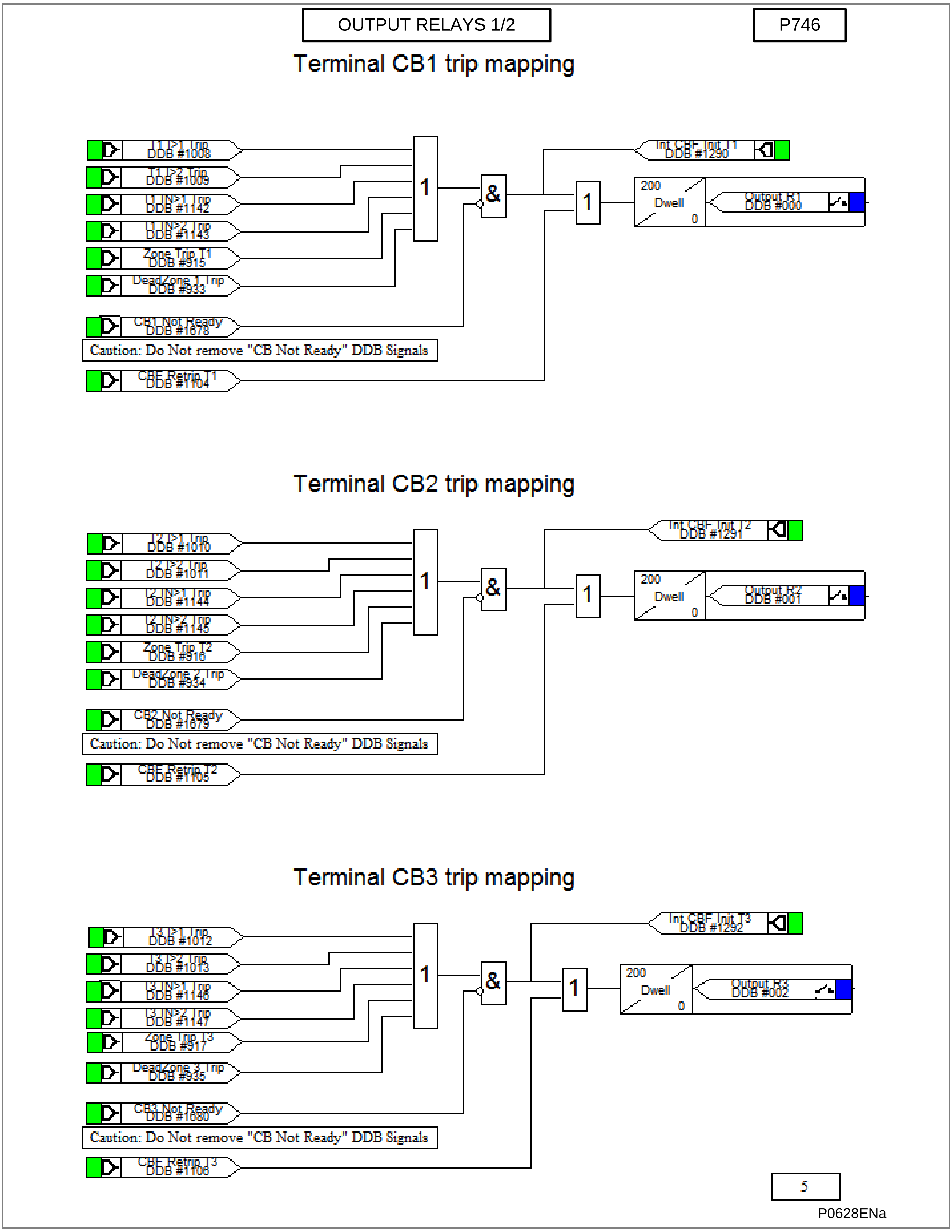


Figure 12 - P746_2 Output Relays 1/2

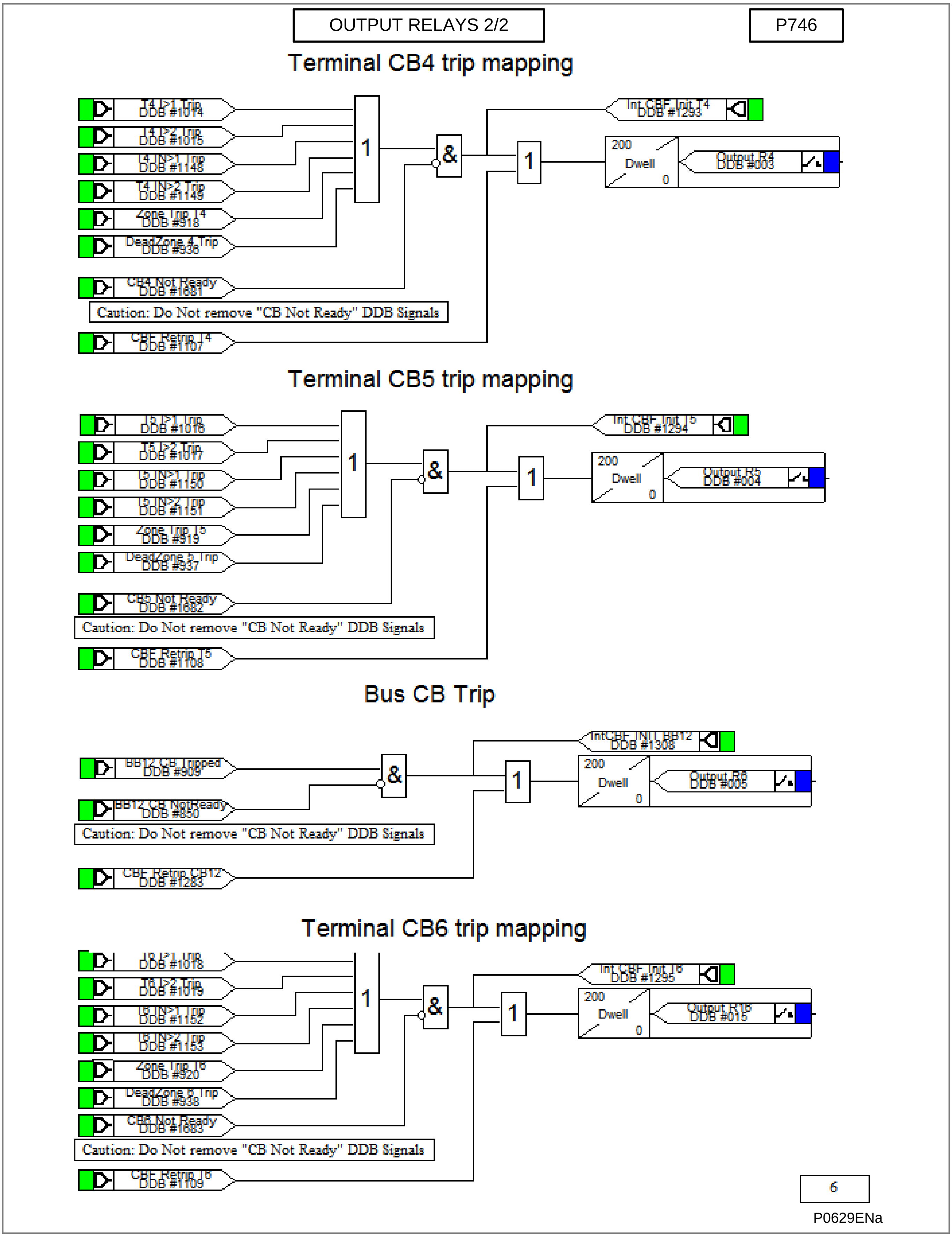


Figure 13 - P746_2 Output Relays 2/2

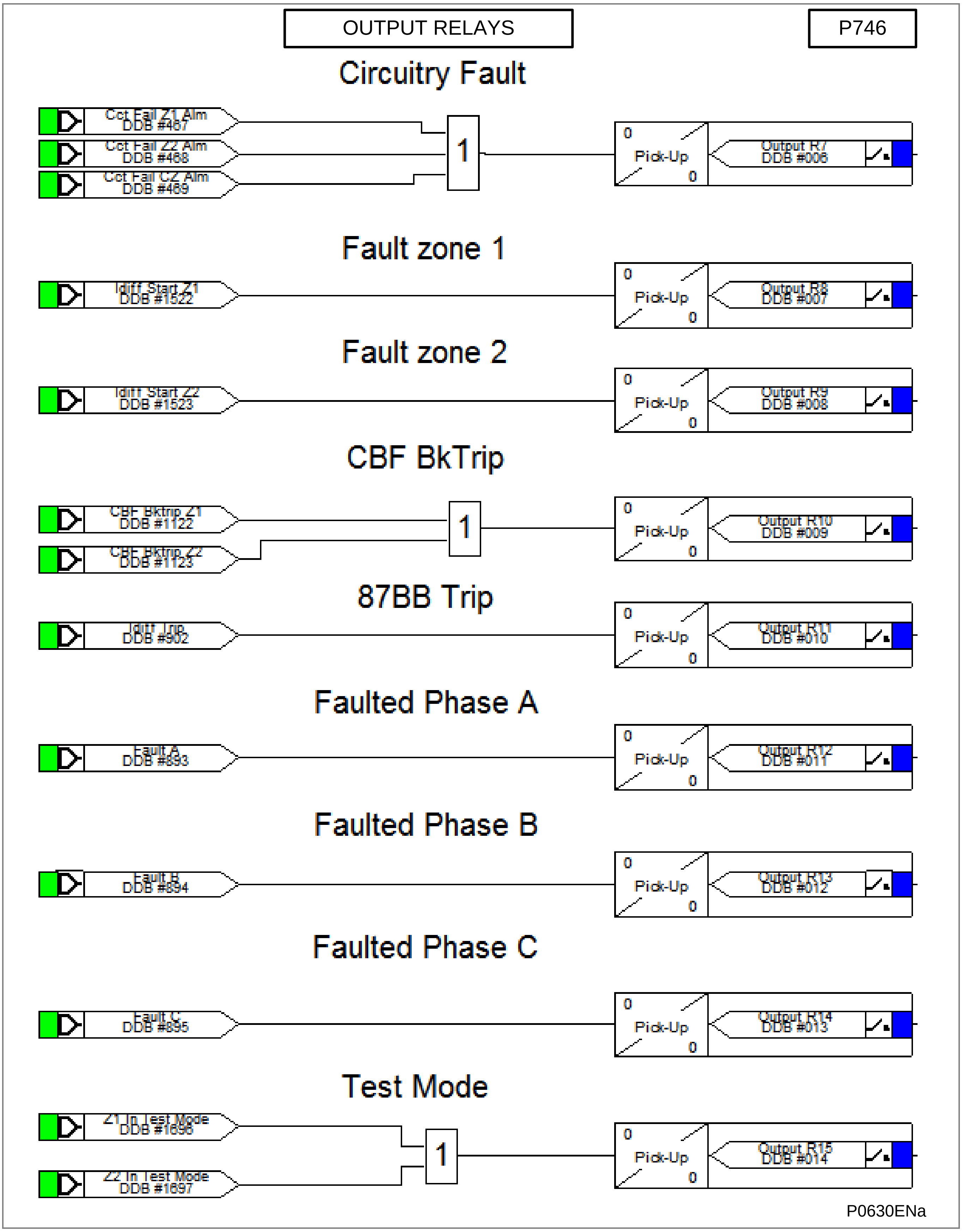


Figure 14 - P746_2 Circuitry Fault

MEASUREMENTS AND RECORDINGS

CHAPTER 9

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Software Version:	B4 (P746_1) / C4 (P746_2)
Hardware Suffix:	M
Connection Diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

Page (MR) 9-

Notes:

1 INTRODUCTION

The relay is equipped with integral measurements, event, fault and disturbance recording facilities suitable for analysis of complex system disturbances.

The relay is flexible enough to allow for the programming of these facilities to specific user application requirements. These requirements are discussed in the sections which follow.

2 EVENT AND FAULT RECORDS

The relay records and time tags up to 512 events and stores them in non-volatile (battery-backed up) memory. This lets the system operator establish the sequence of events that occurred in the relay following a particular power system condition or switching sequence. When the available space is used up, the oldest event is automatically overwritten by the new one (i.e. first in, first out).

The relay's real-time clock provides the time tag to each event, to a resolution of 1 ms.

The event records can be viewed either from the front plate LCD or remotely using the communications ports (using any available protocols, such as Courier or MODBUS).

For local viewing on the LCD of event, fault and maintenance records, select the **VIEW RECORDS** menu column.

For extraction from a remote source using communications, see the *SCADA Communications* chapter or the Easergy Studio (MiCOM S1 Studio) instructions.

For a full list of all the event types and the meaning of their values, see the Menu Database document.

2.1 View Records Column

Menu Text	Col	Row	Default Setting	Available Setting
Description				
VIEW RECORDS	01	00		
This column contains event, fault and maintenance records				
Select Event	01	01	0	From 0 to 511 step 1
This selects the required event record from all the possible ones that may be stored. A value of 0 corresponds to the latest event, with the maximum value the oldest.				
Menu Cell Ref	01	02		Not Settable
Indicates type of event.				
Time & Date	01	03		Not Settable
Time & Date Stamp for the event given by the internal Real Time Clock.				
Event Text	01	04		Not Settable
Up to 16 Character description of the Event (refer to following sections).				
Event Value	01	05		Not Settable
Up to 32 Bit Binary Flag or integer representative of the Event (refer to following sections).				
Select Fault	01	06	0	0 to 19 step 1
This selects the required fault record from the possible 5 that may be stored. A value of 0 corresponds to the latest fault and so on.				
Faulted Phase	01	07		Not Settable
Phase initiating fault recorder starts: Start A, Start B, Start C, Trip A, Trip B, Trip C.				
Start Elements1	01	08		Not Settable
Displays the status of the first 32 start signals				
Start Elements2	01	09		Not Settable
Displays the status of the second 32 start signals				
Start Elements3	01	0A		Not Settable
Displays the status of the third 32 start signals				
Start Elements4	01	0B		Not Settable
Displays the status of the fourth 32 start signals (P746_2 only)				
Trip Elements1	01	10		Not Settable
Displays the status of the first 32 trip signals				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Trip Elements2	01	11		Not Settable
Displays the status of the second 32 trip signals				
Trip Elements3	01	12		Not Settable
Displays the status of the third 32 trip signals				
Fault Alarms2	01	4F		Not Settable
Displays the status of the second 32 fault alarm signals (P746_2 only)				
Fault Alarms	01	50		Not Settable
Displays the status of the first 32 fault alarm signals				
Fault Time	01	51		Not Settable
Displays fault time and date				
Fault Type	01	52		Not Settable
Displays fault type				
Active Group	01	53		Not Settable
Displays active setting group				
System Frequency	01	54		Not Settable
Displays the system frequency				
Fault Duration	01	55		Not Settable
Displays time from the start or trip until the undercurrent elements indicate the CB is open				
CB Operate Time	01	56		Not Settable
Displays time from protection trip to undercurrent elements indicating the CB is open				
Relay Trip Time	01	60		Not Settable
Displays time from protection start to protection trip				
Test Mode	01	61		Not Settable
Indicates which zones were in Test Mode.				
IA-1 Magnitude	01	62		Not Settable
Displays CT1 Phase A Magnitude (One Box Mode)				
IX-1 Magnitude	01	63		Not Settable
Displays CT1 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IB-1 Magnitude	01	64		Not Settable
Displays CT1 Phase B Magnitude (One Box Mode)				
IX-2 Magnitude	01	65		Not Settable
Displays CT2 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IC-1 Magnitude	01	66		Not Settable
Displays CT1 Phase C Magnitude (One Box Mode)				
IX-3 Magnitude	01	67		Not Settable
Displays CT3 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IA-2 Magnitude	01	68		Not Settable
Displays CT2 Phase A Magnitude (One Box Mode)				
IX-4 Magnitude	01	69		Not Settable
Displays CT4 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IB-2 Magnitude	01	6A		Not Settable
Displays CT2 Phase B Magnitude (One Box Mode)				
IX-5 Magnitude	01	6B		Not Settable

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Displays CT5 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IC-2 Magnitude	01	6C		Not Settable
Displays CT2 Phase C Magnitude (One Box Mode)				
IX-6 Magnitude	01	6D		Not Settable
Displays CT6 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IA-3 Magnitude	01	6E		Not Settable
Displays CT3 Phase A Magnitude (One Box Mode)				
IX-7 Magnitude	01	6F		Not Settable
Displays CT7 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IB-3 Magnitude	01	70		Not Settable
Displays CT3 Phase B Magnitude (One Box Mode)				
IX-8 Magnitude	01	71		Not Settable
Displays CT8 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IC-3 Magnitude	01	72		Not Settable
Displays CT3 Phase C Magnitude (One Box Mode)				
IX-9 Magnitude	01	73		Not Settable
Displays CT9 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IA-4 Magnitude	01	74		Not Settable
Displays CT4 Phase A Magnitude (One Box Mode)				
IX-10 Magnitude	01	75		Not Settable
Displays CT10 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IB-4 Magnitude	01	76		Not Settable
Displays CT4 Phase B Magnitude (One Box Mode)				
IX-11 Magnitude	01	77		Not Settable
Displays CT11 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IC-4 Magnitude	01	78		Not Settable
Displays CT4 Phase C Magnitude (One Box Mode)				
IX-12 Magnitude	01	79		Not Settable
Displays CT12 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IA-5 Magnitude	01	7A		Not Settable
Displays CT5 Phase A Magnitude (One Box Mode)				
IX-13 Magnitude	01	7B		Not Settable
Displays CT13 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IB-5 Magnitude	01	7C		Not Settable
Displays CT5 Phase B Magnitude (One Box Mode)				
IX-14 Magnitude	01	7D		Not Settable
Displays CT14 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IC-5 Magnitude	01	7E		Not Settable
Displays CT5 Phase C Magnitude (One Box Mode)				
IX-15 Magnitude	01	7F		Not Settable
Displays CT15 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IA-6 Magnitude	01	80		Not Settable
Displays CT6 Phase A Magnitude (One Box Mode)				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
IX-16 Magnitude	01	81		Not Settable
Displays CT16 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IB-6 Magnitude	01	82		Not Settable
Displays CT6 Phase B Magnitude (One Box Mode)				
IX-17 Magnitude	01	83		Not Settable
Displays CT17 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IC-6 Magnitude	01	84		Not Settable
Displays CT6 Phase C Magnitude (One Box Mode)				
IX-18 Magnitude	01	85		Not Settable
Displays CT18 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IA-7 Magnitude	01	86		Not Settable
Displays CT7 Phase A Magnitude (One Box Mode)				
IX-19 Magnitude	01	87		Not Settable
Displays CT19 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IB-7 Magnitude	01	88		Not Settable
Displays CT7 Phase B Magnitude (One Box Mode)				
IX-20 Magnitude	01	89		Not Settable
Displays CT20 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
IC-7 Magnitude	01	8A		Not Settable
Displays CT7 Phase C Magnitude (One Box Mode)				
IX-21 Magnitude	01	8B		Not Settable
Displays CT21 Magnitude (X =A or B or C depending upon the Protected Phase setting (Three Box Mode)				
VAN Magnitude	01	A0		Not Settable
Phase A to Neutral voltage Magnitude (P746_1 only)				
VBN Magnitude	01	A1		Not Settable
Phase B to Neutral voltage Magnitude (P746_1 only)				
VCN Magnitude	01	A2		Not Settable
Phase C to Neutral voltage Magnitude (P746_1 only)				
V1 Magnitude	01	A4		Not Settable
Positive sequence voltage Magnitude (P746_1 only)				
V2 Magnitude	01	A5		Not Settable
Negative sequence voltage Magnitude (P746_1 only)				
VN Derived Mag	01	A6		Not Settable
Derived Neutral voltage Magnitude (P746_1 only)				
VAB Magnitude	01	A7		Not Settable
Phase A to Phase B voltage Magnitude (P746_1 only)				
VBC Magnitude	01	A8		Not Settable
Phase B to Phase C voltage Magnitude (P746_1 only)				
VCA Magnitude	01	A9		Not Settable
Phase C to Phase A voltage Magnitude (P746_1 only)				
IA Z1 Diff	01	B0		Not Settable
Displays Zone 1 Phase A Differential Current				
IB Z1 Diff	01	B1		Not Settable

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Displays Zone 1 Phase B Differential Current				
IC Z1 Diff	01	B2		Not Settable
Displays Zone 1 Phase C Differential Current				
IA Z1 Bias	01	B3		Not Settable
Displays Zone 1 Phase A Bias Current				
IB Z1 Bias	01	B4		Not Settable
Displays Zone 1 Phase B Bisa Current				
IC Z1 Bias	01	B5		Not Settable
Displays Zone 1 Phase C Bias Current				
IA Z2 Diff	01	B6		Not Settable
Displays Zone 2 Phase A Differential Current				
IB Z2 Diff	01	B7		Not Settable
Displays Zone 2 Phase B Differential Current				
IC Z2 Diff	01	B8		Not Settable
Displays Zone 2 Phase C Differential Current				
IA Z2 Bias	01	B9		Not Settable
Displays Zone 2 Phase A Bias Current				
IB Z2 Bias	01	BA		Not Settable
Displays Zone 2 Phase B Bisa Current				
IC Z2 Bias	01	BB		Not Settable
Displays Zone 2 Phase C Bias Current				
IA Z3 Diff	01	BC		Not Settable
Displays Zone 3 Phase A Differential Current				
IB Z3 Diff	01	BD		Not Settable
Displays Zone 3 Phase B Differential Current				
IC Z3 Diff	01	BE		Not Settable
Displays Zone 3 Phase C Differential Current				
IA Z3 Bias	01	BF		Not Settable
Displays Zone 3 Phase A Bias Current				
IB Z3 Bias	01	C0		Not Settable
Displays Zone 3 Phase B Bisa Current				
IC Z3 Bias	01	C1		Not Settable
Displays Zone 3 Phase C Bias Current				
IA Z4 Diff	01	C2		Not Settable
Displays Zone 4 Phase A Differential Current				
IB Z4 Diff	01	C3		Not Settable
Displays Zone 4 Phase B Differential Current				
IC Z4 Diff	01	C4		Not Settable
Displays Zone 4 Phase C Differential Current				
IA Z4 Bias	01	C5		Not Settable
Displays Zone 4 Phase A Bias Current				
IB Z4 Bias	01	C6		Not Settable
Displays Zone 4 Phase B Bisa Current				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
IC Z4 Bias	01	C7		Not Settable
Displays Zone 4 Phase C Bias Current				
IA CZ Diff	01	C8		Not Settable
Displays Check Zone Phase A Differential Current				
IB CZ Diff	01	C9		Not Settable
Displays Check Zone Phase B Differential Current				
IC CZ Diff	01	CA		Not Settable
Displays Check Zone Phase C Differential Current				
IA CZ Bias	01	CB		Not Settable
Displays Check Zone Phase A Bias Current				
IB CZ Bias	01	CC		Not Settable
Displays Check Zone Phase B Bisa Current				
IC CZ Bias	01	CD		Not Settable
Displays Check Zone Phase C Bias Current				
Select Maint [0...n]	01	F0	0	From 0 to 9 step 1
This selects the required maintenance record from that may be stored. A value of 0 corresponds to the latest record and so on.				
Maint Text	01	F1		Not Settable
Up to 16 Character description of the occurrence (refer to following sections).				
Maint Type	01	F2		Not Settable
These cells are numbers representative of the occurrence. They form a specific error code which should be quoted in any related correspondence to Report Data.				
Maint Data	01	F3		Not Settable
These cells are numbers representative of the occurrence. They form a specific error code which should be quoted in any related correspondence to Report Data.				
Evt Iface Source	01	FA		Not Settable
Interface on which the event was logged				
Evt Access Level	01	FB		Not Settable
Any security event that indicates that it came from an interface action, such as disabling a port, will also record the access level of the interface that initiated the event. This will be recorded in the 'Event State' field of the event.				
Evt Extra Info	01	FC		Not Settable
This cell provides supporting information for the event and can vary between the different event types.				
Evt Unique Id	01	FE		Not Settable
Each event will have a unique event id. The event id is a 32 bit unsigned integer that is incremented for each new event record and is stored in the record in battery-backed memory (BBRAM). The current event id must be non-volatile so as to preserve it du				
Reset Indication	01	FF	No	No or Yes
This serves to reset the trip LED indications provided that the relevant protection element has reset, to reset all LED and relays latched in the PSL, and to reset the latched alarms.				

2.2 Types of Event

An event may be a change of state of a control input or output relay, an alarm condition, or a setting change. The following sections show the various items that constitute an event:

2.2.1 Change of State of Opto-Isolated Inputs

If one or more of the opto (logic) inputs has changed state since the last time the protection algorithm ran, the new status is logged as an event. When this event is selected to be viewed on the LCD, three cells appear, as in shown here:

```
Time & date of event
“LOGIC INPUTS1 (or 2)”
“Event Value 0101010101010101”
```

The Event Value is a multi-bit word with the number of bits corresponding to the number of opto inputs. It shows the status of the opto inputs, where the least significant bit (extreme right) corresponds to opto input 1. The same information is present if the event is extracted and viewed using a PC.

2.2.2 Change of State of One or More Output Relay Contacts

If one or more of the output relay contacts have changed state since the last time the protection algorithm ran, the new status is logged as an event. When this event is selected to be viewed on the LCD, three cells appear, as shown here:

```
Time and Date of Event
Output Contacts
Event Value 010101010101010101010
```

The Event Value is a multi-bit word with the number of bits corresponding to the number of output contacts. It shows the status of the output contacts, where the least significant bit (extreme right) corresponds to output contact 1, etc. The same information is present if the event is extracted and viewed using a PC.

2.2.2.1 Relay Alarm Conditions

Any alarm conditions generated by the relays are logged as individual events. This table shows examples of some of the alarm conditions and how they appear in the event list:

Alarm Status 1		Alarm Status 2		Alarm Status 3	
Bit	Text	Bit	Text	Bit	Text
1	Unused	1	CB Fail Alm T21	1	Battery Fail
2	Unused	2	Breaker Fail	2	Field Volt Fail
3	SG-DDB Invalid	3	CB Fail Alm T1	3	Comm2 H/W FAIL
4	CB Status Alarm	4	CB Fail Alm T2	4	GOOSE IED Absent
5	Q Status Alm	5	CB Fail Alm T3	5	NIC Not Fitted
6-17	Unused	6	CB Fail Alm T4	6	NIC No Response
		7	CB Fail Alm T5	7	NIC Fatal Error
		8	CB Fail Alm T6	8	Unused
		9	CB Fail Alm T7	9	Unused
		10	CB Fail Alm T8	10	Unused
		11	CB Fail Alm T9	11	Unused
		12	CB Fail Alm T10	12	NIC SW Mis-Match
		13	CB Fail Alm T11	13	IP Addr Conflict
		14	CB Fail Alm T12	14-18	Unused

Alarm Status 1		Alarm Status 2		Alarm Status 3	
Bit	Text	Bit	Text	Bit	Text
		15	CB Fail Alm T13		
		16	CB Fail Alm T14		
		17	CB Fail Alm T15		
18	Prot'n Disabled	18	CB Fail Alm T16		
19	F out of range	19	CB Fail Alm T17	19	Bad DNP Settings
20	Cct Fail Z1 Alm	20	CB Fail Alm T18	20-21	Unused
21	Cct Fail Z2 Alm	21	BB12 CBF Alarm		
22	Cct Fail CZ Alm	22	BB13 CBF Alarm	22	Invalid DNPoE IP
23	Cct Fail Z3 Alm	23	BB23 CBF Alarm	23	Invalid Config.
24	Cct Fail Z4 Alm	24	BB14 CBF Alarm	24	Test Mode Alm
25-27	Unused	25	BB24 CBF Alarm	25	Contacts Blk Alm
		26	BB34 CBF Alarm	26	NIC H/W Mismatch
		27	Not Used	27	NIC APP Mismatch
28	CT Fail Alarm	28	Not Used	28	Simul. GOOSE Alm
29	Unused	29	Z4 TestMode Alm	29-32	Unused
30	VT Fail Alarm	30	Z1 TestMode Alm		
31	CB Fail Alm T19	31	Z2 TestMode Alm		
32	CB Fail Alm T20	32	Z3 TestMode Alm		

The previous table shows the abbreviated description given to the various alarm conditions and a corresponding value between 0 and 31. This value is appended to each alarm event in a similar way to the input and output events described previously. It is used by the event extraction software, such as MiCOM S1 Studio, to identify the alarm and is therefore invisible if the event is viewed on the LCD. ON or OFF is shown after the description to signify whether the particular condition has become operated or has reset.

2.2.3 Protection Element Starts and Trips

Any operation of protection elements, (either a start or a trip condition) is logged as an event record, consisting of a text string indicating the operated element and an event value. This value is intended for use by the event extraction software, such as MiCOM S1 Studio, rather than for the user, and is invisible when the event is viewed on the LCD.

2.2.4 General Events

Several events come under the heading of **General Events**. An example appears here.

Nature of event	Displayed text in event record	Displayed value
Level 1 password modified, either from user interface, front or rear port.	PW1 modified UI, F, R or R2	0 UI=6, F=11, R=16, R2=38

A complete list of the General Events is in the Relay Menu Database document. This is a separate document, for each MiCOM Px4x product or product range. They are normally available for download from www.schneider-electric.com

2.2.5 Fault Records

Each time a fault record is generated, an event is also created. The event states that a fault record was generated, with a corresponding time stamp.

Further down the **VIEW RECORDS** column, select the **Select Fault** cell to view the actual fault record, which is selectable from up to 20 records. These records consist of fault flags, fault location, fault measurements, etc. The time stamp given in the fault record is more accurate than the corresponding stamp given in the event record as the event is logged some time after the actual fault record is generated.

The fault record is triggered from the **Fault REC. TRIG.** signal assigned in the default programmable scheme logic. Normally this is assigned to relay 3, protection trip. The fault measurements in the fault record are given at the time of the protection start.

The fault recorder does not stop recording until the reset of the 'Fault REC. TRIG.' signal in order to record all the protection flags during the fault.

It is recommended that the triggering contact be 'self reset' and not latching. If a latching contact were chosen the fault record would not be generated until the contact had fully reset.

2.2.6 Setting Changes

Changes to any setting in the relay are logged as an event. For example:

Type of setting change	Displayed text in event record	Displayed value
Control/Support Setting	C & S Changed	22
Group # Change	Group # Changed	#
Where # = 1 to 4		

Note	*Control/Support settings are communications, measurement, CT/VT ratio settings etc, which are not duplicated in the setting groups. When any of these settings are changed, the event record is created simultaneously. Changes to protection or disturbance recorder settings only generate an event once the settings have been confirmed at the 'setting trap'.*

2.3 Viewing Event Records via MiCOM S1 Studio Support Software

When the event records are extracted and viewed on a PC they look slightly different than when viewed on the LCD. The following shows an example of how various events appear when displayed using MiCOM S1 Studio:

+ Tuesday 09 September 2008 11:30:42.467	Any Start OFF
– Tuesday 09 September 2008 11:30:42.467	T1 IN>1 Start OFF
Description	MiCOM P746
Plant reference	MiCOM
Model number	P74631AK1M0012K
Address	001 Column:0F Row:4E
Event type	Standard Event
Event Value	00000000000000000000000000000000
– Tuesday 09 September 2008 11:30:42.297	Fault N ON
Description	MiCOM P746
Plant reference	MiCOM
Model number	P74631AK1M0012K
Address	001 Column:0F Row:3C
Event type	Standard Event
Event Value	00000000000000000000000000000001
+ Tuesday 09 September 2008 11:30:42.297	Any Start ON
+ Tuesday 09 September 2008 11:30:42.297	T1 IN>1 Start ON
+ Tuesday 09 September 2008 11:30:41.521	Fault Recorded
+ Tuesday 09 September 2008 11:30:41.507	Fault N OFF
+ Tuesday 09 September 2008 11:30:41.507	Any Start OFF

The first line gives the description and time stamp for the event, while the additional information displayed below may be collapsed using the +/– symbol.

For further information regarding events and their specific meaning, refer to the *Relay Menu Database* document. This standalone document not included in this manual.

2.4 Event Filtering

Event reporting can be disabled from all interfaces that support setting changes. The settings that control the various types of events are in the RECORD CONTROL column. The effect of setting each to disabled is in shown in the following table:

> *Note* *Some occurrences can result in more than one type of event, e.g. a battery failure will produce an alarm event and a maintenance record event.*

If the Protection Event setting is Enabled, a further set of settings is revealed which allow the event generation by individual DDB signals to be enabled or disabled.

For further information on events and their specific meaning, see the *Relay Menu Database* document.

The “record control” setting is used to:

- clear events logs, fault records and alarm events,
- enable or disable event generation for any change in relay output, logic input, general and protection events or fault and maintenance record.
- display DDB signals.

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

Menu Text	Col	Row	Default Setting	Available Setting
Description				
DDB 31 - 0	0B	40	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 63 - 32	0B	41	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 95 - 64	0B	42	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 127 - 96	0B	43	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 159 - 128	0B	44	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 191 - 160	0B	45	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 223 - 192	0B	46	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 255 - 224	0B	47	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 287 - 256	0B	48	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 319 - 288	0B	49	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 351 - 320	0B	4A	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 383 - 352	0B	4B	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 415 - 384	0B	4C	11111111111111111111111111111111 (bin)	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 447 - 416	0B	4D	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 479 - 448	0B	4E	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 511 - 480	0B	4F	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 543 - 512	0B	50	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 575 - 544	0B	51	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 607 - 576	0B	52	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 639 - 608	0B	53	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 671 - 640	0B	54	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 703 - 672	0B	55	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 735 - 704	0B	56	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 767 - 736	0B	57	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 799 - 768	0B	58	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
DDB 831 - 800	0B	59	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 863 - 832	0B	5A	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 895 - 864	0B	5B	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 927 - 896	0B	5C	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 959 - 928	0B	5D	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 991 - 960	0B	5E	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1023 - 992	0B	5F	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1055-1024	0B	60	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1087-1056	0B	61	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1119-1088	0B	62	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1151-1120	0B	64	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1183-1152	0B	64	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1215-1184	0B	65	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Choose whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1247-1216	0B	66	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1279-1248	0B	67	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1311-1280	0B	68	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1343-1312	0B	69	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1375-1344	0B	6A	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1407-1376	0B	6B	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1439-1408	0B	6C	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1471-1440	0B	6D	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1503-1472	0B	6E	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1535-1504	0B	6F	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1567-1536	0B	70	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1599-1568	0B	71	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
DDB 1631-1600	0B	72	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1663-1632	0B	73	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1695-1664	0B	74	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1727-1696	0B	75	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1759-1728	0B	76	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1791-1760	0B	77	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1823-1792	0B	78	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1855-1824	0B	79	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1887-1856	0B	7A	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1919-1888	0B	7B	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1951-1920	0B	7C	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 1983-1952	0B	7D	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				
DDB 2015-1984	0B	7E	11111111111111111111111111111111 (bin)	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 2047-2016	0B	7F	11111111111111111111111111111111 (bin)	32-bit binary setting: 1 = event recording Enabled, 0 = event recording Disabled
Chooses whether any individual DDB's should be deselected as a stored event, by setting the relevant bit to 0 (zero). Typically used for repetitive recurrent changes such as an Opto input assigned for Minute Pulse clock synchronizing.				

3 DISTURBANCE RECORDER

The integral disturbance recorder has an area of memory specifically set aside for record storage. The number of records that may be stored by the relay is dependent upon the selected recording duration.

- The relay can typically store a minimum of 50 records, each of 1.5 seconds duration.

Disturbance records continue to be recorded until the available memory is exhausted, at which time the oldest record(s) are overwritten to make space for the newest one.

Each disturbance record consists of up to 21 analogue data channels and up to 32 digital data channels. The relevant CT ratios for the analogue channels are also extracted to enable scaling to primary quantities.

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

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

Menu Text	Col	Row	Default Setting	Available Setting
Description				
DISTURB RECORDER	0C	00		
This column contains settings for the Disturbance Recorder				
Duration	0C	52	1.5 s	From 100 ms to 10.5 s step 10 ms
This sets the overall recording time.				
Trigger Position	0C	54	33.30 %	From 0 % to 100 % step 0.1 %
This sets the trigger point as a percentage of the duration. For example, the default settings show that the overall recording time is set to 1.5s with the trigger point being at 33.3% of this, giving 0.5 s pre-fault and 1.0 s post fault recording times.				
Trigger Mode	0C	56	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	58	VAN for P746_1 IA-T1/IX-T1 for P746_2	Unused, VAN(P746_1 only), VBN(P746_1 only), VCN(P746_1 only), IA-T1/IX-T1, IB-T1/IX-T2, IC-T1/IX-T3, IA-T2/IX-T4, IB-T2/IX-T5, IC-T2/IX-T6, IA-T3/IX-T7, IB-T3/IX-T8, IC-T3/IX-T9, IA-T4/IX-T10, IB-T4/IX-T11, IC-T4/IX-T12, IA-T5/IX-T13, IB-T5/IX-T14, IC-T5/IX-T15, IA-T6/IX-T16, IB-T6/IX-T17, IC-T6/IX-T18, IA-T7/IX-T19(P746_2 only), IB-T7/IX-T20(P746_2 only), IC-T7/IX-T21(P746_2 only), Z1 IA Diff, Z1 IB Diff, Z1 IC Diff, Z1 IA Bias, Z1 IB Bias, Z1 IC Bias, Z2 IA Diff, Z2 IB Diff, Z2 IC Diff, Z2 IA Bias, Z2 IB Bias, Z2 IC Bias, Z3 IA Diff, Z3 IB Diff, Z3 IC Diff, Z3 IA Bias, Z3 IB Bias, Z3 IC Bias, Z4 IA Diff, Z4 IB Diff, Z4 IC Diff, Z4 IA Bias, Z4 IB Bias, Z4 IC Bias, CZ IA Diff, CZ IB Diff, CZ IC Diff, CZ IA Bias, CZ IB Bias, CZ IC Bias
See Measurements and Recordings chapter. By default in P746_1: The Phase A measured voltage is assigned to this channel. By default in P746_2: The CT 1 phase A measured current is assigned to this channel.				
Analog Channel 2	0C	59	VBN for P746_1 IB-T1/IX-T2 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The Phase B measured voltage is assigned to this channel. By default in P746_2: The CT 1 Phase B measured current is assigned to this channel.				
Analog Channel 3	0C	5A	VCN for P746_1 IC-T1/IX-T3 for P746_2	Same as Analog Channel 1

Menu Text	Col	Row	Default Setting	Available Setting
Description				
See Measurements and Recordings chapter. By default in P746_1: The Phase C measured voltage is assigned to this channel. By default in P746_2: The CT 1 Phase C measured current is assigned to this channel.				
Analog Channel 4	0C	5B	IA-T1/IX-T1 for P746_1 IA-T2/IX-T4 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 1 phase A measured current is assigned to this channel. By default in P746_2: The CT 2 Phase A measured current is assigned to this channel.				
Analog Channel 5	0C	5C	IB-T1/IX-T2 for P746_1 IB-T2/IX-T5 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 1 Phase B measured current is assigned to this channel. By default in P746_2: The CT 2 Phase B measured current is assigned to this channel.				
Analog Channel 6	0C	5D	IC-T1/IX-T3 for P746_1 IC-T2/IX-T6 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 1 Phase C measured current is assigned to this channel. By default in P746_2: The CT 2 Phase C measured current is assigned to this channel.				
Analog Channel 7	0C	5E	IA-T2/IX-T4 for P746_1 IA-T3/IX-T7 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 2 Phase A measured current is assigned to this channel. By default in P746_2: The CT 3 Phase A measured current is assigned to this channel.				
Analog Channel 8	0C	5F	IB-T2/IX-T5 for P746_1 IB-T3/IX-T8 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 2 Phase B measured current is assigned to this channel. By default in P746_2: The CT 3 Phase B measured current is assigned to this channel.				
Analog Channel 9	0C	60	IC-T2/IX-T6 for P746_1 IC-T3/IX-T9 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 2 Phase C measured current is assigned to this channel. By default in P746_2: The CT 3 Phase C measured current is assigned to this channel.				
AnalogChannel 10	0C	61	IA-T3/IX-T7 for P746_1 IA-T4/IX-T10 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 3 Phase A measured current is assigned to this channel. By default in P746_2: The CT 4 Phase A measured current is assigned to this channel.				
AnalogChannel 11	0C	62	IB-T3/IX-T8 for P746_1 IB-T4/IX-T11 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 3 Phase B measured current is assigned to this channel. By default in P746_2: The CT 4 Phase B measured current is assigned to this channel.				
AnalogChannel 12	0C	63	IC-T3/IX-T9 for P746_1 IC-T4/IX-T12 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 3 Phase C measured current is assigned to this channel. By default in P746_2: The CT 4 Phase C measured current is assigned to this channel.				
AnalogChannel 13	0C	64	IA-T4/IX-T10 for P746_1 IA-T5/IX-T13 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 4 Phase A measured current is assigned to this channel. By default in P746_2: The CT 5 Phase A measured current is assigned to this channel.				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
AnalogChannel 14	0C	65	IB-T4/IX-T11 for P746_1 IB-T5/IX-T14 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 4 Phase B measured current is assigned to this channel. By default in P746_2: The CT 5 Phase B measured current is assigned to this channel.				
AnalogChannel 15	0C	66	IC-T4/IX-T12 for P746_1 IC-T5/IX-T15 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 4 Phase C measured current is assigned to this channel. By default in P746_2: The CT 5 Phase C measured current is assigned to this channel.				
AnalogChannel 16	0C	67	IA-T5/IX-T13 for P746_1 IA-T6/IX-T16 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 5 Phase A measured current is assigned to this channel. By default in P746_2: The CT 6 Phase A measured current is assigned to this channel.				
AnalogChannel 17	0C	68	IB-T5/IX-T14 for P746_1 IB-T6/IX-T17 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 5 Phase B measured current is assigned to this channel. By default in P746_2: The CT 6 Phase B measured current is assigned to this channel.				
AnalogChannel 18	0C	69	IC-T5/IX-T15 for P746_1 IC-T6/IX-T18 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 5 Phase C measured current is assigned to this channel. By default in P746_2: The CT 6 Phase C measured current is assigned to this channel.				
AnalogChannel 19	0C	6A	IA-T6/IX-T16 for P746_1 IA-T7/IX-T19 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 6 Phase A measured current is assigned to this channel. By default in P746_2: The CT 7 Phase A measured current is assigned to this channel.				
AnalogChannel 20	0C	6B	IB-T6/IX-T17 for P746_1 IB-T7/IX-T20 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 6 Phase B measured current is assigned to this channel. By default in P746_2: The CT 7 Phase B measured current is assigned to this channel.				
AnalogChannel 21	0C	6C	IC-T6/IX-T18 for P746_1 IC-T7/IX-T21 for P746_2	Same as Analog Channel 1
See Measurements and Recordings chapter. By default in P746_1: The CT 6 Phase C measured current is assigned to this channel. By default in P746_2: The CT 7 Phase C measured current is assigned to this channel.				
Digital Input 1	0C	80	Output R1	Any O/P Contacts or Any Opto Inputs or Internal Digital Signals. See data type G32.
The digital channels may monitor any 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	81	No Trigger	No Trigger, Trigger L/H, 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	82	Output R2	Same as Digital Input 1
Same as Digital Input 1				
Input 2 Trigger	0C	83	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Digital Input 3	0C	84	Output R3	Same as Digital Input 1
Same as Digital Input 1				
Input 3 Trigger	0C	85	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 4	0C	86	Output R4	Same as Digital Input 1
Same as Digital Input 1				
Input 4 Trigger	0C	87	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 5	0C	88	Output R5	Same as Digital Input 1
Same as Digital Input 1				
Input 5 Trigger	0C	89	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 6	0C	8A	Output R6	Same as Digital Input 1
Same as Digital Input 1				
Input 6 Trigger	0C	8B	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 7	0C	8C	Output R7	Same as Digital Input 1
Same as Digital Input 1				
Input 7 Trigger	0C	8D	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 8	0C	8E	Output R8	Same as Digital Input 1
Same as Digital Input 1				
Input 8 Trigger	0C	8F	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 9	0C	90	Any Trip	Same as Digital Input 1
Same as Digital Input 1				
Input 9 Trigger	0C	91	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 10	0C	92	Output R10	Same as Digital Input 1
Same as Digital Input 1				
Input 10 Trigger	0C	93	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 11	0C	94	Diff fault Z1	Same as Digital Input 1
Same as Digital Input 1				
Input 11 Trigger	0C	95	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 12	0C	96	Diff fault Z2	Same as Digital Input 1
Same as Digital Input 1				
Input 12 Trigger	0C	97	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 13	0C	98	Diff fault CZ	Same as Digital Input 1
Same as Digital Input 1				
Input 13 Trigger	0C	99	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Same as Input 1 Trigger				
Digital Input 14	0C	9A	Idiff Z1 Start	Same as Digital Input 1
Same as Digital Input 1				
Input 14 Trigger	0C	9B	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 15	0C	9C	Idiff Z2 Start	Same as Digital Input 1
Same as Digital Input 1				
Input 15 Trigger	0C	9D	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 16	0C	9E	Idiff CZ Start	Same as Digital Input 1
Same as Digital Input 1				
Input 16 Trigger	0C	9F	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 17	0C	A0	PhComp Blk Z1	Same as Digital Input 1
Same as Digital Input 1				
Input 17 Trigger	0C	A1	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 18	0C	A2	PhComp Blk Z2	Same as Digital Input 1
Same as Digital Input 1				
Input 18 Trigger	0C	A3	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 19	0C	A4	Unused	Same as Digital Input 1
Same as Digital Input 1				
Input 19 Trigger	0C	A5	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 20	0C	A6	Idiff Trip Z1	Same as Digital Input 1
Same as Digital Input 1				
Input 20 Trigger	0C	A7	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 21	0C	A8	Idiff Trip Z2	Same as Digital Input 1
Same as Digital Input 1				
Input 21 Trigger	0C	A9	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 22	0C	AA	CctFail Blk Z1	Same as Digital Input 1
Same as Digital Input 1				
Input 22 Trigger	0C	AB	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 23	0C	AC	CctFail Blk Z2	Same as Digital Input 1
Same as Digital Input 1				
Input 23 Trigger	0C	AD	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 24	0C	AE	CctFail Blk CZ	Same as Digital Input 1
Same as Digital Input 1				

Menu Text	Col	Row	Default Setting	Available Setting
Description				
Input 24 Trigger	0C	AF	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 25	0C	B0	Diff Z1 Blked	Same as Digital Input 1
Same as Digital Input 1				
Input 25 Trigger	0C	B1	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 26	0C	B2	Diff Z2 Blked	Same as Digital Input 1
Same as Digital Input 1				
Input 26 Trigger	0C	B3	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 27	0C	B4	Diff CZ Blked	Same as Digital Input 1
Same as Digital Input 1				
Input 27 Trigger	0C	B5	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 28	0C	B6	Fault A	Same as Digital Input 1
Same as Digital Input 1				
Input 28 Trigger	0C	B7	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 29	0C	B8	Fault B	Same as Digital Input 1
Same as Digital Input 1				
Input 29 Trigger	0C	B9	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 30	0C	BA	Fault C	Same as Digital Input 1
Same as Digital Input 1				
Input 30 Trigger	0C	BB	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 31	0C	BC	Fault N	Same as Digital Input 1
Same as Digital Input 1				
Input 31 Trigger	0C	BD	No Trigger	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				
Digital Input 32	0C	BE	Function Key 10	Same as Digital Input 1
Same as Digital Input 1				
Input 32 Trigger	0C	BF	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L
Same as Input 1 Trigger				

The pre and post fault recording times are set by a combination of the **Duration** and **Trigger Position** cells. **Duration** sets the overall recording time and the **Trigger Position** sets the trigger point as a percentage of the duration.

- For example, the default settings show that the overall recording time is set to 1.5 s with the trigger point being at 33.3% of this, giving 0.5 s pre-fault and 1 s post-fault recording times.

If a further trigger occurs while a recording is taking place, the recorder ignores the trigger if the **Trigger Mode** is set to **Single**. However, if this is set to **Extended**, the post-trigger timer is reset to zero, extending the recording time.

As can be seen from the menu, each of the analog channels is selectable from the available analog inputs to the relay. The digital channels may be mapped to any of the opto isolated inputs or output contacts, in addition to several internal relay digital signals, such as protection starts and LEDs. The complete list of these signals may be found by viewing the available settings in the relay menu or using a setting file in MiCOM S1 Studio. Any of the digital channels may be selected to trigger the disturbance recorder on either a low-to-high or a high-to-low transition, using the **Input Trigger** cell. The default trigger settings are that any dedicated trip output contacts, such as relay 3, trigger the recorder.

It is not possible to view the disturbance records locally using the LCD; they must be extracted using suitable software such as MiCOM S1 Studio. This process is fully explained in the *SCADA Communications* chapter.

4 MEASUREMENTS

The relay produces a variety of both directly measured quantities. These measurement values are updated every second and can be viewed in the **Measurements** columns (up to two) of the relay or using the MiCOM S1 Studio Measurement viewer.

The relay can measure and display these quantities:

- Zone Phase Currents
- Measured Currents
- Sequence Voltages (P746_1)
- Sequence Currents (One Box Mode)

4.1 Zone Phase Currents

There are also measured values from the protection functions, which are also displayed under the measurement columns of the menu; these are described in the section on the relevant protection function.

The P746 relay can measure and display the following quantities.

- Phase Currents

4.2 Measured Currents

The relay produces current values. They are produced directly from the DFT (Discrete Fourier Transform) used by the relay protection functions and present both magnitude and phase angle measurement.

4.3 Sequence Voltages (P746_1)

Sequence magnitudes are produced by the relay from the measured Fourier values.

4.4 Sequence Currents (One Box Mode)

Sequence quantities are produced by the relay from the measured Fourier values; these are displayed as magnitude and phase angle values.

5 SETTINGS

5.1 Settings

The settings shown under the heading **MEASURE'T SETUP** can be used to configure the relay measurement function. See the following Measurements table for more details:

Menu Text	Col	Row	Default Setting	Available Setting
Description				
MEASURE'T SETUP	0D	00		
This column contains settings for the measurement setup				
Default Display	0D	01	Banner	Not Settable
This displays the default display which is possible to change whilst at the default level using the arrow keys. Only visible on UI.				
Local Values	0D	02	Primary	0 = Primary or 1 = Secondary
Local Measurement Values. This setting controls whether measured values via the front panel user interface and the front Courier port are displayed as primary or secondary quantities.				
Remote Values	0D	03	Primary	0 = Primary or 1 = Secondary
Remote Measurement Values. This setting controls whether measured values via the rear communication port are displayed as primary or secondary quantities.				
Measurement Ref	0D	04	VA	0 = VA, 1 = VB, 2 = VC, 3 = IA, 4 = IB, 5 = IC
Measurement Phase Reference. This menu sets the reference of the measure (phase reference and angle)				
Measurement Mode	0D	05	0	0 to 3 step 1
This setting is used to control the signing of the real and reactive power quantities.				

To avoid the event buffer from being filled with unnecessary time sync. events, it is possible to ignore any event that generated by the time sync. opto input. This can be done by applying the following settings:

5.2 Measurement Display Quantities

The relay has Measurement columns for viewing measurement quantities. These can also be viewed with MiCOM S1 Studio and are shown below.

MEASUREMENTS 1		MEASUREMENTS 2
One box configuration	Three box configuration	
IA-1 Magnitude	IX-1 Magnitude	IA Z1 Diff
IA-1 Phase Angle	IX-1 Phase Angle	IB Z1 Diff
IB-1 Magnitude	IX-2 Magnitude	IC Z1 Diff
IB-1 Phase Angle	IX-2 Phase Angle	IA Z1 Bias
IC-1 Magnitude	IX-3 Magnitude	IB Z1 Bias
IC-1 Phase Angle	IX-3 Phase Angle	IC Z1 Bias
IA-2 Magnitude	IX-4 Magnitude	IA Z2 Diff
IA-2 Phase Angle	IX-4 Phase Angle	IB Z2 Diff
IB-2 Magnitude	IX-5 Magnitude	IC Z2 Diff
IB-2 Phase Angle	IX-5 Phase Angle	IA Z2 Bias
IC-2 Magnitude	IX-6 Magnitude	IB Z2 Bias
IC-2 Phase Angle	IX-6 Phase Angle	IC Z2 Bias
IA-3 Magnitude	IX-7 Magnitude	IA Z3 Diff
IA-3 Phase Angle	IX-7 Phase Angle	IB Z3 Diff

MEASUREMENTS 1		MEASUREMENTS 2
One box configuration	Three box configuration	
IB-3 Magnitude	IX-8 Magnitude	IC Z3 Diff
IB-3 Phase Angle	IX-8 Phase Angle	IA Z3 Bias
IC-3 Magnitude	IX-9 Magnitude	IB Z3 Bias
IC-3 Phase Angle	IX-9 Phase Angle	IC Z3 Bias
IA-4 Magnitude	IX-10 Magnitude	IA Z4 Diff
IA-4 Phase Angle	IX-10 Phase Angle	IB Z4 Diff
IB-4 Magnitude	IX-11 Magnitude	IC Z4 Diff
IB-4 Phase Angle	IX-11 Phase Angle	IA Z4 Bias
IC-4 Magnitude	IX-12 Magnitude	IB Z4 Bias
IC-4 Phase Angle	IX-12 Phase Angle	IC Z4 Bias
IA-5 Magnitude	IX-13 Magnitude	IA CZ Diff
IA-5 Phase Angle	IX-13 Phase Angle	IB CZ Diff
IB-5 Magnitude	IX-14 Magnitude	IC CZ Diff
IB-5 Phase Angle	IX-14 Phase Angle	IA CZ Bias
IC-5 Magnitude	IX-15 Magnitude	IB CZ Bias
IC-5 Phase Angle	IX-15 Phase Angle	IC CZ Bias
IA-6 Magnitude	IX-16 Magnitude	
IA-6 Phase Angle	IX-16 Phase Angle	
IB-6 Magnitude	IX-17 Magnitude	
IB-6 Phase Angle	IX-17 Phase Angle	
IC-6 Magnitude	IX-18 Magnitude	
IC-6 Phase Angle	IX-18 Phase Angle	
I0-1 Magnitude		
I1-1 Magnitude		
I2-1 Magnitude		
IN-1 Derived Mag		
IN-1 Derived Ang		
I0-2 Magnitude		
I1-2 Magnitude		
I2-2 Magnitude		
IN-2 Derived Mag		
IN-2 Derived Ang		
I0-3 Magnitude		
I1-3 Magnitude		
I2-3 Magnitude		
IN-3 Derived Mag		
IN-3 Derived Ang		
I0-4 Magnitude		
I1-4 Magnitude		
I2-4 Magnitude		
IN-4 Derived Mag		
IN-4 Derived Ang		
I0-5 Magnitude		

MEASUREMENTS 1		MEASUREMENTS 2
One box configuration	Three box configuration	
I1-5 Magnitude		
I2-5 Magnitude		
IN-5 Derived Mag		
IN-5 Derived Ang		
I0-6 Magnitude		
I1-6 Magnitude		
I2-6 Magnitude		
IN-6 Derived Mag		
IN-6 Derived Ang		
VAN Magnitude		
VAN Phase Angle		
VBN Magnitude		
VBN Phase Angle		
VCN Magnitude		
VCN Phase Angle		
V1 Magnitude		
V2 Magnitude		
V0 Magnitude		
VN Derived Mag		
VN Derived Angle		
VAB Magnitude		
VAB Phase Angle		
VBC Magnitude		
VBC Phase Angle		
VCA Magnitude		
VCA Phase Angle		
VAN RMS		
VBN RMS		
VCN RMS		
Frequency		
IA-7 Magnitude	IX-19 Magnitude	
IA-7 Phase Angle	IX-19 Phase Angle	
IB-7 Magnitude	IX-20 Magnitude	
IB-7 Phase Angle	IX-20 Phase Angle	
IC-7 Magnitude	IX-21 Magnitude	
IC-7 Phase Angle	IX-21 Phase Angle	
I0-6 Magnitude		
I1-6 Magnitude		
I2-6 Magnitude		
IN-6 Derived Mag		
IN-6 Derived Ang		

Notes:

PRODUCT DESIGN

CHAPTER 10

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Software Version:	B4 (P746_1) / C4 (P746_2)
Hardware Suffix:	M
Connection Diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

Page (PD) 10-

FIGURES

Page (PD) 10-

TABLES

Page (PD) 10-

1 RELAY SYSTEM OVERVIEW

1.1 Hardware Overview

The relay is based on a modular hardware design where each module performs a separate function. This section describes the functional operation of the various hardware modules. Some modules are essential while others are optional depending on the user's requirements (see *Product Specific Options* and *Hardware Communications Options*).

All modules are connected by a parallel data and address bus which allows the processor board to send and receive information to and from the other modules as required.

There is also a separate serial data bus for transferring sample data from the input module to the processor. See the *Relay modules* diagram.

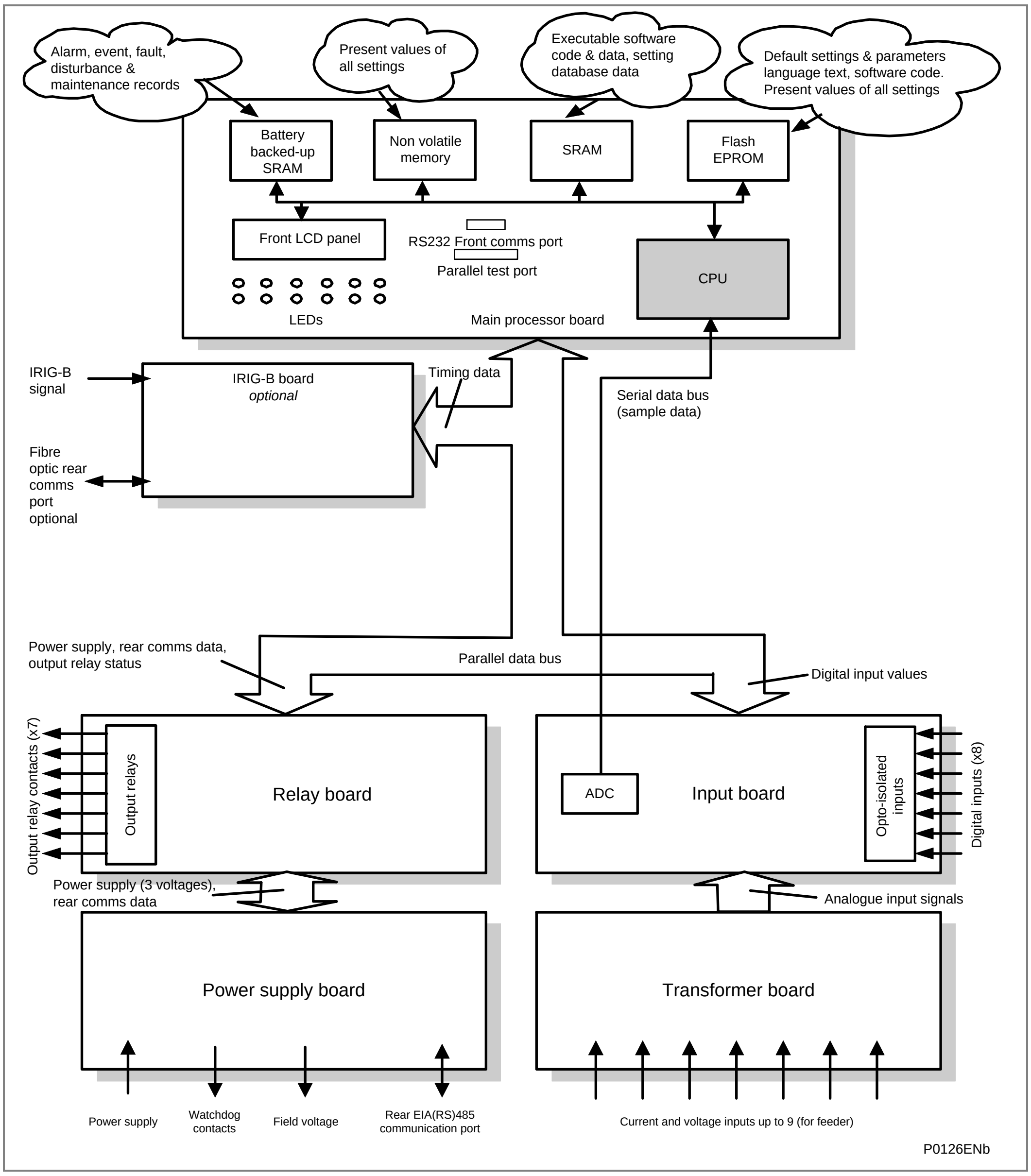


Figure 1 - Relay modules

1.2 Mechanical Layout

The relay case is pre-finished steel with a conductive covering of aluminum and zinc. This provides good earthing at all joints with a low impedance path to earth that is essential for shielding from external noise. The boards and modules use multi-point grounding (earthing) to improve immunity to external noise and minimize the effect of circuit noise. Ground planes are used on boards to reduce impedance paths and spring clips are used to ground the module metalwork.

Heavy duty terminal blocks are used at the rear of the relay for the current and voltage signal connections. Medium duty terminal blocks are used for the digital logic input signals, output relay contacts, power supply and rear communication port. A BNC connector is used for the optional IRIG-B signal. 9-pin and 25-pin female D-connectors are used at the front of the relay for data communication.

Inside the relay the boards plug into the connector blocks at the rear, and can be removed from the front of the relay only. The connector blocks to the relay's CT inputs have internal shorting links inside the relay. These automatically short the current transformer circuits before they are broken when the board is removed.

The front panel consists of a membrane keypad with tactile dome keys, an LCD and 12 or 22 LEDs (depending on the model) mounted on an aluminum backing plate.

1.3 Processor Board

The processor board performs all calculations for the relay and controls the operation of all other modules in the relay. The processor board also contains and controls the user interfaces (LCD, LEDs, keypad and communication interfaces).

The relay is based around a TMS320VC33-150MHz (peak speed), floating-point, 32-bit Digital Signal Processor (DSP) operating at a clock frequency of half this speed. This processor performs all of the calculations for the relay, including the protection functions, control of the data communication and user interfaces including the operation of the LCD, keypad and LEDs.

The processor board is directly behind the relay's front panel. This allows the LCD and LEDs and front panel communication ports to be mounted on the processor board. These ports are:

- The 9-pin D-connector for EIA(RS)232 serial communications used for MiCOM S1 Studio and Courier communications.
- The 25-pin D-connector relay test port for parallel communication.

All serial communication is handled using a Field Programmable Gate Array (FPGA).

The main processor board has:

- 8 MB SRAM for the working area. This is fast access (zero wait state) volatile memory used to temporarily store and execute the processor software.
- 8 MB flash ROM to store the software code, text, configuration data, default settings, and present settings.
- 4 MB battery-backed SRAM to store disturbance, event, fault and maintenance records.

1.4 Internal Communication Buses

The relay has two internal buses for the communication of data between different modules. The main bus is a parallel link that is part of a 64-way ribbon cable. The ribbon cable carries the data and address bus signals in addition to control signals and all power supply lines. Operation of the bus is driven by the main processor board that operates as a master while all other modules in the relay are slaves.

The second bus is a serial link that is used exclusively for communicating the digital sample values from the input module to the main processor board. The DSP has a built-in serial port that is used to read the sample data from the serial bus. The serial bus is also carried on the 64-way ribbon cable.

1.5 Input Module

The input module provides the interface between the relay processor board(s) and the analog and digital signals coming into the relay. The input module consists of the main input board and the transformer board.

1.5.1 Transformer Board

The transformer board holds up to three Voltage Transformers (VTs) and up to 21 Current Transformers (CTs) for the following model options:

Model	Option	Alternative Option
P746_1	3 VTs, 18 CTs	
P746_2	21 CTs	

The current inputs will accept either 1A or 5A nominal current (menu option) and the voltage inputs are specified for 110V nominal voltage. The transformers are used both to step-down the currents and voltages to levels appropriate to the relay's electronic circuitry and to provide effective isolation between the relay and the power system.

1.5.2 Input Module

The input module contains two boards, the main input board and a Universal Opto Isolated Logic Input board.

The main input board is shown as a block diagram in the *Main input board* diagram. It provides the circuitry for the digital input signals and the Analog-to-Digital (A-D) conversion for the analog signals. It takes the differential analog signals from the CTs and VTs on the transformer board(s), converts these to digital samples and transmits the samples to the main processor board through the serial data bus. On the input board, the analog signals are converted using a dedicated sigma-delta A-D convertor for each channel. This allows all of the channels to be sampled concurrently with no sampling skew between channels. The sampled signals are then digitally filtered prior to the data being sent to the main processor via the serial link. In relay models using the second transformer board, a second input board is also fitted to provide the A-D conversion for the additional channels

The sample rate is kept at 24 samples per cycle of the power waveform by a logic control circuit driven by the frequency tracking function on the main processor board. The calibration non-volatile memory holds the calibration coefficients that are used by the processor board to correct for any amplitude or phase error introduced by the transformers and analog circuitry.

The digital input signals are opto isolated on the main input board to prevent excessive voltages on these inputs causing damage to the relay's internal circuitry. The design of the opto input circuit allows the operating voltage to be configured for each input using the relay menu from a choice of five nominal battery voltages. Depending on the relay model, more than eight digital input signals can be accepted by the relay. This is achieve by additional opto-board containing the same provision for eight isolated digital inputs as the main input board, but with no provision for the analogue inputs.

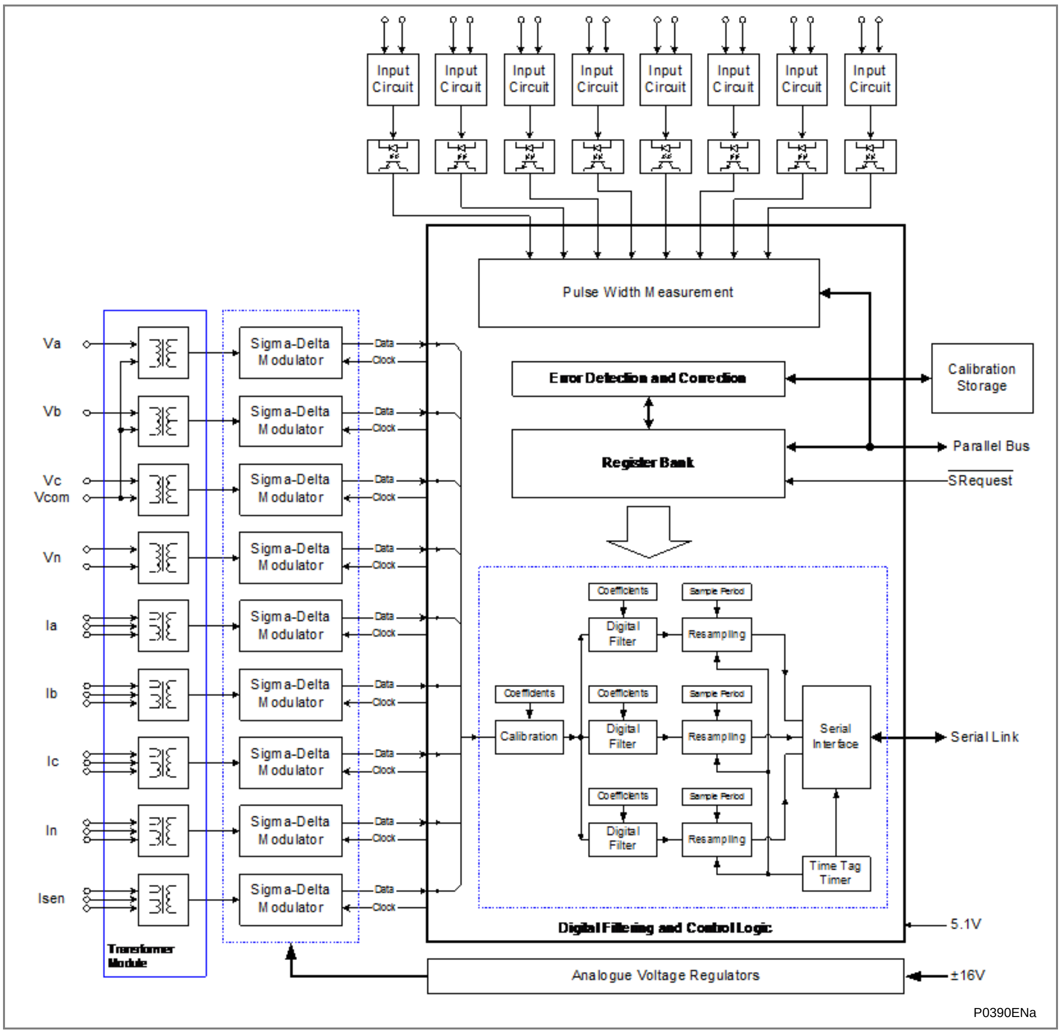


Figure 2 - Main input module

The other function of the input board is to read the signals on the digital inputs and send them through the parallel data bus to the processor board. The input board holds eight optical isolators for connecting up to eight digital input signals. Opto-isolators are used with digital signals for the same reason as transformers are used with analog signals: to isolate the relay's electronics from the power system environment. The input board has hardware filters to remove noise from the digital signals. The digital signals are then buffered so they can be read on the parallel data bus. Depending on the relay model, more than eight digital input signals can be accepted by the relay. This is done using an additional opto-board that contains the same provision for eight isolated digital inputs as the main input board, but does not contain any of the circuits for analog signals which are provided on the main input board.

1.5.3 Universal Opto Isolated Logic Inputs

This series of relays have universal opto-isolated logic inputs that can be programmed for the nominal battery voltage of the circuit of which they are a part. This allows different voltages for different circuits such as signaling and tripping. They can also be programmed as Standard 60% - 80% or 50% - 70% to satisfy different operating constraints.

Threshold levels are shown in this table:

Nominal battery voltage (Vdc)	Standard 60% - 80%		50% - 70%	
	No operation (Logic 0) Vdc	Operation (Logic 1) Vdc	No operation (Logic 0) Vdc	Operation (Logic 1) Vdc
24/27	<16.2	>19.2	<12.0	>16.8
30/34	<20.4	>24.0	<15.0	>21.0
48/54	<32.4	>38.4	<24.0	>33.6
110/125	<75.0	>88.0	<55.0	>77.0
220/250	<150.0	>176.0	<110	>154

Table 1 - Threshold Levels

This lower value eliminates fleeting pick-ups that may occur during a battery earth fault, when stray capacitance may present up to 50% of battery voltage across an input.

Each input also has selectable filtering. This allows a pre-set ½ cycle filter to be used to prevent induced noise on the wiring. However, although the ½ cycle filter is secure it can be slow, particularly for intertripping. If the ½ cycle filter is switched off to improve speed, double pole switching or screened twisted cable may be needed on the input to reduce ac noise.

1.6 Power Supply Module (including Output Relays)

The power supply module contains two boards, one for the power supply unit and the other for the output relays. It provides power to all of the other modules in the relay, as well as the EIA(RS)485 electrical connection for the rear communication port. The second board of the power supply module contains the relays that provide the output contacts.

1.6.1 Power Supply Board (including EIA(RS)485 Communication Interface)

One of three different configurations of the power supply board can be fitted to the relay. This will be specified at the time of order and depends on the nature of the supply voltage that will be connected to the relay. The options are shown in the following table:

Nominal dc range	Nominal ac range
24 - 32 V dc	dc only
48 - 110 V dc	dc only
110 - 250 V dc	100 - 240 V ac rms

Table 2 - Power supply options

The output from all versions of the power supply module are used to provide isolated power supply rails to all of the other modules in the relay. Three voltage levels are used in the relay: 5.1 V for all of the digital circuits, ±16 V for the analog electronics such as on the input board, and 22 V for driving the output relay coils. All power supply voltages including the 0 V earth line are distributed around the relay through the 64-way ribbon cable. The power supply board also provides the 48 V field voltage. This is brought out to terminals on the back of the relay so that it can be used to drive the optically-isolated digital inputs.

The two other functions provided by the power supply board are the EIA(RS)485 communications interface and the watchdog contacts for the relay. The EIA(RS)485 interface is used with the relay’s rear communication port to provide communication using one of either Courier, MODBUS, IEC60870-5-103, or DNP3.0 protocols. The EIA(RS)485 hardware supports half-duplex communication and provides optical isolation of the serial data that is transmitted and received. All internal communication of data from the power supply board is through the output relay board connected to the parallel bus.

The watchdog facility has two output relay contacts, one Normally Open (N/O)and one Normally Closed (N/C). These are driven by the main processor board and indicate that the relay is in a healthy state.

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

1.6.2 Output Relay Board

Depending on the relay model, more output contacts can be provided by using up to three extra relay boards. Each additional relay board provides a further four or eight output relays.

1.6.3 High Break Relay Board

The output relay board holds four relays, all normally open. The relays are driven from the 22V power supply line. The relays' state is written to or read from using the parallel data bus.

This board uses a hybrid of MOSFET Solid State Devices (SSD) in parallel with high capacity relay output contacts. The MOSFET has a varistor across it to provide protection which is required when switching off inductive loads because the stored energy in the inductor causes a reverse high voltage which could damage the MOSFET.

When there is a control input command to operate an output contact, the miniature relay is operated at the same time as the SSD. The miniature relay contact closes in nominally 3.5 ms and is used to carry the continuous load current; the SSD operates in <0.2 ms and is switched off after 7.5 ms. When the control input resets to open the contacts, the SSD is again turned on for 7.5 ms. The miniature relay resets in nominally 3.5 ms before the SSD so the SSD is used to break the load. The SSD absorbs the energy when breaking inductive loads and so limits the resulting voltage surge. This contact arrangement is for switching dc circuits only. As the SSD comes on very fast (<0.2 ms) these high break output contacts have the added advantage of being very fast operating. See the *High break contact operation* diagram below:

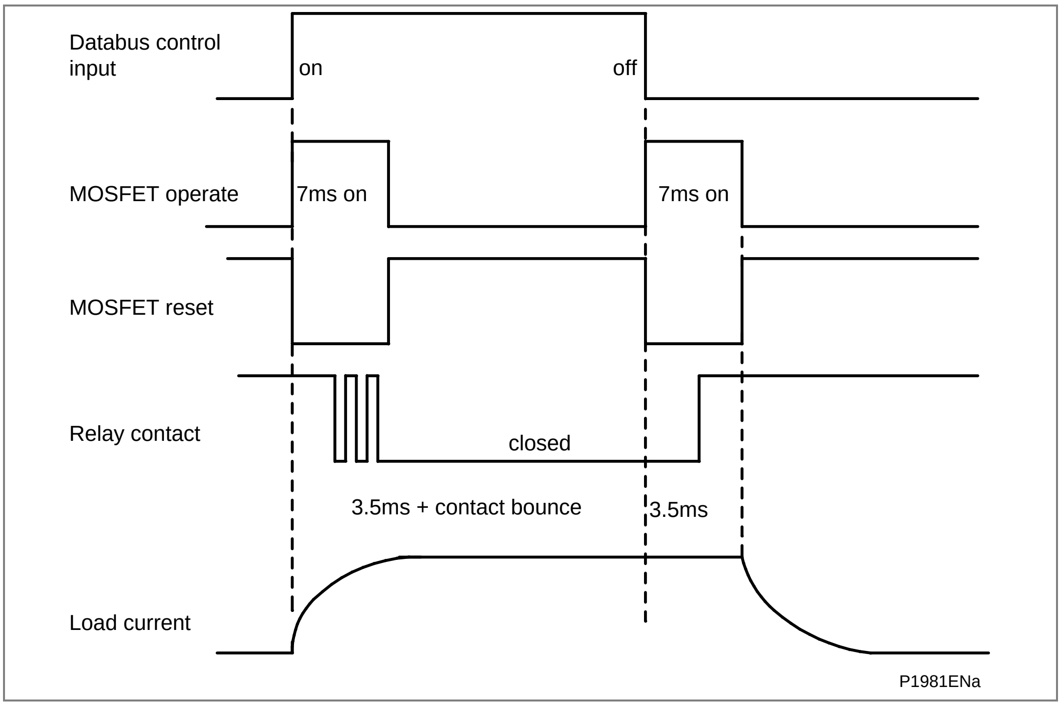


Figure 3 - High break contact operation

1.6.3.1 High Break Contact Applications

1. Efficient Scheme Engineering

   In traditional hardwired scheme designs, high break capability could only be achieved using external electromechanical trip relays. External tripping relays can be used or the high break contacts inside MiCOM relays can be used, reducing panel space.

2. Accessibility of CB Auxiliary Contacts

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

3. Breaker Fail

   The technique to use 52a contacts in trip circuits was described above. However, in the event of failure of the local circuit breaker (stuck breaker), or defective auxiliary contacts (stuck contacts), the 52a contact action is incorrect. The interrupting duty at the local breaker then falls on the relay output contacts which may not be rated to perform this duty. MiCOM high break contacts will avoid the risk of burnt relay contacts.

4. Initiation of Teleprotection

   The MiCOM high break contacts also offer fast making, which can provide faster tripping. Also fast keying of teleprotection is a benefit. Fast keying bypasses the usual contact operation time so that permissive, blocking and intertrip commands can be routed faster.

1.7 Hardware Communications Options

The Hardware Communications Options could mean that a second additional board is present if it was specified when the relay was ordered. Any such board is fitted into Slot A, as this is the optional communications slot.

The hardware options board commonly allows a choice of IRIG-B, Ethernet and Second Rear Comms Ports. Some of these choices are mutually exclusive whereas others provide more than one option on the same board. An up-to-date list of the available combinations for the Hardware/Software combination of this product is shown in the *Ordering Options* section in *Chapter 1 – Introduction*.

The main options are described in more detail in the these sections:

- IRIG-B Modulated and/or Un-modulated Board (Optional)
- Second Rear Communications Board (Optional)
- Ethernet Board (Options)

1.8 IRIG-B Modulated and/or Un-modulated Board (Optional)

The optional IRIG-B board is an order option that can be fitted to provide an accurate timing reference for the relay. This can be used wherever an IRIG-B signal is available. The IRIG-B signal is connected to the board with a BNC connector on the back of the relay. The timing information is used to synchronize the relay’s internal real-time clock to an accuracy of 1 ms. The internal clock is then used for the time tagging of the event, fault maintenance and disturbance records. Modulated IRIG-B is available on its own or with any of the other communications options. Un-modulated is only available on the optional Ethernet boards

1.9 Second Rear Communications Board (Optional)

For relays with Courier, MODBUS, IEC60870-5-103 or DNP3.0 protocol on the first rear communications port there is the hardware option of a second rear communications port, which runs the Courier language. This can be used over one of three physical links: twisted pair K-BUS (non-polarity sensitive), twisted pair EIA(RS)485 (connection polarity sensitive) or EIA(RS)232.

This optional second rear port is designed typically for dial-up modem access by protection engineers and operators, when the main port is reserved for SCADA traffic.

The port supports full local or remote protection and control access by MiCOM S1 Studio software. The second rear port is also available with an on board IRIG-B input.

The second rear communications board, Ethernet and IRIG-B boards are mutually exclusive since they use the same hardware slot. Two versions of second rear communications board are available; with and without modulated IRIG-B. The second rear communications board is shown in the following diagram.

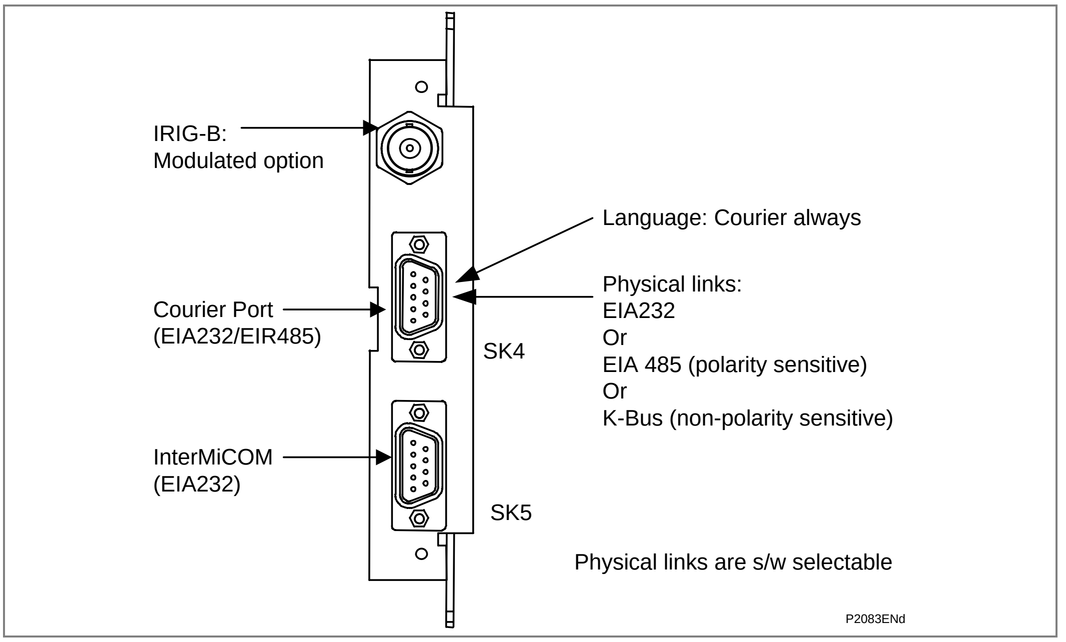


Figure 4 - Second rear comms. Port

1.10 Ethernet Board (Options)

This is a mandatory board for IEC 61850 enabled relays. It provides network connectivity through copper or fiber media at 100Mb/s. This board, the IRIG-B board and second rear comms. board are mutually exclusive as they all use slot A within the relay case.

All modules are connected by a parallel data and address bus that allows the processor board to send and receive information to and from the other modules as required. There is also a separate serial data bus for conveying sample data from the input module to the processor. The relay modules and information flow diagram shows the modules of the relay and the flow of information between them.

This optional board is required for providing network connectivity using IEC 61850 and/or DNP3oE. There are a variety of different boards which provide Ethernet connectivity.

Important	The choice of communication board options varies according to the Hardware Suffix and the Software Version of the MiCOM product. These are shown in the *Ordering Options* section in *Chapter 1 – Introduction*.

By way of example, the board options may include:

- single-port Ethernet boards (which use 100 Mbits/s Copper and modulated/unmodulated IRIG-B connectivity)
- Redundant Ethernet with PRP/HSR/Dual IP and a mixture of LC/RJ45 ports and modulated/unmodulated IRIG-B connectivity

These options are mutually exclusive as they all use slot A in the relay case.

Note	Each Ethernet board has a unique MAC address used for each Ethernet communication interface. The MAC address is printed on the rear of the board, next to the Ethernet sockets.

Note	The 100 Mbits/s Fiber Optic ports use LC type connectors and are suitable for 1310 nm multi-mode fiber type.

Copper ports use RJ45 type connectors. When using copper Ethernet, it is important to use Shielded Twisted Pair (STP) or Foil Twisted Pair (FTP) cables, to shield the IEC 61850 communications against electromagnetic interference. The RJ45 connector at each end of the cable must be shielded, and the cable shield must be connected to this RJ45 connector shield, so that the shield is grounded to the relay case. Both the cable and the RJ45 connector at each end of the cable must be Category 5 minimum, as specified by the IEC 61850 standard.

It is recommended that each copper Ethernet cable is limited to a maximum length of 3 m and confined to one bay or cubicle.

When using IEC61850 communications through the Ethernet board, the rear EIA(RS)485 and front EIA(RS)232 ports are available for simultaneous use. The front port always uses the Courier protocol. The rear port protocol depends upon the protocol option selected.

One example of an Ethernet board is shown in this *Ethernet board connectors* diagram:

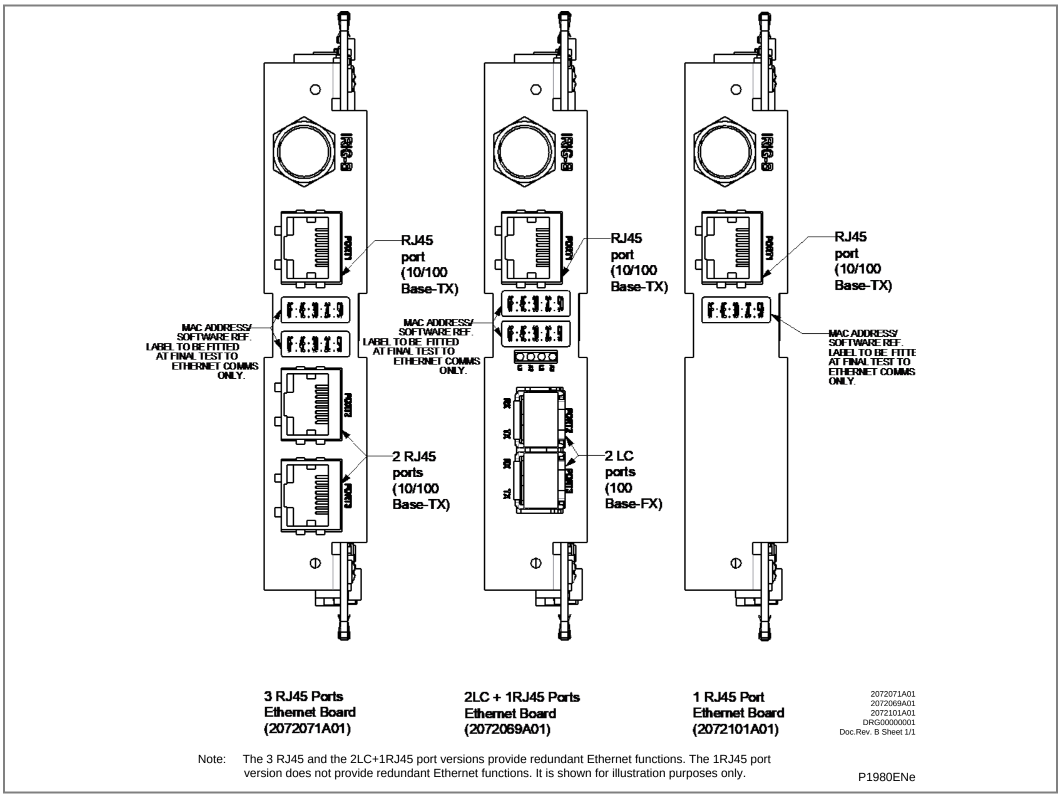


Figure 5 - Ethernet board connectors (3 RJ45 or 2 LC + RJ45 or 1 RJ45)

2 RELAY SOFTWARE

The relay software was introduced in the overview of the relay at the start of this chapter. The software can be considered to be made up of these sections:

- The real-time operating system
- The system services software
- The platform software
- The protection and control software

These four elements are all processed by the same processor board.This section describes in detail the ***platform software*** and the ***protection and control software***, which between them control the functional behavior of the relay. The following *Relay software structure* diagram shows the structure of the relay software.

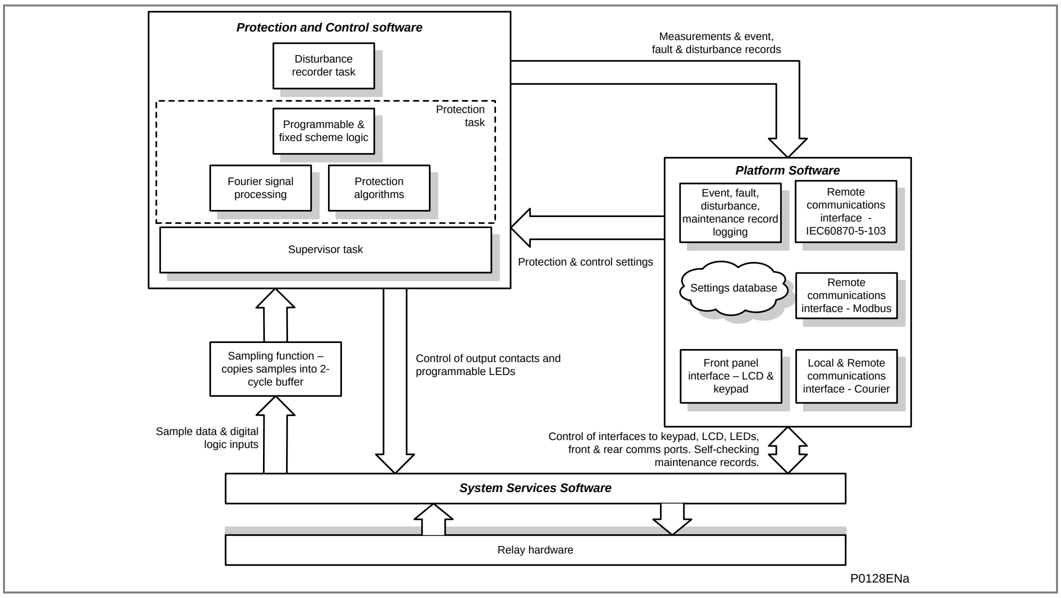


Figure 6 - Relay software structure

2.1 Real-Time Operating System

The real-time operating system provides a framework for the different parts of the relay's software to operate in.

The software is split into tasks; the real-time operating system is used to schedule the processing of the tasks to ensure that they are processed in the time available and in the desired order of priority. The operating system is also responsible in part for controlling the communication between the software tasks through the use of operating system messages.

2.2 System Services Software

As shown in the above *Relay software structure* diagram, the system services software provides the low-level control of the relay hardware. It also provides the interface between the relay's hardware and the higher-level functionality of the platform software and the protection and control software.

For example, the system services software provides drivers for items such as the LCD display, the keypad and the remote communication ports. It also controls the boot of the processor and downloading of the processor code into SRAM from non-volatile flash EPROM at power up.

2.3 Platform Software

The platform software has these main functions:

- To deal with the management of the relay settings.
- To control the logging of all records that are generated by the protection software, including alarms and event, fault, disturbance and maintenance records.
- To store and maintain a database of all of the relay's settings in non-volatile memory.
- To provide the internal interface between the settings database and each of the relay's user interfaces. These interfaces are the front panel interface and the front and rear communication ports, using whichever communication protocol has been specified (Courier, MODBUS, IEC60870-5-103 and DNP3.0). The platform software converts the information from the database into the format required.

The platform software notifies the protection and control software of all settings changes and logs data as specified by the protection and control software.

2.3.1 Record Logging

The logging function is provided to store all alarms, events, faults and maintenance records. The records for all of these incidents are logged in battery backed-up SRAM to provide a non-volatile log of what has happened. The relay maintains four logs: one each for up to 32 alarms, 512 event records, 20 fault records and 10 maintenance records. The logs are maintained so that the oldest record is overwritten with the newest record. The logging function can be initiated from the protection software or the platform software.

The logging function can be initiated from the protection software or the platform software, and is responsible for logging of a maintenance record in the event of a relay failure. This includes errors that have been detected by the platform software itself or error that are detected by either the system services or the protection software functions. See also the section on *Self-Testing and Diagnostics* later in this section.

2.3.2 Settings Database

The settings database contains all of the settings and data for the relay, including the protection, disturbance recorder and control and support settings. The settings are maintained in non-volatile memory. The platform software's management of the settings database make sure that only one user interface modifies the database settings at any one time. This feature is used to avoid confusion between different parts of the software during a setting change. For changes to protection settings and disturbance recorder settings, the platform software operates a 'scratchpad' in SRAM memory. This allows a number of setting changes to be made in any order but applied to the protection elements, disturbance recorder and saved in the database in non-volatile memory, at the same time. If a setting change affects the protection and control task, the database advises it of the new values.

The database is directly compatible with Courier communications.

2.3.3 Database Interface

The other function of the platform software is to implement the relay's internal interface between the database and each of the relay's user interfaces. The database of settings and measurements must be accessible from all of the relay's user interfaces to allow read and modify operations. The platform software presents the data in the appropriate format for each user interface.

2.4 Protection and Control Software

The protection and control software interfaces with the platform software for settings changes and logging of records, and with the system services software for acquisition of sample data and access to output relays and digital opto-isolated inputs. It also performs the calculations for all of the protection algorithms of the relay. This includes digital signal processing such as Fourier filtering and ancillary tasks such as the disturbance recorder.

The protection and control software task processes all of the protection elements and measurement functions of the relay. It has to communicate with both the system services software and the platform software, and organize its own operations. The protection software has the highest priority of any of the software tasks in the relay, to provide the fastest possible protection response. It also has a supervisor task that controls the start-up of the task and deals with the exchange of messages between the task and the platform software.

After initialization at start-up, the protection and control task waits until there are enough samples to process. The sampling function is called by the system services software and takes each set of new samples from the input module and stores them in a two-cycle buffer. The protection and control software resumes execution when the number of unprocessed samples in the buffer reaches a certain number. Samples are taken 24 times every power cycle. Every 6 samples the protection task is executed (4 times per cycle). The protection elements are split into groups so that different elements are processed each time, and every element is processed at least once per cycle. The protection and control software is suspended again when all of its processing on a set of samples is complete. This allows operations by other software tasks to take place.

2.4.1 Signal Processing

The sampling function filters the digital input signals from the opto-isolators and tracks the frequency of the analog signals. The digital inputs are checked against their previous value over a period of half a cycle. Therefore a change in the state of one of the inputs must be maintained over at least half a cycle before it is registered with the protection and control software.

The frequency tracking of the analog input signals is achieved by a recursive Fourier algorithm which is applied to one of the input signals, and works by detecting a change in the measured signal’s phase angle. The calculated value of the frequency is used to modify the sample rate being used by the input module to achieve a constant sample rate of 24 samples per cycle of the power waveform. The value of the frequency is also stored for use by the protection and control task.

When the protection and control task is re-started by the sampling function, it calculates the Fourier components for the analog signals. The Fourier components are calculated using a one-cycle, 24-sample Discrete Fourier Transform (DFT). The DFT is always calculated using the last cycle of samples from the 2-cycle buffer, which is the most recent data. Used in this way, the DFT extracts the power frequency fundamental component from the signal and produces the magnitude and phase angle of the fundamental in rectangular component format. The DFT provides an accurate measurement of the fundamental frequency component, and effective filtering of harmonic frequencies and noise. This performance is achieved with the relay input module which provides hardware anti-alias filtering to attenuate frequencies above the half sample rate, and frequency tracking to maintain a sample rate of 24 samples per cycle. The Fourier components of the input current and voltage signals are stored in memory so they can be accessed by all of the protection elements’ algorithms. The samples from the input module are also used in an unprocessed form by the disturbance recorder for waveform recording and to calculate true RMS values of current, voltage and power for metering purposes.

2.4.2 Frequency Response

With the exception of the RMS measurements, all other measurements and protection functions are based on the Fourier-derived fundamental component. The fundamental component is extracted by using a 24-sample DFT. This gives good harmonic rejection for frequencies up to the 23rd harmonic. The 23rd is the first predominant harmonic that is not attenuated by the Fourier filter and this is known as an 'Alias'. However, the Alias is attenuated by approximately 85% by an additional, analog, 'anti-aliasing' filter (low pass filter). The combined affect of the anti-aliasing and Fourier filters is shown in the following *Frequency response* diagram.

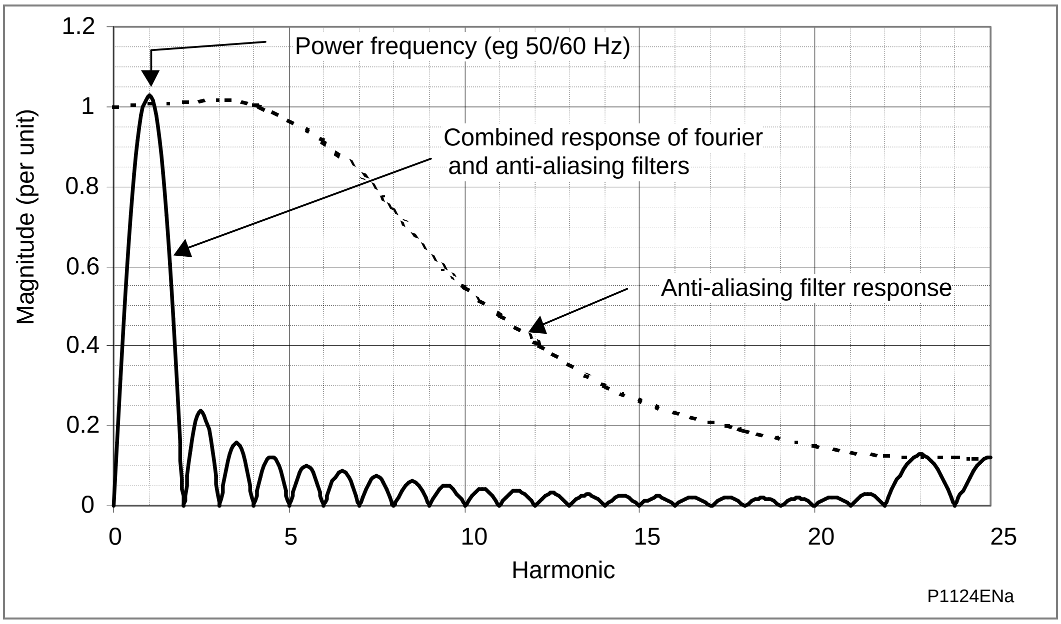


Figure 7 - Frequency response

For power frequencies that are not equal to the selected rated frequency, the harmonics are attenuated to zero amplitude. For small deviations of ±1Hz, this is not a problem but to allow for larger deviations, frequency tracking is used.

Frequency tracking automatically adjusts the sampling rate of the analog to digital conversion to match the applied signal. In the absence of a suitable signal to amplitude track, the sample rate defaults to the selected rated frequency (Fn). If the a signal is in the tracking range of 45 to 66 Hz, the relay locks onto the signal and the measured frequency coincides with the power frequency as shown in the above *Frequency response* diagram. The outputs for harmonics up to the 23rd are zero. The relay frequency tracks off any voltage or current in the order VA/VB/VC/IA/IB/IC down to 10% Vn for voltage and 5%In for current.

2.4.3 Programmable Scheme Logic (PSL)

The Programmable Scheme Logic (PSL) allows the relay user to configure an individual protection scheme to suit their own particular application. This is done with programmable logic gates and delay timers.

The input to the PSL is any combination of the status of the digital input signals from the opto-isolators on the input board, the outputs of the protection elements such as protection starts and trips, and the outputs of the fixed PSL. The fixed PSL provides the relay's standard protection schemes. The PSL consists of software logic gates and timers. The logic gates can be programmed to perform a range of different logic functions and can accept any number of inputs. The timers are used either to create a programmable delay or to condition the logic outputs, such as to create a pulse of fixed duration on the output, regardless of the length of the pulse on the input. The outputs of the PSL are the LEDs on the front panel of the relay and the output contacts at the rear.

The execution of the PSL logic is event driven: the logic is processed whenever any of its inputs change, for example as a result of a change in one of the digital input signals or a trip output from a protection element. Also, only the part of the PSL logic that is affected by the particular input change that has occurred is processed. This reduces the amount of processing time that is used by the PSL. The protection and control software updates the logic delay timers and checks for a change in the PSL input signals every time it runs.

This system provides flexibility for the user to create their own scheme logic design. However, it also means that the PSL can be configured into a very complex system, and because of this setting of the PSL is implemented through the PC support package Easergy Studio/MiCOM S1 Studio.

2.4.4 Function Key Interface

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

2.4.4.1 PSL Data

In the PSL editor in MiCOM S1 Studio, when a PSL file is downloaded to the relay the user can specify the group to download the file and a 32 character PSL reference description. This PSL reference is shown in the **Grp. 1/2/3/4 PSL Ref.** cell in the **PSL DATA** menu in the relay. The download date and time and file checksum for each group's PSL file is also shown in the **PSL DATA** menu in cells **Date/Time** and **Grp. 1/2/3/4 PSL ID**. The PSL data can be used to show if a PSL has been changed and can 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 **P746??????0yy0?** where x refers to the model such as 1, 2, 3 and yy refers to the software version such as 05. 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.

The default date and time is the date and time when the defaults were loaded.

Note	*The PSL DATA column information is only supported by Courier and MODBUS, but not DNP3.0 or IEC60870-5-103.*

2.4.5 Event, Fault and Maintenance Recording

A change in any digital input signal or protection element output signal is used to indicate that an event has taken place. When this happens, the protection and control task sends a message to the supervisor task to show that an event is available to be processed. The protection and control task writes the event data to a fast buffer in SRAM that is controlled by the supervisor task. When the supervisor task receives either an event or fault record message, it instructs the platform software to create the appropriate log in battery backed-up SRAM. The supervisor's buffer is faster than battery backed-up SRAM, therefore the protection software is not delayed waiting for the records to be logged by the platform software. However, if a large number of records to be logged are created in a short time, some may be lost if the supervisor's buffer is full before the platform software is able to create a new log in battery backed-up SRAM. If this occurs, an event is logged to indicate this loss of information.

Maintenance records are created in a similar manner with the supervisor task instructing the platform software to log a record when it receives a maintenance record message. However, it is possible that a maintenance record may be triggered by a fatal error in the relay, in which case it may not be possible to successfully store a maintenance record, depending on the nature of the problem. See the *Self-Testing and Diagnostics* section.

Fault records are stored in the sequence of events. They can be viewed locally or remotely and include:

- Faulty phase(s)
- Protection Tripped
- Protection Started
- Fault duration
- Fault type (Zone internal or external fault)
- Operating time
- Primary or Secondary RMS values of each current input
- Primary or Secondary RMS values of differential and biased current of each phase

2.4.6 Disturbance Recorder

The analog values and logic signals are routed from the protection and control software to the disturbance recorder software. The platform software interfaces with the disturbance recorder to allow the stored records to be extracted.

The disturbance recording is started from any relay start or trip, or any specific opto-isolator input or internal information. The recording time is user selectable up to a maximum of 10 seconds. The disturbance recorder operates as a separate task to the protection and control task. It can record the waveforms for up to 21 analog channels and the values of up to 32 digital signals. The disturbance recorder is supplied with data once per cycle by the protection and control task. The disturbance recorder collates the data that it receives into the required length disturbance record. The disturbance records that can also store the data in COMTRADE format can be extracted using MiCOM S1 Studio, allowing the use of other packages to view the recorded data.

3 SELF-TESTING AND DIAGNOSTICS

The relay includes several self-monitoring functions to check the operation of its hardware and software when it is in service. These are included so that if an error or fault occurs in the relay's hardware or software, the relay is able to detect and report the problem and attempt to resolve it by performing a reboot. The relay must therefore be out of service for a short time, during which the **Healthy** LED on the front of the relay is OFF and, the watchdog contact at the rear is ON. If the reboot fails to resolve the problem, the relay takes itself permanently out of service; the **Healthy** LED stays OFF and watchdog contact stays ON.

If a problem is detected by the self-monitoring functions, the relay stores a maintenance record in battery backed-up SRAM.

The self-monitoring is implemented in two stages:

- firstly a thorough diagnostic check that is performed when the relay is booted-up
- secondly a continuous self-checking operation that checks the operation of the relay's critical functions while it is in service.

3.1 Start-Up Self-Testing

The self-testing that is carried out when the relay is started takes a few seconds to complete, during which time the relay's protection is unavailable. This is shown by the **Healthy** LED on the front of the relay which is ON when the relay has passed all tests and entered operation. If the tests detect a problem, the relay remains out of service until it is manually restored to working order.

The operations that are performed at start-up are:

- System Boot
- Initialization Software
- Platform Software Initialization and Monitoring

3.1.1 System Boot

The integrity of the flash memory is verified using a checksum before the program code and data are copied into SRAM and executed by the processor. When the copy is complete the data then held in SRAM is checked against that in flash memory to ensure they are the same and that no errors have occurred in the transfer of data from flash memory to SRAM. The entry point of the software code in SRAM is then called which is the relay initialization code.

3.1.2 Initialization Software

The initialization process includes the operations of initializing the processor registers and interrupts, starting the watchdog timers (used by the hardware to determine whether the software is still running), starting the real-time operating system and creating and starting the supervisor task.

In the initialization process the relay checks the following.

- The status of the battery
- The integrity of the battery backed-up SRAM that stores event, fault and disturbance records
- The voltage level of the field voltage supply that drives the opto-isolated inputs
- The operation of the LCD controller
- The watchdog operation

When the initialization software routine is complete, the supervisor task starts the platform software.

3.1.3 Platform Software Initialization and Monitoring

In starting the platform software, the relay checks the integrity of the data held in non-volatile memory with a checksum, the operation of the real-time clock, and the IRIG-B board if fitted. The final test that is made concerns the input and output of data; the presence and healthy condition of the input board is checked and the analog data acquisition system is checked through sampling the reference voltage.

At the successful conclusion of all of these tests the relay is entered into service and the protection started-up.

3.2 Continuous Self-Testing

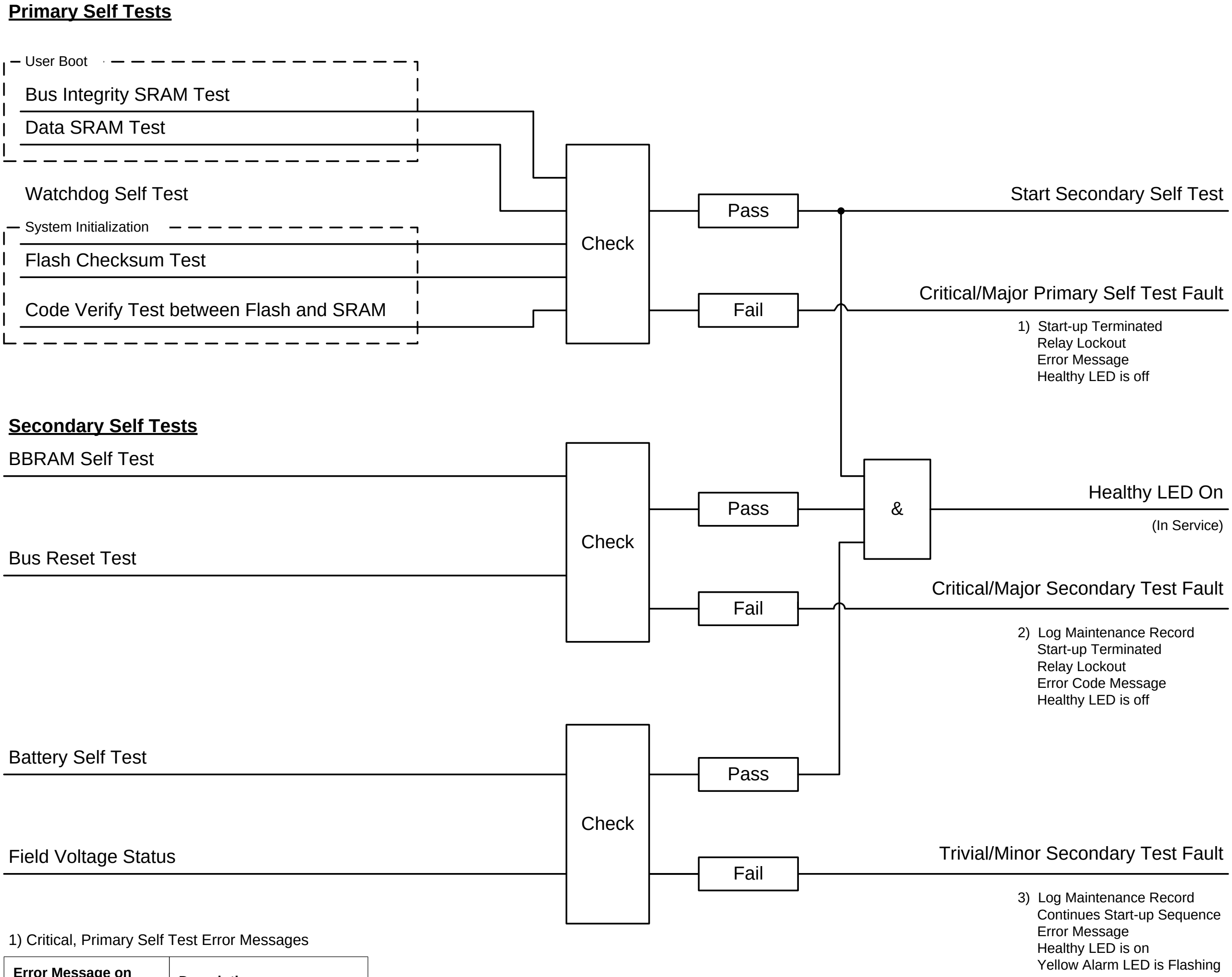
When the relay is in service, it continually checks the operation of the critical parts of its hardware and software. The checking is carried out by the system services software (see section on relay software earlier in this section) and the results reported to the platform software.

The functions that are checked are as follows:

- The flash EPROM containing all program code and language text is verified by a checksum
- The code and constant data held in SRAM is checked against the corresponding data in flash EPROM to check for data corruption
- The SRAM containing all data other than the code and constant data is verified with a checksum
- The non-volatile memory containing setting values is verified by a checksum, whenever its data is accessed
- The battery status
- The level of the field voltage
- The integrity of the digital signal I/O data from the opto-isolated inputs and the relay contacts, is checked by the data acquisition function every time it is executed. The operation of the analog data acquisition system is checked by the acquisition function every time it is executed. This is done by sampling the reference voltage on a spare multiplexed channel
- The operation of the IRIG-B board is checked, where it is fitted, by the software that reads the time and date from the board

If the Ethernet board is fitted, it is checked by the software on the main processor board. If the Ethernet board fails to respond, an alarm is raised and the board is reset in an attempt to resolve the problem

In the unlikely event that one of the checks detects an error in the relay’s subsystems, the platform software is notified and it will attempt to log a maintenance record in battery backed-up SRAM. If the problem is with the battery status or the IRIG-B board, the relay continues in operation. However, for problems detected in any other area the relay shuts down and reboots. This result in a period of up to 5 seconds when protection is unavailable, but the complete restart of the relay including all initializations should clear most problems that could occur. An integral part of the start-up procedure is a thorough diagnostic self-check. If this detects the same problem that caused the relay to restart, the restart has not cleared the problem and the relay takes itself permanently out of service. This is indicated by the **Healthy** LED on the front of the relay which goes OFF, and the watchdog contact that goes ON.



1) Critical, Primary Self Test Error Messages

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

2) Critical, Secondary Self Test Error Messages

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

3) Trivial, Secondary Power on Self Tests Alarm Indications

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

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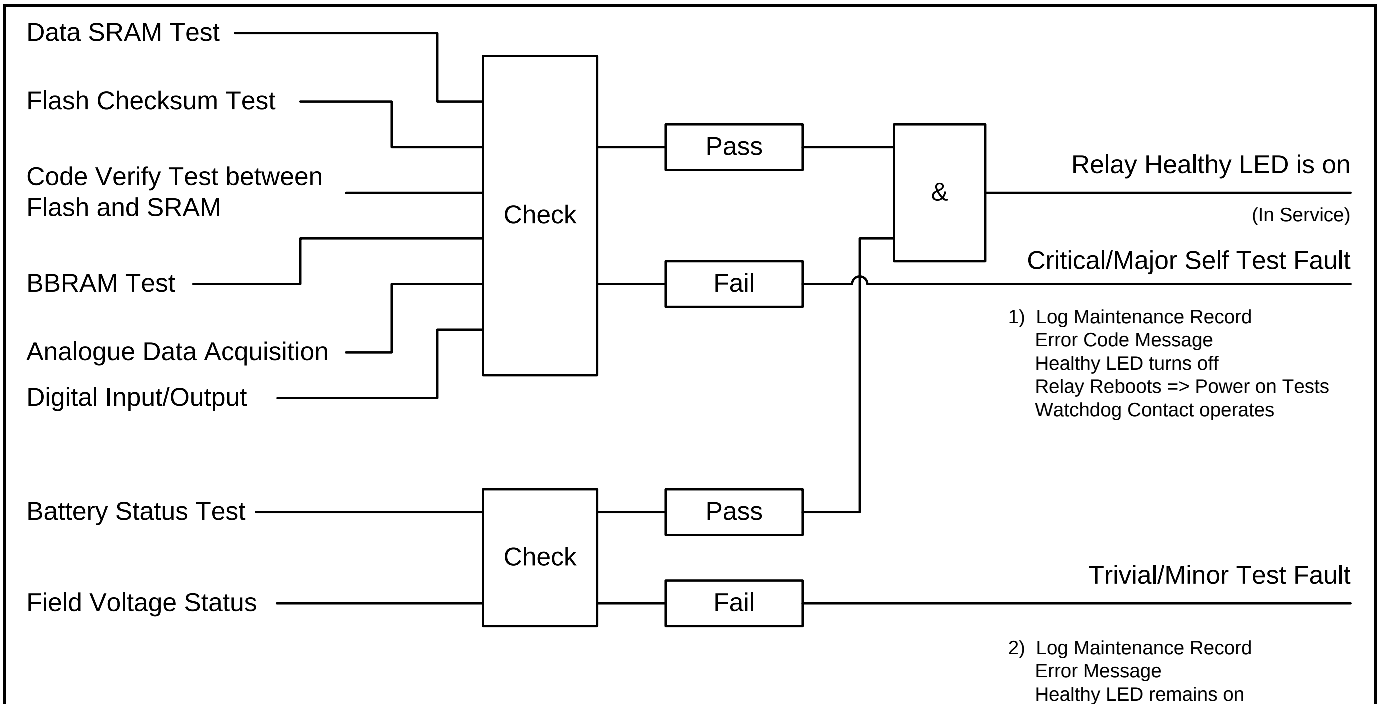
Figure 8 - Start-up self-testing logic



1) Critical, Continuous Self-Test Error codes

Error Code	Description
0x0C160011	The continuous self tests detected an error in SRAM
0x0C160012	The continuous self tests detected an error in the Flash memory checksum
0x0C160013	The continuous self tests detected an error in the code comparison
0x0C160014	The continuous self tests detected an error in the Battery Backed RAM
0x0C1600A0	The continuous self tests detected an error in the acquisition card
0x0C1600Bn	The continuous self tests detected an error in relay card n (number from 0)
0x0C1600Cn	The continuous self tests detected an error in opto card n (number from 0)

2) Trivial, Continuous Self-Test alarm indications

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

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Figure 9 - Continuous self-testing logic

Notes:

COMMISSIONING

CHAPTER 11

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Hardware Suffix:	M
Software Version:	B4 (P746_1) / C4 (P746_2)
Connection Diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

Page (CM) 11-

TABLES

FIGURES

Notes:

1 INTRODUCTION

About MiCOM Range

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

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

The components within MiCOM are:

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

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

For up-to-date information, please see:

www.schneider-electric.com

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

The MiCOM P40 range of products includes various devices which have different functions. This chapter includes information related to the Commissioning of one or more of these devices. Many, although not all, of the commissioning tasks are common to these products.

This chapter applies to the MiCOM P40 product(s) shown on the second page of this chapter. If no product/variant applicability is stated, this means the following information relates to all the products/variants in shown on the second page of this chapter. Where a particular section or paragraph relates only to some of the products/variants, this is stated in the heading or at the beginning of the paragraph or section.

When using this chapter, you (i.e. in your role as the Commissioning Engineer), need to be aware of:

- The MiCOM product number you are commissioning
- The features associated with that MiCOM product number
- The subset of features which have been enabled for the specific piece of equipment you are commissioning
- Any work instructions which determine how the equipment should be installed and which of its functions have been enabled and how they should relate to other equipment
- You will then be able to select which of the following sections/subsections you need to follow. Some of these sections will not be relevant for the particular commissioning tasks you are performing. By way of example, if the MiCOM device you are commissioning has an Auto-Reclose function you need to refer to the sections which cover Auto-Reclose, otherwise you can ignore them.
- You should start using this chapter at the beginning and work your way through to the end. At key points in the chapter, you will have to know what technical functions have been enabled, as you may be asked to omit certains sections of this chapter if they are not relevant for your current commissioning task.

MiCOM P40 relays are fully numerical in their design, implementing all protection and non-protection functions in software. The relays use a high degree of self-checking and give an alarm in the unlikely event of a failure. Therefore, the commissioning tests do not need to be as extensive as with non-numeric electronic or electro-mechanical relays.

To commission numeric relays, it is only necessary to verify that the hardware is functioning correctly and the application-specific software settings have been applied to the relay. It is considered unnecessary to test every function of the relay if the settings have been verified by one of the following methods:

- Extracting the settings applied to the relay using appropriate setting software (preferred method)
- Using the operator interface

To confirm that the product is operating correctly once the application-specific settings have been applied, perform a test on a single protection element.

Unless previously agreed to the contrary, the customer is responsible for determining the application-specific settings to be applied to the relay and for testing any scheme logic applied by external wiring or configuration of the relay’s internal programmable scheme logic.

Blank commissioning test and setting records are provided within this manual for completion as required.

As the relay’s menu language is user-selectable, the Commissioning Engineer can change it to allow accurate testing as long as the menu is restored to the customer’s preferred language on completion.

To simplify the specifying of menu cell locations in these Commissioning Instructions, they are given in the form [courier reference: COLUMN HEADING, Cell Text]. For example, the cell for selecting the menu language (first cell under the column heading) is in the System Data column (column 00) so it is given as [0001: SYSTEM DATA, Language].

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

Caution	**The relay must not be disassembled in any way during commissioning.**

2 SETTING FAMILIARISATION

When first commissioning a relay, allow sufficient time to become familiar with how to apply the settings.

The *Relay Menu Database document* and the *Introduction* or *Settings* chapters contain a detailed description of the menu structure of Schneider Electric relays. The relay menu database is a separate document which can be downloaded from our website:

www.schneider-electric.com

With the secondary front cover in place, all keys except the ⏎ key are accessible. All menu cells can be read. LEDs and alarms can be reset. However, no protection or configuration settings can be changed, or fault and event records cleared.

Removing the secondary front cover allows access to all keys so that settings can be changed, LEDs and alarms reset, and fault and event records cleared. However, to make changes to menu cells, the appropriate user role and password is needed.

Alternatively, if a portable PC with suitable setting software is available (such as MiCOM S1 Studio), the menu can be viewed one page at a time, to display a full column of data and text. This PC software also allows settings to be entered more easily, saved to a file for future reference, or printed to produce a settings record. Refer to the PC software user manual for details. If the software is being used for the first time, allow sufficient time to become familiar with its operation.

3 EQUIPMENT REQUIRED FOR COMMISSIONING

3.1 Minimum Equipment Required

The minimum equipment needed varies slightly, depending on the features provided by each type of MiCOM product. The list of minimum equipment is given below:

- A portable PC, with an RS232 port as well as appropriate software
- Multifunctional dynamic current and voltage injection test set
- Multimeter with suitable ac current range, and ac and dc voltage ranges of 0 - 440V and 0 - 250V respectively
- Continuity tester (if not included in multimeter)
- Phase angle meter
- Phase rotation meter

Note *Modern test equipment may contain many of the above features in one unit.*

3.2 Optional Equipment

- Fiber optic power meter (and fibre optic test leads may be required depending upon application).
- Multi-finger test plug type Easergy test plug (if Easergy test block type is installed)
- An electronic or brushless insulation tester with a dc output not exceeding 500 V (for insulation resistance testing when required)
- K-Bus to EIA(RS)232 protocol converter (if the first rear EIA(RS)485 K-Bus port or second rear port configured for K-Bus is being tested and one is not already installed)
- EIA(RS)485 to EIA(RS)232 converter (if first rear EIA(RS)485 port or second rear port configured for EIA(RS)485 is being tested)
- A printer, for printing a setting record from the portable PC

4 PRODUCT CHECKS

These product checks cover all aspects of the relay that need to be checked to ensure:

- that it has not been physically damaged before commissioning
- that it is functioning correctly and
- that all input quantity measurements are within the stated tolerances

If the application-specific settings have been applied to the relay before commissioning, it is advisable to make a copy of the settings to allow their restoration later.

If Programmable Scheme Logic (PSL) (other than the default settings with which the relay was supplied) has been applied, the default settings should be restored before commissioning. This can be done by:

- Obtaining a setting file from the customer. This requires a portable PC with appropriate setting software for transferring the settings from the PC to the relay.
- Extracting the settings from the relay itself. This requires a portable PC with appropriate setting software.
- Manually creating a setting record. This could be done by stepping through the front panel menu using the front panel user interface.

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

4.1 With the Relay De-Energised

The following group of tests should be carried out without the auxiliary supply applied to the relay and with the trip circuit isolated.

Before inserting the test plug, refer to the scheme diagram to ensure this will not cause damage or a safety hazard. For example, the test block may be associated with protection current transformer circuits. Before the test plug is inserted into the test block, make sure the sockets in the test plug which correspond to the current transformer secondary windings are linked.

Warning **The current and voltage transformer connections must be isolated from the relay for these checks. If a MiCOM P991 or an Easergy test block is provided, insert the Easergy or MiCOM P992 test plug, which open-circuits all wiring routed through the test block.**

Danger **Never open-circuit the secondary circuit of a current transformer because the high voltage produced may be lethal. It could also damage insulation.**

If a test block is not provided, isolate the voltage transformer supply to the relay using the panel links or connecting blocks. Short-circuit and disconnect the line current transformers from the relay terminals. Where means of isolating the auxiliary supply and trip circuit (such as isolation links, fuses and MCB) are provided, these should be used. If this is impossible, the wiring to these circuits must be disconnected and the exposed ends suitably terminated to prevent them from being a safety hazard.

4.1.1 Visual Inspection

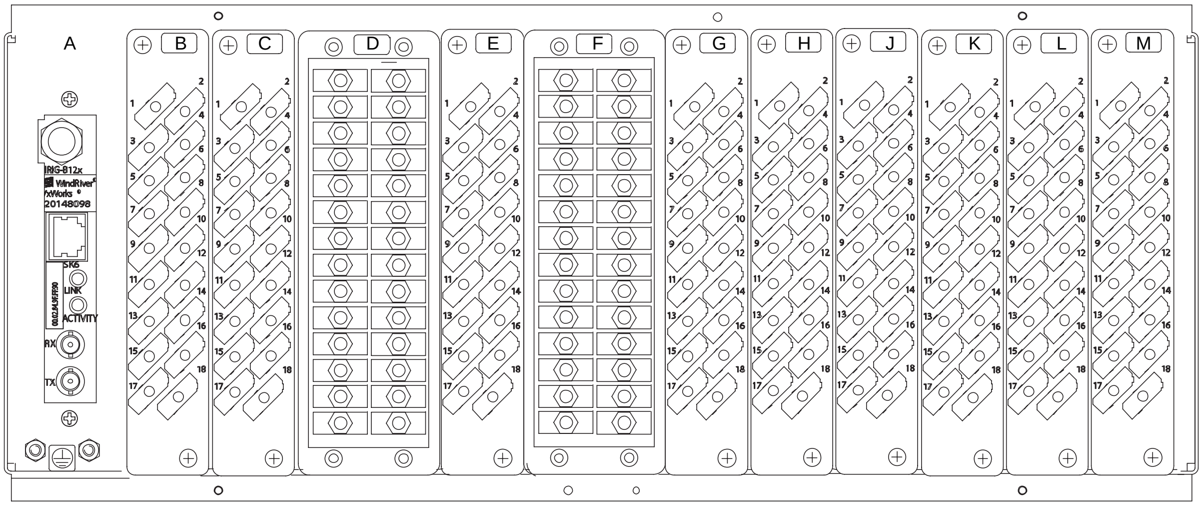
Caution	Check the rating information under the top access cover on the front of the relay. Check that the relay being tested is correct for the protected line or circuit. Ensure that the circuit reference and system details are entered onto the setting record sheet. Double-check the CT secondary current rating, and be sure to record the actual CT tap which is in use.

Carefully examine the relay to see that no physical damage has occurred since installation.

Ensure that the case earthing connections, at the bottom left-hand corner at the rear of the relay case, are used to connect the relay to a local earth bar using an adequate conductor.

4.1.2 Current Transformer Shorting Contacts

If required, the current transformer shorting contacts can be checked to ensure that they close when the heavy duty terminal block shown in the following figure(s) is disconnected from the current input PCB. The heavy duty terminal block location depends on the relay model.



A – IRIG-B / Ethernet / COMMS
B – Opto / high break
C - Opto / high break
D – Sigma Delta analogue input board
E – Sigma Delta Opto Board
F – Sigma Delta analogue input board
G – Sigma Delta Opto Board
H – Relay / Opto / high break
J – Relay / high break
K - Relay / high break
L – Relay board
M – Power supply board

P3xxxENx

Figure 1 - Rear terminal blocks on P746

Heavy duty terminal blocks are fastened to the rear panel using four Pozidriv or PZ1 screws. These are at the top and bottom between the first and second, and third and fourth, columns of terminals (see the *Location of Securing Screws for Terminal Blocks* diagram below).

Note	*Use a magnetic-bladed screwdriver to avoid losing screws or leaving them in the terminal block.*

Pull the terminal block away from the rear of the case and check with a continuity tester that all the shorting switches being used are closed. The following table(s) shows the terminals between which shorting contacts are fitted.

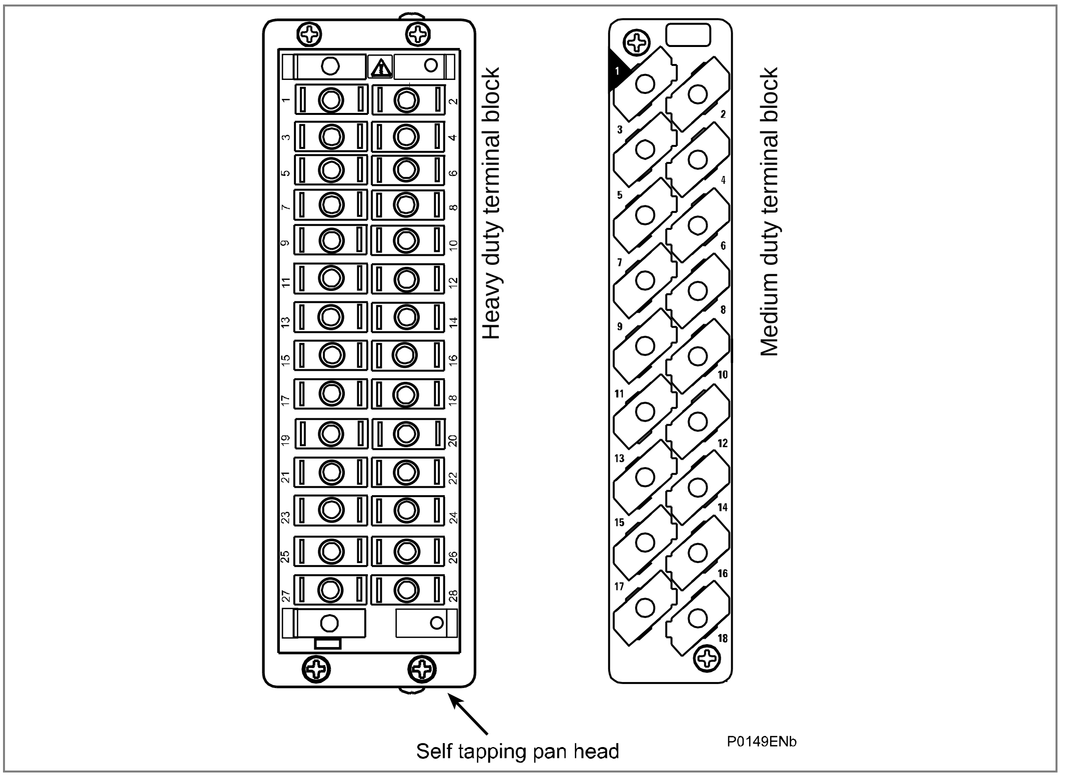


Figure 2 - Location of securing screws for heavy duty terminal blocks

Current input		Shorting contact between terminals
one box mode	three box mode	
$I_{A(1)}$	$I_{A(1)}$ (or $I_{B(1)}$ or $I_{C(1)}$)	D23 - D24
$I_{B(1)}$	$I_{A(2)}$ (or $I_{B(2)}$ or $I_{C(2)}$)	D25 - D26
$I_{C(1)}$	$I_{A(3)}$ (or $I_{B(3)}$ or $I_{C(3)}$)	D27 - D28
$I_{A(2)}$	$I_{A(4)}$ (or $I_{B(4)}$ or $I_{C(4)}$)	D17 - D18
$I_{B(2)}$	$I_{A(5)}$ (or $I_{B(5)}$ or $I_{C(5)}$)	D19 - D20
$I_{C(2)}$	$I_{A(6)}$ (or $I_{B(6)}$ or $I_{C(6)}$)	D21 - D22
$I_{A(3)}$	$I_{A(7)}$ (or $I_{B(7)}$ or $I_{C(7)}$)	D11 - D12
$I_{B(3)}$	$I_{A(8)}$ (or $I_{B(8)}$ or $I_{C(8)}$)	D13 - D14
$I_{C(3)}$	$I_{A(9)}$ (or $I_{B(9)}$ or $I_{C(9)}$)	D15 - D16
$I_{A(4)}$	$I_{A(10)}$ (or $I_{B(10)}$ or $I_{C(10)}$)	F23 - F24
$I_{B(4)}$	$I_{A(11)}$ (or $I_{B(11)}$ or $I_{C(11)}$)	F25 - F26
$I_{C(4)}$	$I_{A(12)}$ (or $I_{B(12)}$ or $I_{C(12)}$)	F27 - F28
$I_{A(5)}$	$I_{A(13)}$ (or $I_{B(13)}$ or $I_{C(13)}$)	F17 - F18
$I_{B(5)}$	$I_{A(14)}$ (or $I_{B(14)}$ or $I_{C(14)}$)	F19 - F20
$I_{C(5)}$	$I_{A(15)}$ (or $I_{B(15)}$ or $I_{C(15)}$)	F21 - F22
$I_{A(6)}$	$I_{A(16)}$ (or $I_{B(16)}$ or $I_{C(16)}$)	F11 - F12
$I_{B(6)}$	$I_{A(17)}$ (or $I_{B(17)}$ or $I_{C(17)}$)	F13 - F14
$I_{C(6)}$	$I_{A(18)}$ (or $I_{B(18)}$ or $I_{C(18)}$)	F15 - F16
$I_{A(7)}$	$I_{A(19)}$ (or $I_{B(19)}$ or $I_{C(19)}$)	D7 - D8 (P746_2 only)
$I_{B(7)}$	$I_{A(20)}$ (or $I_{B(20)}$ or $I_{C(20)}$)	D9 - D10 (P746_2 only)
$I_{C(7)}$	$I_{A(21)}$ (or $I_{B(21)}$ or $I_{C(21)}$)	F7 - F8 (P746_2 only)

Table 1 - Current transformer shorting contact locations

4.1.3 Insulation

Insulation resistance tests are only necessary during commissioning if it is required for them to be done and they have not been performed during installation.

Isolate all wiring from the earth and test the insulation with an electronic or brushless insulation tester at a dc voltage not exceeding 500V. Terminals of the same circuits should be temporarily connected together.

The main groups of relay terminals are:

a. Current transformer circuits
b. Auxiliary voltage supply.
c. Field voltage output and opto-isolated control inputs.
d. Relay contacts.
e. Case earth.

The insulation resistance should be greater than 100MΩ at 500V.

On completion of the insulation resistance tests, ensure all external wiring is correctly reconnected to the relay.

4.1.4 External wiring

Caution	**Check that the external wiring is correct to the relevant relay diagram and scheme diagram. Ensure as far as practical that phasing/phase rotation appears to be as expected. The relay diagram number appears on the rating label under the top access cover on the front of the relay.** **Schneider Electric supply the corresponding connection diagram with the order acknowledgement for the relay.**

If a MiCOM P991 or an Easergy test block is provided, check the connections against the wiring diagram. It is recommended that the supply connections are to the live side of the test block (colored orange with the odd numbered terminals 1, 3, 5, 7, and so on). The auxiliary supply is normally routed through terminals 13 (supply positive) and 15 (supply negative), with terminals 14 and 16 connected to the relay's positive and negative auxiliary supply terminals respectively. However, check the wiring against the schematic diagram for the installation to ensure compliance with the customer's normal practice.

4.1.5 Watchdog Contacts

Using a continuity tester, check that the watchdog contacts are in the states shown in the *Watchdog contact statu*s table for a de-energized relay.

Terminals	Contact state	
	Relay de-energised	Relay energised
M11 – M12	Closed	Open
M13 – M14	Open	Closed

Table 2 - Watchdog contact status

4.1.6 Auxiliary Supply

Caution	The relay can be operated from either a dc only or an ac/dc auxiliary supply depending on the relay's nominal supply rating. The incoming voltage must be within the operating range specified in the following table.

Without energizing the relay, measure the auxiliary supply to ensure it is within the operating range.

Note	*The relay can withstand an ac ripple of up to 12% of the upper rated voltage on the dc auxiliary supply.*

Nominal Supply Rating		Operating Ranges	
dc	ac	dc	ac
24 - 32V dc	-	19 - 38V dc	-
48 - 110V dc	-	37 - 150V dc	-
110 - 250V dc	100 - 240V ac rms	87 - 300V dc	80 - 265V ac

Table 3 - Operational range of auxiliary supply Vx

Caution	Do not energize the relay using the battery charger with the battery disconnected as this can irreparably damage the relay's power supply circuitry.

Caution	Energize the relay only if the auxiliary supply is within the operating range. If a test block is provided, it may be necessary to link across the front of the test plug to connect the auxiliary supply to the relay.

4.2 With the Relay Energised

The following group of tests verify that the relay hardware and software is functioning correctly and should be carried out with the auxiliary supply applied to the relay.

Caution	The current and voltage transformer connections must remain isolated from the relay for these checks. The trip circuit should also remain isolated to prevent accidental operation of the associated circuit breaker.

Caution	The InterMiCOM64 communication channel (when fitted) should be disconnected to prevent the remote end relay being affected during the tests.

4.2.1 Watchdog Contacts

Using a continuity tester, check that the watchdog contacts are in the states shown in the *Watchdog contact status* table for a de-energized relay.

4.2.2 LCD Front Panel Display

The Liquid Crystal Display (LCD) is designed to operate in a wide range of substation ambient temperatures. For this purpose, the Px40 relays have an **LCD Contrast** setting. This allows the user to adjust the lightness or darkness of the displayed characters. The contrast is factory preset to account for a standard room temperature, however it may be necessary to adjust the contrast to give the best in-service display. To change the contrast, at the bottom of the **CONFIGURATION** column, use cell [09FF: LCD Contrast] to increment (darker) or decrement (lighter), as required.

Important	***Before applying a contrast setting, ensure that it does not make the display too light or dark so the menu text becomes unreadable. If this happens, it is possible to restore the display by downloading a MiCOM S1 Studio setting file, with the LCD Contrast set in the typical range of 7 to 11.***

4.2.3 Date and Time

Before setting the date and time, ensure that the factory-fitted battery isolation strip that prevents battery drain during transportation and storage has been removed. With the lower access cover open, the presence of the battery isolation strip can be checked by a red tab protruding from the positive side of the battery compartment. Lightly pressing the battery to prevent it falling out of the battery compartment, pull the red tab to remove the isolation strip.

The data and time should now be set to the correct values. The method of setting depends on whether accuracy is being maintained through the optional Inter-Range Instrumentation Group standard B (IRIG-B) port on the rear of the relay or by using SNTP via Ethernet.

4.2.3.1 With an IRIG-B Signal

Note	*For P741 the IRIG-B signal may apply to the Central Unit only.*

If a satellite time clock signal conforming to IRIG-B is provided and the relay has the optional IRIG-B port fitted, the satellite clock equipment should be energized.

To allow the relay's time and date to be maintained from an external IRIG-B source cell [DATE and TIME, IRIG-B Sync.] must be set to **Enabled**.

Ensure the relay is receiving the IRIG-B signal by checking that cell [DATE and TIME, IRIG-B Status] reads **Active**.

Once the IRIG-B signal is active, adjust the time offset of the universal coordinated time (satellite clock time) on the satellite clock equipment so that local time is displayed.

Check the time, date and month are correct in cell [0801: DATE and TIME, Date/Time]. The IRIG-B signal does not contain the current year so needs to be set manually in this cell.

If the auxiliary supply fails, with a battery fitted in the compartment behind the bottom access cover, the time and date is maintained. Therefore, when the auxiliary supply is restored, the time and date are correct and need not be set again.

To test this, remove the IRIG-B signal, then remove the auxiliary supply from the relay. Leave the relay de-energized for approximately 30 seconds. On re-energization, the time in cell [DATE and TIME, Date/Time] should be correct. Then reconnect the IRIG-B signal.

4.2.3.2 With SNTP

If SNTP time synch has been configured for IEC61850 or DNP3oE communications then check the SNTP Status in the DATE and TIME column.

Once the SNTP signal is active, adjust the time offset of the universal coordinated time (satellite clock time) on the satellite clock equipment so that local time is displayed. Check the time, date and month are correct in cell [0801: DATE and TIME, Date/Time].

4.2.3.3 Without an IRIG-B or SNTP Signal

Note	*For P741 the IRIG-B signal may not apply to the Central Unit only. For the P742/P743 it may apply to the Peripheral Unit only.*

If the time and date is not being maintained by an IRIG-B signal, ensure that cell [0804: DATE and TIME, IRIG-B Sync.] is set to **Disabled**.

Set the date and time to the correct local time and date using cell [0801: DATE and TIME, Date/Time].

If the auxiliary supply fails, with a battery fitted in the compartment behind the bottom access cover, the time and date are maintained. Therefore when the auxiliary supply is restored, the time and date are correct and need not be set again.

To test this, remove the auxiliary supply from the relay for approximately 30 seconds. On re-energization, the time in cell [0801: DATE and TIME, Date/Time] should be correct.

4.2.4 Light Emitting Diodes (LEDs)

On power-up, the green LED should switch on and stay on, indicating that the relay is healthy. The relay has non-volatile memory which stores the state (on or off) of the alarm, trip and, if configured to latch, user-programmable LED indicators when the relay was last energized from an auxiliary supply. Therefore, these indicators may also switch on when the auxiliary supply is applied.

If any of these LEDs are on, reset them before proceeding with further testing. If the LED successfully resets (the LED switches off), there is no testing required for that LED because it is known to be operational.

Note	*It is likely that alarms related to the communications channels will not reset at this stage.*

4.2.4.1 Testing the Alarm and Out-of-Service LEDs

The alarm and out of service LEDs can be tested using the **COMMISSIONING TESTS** menu column. Set cell [0F0F: COMMISSIONING TESTS, Test Mode] to **Contacts Blocked**. Check that the out of service LED is on continuously and the alarm LED flashes.

It is not necessary to return cell [0F0F: COMMISSIONING TESTS, Test Mode] to **Disabled** at this stage because the test mode will be required for later tests.

4.2.4.2 Testing the Trip LED

The trip LED can be tested by initiating a manual circuit breaker trip from the relay. However, the trip LED will operate during the setting checks performed later. Therefore, no further testing of the trip LED is required at this stage.

4.2.4.3 Testing the User-Programmable LEDS

To test the user-programmable LEDs set cell [0F12: COMMISSIONING TESTS, Test LEDs] to **Apply Test**. Check that all the programmable LEDs on the relay switch on.

- The ‘Red LED Status’ cell is an 18-bit binary string that indicates which of the user-programmable LEDs on the device are illuminated when accessing the device from a remote location, a ‘1’ indicating a particular Red LED is lit.
- The ‘Green LED Status’ cell is an 18-bit binary string that indicates which of the user-programmable LEDs on the device are illuminated when accessing the device from a remote location, a ‘1’ indicating a particular Green LED is lit.
- If a ‘Red LED Status’ cell AND the same ‘Green LED Status’ cell are at ‘1’ the particular LED is lit Orange
- If a ‘Red LED Status’ cell AND the same ‘Green LED Status’ cell are at ‘0’ the particular LED is not lit.

4.2.5 Field Voltage Supply

The relay generates a field voltage of nominally 48 V that can be used to energize the opto-isolated inputs (alternatively the substation battery may be used).

Measure the field voltage across terminals 7 and 9 on the terminal block shown in the following table. Check that the field voltage is in the range 48 V when no load is connected and that the polarity is correct.

Repeat for terminals 8 and 10

Supply rail	Terminals
+ve	M7 & M8
–ve	M9 & M10

Table 4 - Field voltage terminals

4.2.6 Input Opto-Isolators

This test checks that all the opto-isolated inputs on the relay are functioning correctly.

The opto-isolated inputs should be energised one at a time, see the *Connection Diagrams* chapter for terminal numbers. Ensuring correct polarity, connect the field supply voltage to the appropriate terminals for the input being tested.

Note	*The opto-isolated inputs may be energised from an external dc auxiliary supply (e.g. the station battery) in some installations. Check that this is not the case before connecting the field voltage otherwise damage to the relay may result.*

The status of each opto-isolated input can be viewed using either cell [SYSTEM DATA, Opto I/P Status] or [COMMISSION TESTS, Opto I/P Status], a ‘1’ indicating an energised input and a ‘0’ indicating a de-energised input. When each opto-isolated input is energised one of the characters on the bottom line of the display will change to indicate the new state of the inputs.

4.2.7 Output Relays

This test checks that all the output relays are functioning correctly.

See the Connection Diagrams chapter for terminal numbers.

Ensure that the relay is still in test mode by viewing cell [COMMISSION TESTS, Test Mode] to ensure that it is set to ‘Blocked’.

The output relays should be energised one at a time. To select output relay 1 for testing, set cell [COMMISSION TESTS, Test Pattern] as appropriate.

Connect a continuity tester across the terminals corresponding to output relay 1 as given in the Connection Diagrams chapter.

To operate the output relay set cell COMMISSION TESTS, Contact Test] to ‘Apply Test’. Operation will be confirmed by the continuity tester operating for a normally open contact and ceasing to operate for a normally closed contact. Measure the resistance of the contacts in the closed state.

Reset the output relay by setting cell [COMMISSION TESTS, Contact Test] to ‘Remove Test’.

Note	*It should be ensured that thermal ratings of anything connected to the output relays during the contact test procedure is not exceeded by the associated output relay being operated for too long. It is therefore advised that the time between application and removal of contact test is kept to the minimum.*

Return the relay to service by setting cell [COMMISSION TESTS, Test Mode] to ‘Disabled’.

4.2.8 First Rear Communications Port

This test should only be performed where the relay is to be accessed from a remote location and varies depending on the communications standard adopted.

It is not the intention of the test to verify the operation of the complete system from the relay to the remote location, just the relay’s rear communications port and any protocol converter necessary.

A variety of communications protocols may be available. For further details, please see whichever of these sections are relevant for the device you are commissioning:

An LC fiber optic cable can be used with certain Ethernet boards.

4.2.8.1 Courier Communications

If a protocol converter is installed, connect a portable PC running the appropriate software to the incoming (remote from relay) side of the protocol converter. Ensure that the communications baud rate and parity settings in the application software are set the same as those on the protocol converter (usually a KITZ but could be a SCADA RTU). The relays courier address in cell [0E02: COMMUNICATIONS, Remote Access] must be set to a value between 1 and 254. Check that communications can be established with this relay using the portable PC.

Check that, using the Easergy MiCOM Studio, communications with the relay can be established.

4.2.9 Second Rear Communications Port

This test should only be performed where the relay is to be accessed from a remote location and varies depending on the communications standard being adopted.

It is not the intention of the test to verify the operation of the complete system from the relay to the remote location, just the relay’s rear communications port and any protocol converter necessary.

The second rear communications port uses Courier communications allowing remote engineering access with Easergy MiCOM Studio.

4.2.9.1 EIA(RS)485 Configuration

If an EIA(RS)485 to EIA(RS)232 converter (Schneider Electric CK222) is installed, connect a portable PC running the appropriate software (Easergy Studio/MiCOM S1 Studio) to the EIA(RS)232 side of the converter and the second rear communications port of the relay to the EIA(RS)485 side of the converter.

The terminal numbers for the relay’s EIA(RS)485 port are shown in the *Second rear communications port EIA(RS)232 terminals* table.

Ensure that the communications baud rate and parity settings in the application software are the same as those in the relay. The relay’s Courier address in cell [0E90: COMMUNICATIONS, RP2 Address] must be set to a value between 1 and 254. The second rear communications port’s configuration [0E88: COMMUNICATIONS RP2 Port Config.] must be set to EIA(RS)485.

Check that communications can be established with this relay using the portable PC.

4.2.9.2 EIA(RS)232 Configuration

Connect a portable PC running the appropriate software (MiCOM S1 Studio) to the rear EIA(RS)232 port of the relay. This port is actually compliant with EIA(RS)574; the 9-pin version of EIA(RS)232, see www.tiaonline.org.

The second rear communications port connects using the 9-way female D-type connector (SK4). The connection is compliant with EIA(RS)574.

Pin	Connection
1	No Connection
2	RxD
3	TxD
4	DTR#
5	Ground
6	No Connection
7	RTS#
8	CTS#
9	No Connection
# These pins are control lines for use with a modem.	

Table 5 - Second rear communications port EIA(RS)232 terminals

Connections to the second rear port configured for EIA(RS)232 operation can be made using a screened multi-core communication cable up to 15 m long, or a total capacitance of 2500 pF. Terminate the cable at the relay end with a 9-way, metal-shelled, D-type male plug. The terminal numbers for the relay's EIA(RS)232 port are shown in the previous table.

Ensure that the communications baud rate and parity settings in the application software are set the same as those in the relay. The relay's Courier address in cell [0E90: COMMUNICATIONS, RP2 Address] must be set to a value between 1 and 254. The second rear communication's port configuration [0E88: COMMUNICATIONS RP2 Port Config] must be set to EIA(RS)232.

Check that communications can be established with this relay using the portable PC.

4.2.10 Current Inputs

We recommend using the "MiCOM P746 remote HMI" tool. Otherwise, the following process can be done:

This test verifies that the accuracy of current measurement is within acceptable tolerances.

All relays leave the factory set for operation at a system frequency of 50 Hz. If operation at 60 Hz is required, this must be set in cell [0009: SYSTEM DATA, Frequency].

Caution	***To avoid spurious operation of protection elements during injection testing, ensure that current operated elements are disabled.***

Apply current equal to the line current transformer secondary winding rating to each current transformer input of the corresponding rating in turn, checking its magnitude using a multimeter. Refer to the *Current input terminals* table for the corresponding reading in the relay's **MEASUREMENTS 1** columns, as appropriate, and record the value displayed.

The measured current values displayed on the relay LCD, or on a portable PC connected to the front communication port, are either in primary or secondary Amperes. If cell [0D02: MEASURE'T SETUP, Local Values] is set to **Primary**, the values displayed should be equal to the applied current multiplied by the corresponding current transformer ratio set in the **CT and VT RATIOS** menu column (see the *CT ratio settings* table). If cell [0D02: MEASURE'T SETUP, Local Values] is set to **Secondary**, the value displayed should be equal to the applied current.

Note	*If a PC connected to the relay's rear communications port is used to display the measured current, the process is similar. However, the setting of cell [0D03: MEASURE'T SETUP, Remote Values] determines whether the displayed values are in primary or secondary Amperes.*

The measurement accuracy of the relay is ±5%. However, an additional allowance must be made for the accuracy of the test equipment being used.

	P746
Cell in MEASUREMENTS 1 column (02)	**Corresponding CT Ratio (in 'CT and VT RATIOS' column(0A) of menu)**
[IA Magnitude] [IB Magnitude] [IC Magnitude]	$\frac{\text{Phase CT Primary}}{\text{Phase CT Secondary}}$

Table 6 - CT ratio settings

5 COMMISSIONING TEST MENU

To help minimize the time needed to test MiCOM relays the relay provides several test facilities under the '**COMMISSION TESTS**' menu heading. There are menu cells which allow the status of the opto-isolated inputs, output relay contacts, internal Digital Data Bus (DDB) signals and user-programmable LEDs to be monitored. Additionally there are cells to test the operation of the output contacts, user-programmable LEDs and, where available, the auto-reclose cycles.

The following table shows the relay menu of commissioning tests, including the available setting ranges and factory defaults. Each of the main menu tests are described in more detail in the following sections.

COMMISSION TESTS		
Menu Text	**Default Setting**	**Settings**
Opto I/P Status	-	-
Relay O/P Status	-	-
Test Port Status	-	-
Monitor Bit 1	64 - (LED 1)	0 to 2047
Monitor Bit 2	65 - (LED 2)	0 to 2047
Monitor Bit 3	66 - (LED 3)	0 to 2047
Monitor Bit 4	67 - (LED 4)	0 to 2047
Monitor Bit 5	68 - (LED 5)	0 to 2047
Monitor Bit 6	69 - (LED 6)	0 to 2047
Monitor Bit 7	70 - (LED 7)	0 to 2047
Monitor Bit 8	71 - (LED 8)	0 to 2047
Test Mode	Disabled	Disabled, Test Mode, Contacts Blocked
Test Pattern	All bits set to 0	0 = Not Operated, 1 = Operated
Contact Test	No Operation	No Operation, Apply Test, Remove Test
Test LEDs	No Operation	No Operation, Apply Test
Test Auto-reclose	No Operation	No Operation, 3 Pole Test
Red LED Status	-	-
Green LED Status	-	-
Test Zone	-	-
Note *See Relay Menu Database for details of DDB signals*		

Table 7 - Commission Tests

5.1 Opto I/P Status

We recommend using the "Monitor DDB signal" tool which is in the PSL Editor included in Easergy Studio. Otherwise, the following process can be done:

This menu cell displays the status of the relay's opto-isolated inputs as a binary string, a '**1**' indicating an energized opto-isolated input and a '**0**' a de-energized one. If the cursor is moved along the binary numbers the corresponding label text will be displayed for each logic input.

It can be used during commissioning or routine testing to monitor the status of the opto-isolated inputs whilst they are sequentially energized with a suitable dc voltage.

5.2 Relay O/P Status

We recommend using the "Monitor DDB signal" tool which is in the PSL Editor included in Easergy Studio. Otherwise, the following process can be done:
This menu cell displays the status of the Digital Data Bus (DDB) signals that result in energization of the output relays as a binary string, a '**1**' indicating an operated state and '**0**' a non-operated state. If the cursor is moved along the binary numbers the corresponding label text will be displayed for each relay output.

The information displayed can be used during commissioning or routine testing to indicate the status of the output relays when the relay is '**in service**'. Additionally fault finding for output relay damage can be performed by comparing the status of the output contact under investigation with it's associated bit.

Note	*When the '**Test Mode**' cell is set to '**Enabled**' this cell will continue to indicate which contacts would operate if the relay was in-service, it does not show the actual status of the output relays.*

5.3 Test Port Status

This menu cell displays the status of the eight Digital Data Bus (DDB) signals that have been allocated in the '**Monitor Bit**' cells. If the cursor is moved along the binary numbers the corresponding DDB signal text string will be displayed for each monitor bit.

By using this cell with suitable monitor bit settings, the state of the DDB signals can be displayed as various operating conditions or sequences are applied to the relay. Thus the Programmable Scheme Logic (PSL) can be tested.

As an alternative to using this cell, the optional monitor/download port test box can be plugged into the monitor/download port located behind the bottom access cover. Details of the monitor/download port test box can be found in the *Using a Monitor/Download Port Test Box* section of this chapter.

5.4 LED Status

The '**LED Status**' is an eight bit binary strings that indicate which of the user-programmable LEDs on the relay are illuminated when accessing the relay from a remote location, a '**1**' indicating a particular LED is lit and a '**0**' not lit.

5.5 Monitor Bits 1 to 8

The eight '**Monitor Bit**' cells allow the user to select the status of which digital data bus signals can be observed in the '**Test Port Status**' cell or via the monitor/download port.

Each '**Monitor Bit**' is set by entering the required Digital Data Bus (DDB) signal number from the list of available DDB signals in the Programmable Logic chapter. The pins of the monitor/download port used for monitor bits are given in the following table. The signal ground is available on pins 18, 19, 22 and 25.

Monitor bit	1	2	3	4	5	6	7	8
Monitor/download port pin	11	12	15	13	20	21	23	24

The required DDB signal numbers are 0 – 2047.
Table 8 - Monitor Bits

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.**

5.6 Test Mode

The **Test Mode** menu cell (in the **COMMISSION TESTS** column) is used to allow secondary injection testing to be performed on the relay.

To select test mode set the Test Mode menu cell to '**Test Mode**'. It causes an alarm condition to be recorded, the yellow ALARM LED to light and an alarm message '**Test Mode Alm**' to be generated.

Test Mode freezes any information stored in the **CB CONDITION** column and (in IEC60870-5-103 builds) changes the Cause Of Transmission (COT) to Test Mode. For relays supporting IEC 61850 Edition 2, the test bit for data quality attribute shall set to TRUE, and the Logical Device Mode will set to test.

Test mode can also be enabled by energizing an opto mapped to the **Test Mode** signal.

To enable testing of output contacts set the **Test Mode** cell to **Contacts Blocked**. It causes an alarm condition to be recorded, the yellow ALARM LED to light and an alarm message '**Contacts Blk Alm**' to be generated.

In **Contact Blocked** mode, the protection function still works but the contacts will not operate. Also the **test pattern** and contact test functions are visible, which can be used to manually operate the output contacts. For relays supporting IEC 61850 Edition 2, the test bit for data quality attribute shall set to TRUE, and the Logical Device Mode will set to test/blocked.

Contacts Blocked can also be enabled by energizing an opto mapped to the **Contacts Blocked** signal.

Once testing is complete the cell must be set back to '**Disabled**' to restore the relay back to service.

WARNING	**If you use or enable Test Mode, you must disable Test Mode before putting the relay back into active service. IT IS POTENTIALLY EXTREMELY UNSAFE TO ATTEMPT TO USE ANY RELAY WHICH IS STILL IN TEST MODE IN ACTIVE SERVICE.**

5.7 Test Pattern

The '**Test Pattern**' cell is used to select the output relay contacts that will be tested when the '**Contact Test**' cell is set to '**Apply Test**'. The cell has a binary string with one bit for each user-configurable output contact which can be set to '**1**' to operate the output under test conditions and '**0**' to not operate it.

5.8 Contact Test

When the '**Apply Test**' command in this cell is issued the contacts set for operation (set to '**1**') in the '**Test Pattern**' cell change state. After the test has been applied the command text on the LCD will change to '**No Operation**' and the contacts will remain in the Test State until reset issuing the '**Remove Test**' command. The command text on the LCD will again revert to '**No Operation**' after the '**Remove Test**' command has been issued.

Note	*When the '**Test Mode**' cell is set to '**Enabled**' the '**Relay O/P Status**' cell does not show the current status of the output relays and hence can not be used to confirm operation of the output relays. Therefore it will be necessary to monitor the state of each contact in turn.*

5.9 Test LEDs

When the '**Apply Test**' command in this cell is issued the eight/eighteen user-programmable LEDs will illuminate for approximately 2 seconds before they extinguish and the command text on the LCD reverts to '**No Operation**'.

5.10 Red LED Status and Green LED Status

The **Red LED Status** and **Green LED Status** cells are 18-bit binary strings that show which of the user-programmable LEDs on the relay are ON when accessing the relay from a remote location. **1** indicates a particular LED is ON and a **0** OFF. When the status of a particular LED in both cells is **1**, this means the LED is yellow.

5.11 Using a Monitor/Download Port Test Box

A monitor/download port test box containing 8 LEDs and a switchable audible indicator is available from Schneider Electric, or one of their regional sales offices. It is housed in a small plastic box with a 25-pin male D-connector that plugs directly into the relay's monitor/download port. There is also a 25-pin female D-connector which allows other connections to be made to the monitor/download port whilst the monitor/download port test box is in place.

Each LED corresponds to one of the monitor bit pins on the monitor/download port with '**Monitor Bit 1**' being on the left hand side when viewing from the front of the relay. The audible indicator can either be selected to sound if a voltage appears on any of the eight monitor pins or remain silent so that indication of state is by LED alone.

5.12 Test Zone

The 'Test Zone' cell is used to select the status of each zone. This cell has a binary string with one bit per zone which can be set to '1' to block busbar protection & disable breaker failure protection and '0' to maintain the zone in operating mode. When a zone is set to '1', the current sum calculation remains active for monitoring but trip orders cannot be sent by either the busbar protection or the breaker failure protection. Zones can be in test when other zone remains active.

6 SETTING CHECKS

The setting checks ensure that all of the application-specific relay settings (both the relay's function and Programmable Scheme Logic (PSL) settings) for the particular installation have been correctly applied to the relay.

Important	**This section includes a series of tests and checks which apply to one or more MiCOM products. Some of these tests and checks will not apply to the product you are commissioning or the features the product is using. You will need to be aware of whether the commissioning test applies to you - this information is provided after each heading.**

Caution	**The trip circuit should remain isolated during these checks to prevent accidental operation of the associated circuit breaker.**

Caution	**For busbar protection stability reasons, whatever is the maintenance mode selected, the Check Zone will never be disabled, thus, the time to inject current shall be shorter than the ID>1 set timer to avoid Circuitry Fault alarms.**

6.1 Apply Application-Specific Settings

There are different methods of applying the settings:

- Transferring settings from a pre-prepared setting file to the relay using a laptop PC running the appropriate software (such as Easergy/MiCOM S1 Studio). Use the front EIA(RS)232 port (under the bottom access cover), or the first rear communications port (Courier protocol with a protocol converter connected), or the second rear communications port. This is the preferred method for transferring function settings as it is much faster and there is less margin for error. If PSL other than the default settings with which the relay is supplied is used, this is the only way of changing the settings.

  If a setting file has been created for the particular application and provided on a memory device, the commissioning time is further reduced, especially if application-specific PSL is applied to the relay.
- Enter the settings manually using the relay's operator interface. This method is not suitable for changing the PSL.

Caution	***When the installation needs application-specific Programmable Scheme Logic (PSL), it is essential that the appropriate .psl file is downloaded (sent) to the relay, for each setting group that will be used. If the user fails to download the required .psl file to any setting group that may be brought into service, the factory default PSL will still be resident. This may have severe operational and safety consequences.***

6.2 Demonstrate Correct Relay Operation

The purpose of these tests is as follows:

- To determine that the primary protection function of the relay, current differential, can trip according to the correct application settings.
- To verify correct setting of any backup phase/phase overcurrent protection.
- To verify correct assignment of the inputs, relays and trip contacts, by monitoring the response to a selection of fault injections.

6.2.1 Current Differential Bias Characteristic

To avoid spurious operation of any Overcurrent, earth fault or breaker fail elements, these should be disabled for the duration of the differential element tests. This is done in the relay's CONFIGURATION column. Ensure that cells, [Overcurrent Prot], [Earth Fault Prot] and [CB Fail] are all set to "Disabled". Make a note of which elements need to be re-enabled after testing.

6.2.1.1 Connect the Test Circuit

The following tests require an injection test set, able to feed the relay with one or two currents variable in phase and magnitude.

6.2.1.1.1 **If Only One Current is Available:**

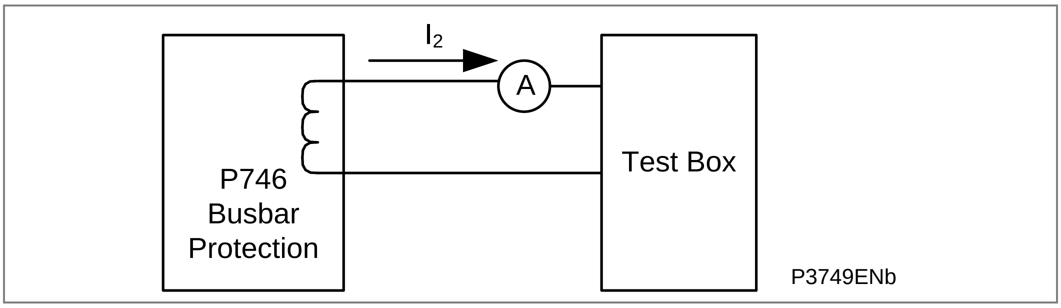
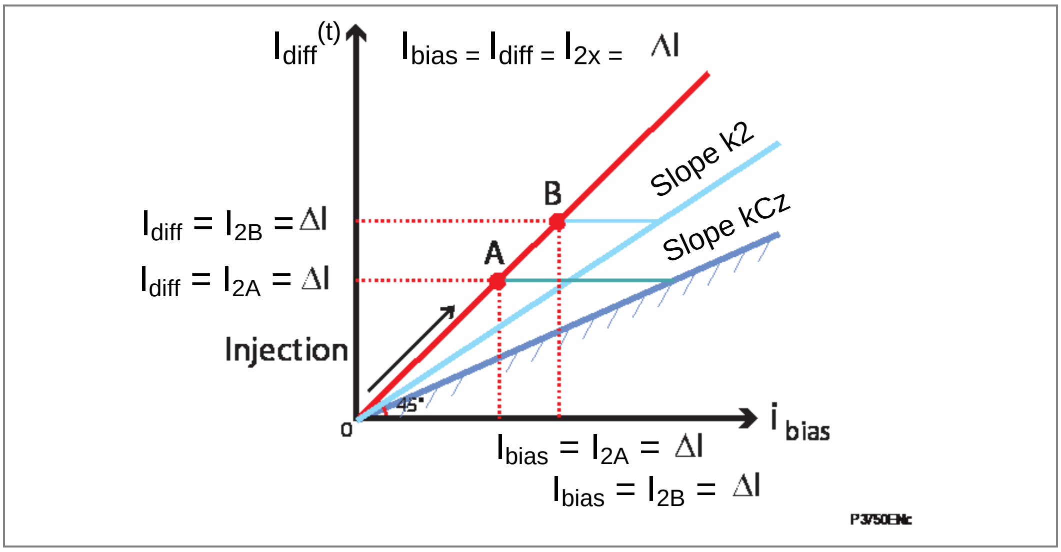


Figure 3 - Connection for Bias Characteristic Testing



An increasing current I_2 is injected into a phase (and neutral) of the feeder 2 which is used as differential and bias current.

$I_{diff} = I_{bias} = I_2$

K2 : Zone percentage bias, Characteristic limit: I_{diff} = ID>2

KCZ : Check Zone percentage bias, Characteristic limit: I_{diff} = IDCZ>2

In this case, we increase I_2 from 0 to A then B point until the differential element operates:

KCZ : Check Zone percentage bias, Characteristic limit: I_{diff} = IDCZ>2, point A

K2 : Zone percentage bias, Characteristic limit: I_{diff} = ID>2, point B

When we reach the point A the P746 LED 8 will operate and when we reach the point B the differential element will operate.

Note 1	*I_D>1 alarm timer will be set to 100s during the test.*
Note 2	*This test does not allow checking the slopes but only the thresholds.*

6.2.1.1.2 **If Two Currents are Available:**

This method will be preferred whenever possible.

Note	*The 2 CTs can have different ratios. This must be taken into account when injecting at the CT secondary side.*

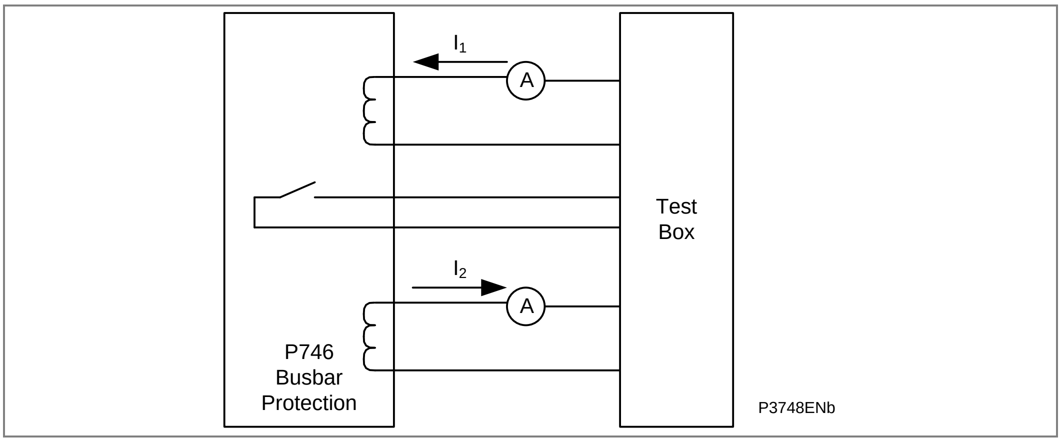
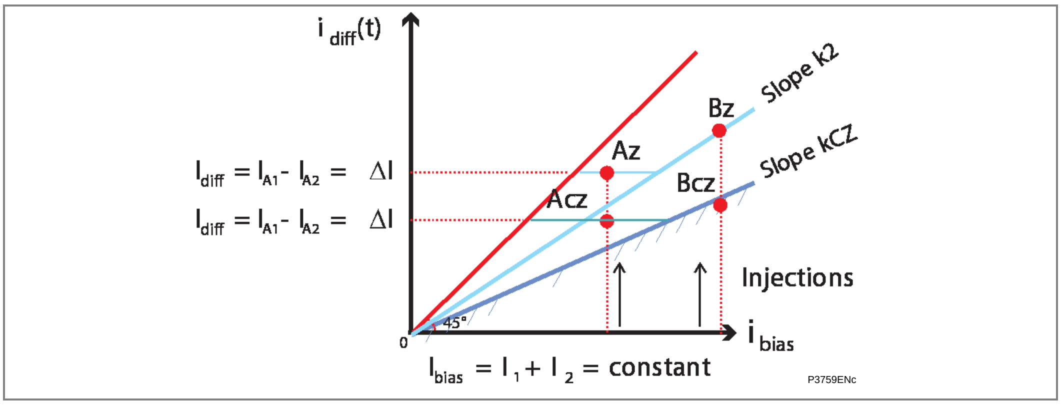


Figure 4 - Connection for Bias Characteristic Testing



Note	*The easiest way to test the thresholds is to inject an increasing slope for I_1 and a decreasing slope for I_2. The $I_{bias} = I_1 + I_2$ is thus constant and $\Delta I = I_{diff} = I_2 - I_1$ is increasing.*

Important	**For the Check zone, the I_{bias} includes all the substation feeder currents.**

To Test the Thresholds:

I_{bias} is fixed to a lowest value of ID>2/k2 and IDCZ>2/kCZ, the Az and Acz points will thus be ID>2 and IDCZ>2. So $I_{bias} = I_1 + I_2$ = fixed value (Points A)

To Test the Differential Slopes and Blocking Algorithm:

I_{bias} is fixed to a value greater than ID>2/k2 and IDCZ>2/kCZ the Bz and Bcz points will thus be I_{bias} x k2 and I_{bias} x kCZ. So $I_{bias} = I_1 + I_2$ = fixed value (Points B)

When we reach the point Xcz the P74x/P746 LED 8 will operate and when we reach the point Xz the differential element will operate.

Important	**This test simulates a current going out and a current going in thus, the current phase comparison algorithm will prevent the trip as long as the smallest injected current is above x% of the nominal CT current (In):**

The chosen I_{bias} must be lower than 2 x x% x In / (1- k2)*.

X% is the percentage of In current flowing through each CT above which the angle is taken into account and is defined in the Excel Setting spreadsheet tool.

Example with CT of 2000/1:

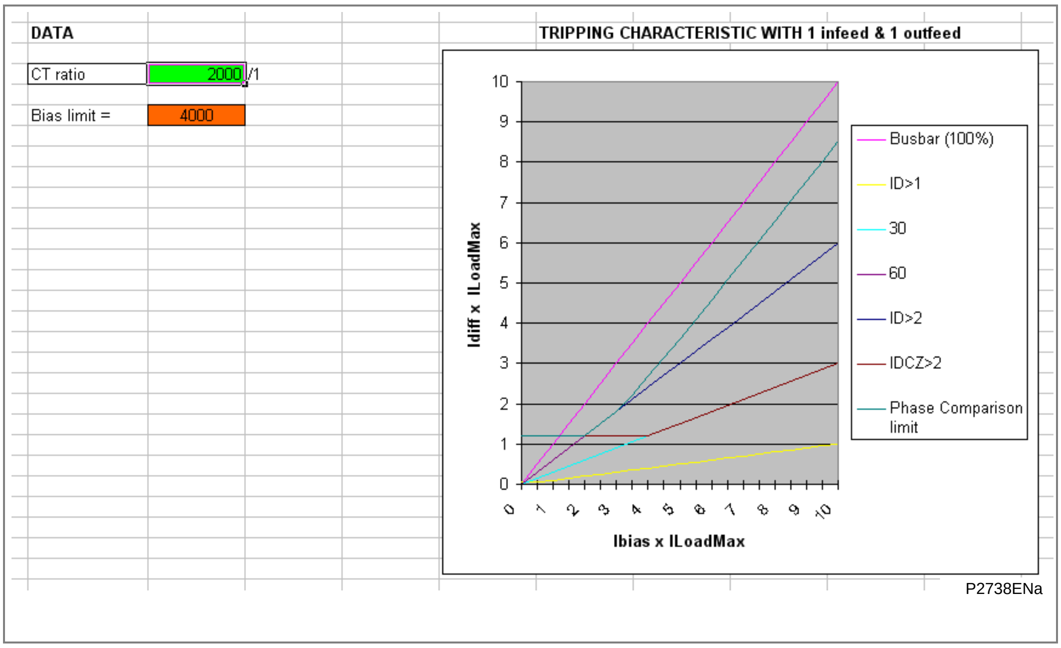


Figure 5 - Tripping characteristic with 1 infeed and I outfeed

For example,if k2 is 60%, x% = 50% and if the CT ratio of the smallest injected current is 1000/1, $I_{biasmax}$ is 2500A (so ID>2 up to 1500 A).

For example, if k2 is 60%, x% = 50% and if the CT ratio of the smallest injected current is 500/1, $I_{biasmax}$ is 1250A (so ID>2 up to 750 A).

For example,if k2 is 60% x% = 40% and if the CT ratio of the smallest injected current is 1000/1, $I_{biasmax}$ is 2000A (so ID>2 up to 1200 A).

For example, if k2 is 60% x% = 40% and if the CT ratio of the smallest injected current is 500/1, $I_{biasmax}$ is 1000A (so ID>2 up to 600 A).

To calculate the phase comparison threshold pct, pct = $(I_1 - I_2) / (I_1 + I_2)$

The differential current will increase twice the value ΔI.

Note	*I_D>1 alarm timer will be set to 100s during the test.* *To test the tripping time, inject 4 × I_D>2 at 60Hz and 3.5 × I_D>2 at 50Hz whenever possible, in order to ensure subcycle tripping times* **: for information:* *During the injection: $I_{bias} = I_1 + I_2$ thus $I_1 = I_{bias} - I_2$ and I_2 = x% of In thus $I_1 = I_{bias}$ - x% of In* *To trip, IDiff must be ≥ k2 x I_{bias}, i.e. $I_1 - I_2 \geq k2\ I_{bias}$ thus I_{bias} - x% of In - x% of In ≥ k2 I_{bias}* *Conclusion: I_{bias} ≥ 2 times x% of In /(1 - k2)*

To Test the Differential Slopes ONLY:

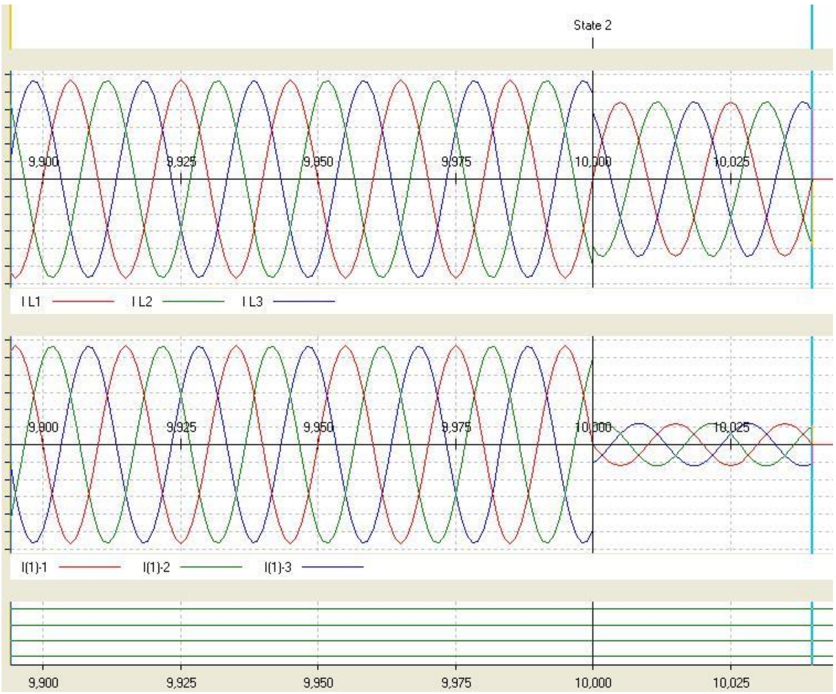
To check a slope of k%, the 2 following tests shall be performed.

One showing no operation at m = 95% of k% and one showing operation at n = 105% of k%.

To avoid the blocking of the phase comparison algorithm, the following sequences shall be played (using state sequencer for example) with the smallest injected current below x% of In:

First Test:

- Chose I_{bias} then Inject outgoing $I_1 = I_{bias}/2$ and ingoing $I_2 = I_{bias}/2$ for 10s (for example).
- Check on the HMI Tool that the right I_{bias} is displayed and the differential current is 0.
- Inject outgoing $I_1 = I_{bias} \times (1 + m) / 2$ and ingoing $I_2 = I_{bias} \times (1 - m) / 2$ for 40ms
- I_2 must be lower than x% of In
- No trip

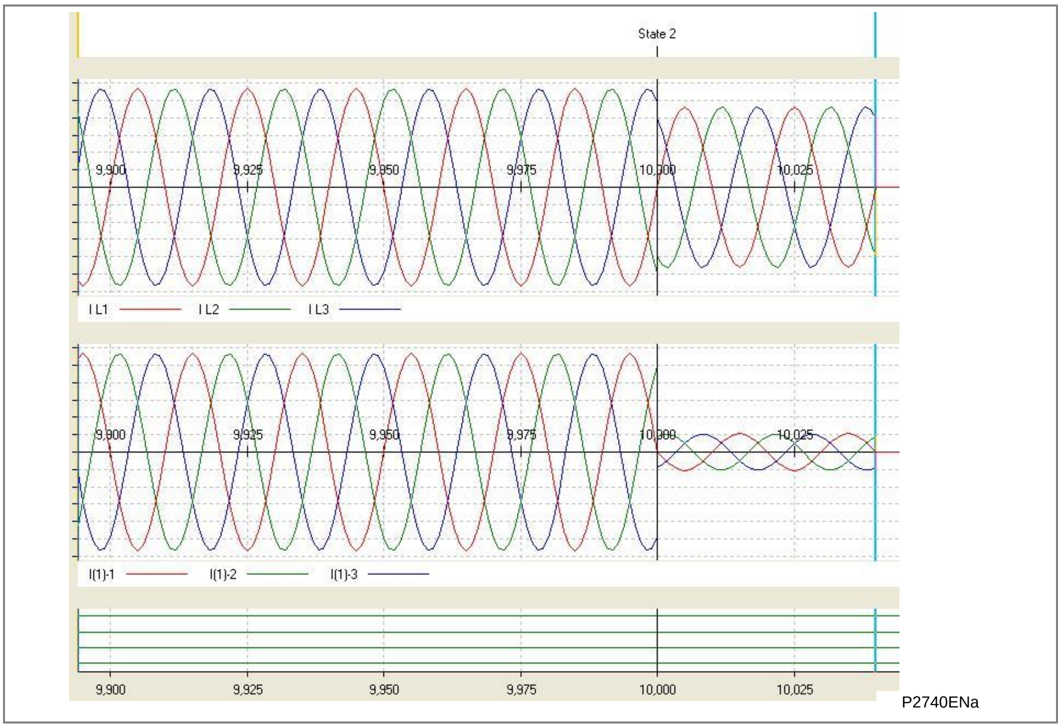


P2739ENa

Second Test:

- Keep the same I_{bias} then Inject the same outgoing I_1 and ingoing I_2 for 10s (for example).
- Check on the P746 HMI Tool that the right I_{bias} is displayed and the differential current is 0.
- Inject outgoing $I_1 = I_{bias} \times (1 + n) / 2$ and ingoing $I_2 = I_{bias} \times (1 - n) / 2$ for 40 ms
- I_2 must be lower than x% of In
- Trip

Note	*The same test can be performed to test the CZ signal either by mapping an unlatched LED or a unlatched output relay on the Diff CZ Blked DDB.*



Example:

Phase comparison threshold x% = 50%,

Busbar protection bias slope k% = 60% (thus m% = 57% and n% = 63%)

ID>2 = 1100 A (thus minimum bias current = ID>2/ k% = 1100 / 0.6 = 1834 A)

CT1 = 1000/1 (thus):

- Maximum current of 50% of 1000 A = 500 A to not be used by the phase comparison
- Maximum of bias current = 2 x I_1./ (1 – n) = 2 x 500 / 0.43 = 2325 A

CT2 = 2000/1 (thus):

- Maximum current of 50% of 2000 A = 1000A to not be used by the phase comparison)
- Maximum of bias current = 2 x I_2./ (1 – n) = 2 x 1000 / 0.43 = 4650 A

First Test:

- Chose min I_{bias} = 2 kA (more than 1834 A and less than 4650 A)
- Inject outgoing I_1 = 1000 A prim (1 A sec) and ingoing I_2.= 1000 A prim (0.5 A sec) for 10s.
  - I bias = 1000 + 1000 = 2000 A
  - I diff = 1000 – 1000 = 0 A
- Check on the P746 HMI Tool that the right I_{bias} = 2 kA is displayed and the differential current is 0.
- Inject outgoing I_1 = 1570 A prim and ingoing I_2.= 430 A prim for 40ms
  - I bias = 1570 + 430 = 2000 A
  - I diff = 1570 – 430 = 1140 A
  - 1140 A = 57% of 2000 A
- No trip

Second Test:

- Keep the same I_{bias} = 2 kA then Inject the same outgoing I_1 and ingoing I_2 for 10s.
- Check on the P746 HMI Tool that the right I_{bias} = 2 kA is displayed and the differential current is 0.
  - I bias = 1000 + 1000 = 2000 A
  - I diff = 1000 – 1000 = 0 A
- Inject outgoing I_1 = 0.815 A prim and ingoing I_2.= 0.185 A prim for 40 ms
  - I bias = 1630 + 370 = 2000 A
  - I diff = 1630 – 370 = 1260 A
  - 1260 A = 63% of 2000 A
- Trip

Third Test:

- Chose max I_{bias} = 4.5 kA (more than 1834 A and less than 4650 A)
- Inject outgoing I_1 = 2250 A prim (2.25 A sec) and ingoing I_2.= 2250 A prim (1.125 A sec) for 10s.
  - I bias = 2250 + 2250 = 4500 A
  - I diff = 2250 – 2250 = 0 A
- Check on the P746 HMI Tool that the right I_{bias} = 9 kA is displayed and the differential current is 0.
- Inject outgoing I_1 = 3535.5A prim and ingoing I_2.= 967.5 A prim for 40ms
  - I bias = 3535.5 + 967.5 = 4500 A
  - I diff = 3535.5 - 967.5 = 2565 A
  - 2565 A = 57% of 4500 A
- No trip

Fourth Test:

- Keep the same I_{bias} = 4.5 kA then Inject the same outgoing I_1 and ingoing I_2 for 10s.
- Check on the P746 HMI Tool that the right I_{bias} = 2 kA is displayed and the differential current is 0.
  - I bias = 2250 + 2250 = 4500 A
  - I diff = 2250 – 2250 = 0 A
- Inject outgoing I_1 = 3667.5 A prim and ingoing I_2.= 832.5 A prim for 40 ms
  - I bias = 3667.5+ 832.5= 4500 A
  - I diff = 3667.5– 832.5= 2835 A
  - 2835 A = 63% of 4500 A
- Trip

<u>To Test the Phase Comparison Pick-Up Only:</u>

When an unlatched Led or a unlatched output relay is mapped on a PhComp Blk Zx or PhComp Blk Zx Y ddb, the 2 following tests can be performed.

Note	*PhCompBlk Zx ddb is an AND gate of the PhComp Blk Zx A, B, C ddbs so it will only change for three phase test.*

One showing no operation at m = 99% of x% and one showing operation at n = 101% of x%.

First Test:

- Inject outgoing I_1 = m% of CT1 and ingoing I_2.= I_1 for 10s (for example).
- No Led or relay output pick-up

Second Test:

- Inject outgoing I_1 = n% of CT1 and ingoing I_2.= I_1 for 10s (for example).
- Led or relay output pick-up

Note	*The same test can be performed to test it on the CZ using the adequate ddbs.*

6.2.1.2 Slopes and Thresholds

If a LED has been assigned to display the trip information, these may be used to indicate correct operation. If not, monitor option will need to be used – see the next paragraph.

On P746 go to GROUP1-->BUSBAR PROTECT and set I_D>1 Alarm timer to 100s then go to COMMISSION TESTS column in the menu, scroll down and change cells [Monitor Bit 1] to [BUSBAR_TRIPPING]. Doing so, cell [Test Port Status] will appropriately set or reset the bits that now represent BUSBAR_TRIPPING (with the rightmost bit representing Busbar Trip. From now on you should monitor the indication of [Test Port Status]. Make a note of which elements need to be re-enabled or re-set after testing.

Test of I_D>2:

I_D>1 Alarm Timer should be set to 100s during testing.

Inject a I_2 current smaller than I_D>2 and slowly increase I_2 until tripping.

Test of the operating time of the differential element:

Inject a I_2 current greater than twice I_D>2 threshold and measure the operating time of the differential element.

Test of I_D>1:

I_D>1 Alarm Timer should be set to 100ms.

Inject a I_2 current smaller than I_D>1 and slowly increase I_2 until circuit fault appears (LED Alarm of LED circuitry fault).

Test of I_D>1 Alarm Timer:

I_D>1 Alarm Timer should be set to 5s.

Inject a I2 current greater than twice the I_D>1 threshold and check that the Circuitry Fault Alarm is coming in 5s.

6.2.2 Phase Overcurrent Protection

If the overcurrent protection function is being used, both I>1 and I>2 elements should be tested.

To avoid spurious operation of any current differential, earth fault, breaker fail or CT supervision elements, these should be disabled for the duration of the overcurrent tests. This is done in the relay's CONFIGURATION column. Make a note of which elements need to be re-enabled after testing.

6.2.2.1 Connect the Test Circuit

Determine which output relay has been selected to operate when an I>1 trip and an I>2 occur by viewing the relay's programmable scheme logic.

The programmable scheme logic can only be changed using the appropriate software. If this software has not been available then the default output relay allocations will still be applicable.

If the trip outputs are phase-segregated (i.e. a different output relay allocated for each phase), the relay assigned for tripping on 'A' phase faults should be used.

The associated terminal numbers can be found from the external connection diagram (Chapter P746/EN CO).

Connect the output relay so that its operation will trip the test set and stop the timer.

Connect the current output of the test set to the 'A' phase current transformer input of the relay.

Ensure that the timer will start when the current is applied to the relay.

Perform the Test

Ensure that the timer is reset.

Apply a current of twice the setting in cell [GROUP 1 OVERCURRENT, I>1 Current Set] to the relay and note the time displayed when the timer stops.

Check that the red trip LED has illuminated.

Check the Operating Time

Check that the operating time recorded by the timer is within the range shown in the following table.

Note	*Except for the definite time characteristic, the operating times given in the following table are for a time multiplier or time dial setting of 1. Therefore, to obtain the operating time at other time multiplier or time dial settings, the time given in the table must be multiplied by the setting of cell [GROUP 1 OVERCURRENT, I>1 TMS] for IEC and UK characteristics or cell [GROUP 1 OVERCURRENT, Time Dial] for IEEE and US characteristics.*

In addition, for definite time and inverse characteristics there is an additional delay of up to 0.02 second and 0.08 second respectively that may need to be added to the relay's acceptable range of operating times.

For all characteristics, allowance must be made for the accuracy of the test equipment being used.

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 – 3.99
IEEE V Inverse	7.03	6.68 – 7.38
IEEE E Inverse	9.52	9.04 – 10
US Inverse	2.16	2.05 – 2.27
US ST Inverse	12.12	11.51 – 12.73

Table 9 - Characteristic operating times for I>1

Perform the DT tests for the function I>2.

Upon completion of the tests any current differential, overcurrent, earth fault, breaker fail or supervision ements which were disabled for testing purposes must have their original settings restored in the CONFIGURATION column.

6.2.3 Breaker Failure Protection

6.2.3.1 External Initiation of BF Protection

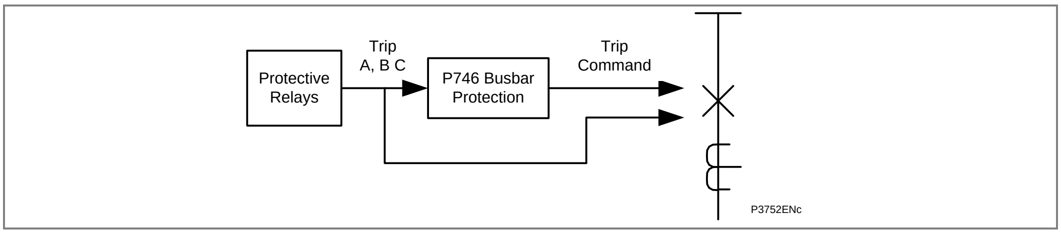


Figure 6 - External initiation of BF protection

To test the retrip:

As shown in the above figure, we initiate the opto inputs “External Trip A,B,C” and apply a current twice the I< threshold.

Check that the P746 issues a retrip order after the settable time tBF3.

Important	**The time indicated on the LCD is the duration of the operation of this trip command.**

The fast reset retrip order is equal to the fault clearance time + 13ms – tBF3 pick-up time.

For example if tBF3 = 50ms and the fault is cleared after 60ms, the P746 displayed value will be 23ms.

To test the backtrip:

Do the same tests as for retrip however apply a faulty current for more than tBF4 and check that the backtrip signal is sent.

Check that feeder 1 and feeder 2 connected to the bus-section 1 are tripped.

6.2.3.2 CB Unavailable:

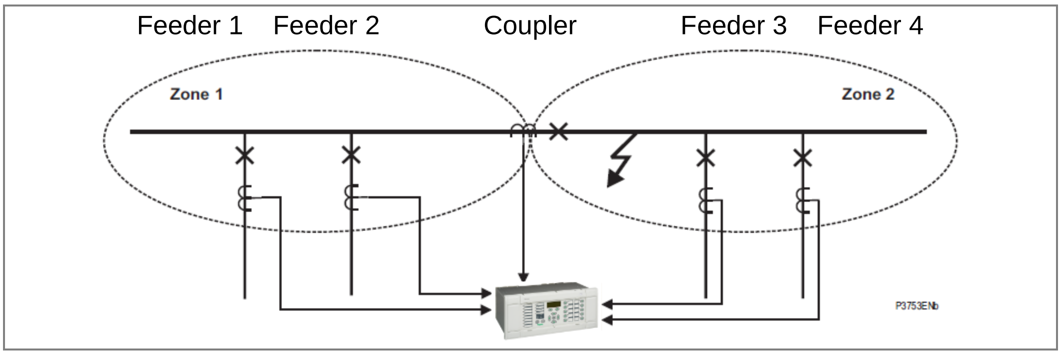


Figure 7 - CB unavailable

Apply an internal fault in zone 2 and energise the opto input “CB unavailable” of the coupler and check that both bus-sections are tripped simultaneously.

Note	*If the input “CB unavailable” is energised, the CB will be not tripped.*

6.2.3.3 Internal Initiation Breaker Failure Protection

This Breaker failure Protection can be initiated only by a trip command issued by the P746.

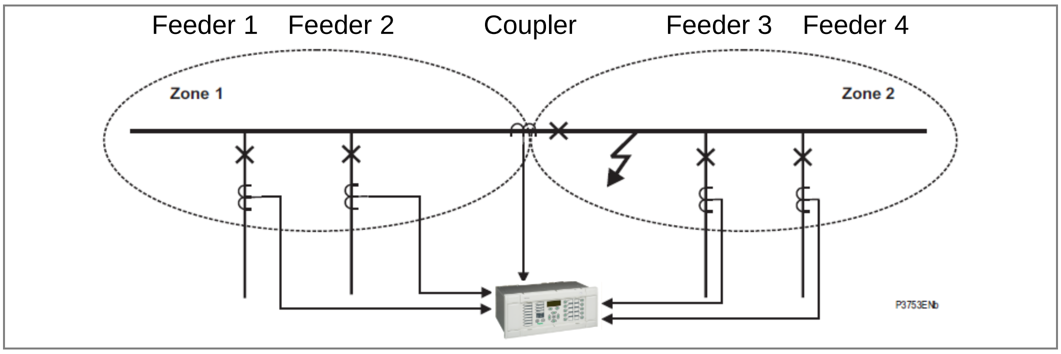


Figure 8 - Internal initiation of BF protection

Simulate a busbar fault on the bus-section 2.

Continue to apply fault current in the bus-coupler and CT3 until the timer tBF1 elapsed.

Check that the retrip signal is given by coupler CB and backtrip signal is sent after tBF2.

Check that the P746 issued a trip command to both bus-sections (feeder 1, feeder 2 feeder 4 and feeder 3 should have operated).

6.3 Check Application Settings

Carefully check applied settings against the required application-specific settings to ensure they have been entered correctly. However, this is not considered essential if a customer-prepared setting file on a memory device has been transferred to the relay using a portable PC.

There are two methods of checking the settings:

- Extract the settings from the relay using a portable PC running the appropriate software (MiCOM S1 Studio) using the front EIA(RS)232 port, under the bottom access cover, or the first rear communications port (Courier protocol with a KITZ protocol converter connected), or the second rear communications port. Compare the settings transferred from the relay with the original written application-specific setting record (for cases where the customer has only provided a printed copy of the required settings but a portable PC is available).
- Step through the settings using the relay's operator interface and compare them with the original application-specific setting record.

Unless previously agreed to the contrary, the application-specific PSL is not checked as part of the commissioning tests.

Due to the versatility and possible complexity of the PSL, it is beyond the scope of these commissioning instructions to detail suitable test procedures. Therefore, when PSL tests must be performed, written tests that satisfactorily demonstrate the correct operation of the application-specific scheme logic should be devised by the engineer who created it. These tests should be provided to the Commissioning Engineer with the memory device containing the PSL setting file.

7 ON-LOAD CHECKS

We recommend using the “MiCOM P746 remote HMI” tool.
The objectives of the on-load checks are to:

- Confirm the external wiring to the current inputs is correct.
- Ensure the on-load differential current is well below the relay setting.

However, these checks can only be carried out if there are no restrictions preventing the energisation of the plant being protected and the other P746 relays in the group have been commissioned.

Caution	**Remove all test leads and temporary shorting leads, and replace any external wiring that was removed to allow testing.**

Caution	**If any of the external wiring was disconnected from the relay to run any tests, make sure that all connections are restored according to the external connection or scheme diagram.**

7.1 Confirm Current Transformer Wiring

We recommend using the “MiCOM P746 remote HMI” tool. Otherwise, the following process can be done:

Caution	**Measure the current transformer secondary values for each input using a multimeter connected in series with corresponding relay current input.**

Caution	***Check that the current transformer polarities are correct.***

Caution	**Ensure the current flowing in the neutral circuit of the current transformers is negligible.**

Compare the values of the secondary phase currents (and any phase angle) with the relay’s measured values, which can be found in the **MEASUREMENTS 1** menu column.

Note	*Under normal load conditions the earth fault function measures little or no current. It is therefore necessary to simulate a phase-to-neutral fault. This can be achieved by temporarily disconnecting one or two of the line current transformer connections to the relay and shorting the terminals of these current transformer secondary windings.*

If cell [0D02: MEASURE’T SETUP, Local Values] is set to **Secondary**, the current displayed on the relay LCD or a portable PC connected to the front EIA(RS)232 communication port should be equal to the applied secondary current. The values should be within 1% (5% for the P741/P742/P743/P746) of the applied secondary currents. However, an additional allowance must be made for the accuracy of the test equipment being used.

If cell [0D02: MEASURE’T SETUP, Local Values] is set to **Primary**, the current displayed should be equal to the applied secondary current multiplied by the corresponding current transformer ratio set in the **CT & VT RATIOS** menu column (see the *Measured Voltages and VT Ratio Settings* table). Again the values should be within 10% (1% for the P34x, 5% for the P741/P742/P743/P746) of the expected value, plus an additional allowance for the accuracy of the test equipment being used.

Note	*If the relay is applied with a single dedicated current transformer for the earth fault function, it may not be possible to check the relay’s measured values as the neutral current will be almost zero.*

7.2 Confirm Voltage Transformer Wiring

We recommend using the “MiCOM P746 remote HMI” tool. Otherwise, the following process can be done:

8 FINAL CHECKS

The tests are now complete.

Caution	Remove all test or temporary shorting leads. If it has been necessary to disconnect any of the external wiring from the relay to perform the wiring verification tests, make sure all connections are replaced according to the relevant external connection or scheme diagram.

Ensure that the relay is restored to service by checking that cell [0F0F: COMMISSIONING TESTS, Test Mode] is set to ‘**Disabled**’.

If the menu language was changed to allow accurate testing, it must now be restored to the customer’s preferred language.

If a MiCOM P991 or Easergy test block is installed, remove the MiCOM P992 or Easergy test plug and replace the test block cover so that the protection is put into service.

Ensure that all event records, fault records, disturbance records, alarms and LEDs have been reset before leaving the relay.

If applicable, replace the secondary front cover on the relay.

TEST AND SETTINGS RECORDS

CHAPTER 12

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Software Version:	B4 (P746_1) / C4 (P746_2)
Hardware Suffix:	M
Connection Diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

Notes:

1 COMMISSIONING TEST RECORD

1.1 About this Chapter

The Commissioning chapter provides instructions on how to commission the relay – including how to calibrate it and how to establish that it is functioning as intended.

This chapter provides you with a series of templates. You can use this to record the tests which have been made and the settings which have been used. You should use this chapter in conjunction with the Commissioning chapter and any work instructions you have as to what functionality and settings the relay should use.

1.2 Date Record

Date:		Engineer:	
Station:		Circuit:	
		System Frequency:	……… Hz
VT Ratio:	……… / ……… V	CT Ratio (tap in use):	……… /A

1.3 Front Plate Information

Relay type	MiCOM P…………
Model number	
Serial number	
Rated current In	
Rated voltage Vn	
Auxiliary voltage Vx	

1.4 Test Equipment Used

This section should be completed to allow future identification of protective devices that have been commissioned using equipment that is later found to be defective or incompatible but may not be detected during the commissioning procedure.

Overcurrent test set	Model: Serial No:	
Injection test set	Model: Serial No:	
Phase angle meter	Model: Serial No:	
Phase rotation meter	Model: Serial No:	
Optical power meter	Model: Serial No:	
Insulation tester	Model: Serial No:	
Setting software:	Type: Version:	

1.5 Product Checks

	Have all relevant safety instructions been followed?	Yes/No*

Note *The numbers in bold on the left-hand side represent the relevant Section of the Commissioning chapter.*

4	**PRODUCT CHECKS**	
4.1	**With the Relay De-Energised**	
4.1.1	**Visual Inspection**	
	Relay damaged?	Yes/No*
	Rating information correct for installation?	Yes/No*
	Case earth installed?	Yes/No*
4.1.2	**Current Transformer Shorting Contacts Close?**	Yes/No/Not checked*
4.1.3	**Insulation Resistance >100MΩ at 500V dc**	Yes/No/Not tested*
4.1.4	**External Wiring**	
	Wiring checked against diagram?	Yes/No*
	Test block connections checked?	Yes/No/na*
4.1.5	**Watchdog Contacts (Auxiliary Supply Off)**	
	Terminals 11 and 12 Contact closed?	Yes/No*
	Contact resistance	____Ω/Not measured*
	Terminals 13 and 14 Contact open?	Yes/No*
4.1.6	**Measured Auxiliary Supply**	______V ac/dc*
4.2	**With the Relay Energised**	
4.2.1	**Watchdog Contacts (Auxiliary Supply On)**	
	Terminals 11 and 12 Contact open?	Yes/No*
	Terminals 13 and 14 Contact closed?	Yes/No*
	Contact resistance	____Ω/Not measured*
4.2.2	**Date and Time**	
	Clock set to local time?	Yes/No*
	Time maintained when auxiliary supply removed?	Yes/No*
4.2.3	**Keys and Light Emitting Diodes**	
	Keys working?	Yes/No*
	Hot Keys working?	Yes/No*
	Alarm (yellow) LED working?	Yes/No*
	Out of service (yellow) LED working?	Yes/No*
	Trip (red) LED Working?	Yes/No*
	All 8 left programmable LEDs working?	Yes/No/Not checked *
	All 10 right programmable LEDs working?	Yes/No/Not checked *
4.2.4	**Field Supply Supply Voltage**	
	Value measured between terminals 7 and 9	______V dc
	Value measured between terminals 8 and 10	______V dc

5.2.6 Input opto-isolators (numbers vary depending on the product)

Opto input 1	working?	Yes	☐	No	☐		
Opto input 2	working?	Yes	☐	No	☐		
Opto input 3	working?	Yes	☐	No	☐		
Opto input 4	working?	Yes	☐	No	☐		
Opto input 5	working?	Yes	☐	No	☐		
Opto input 6	working?	Yes	☐	No	☐		
Opto input 7	working?	Yes	☐	No	☐		
Opto input 8	working?	Yes	☐	No	☐		
Opto input 9	working?	Yes	☐	No	☐		
Opto input 10	working?	Yes	☐	No	☐		
Opto input 11	working?	Yes	☐	No	☐		
Opto input 12	working?	Yes	☐	No	☐		
Opto input 13	working?	Yes	☐	No	☐		
Opto input 14	working?	Yes	☐	No	☐		
Opto input 15	working?	Yes	☐	No	☐		
Opto input 16	working?	Yes	☐	No	☐		
Opto input 17	working?	Yes	☐	No	☐	N/A	☐
Opto input 18	working?	Yes	☐	No	☐	N/A	☐
Opto input 19	working?	Yes	☐	No	☐	N/A	☐
Opto input 20	working?	Yes	☐	No	☐	N/A	☐
Opto input 21	working?	Yes	☐	No	☐	N/A	☐
Opto input 22	working?	Yes	☐	No	☐	N/A	☐
Opto input 23	working?	Yes	☐	No	☐	N/A	☐
Opto input 24	working?	Yes	☐	No	☐	N/A	☐

Opto input 25	working?	Yes	☐	No	☐	N/A	☐
Opto input 26	working?	Yes	☐	No	☐	N/A	☐
Opto input 27	working?	Yes	☐	No	☐	N/A	☐
Opto input 28	working?	Yes	☐	No	☐	N/A	☐
Opto input 29	working?	Yes	☐	No	☐	N/A	☐
Opto input 30	working?	Yes	☐	No	☐	N/A	☐
Opto input 31	working?	Yes	☐	No	☐	N/A	☐
Opto input 32	working?	Yes	☐	No	☐	N/A	☐
Opto input 33	working?	Yes	☐	No	☐	N/A	☐
Opto input 34	working?	Yes	☐	No	☐	N/A	☐
Opto input 35	working?	Yes	☐	No	☐	N/A	☐
Opto input 36	working?	Yes	☐	No	☐	N/A	☐
Opto input 37	working?	Yes	☐	No	☐	N/A	☐
Opto input 38	working?	Yes	☐	No	☐	N/A	☐
Opto input 39	working?	Yes	☐	No	☐	N/A	☐
Opto input 40	working?	Yes	☐	No	☐	N/A	☐

4.2.5 Input Opto-Isolators

Opto input 1 working?	Yes/No*
Opto input 2 working?	Yes/No*
Opto input 3 working?	Yes/No*
Opto input 4 working?	Yes/No*
Opto input 5 working?	Yes/No*
Opto input 6 working?	Yes/No*
Opto input 7 working?	Yes/No*
Opto input 8 working?	Yes/No*
Opto input 9 working?	Yes/No*

Opto input 10 working?	Yes/No*
Opto input 11 working?	Yes/No*
Opto input 12 working?	Yes/No*
Opto input 13 working?	Yes/No*
Opto input 14 working?	Yes/No*
Opto input 15 working?	Yes/No*
Opto input 16 working?	Yes/No*
Opto input 17 working?	Yes/No/na*
Opto input 18 working?	Yes/No/na*
Opto input 19 working?	Yes/No/na*
Opto input 20 working?	Yes/No/na*
Opto input 21 working?	Yes/No/na*
Opto input 22 working?	Yes/No/na*
Opto input 23 working?	Yes/No/na*
Opto input 24 working?	Yes/No/na*
Opto input 25 working?	Yes/No/na*
Opto input 26 working?	Yes/No/na*
Opto input 27 working?	Yes/No/na*
Opto input 28 working?	Yes/No/na*
Opto input 29 working?	Yes/No/na*
Opto input 30 working?	Yes/No/na*
Opto input 31 working?	Yes/No/na*
Opto input 32 working?	Yes/No/na*
Opto input 33 working?	Yes/No/na*
Opto input 34 working?	Yes/No/na*
Opto input 35 working?	Yes/No/na*
Opto input 36 working?	Yes/No/na*
Opto input 37 working?	Yes/No/na*
Opto input 38 working?	Yes/No/na*
Opto input 39 working?	Yes/No/na*
Opto input 40 working?	Yes/No/na*

4.2.6 Output Relays

Relay 1 Working?			Yes/No*
	Contact resistance		____Ω/Not measured*
Relay 2 Working?			Yes/No*
	Contact resistance		____Ω/Not measured*
Relay 3 Working?			Yes/No*
	Contact resistance		____Ω/Not measured*
Relay 4 Working?			Yes/No*
	Contact resistance		____Ω/Not measured*
Relay 5	Working?		Yes/No*
	Contact resistance		____Ω/Not measured*
Relay 6	Working?		Yes/No*
	Contact resistance		____Ω/Not measured*
Relay 7	Working?		Yes/No*
	Contact resistance	(N/C)	____Ω/Not measured*
		(N/O)	____Ω/Not measured*
Relay 8	Working?		Yes/No*
	Contact resistance	(N/C)	____Ω/Not measured*
		(N/O)	____Ω/Not measured*

Relay 9	working?		Yes	☐	No	☐	N/A ☐
	Contact resistance		Ω	☐	Not measured	☐	
Relay 10	working?		Yes	☐	No	☐	N/A ☐
	Contact resistance		Ω	☐	Not measured	☐	
Relay 11	working?		Yes	☐	No	☐	N/A ☐
	Contact resistance		Ω	☐	Not measured	☐	
Relay 12	working?		Yes	☐	No	☐	N/A ☐
	Contact resistance		Ω	☐	Not measured	☐	
Relay 13	working?		Yes	☐	No	☐	N/A ☐
	Contact resistance		Ω	☐	Not measured	☐	
Relay 14	working?		Yes	☐	No	☐	N/A ☐
	Contact resistance		Ω	☐	Not measured	☐	
Relay 15	working?		Yes	☐	No	☐	N/A ☐
	Contact resistance	(N/C)	Ω	☐	Not measured	☐	
		(N/O)	Ω	☐	Not measured	☐	
Relay 16	working?		Yes	☐	No	☐	N/A ☐
	Contact resistance	(N/C)	Ω	☐	Not measured	☐	
		(N/O)	Ω	☐	Not measured	☐	

Relay 17	Working?	Yes/No/na*
	Contact resistance	____Ω/Not measured*
Relay 18	Working?	Yes/No/na*
	Contact resistance	____Ω/Not measured*
Relay 19	Working?	Yes/No*
	Contact resistance	____Ω/Not measured*

Relay 20	Working?	Yes/No/na*

	Contact resistance		____Ω/Not measured*
Relay 21	Working?		Yes/No/na*
	Contact resistance		____Ω/Not measured*
Relay 22	Working?		Yes/No/na*
	Contact resistance		____Ω/Not measured*
Relay 23	Working?		Yes/No/na*
	Contact resistance	(N/C)	____Ω/Not measured*
		(N/O)	____Ω/Not measured*
Relay 24	Working?		Yes/No/na*
	Contact resistance	(N/C)	____Ω/Not measured*
		(N/O)	____Ω/Not measured*
Relay 25	Working?		Yes/No/na*
	Contact resistance		____Ω/Not measured*
Relay 26	Working?		Yes/No/na*
	Contact resistance		____Ω/Not measured*
Relay 27	Working?		Yes/No*
	Contact resistance		____Ω/Not measured*
Relay 28	Working?		Yes/No/na*
	Contact resistance		____Ω/Not measured*
Relay 29	Working?		Yes/No/na*
	Contact resistance		____Ω/Not measured*
Relay 30	Working?		Yes/No/na*
	Contact resistance		____Ω/Not measured*
Relay 31	Working?		Yes/No/na*
	Contact resistance	(N/C)	____Ω/Not measured*
		(N/O)	____Ω/Not measured*
Relay 32	Working?		Yes/No/na*
	Contact resistance	(N/C)	____Ω/Not measured*
		(N/O)	____Ω/Not measured*

4.2.9 Current Inputs (one box mode)

It is highly recommended to use the P746 Remote HMI that provides the full picture of all the below values

Displayed Current		Primary/Secondary*
Phase CT1 Ratio		_______ /na*
Input CT1	Applied value	Displayed value
IA	_______A	_______A
IB	_______A	_______A
IC	_______A	_______A
Phase CT2 Ratio		_______ /na*
Input CT2	Applied value	Displayed value
IA	_______A	_______A
IB	_______A	_______A
IC	_______A	_______A
Phase CT3 Ratio		_______ /na*
Input CT3	Applied value	Displayed value
IA	_______A	_______A
IB	_______A	_______A
IC	_______A	_______A
Phase CT4 Ratio		_______ /na*
Input CT4	Applied value	Displayed value
IA	_______A	_______A
IB	_______A	_______A
IC	_______A	_______A
Phase CT5 Ratio		_______ /na*
Input CT5	Applied value	Displayed value
IA	_______A	_______A
IB	_______A	_______A
IC	_______A	_______A
Phase CT6 Ratio		_______ /na*
Input CT6	Applied value	Displayed value
IA	_______A	_______A
IB	_______A	_______A
IC	_______A	_______A
Phase CT7 Ratio (P746_2 only)		_______ /na*
Input CT7	Applied value	Displayed value
IA	_______A/na*	_______A/na*
IB	_______A/na*	_______A/na*
IC	_______A/na*	_______A/na*

4.2.10 Current Inputs (three box mode)

It is highly recommended to use the P746 Remote HMI that provides the full picture of all the below values

Displayed Current		Primary/Secondary*
Phase CT Ratio		_______ /na*
	Applied value	Displayed value
Input CT1 IA or IB or IC	_______A	_______A
Phase CT1 Ratio		_______ /na*
Input CT2 IA or IB or IC	_______A	_______A
Phase CT2 Ratio		_______ /na*
Input CT3 IA or IB or IC	_______A	_______A
Phase CT3 Ratio		_______ /na*
Input CT4 IA or IB or IC	_______A	_______A
Phase CT4 Ratio		_______ /na*
Input CT5 IA or IB or IC	_______A	_______A
Phase CT5 Ratio		_______ /na*
Input CT6 IA or IB or IC	_______A	_______A
Phase CT6 Ratio		_______ /na*
Input CT7 IA or IB or IC	_______A	_______A
Phase CT7 Ratio		_______ /na*
Input CT8 IA or IB or IC	_______A	_______A
Phase CT8 Ratio		_______ /na*
Input CT9 IA or IB or IC	_______A	_______A
Phase CT9 Ratio		_______ /na*
Input CT10 IA or IB or IC	_______A	_______A
Phase CT10 Ratio		_______ /na*
Input CT11 IA or IB or IC	_______A	_______A
Phase CT11 Ratio		_______ /na*
Input CT12 IA or IB or IC	_______A	_______A
Phase CT12 Ratio		_______ /na*
Input CT13 IA or IB or IC	_______A	_______A
Phase CT13 Ratio		_______ /na*
Input CT14 IA or IB or IC	_______A	_______A
Phase CT14 Ratio		_______ /na*
Input CT15 IA or IB or IC	_______A	_______A
Phase CT15 Ratio		_______ /na*
Input CT16 IA or IB or IC	_______A	_______A
Phase CT16 Ratio		_______ /na*
Input CT17 IA or IB or IC	_______A	_______A
Phase CT17 Ratio		_______ /na*
Input CT18 IA or IB or IC	_______A	_______A
Phase CT18 Ratio		_______ /na*
Input CT19 IA or IB or IC	_______A/na*	_______A/na*
Phase CT19 Ratio		_______ /na*
Input CT20 IA or IB or IC	_______A/na*	_______A/na*
Phase CT20 Ratio		_______ /na*

Input CT21 IA or IB or IC	_______A/na*	_______A/na*
Phase CT21 Ratio		_______ /na*

4.2.11 Voltage Inputs (P746_1 only)

It is highly recommended to use the P746 Remote HMI that provides the full picture of all the below values

Displayed Voltage		Primary/Secondary*
Phase VT Ratio		_______ /na*
Input CT	Applied value	Displayed value
VA	_______V/na*	_______V/na*
VB	_______V/na*	_______V/na*
VC	_______V/na*	_______V/na*

6 SETTING CHECKS

6.1	**Apply Application-Specific Settings**	Yes/No*
	Application-specific programmable scheme logic settings applied?	Yes/No/na*
	Protection function timing tested?	Yes/No*
	Applied current	_________A
	Expected operating time	_________s
	Measured operating time	_________s

7 On-Load Checks

It is highly recommended to use the P746 Remote HMI that provides the full picture of all the below values

Test wiring removed?	Yes/No/na*
Disturbed customer wiring re-checked?	Yes/No/na*

7.1 Confirm Current Transformer Wiring

7.1.2 Current Connections

All used CT wiring checked?	Yes/No/na*
All used CT polarities correct?	Yes/No*

7.3 Current Differential measurement check for each zone

Yes/ No*

It is highly recommended to use the P746 Remote HMI that provides the full picture of all the below values

Zone 1	Applied value	Displayed value
IA	_______A	_______A
IB	_______A	_______A
IC	_______A	_______A
Zone 2	Applied value	Displayed value
IA	_______A/na*	_______A/na*
IB	_______A/na*	_______A/na*
IC	_______A/na*	_______A/na*
Zone 3	Applied value	Displayed value
IA	_______A/na*	_______A/na*
IB	_______A/na*	_______A/na*
IC	_______A/na*	_______A/na*
Zone 4	Applied value	Displayed value
IA	_______A/na*	_______A/na*
IB	_______A/na*	_______A/na*
IC	_______A/na*	_______A/na*

7.4 Bias Current measurement check for each zone

Yes/ No*

It is highly recommended to use the P746 Remote HMI that provides the full picture of all the below values

Zone 1	Applied value	Displayed value
IA	_______A	_______A
IB	_______A	_______A
IC	_______A	_______A
Zone 2	Applied value	Displayed value
IA	_______A/na*	_______A/na*
IB	_______A/na*	_______A/na*
IC	_______A/na*	_______A/na*
Zone 3	Applied value	Displayed value

IA	_______A/na*	_______A/na*
IB	_______A/na*	_______A/na*
IC	_______A/na*	_______A/na*
Zone 4	Applied value	Displayed value
IA	_______A/na*	_______A/na*
IB	_______A/na*	_______A/na*
IC	_______A/na*	_______A/na*

8 FINAL CHECKS

Test wiring removed?	Yes/No/na*
Disturbed customer wiring re-checked?	Yes/No/na*
Test mode disabled?	Yes/No*
Circuit breaker operations counter reset?	Yes/No/na*
Current counters reset?	Yes/No/na*
Event records reset?	Yes/No*
Fault records reset?	Yes/No*
Disturbance records reset?	Yes/No*
Alarms reset?	Yes/No*
LED’s reset?	Yes/No*
Secondary front cover replaced?	Yes/No/na*

Commissioning Engineer	Customer Witness
Date:	Date:

2 CREATING A SETTING RECORD

You often need to create a record of what settings have been applied to a device. In the past, you could have used paper printouts of all the available settings, and mark up the ones you had used. Keeping such a paper-based Settings Records can be time-consuming and prone to error (e.g. due to being settings written down incorrectly).

The Easergy Studio (MiCOM S1 Studio) software lets you read/write MiCOM devices.

- **Extract** lets you download all the settings from a MiCOM Px40 device. A summary is given in Extract Settings from a MiCOM Px40 Device below.
- **Send** lets you send the settings you currently have open in the Studio software. A summary is given in Send Settings to a MiCOM Px40 Device below.

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

In most cases, it will be quicker and less error prone to extract settings electronically and store them in a settings file on a memory stick. In this way, there will be a digital record which is certain to be accurate. It is also possible to archive these settings files in a repository; so they can be used again or adapted for another use.

Full details of how to do these tasks is provided in the MiCOM S1 Studio help.

A quick summary of the main steps is given below.

In each case you need to make sure that:

- Your computer includes the MiCOM S1 Studio software.
- Your computer and the MiCOM device are powered on.
- You have used a suitable cable to connect your computer to the MiCOM device (Front Port, Rear Port, Ethernet port or Modem as available).

2.1 Extract Settings from a MiCOM Px40 Device

Full details of how to do this is provided in the Easergy Studio help.

As a quick guide, you need to do the following:

1. In Easergy Studio, click the Quick Connect… button.
2. Select the relevant Device Type in the Quick Connect dialog box.
3. Click the relevant port in the Port Selection dialog box.
4. Enter the relevant connection parameters in the Connection Parameters dialog box and click the Finish button
5. Easergy Studio will try to communicate with the Px40 device. It will display a connected message if the connection attempt is successful.
6. The device will appear in the Studio Explorer pane on the top-left of the interface.
7. Click the + button to expand the options for the device, then click on the Settings folder.
8. Right-click on Settings and select the Extract Settings link to read the settings on the device and store them on your computer or a memory stick.
9. After retrieving the settings file, close the dialog box by clicking the Close button.

2.2 Send Settings to a MiCOM Px40 Device

Full details of how to do this is provided in the Easergy Studio help.

As a quick guide, you need to do the following:

1. In Easergy Studio, click the Quick Connect… button.
2. Select the relevant Device Type in the Quick Connect dialog box.
3. Click the relevant port in the Port Selection dialog box.
4. Enter the relevant connection parameters in the Connection Parameters dialog box and click the Finish button
5. Easergy Studio will try to communicate with the Px40 device. It will display a connected message if the connection attempt is successful.
6. The device will appear in the Studio Explorer pane on the top-left hand side of the interface.
7. Click the + button to expand the options for the device and then right-click on the Settings link.
8. To add an existing file, right-click the settings folder and choose Add Existing File.
9. To create a new file, right-click the settings folder and select Add. A file with the next sequential number will be created. Double-click the file to edit.
10. Right-click on the device name and select the Send link.

Note	*When you send settings to a MiCOM Px40 device, the data is stored in a temporary location at first. This temporary data is tested to make sure it is complete. If the temporary data is complete, it will be programmed into the MiCOM Px40 device. This avoids the risk of a device being programmed with incomplete or corrupt settings.*

11. In the Send To dialog box, select the settings file(s) you wish to send, then click the Send button.
12. Close the Send To dialog box by clicking the Close button.

Notes:

MAINTENANCE

CHAPTER 13

Date:	09/2016	
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.	
Hardware suffix:	All MiCOM Px4x products	
Software version:	All MiCOM Px4x products	
Connection diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P445: 10P445xx (xx = 01 to 04) P44x (P441, P442 & P444): 10P44101 (SH 1 & 2) 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)	P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 1 to 10) 10P643xx (xx = 1 to 6) 10P645xx (xx = 1 to 9) P74x (P741, P742 & P743): 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)

CONTENTS

Page (MT) 13-

Notes:

1 MAINTENANCE PERIOD

Warning **Before inspecting any wiring, performing any tests or carrying out any work on the equipment, you should be familiar with the contents of the Safety Information and Technical Data sections and the information on the equipment's rating label.**

It is recommended that products supplied by Schneider Electric receive periodic monitoring after installation. In view of the critical nature of protective and control equipment, and their infrequent operation, it is desirable to confirm that they are operating correctly at regular intervals.

Schneider Electric protection and control equipment is designed for a life in excess of 20 years.

MiCOM relays are self-supervising and so require less maintenance than earlier designs. Most problems will result in an alarm so that remedial action can be taken. However, some periodic tests should be done to ensure that the equipment is functioning correctly and the external wiring is intact.

If the customer's organization has a preventative maintenance policy, the recommended product checks should be included in the regular program. Maintenance periods depend on many factors, such as:

- The operating environment
- The accessibility of the site
- The amount of available manpower
- The importance of the installation in the power system
- The consequences of failure

2 MAINTENANCE CHECKS

Although some functionality checks can be performed from a remote location by using the communications ability of the equipment, these are predominantly restricted to checking that the equipment, is measuring the applied currents and voltages accurately, and checking the circuit breaker maintenance counters. Therefore it is recommended that maintenance checks are performed locally (i.e. at the equipment itself).

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

Warning **If a P391 is used, you should also be familiar with the ratings and warning statements in the P391 technical manual.**

2.1 Alarms

The alarm status LED should first be checked to identify if any alarm conditions exist. If so, press the read key (📖) repeatedly to step through the alarms.

Clear the alarms to extinguish the LED.

2.2 Opto-Isolators

The opto-isolated inputs can be checked to ensure that the equipment responds to energization by repeating the commissioning test detailed in the Commissioning chapter.

2.3 Output Relays

The output relays can be checked to ensure that they operate by repeating the commissioning test detailed in the Commissioning chapter.

2.4 Measurement Accuracy

If the power system is energized, the values measured by the equipment can be compared with known system values to check that they are in the approximate range that is expected. If they are, the analog/digital conversion and calculations are being performed correctly by the relay. Suitable test methods can be found in the Commissioning chapter.

Alternatively, the values measured by the equipment can be checked against known values injected via the test block, if fitted, or injected directly into the equipment terminals. Suitable test methods can be found in the Commissioning chapter. These tests will prove the calibration accuracy is being maintained.

3 METHOD OF REPAIR

If the equipment should develop a fault whilst in service, depending on the nature of the fault, the watchdog contacts will change state and an alarm condition will be flagged. Due to the extensive use of surface-mount components, faulty Printed Circuit Boards (PCBs) should be replaced, as it is not possible to perform repairs on damaged PCBs. Therefore either the complete equipment module or just the faulty PCB (as identified by the in-built diagnostic software), can be replaced. Advice about identifying the faulty PCB can be found in the Troubleshooting chapter.

The preferred method is to replace the complete equipment module as it ensures that the internal circuitry is protected against electrostatic discharge and physical damage at all times and overcomes the possibility of incompatibility between replacement PCBs. However, it may be difficult to remove installed equipment due to limited access in the back of the cubicle and the rigidity of the scheme wiring.

Replacing PCBs can reduce transport costs but requires clean, dry conditions on site and higher skills from the person performing the repair. If the repair is not performed by an approved service center, the warranty will be invalidated.

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

This should ensure that no damage is caused by incorrect handling of the electronic components.

3.1 Replacing the Complete Equipment IED/Relay

The case and rear terminal blocks have been designed to facilitate removal of the IED/relay should replacement or repair become necessary without having to disconnect the scheme wiring.

Warning	Before working at the rear of the equipment, isolate all voltage and current supplies to the equipment.

Note	The MiCOM range has integral current transformer shorting switches which will close when the heavy duty terminal block is removed.

1. Disconnect the equipment's earth, IRIG-B and fiber optic connections, as appropriate, from the rear of the device.

   There are two types of terminal block used on the equipment, medium and heavy duty, which are fastened to the rear panel using Pozidriv or PZ1 screws. The P24x/P34x/P64x ranges also includes an RTD/CLIO terminal block option. These block types are shown in the ***Commissioning*** chapter.

Important	The use of a magnetic bladed screwdriver is recommended to minimize the risk of the screws being left in the terminal block or lost.

2. Without exerting excessive force or damaging the scheme wiring, pull the terminal blocks away from their internal connectors.
3. Remove the screws used to fasten the equipment to the panel, rack, etc. These are the screws with the larger diameter heads that are accessible when the access covers are fitted and open.

Warning	If the top and bottom access covers have been removed, do not remove the screws with the smaller diameter heads which are accessible. These screws secure the front panel to the equipment.

4. Withdraw the equipment carefully from the panel, rack, etc. because it will be heavy due to the internal transformers.

To reinstall the repaired or replacement equipment, follow the above instructions in reverse, ensuring that each terminal block is relocated in the correct position and the case earth, IRIG-B and fiber optic connections are replaced. To facilitate easy identification of each terminal block, they are labeled alphabetically with 'A' on the left-hand side when viewed from the rear.

Once reinstallation is complete, the equipment should be re-commissioned using the instructions in the Commissioning chapter.

3.2 Replacing a PCB

Replacing PCBs and other internal components must be undertaken only by Service Centers approved by Schneider Electric. Failure to obtain the authorization of Schneider Electric after sales engineers prior to commencing work may invalidate the product warranty.

Warning **Before removing the front panel to replace a PCB, remove the auxiliary supply and wait at least 30 seconds for the capacitors to discharge.**
We strongly recommend that the voltage and current transformer connections and trip circuit are isolated.

Schneider Electric support teams are available world-wide. We strongly recommend that any repairs be entrusted to those trained personnel. For this reason, details on product disassembly and re-assembly are not included here.

4 RE-CALIBRATION

Re-calibration is not required when a PCB is replaced **unless it happens to be one of the boards in the input module;** the replacement of either directly affects the calibration.

Warning	**Although it is possible to carry out re-calibration on site, this requires test equipment with suitable accuracy and a special calibration program to run on a PC. It is therefore recommended that the work be carried out by the manufacturer, or entrusted to an approved service center.**

5 CHANGING THE BATTERY

Each relay/IED has a battery to maintain status data and the correct time when the auxiliary supply voltage fails. The data maintained includes event, fault and disturbance records and the thermal state at the time of failure.

This battery will periodically need changing, although an alarm will be given as part of the relay's/IED's continuous self-monitoring in the event of a low battery condition.

If the battery-backed facilities are not required to be maintained during an interruption of the auxiliary supply, the steps below can be followed to remove the battery, but do not replace with a new battery.

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

5.1 Instructions for Replacing the Battery

1. Open the bottom access cover on the front of the equipment.
2. Gently extract the battery from its socket. If necessary, use a small, insulated screwdriver to prize the battery free.
3. Ensure that the metal terminals in the battery socket are free from corrosion, grease and dust.
4. The replacement battery should be removed from its packaging and placed into the battery holder, taking care to ensure that the polarity markings on the battery agree with those adjacent to the socket.

Note	*Only use a type ½AA Lithium battery with a nominal voltage of 3.6 V and safety approvals such as UL (Underwriters Laboratory), CSA (Canadian Standards Association) or VDE (Vereinigung Deutscher Elektrizitätswerke).*

5. Ensure that the battery is securely held in its socket and that the battery terminals are making good contact with the metal terminals of the socket.
6. Close the bottom access cover.

5.2 Post Modification Tests

To ensure that the replacement battery will maintain the time and status data if the auxiliary supply fails, check cell [0806: DATE and TIME, Battery Status] reads 'Healthy'. If further confirmation that the replacement battery is installed correctly is required, the commissioning test is described in the Commissioning chapter, 'Date and Time', can be performed.

5.3 Battery Disposal

The battery that has been removed should be disposed of in accordance with the disposal procedure for Lithium batteries in the country in which the equipment is installed.

6 CLEANING

Warning **Before cleaning the equipment ensure that all ac and dc supplies, current transformer and voltage transformer connections are isolated to prevent any chance of an electric shock whilst cleaning.**

The equipment may be cleaned using a lint-free cloth moistened with clean water. The use of detergents, solvents or abrasive cleaners is not recommended as they may damage the relay's surface and leave a conductive residue.

TROUBLESHOOTING

CHAPTER 14

Date:	09/2016	
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.	
Hardware Suffix:	All MiCOM Px4x products	
Software Version:	All MiCOM Px4x products	
Connection Diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P445: 10P445xx (xx = 01 to 04) P44x(P442 & P444): 10P44101 (SH 1 & 2) 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)	P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 1 to 10) 10P643xx (xx = 1 to 6) 10P645xx (xx = 1 to 9) P74x (P741, P742 & P743): 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)

CONTENTS

TABLES

Notes:

1 INTRODUCTION

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

The purpose of this chapter of the service manual is to allow an error condition on the relay to be identified so that appropriate corrective action can be taken.

If the relay has developed a fault, it should be possible in most cases to identify which relay module requires attention. The *Maintenance* chapter advises on the recommended method of repair where faulty modules need replacing. It is not possible to perform an on-site repair to a faulted module.

In cases where a faulty relay/module is being returned to the manufacturer or one of their approved service centers, completed copy of the Repair/Modification Return Authorization Form located at the end of this chapter should be included.

2 INITIAL PROBLEM IDENTIFICATION

Consult the following table to find the description that best matches the problem experienced, then consult the section referenced to perform a more detailed analysis of the problem.

Symptom	Refer To
Relay fails to power up	Power-Up Errors section
Relay powers up - but indicates error and halts during power-up sequence	Error Message/Code On Power-Up section
Relay Powers up but Out of Service LED is illuminated	Out of Service LED illuminated on Power Up section
Error during normal operation	Error Code During Operation section
Mal-operation of the relay during testing	Mal-Operation of the Relay during Testing section

Table 1 - Problem identification

3 POWER UP ERRORS

If the relay does not appear to power up then the following procedure can be used to determine whether the fault is in the external wiring, auxiliary fuse, power supply module of the relay or the relay front panel.

Test	Check	Action
1	Measure auxiliary voltage on terminals 1 and 2; verify voltage level and polarity against rating the label on front. Terminal 1 is –dc, 2 is +dc	If auxiliary voltage is present and correct, then proceed to test 2. Otherwise the wiring/fuses in auxiliary supply should be checked.
2	Do LEDs/and LCD backlight illuminate on power-up, also check the N/O watchdog contact for closing.	If they illuminate or the contact closes and no error code is displayed then error is probably in the main processor board (front panel). If they do not illuminate and the contact does not close then proceed to test 3.
3	Check Field voltage output (nominally 48V DC)	If field voltage is not present then the fault is probably in the relay power supply module.

Table 2 - Failure of relay to power up

4 ERROR MESSAGE/CODE ON POWER-UP

During the power-up sequence of the relay self-testing is performed as indicated by the messages displayed on the LCD. If an error is detected by the relay during these self-tests, an error message will be displayed and the power-up sequence will be halted. If the error occurs when the relay application software is executing, a maintenance record will be created and the relay will reboot.

Test	Check	Action
1	Is an error message or code permanently displayed during power up?	If relay locks up and displays an error code permanently then proceed to Test 2. If the relay prompts for input by the user proceed to Test 4. If the relay re-boots automatically then proceed to Test 5.
2	Record displayed error, then remove and re-apply relay auxiliary supply.	Record whether the same error code is displayed when the relay is rebooted. If no error code is displayed then contact the local service center stating the error code and relay information. If the same code is displayed proceed to Test 3.
3	Error code Identification Following text messages (in English) will be displayed if a fundamental problem is detected preventing the system from booting: Bus Fail address lines SRAM Fail data lines FLASH Fail format error FLASH Fail checksum Code Verify Fail These hex error codes relate to errors detected in specific relay modules:	These messages indicate that a problem has been detected on the main processor board of the relay (located in the front panel).
	0c140005/0c0d0000	Input Module (inc. Opto-isolated inputs)
	0c140006/0c0e0000	Output Relay Cards
	Last 4 digits provide details on the actual error.	Other error codes relate to problems within the main processor board hardware or software. It will be necessary to contact Schneider Electric with details of the problem for a full analysis.
4	Relay displays message for corrupt settings and prompts for restoration of defaults to the affected settings.	The power up tests have detected corrupted relay settings, it is possible to restore defaults to allow the power-up to be completed. It will then be necessary to re-apply the application-specific settings.
5	Relay resets on completion of power up - record error code displayed	Error 0x0E080000, Programmable Scheme Logic (PSL) error due to excessive execution time. Restore default settings by performing a power up with ◁ and ▷ keys depressed, confirm restoration of defaults at prompt using (↵) key. If relay powers up successfully, check PSL for feedback paths. Other error codes will relate to software errors on the main processor board, contact Schneider Electric.

Table 3 - Power-up self-test error

5 OUT OF SERVICE LED ILLUMINATED ON POWER UP

Test	Check	Action	
1	Using the relay menu confirm whether the Commission Test/Test Mode setting is Contact Blocked. Otherwise proceed to test 2.	If the setting is Contact Blocked then disable the test mode and, verify that the Out of Service LED is extinguished.	
2	Select and view the last maintenance record from the menu (in the View Records).	Check for H/W Verify Fail this indicates a discrepancy between the relay model number and the hardware; examine the "**Maint. Data**", this indicates the causes of the failure using bit fields:	
		Bit	**Meaning**
		0	The application type field in the model number does not match the software ID
		1	The application field in the model number does not match the software ID
		2	The variant 1 field in the model number does not match the software ID
		3	The variant 2 field in the model number does not match the software ID
		4	The protocol field in the model number does not match the software ID
		5	The language field in the model number does not match the software ID
		6	The VT type field in the model number is incorrect (110V VTs fitted)
		7	The VT type field in the model number is incorrect (440V VTs fitted)
		8	The VT type field in the model number is incorrect (no VTs fitted)

Table 4 - Out of service LED illuminated

6 ERROR CODE DURING OPERATION

The relay performs continuous self-checking, if an error is detected then an error message will be displayed, a maintenance record will be logged and the relay will reset (after a 1.6 second delay). A permanent problem (for example due to a hardware fault) will generally be detected on the power up sequence, following which the relay will display an error code and halt. If the problem was transient in nature then the relay should reboot correctly and continue in operation. The nature of the detected fault can be determined by examination of the maintenance record logged.

There are also two cases where a maintenance record will be logged due to a detected error where the relay will not reset. These are detection of a failure of either the field voltage or the lithium battery, in these cases the failure is indicated by an alarm message, however the relay will continue to operate.

If the field voltage is detected to have failed (the voltage level has dropped below threshold), then a scheme logic signal is also set. This allows the scheme logic to be adapted in the case of this failure (for example if a blocking scheme is being used).

In the case of a battery failure it is possible to prevent the relay from issuing an alarm using the setting under the Date and Time section of the menu. This setting ‘**Battery Alarm**’ can be set to '**Disabled**' to allow the relay to be used without a battery, without an alarm message being displayed.

In the case of an RTD board failure, an alarm "RTD board fail" message is displayed, the RTD protection is disabled, but the operation of the rest of the relay functionality is unaffected.

7 MAL-OPERATION OF THE RELAY DURING TESTING

7.1 Failure of Output Contacts

An apparent failure of the relay output contacts may be caused by the relay configuration; the following tests should be performed to identify the real cause of the failure.

Note	*The relay self-tests verify that the coil of the contact has been energized, an error will be displayed if there is a fault in the output relay board.*

Test	Check	Action
1	Is the Out of Service LED illuminated?	Illumination of this LED may indicate that the relay is Contact Blocked or that the protection has been disabled due to a hardware verify error (see the *Out of service LED illuminated* table..
2	Examine the Contact status in the Commissioning section of the menu.	If the relevant bits of the contact status are operated, proceed to test 4, if not proceed to test 3.
3	Verify by examination of the fault record or by using the test port whether the protection element is operating correctly.	If the protection element does not operate verify whether the test is being correctly applied. If the protection element does operate, it will be necessary to check the PSL to ensure that the mapping of the protection element to the contacts is correct.
4	Using the Commissioning/Test mode function apply a test pattern to the relevant relay output contacts and verify whether they operate (note the correct external connection diagram should be consulted). A continuity tester can be used at the rear of the relay for this purpose.	If the output relay does operate, the problem must be in the external wiring to the relay. If the output relay does not operate this could indicate a failure of the output relay contacts (note that the self-tests verify that the relay coil is being energized). Ensure that the closed resistance is not too high for the continuity tester to detect.

Table 5 - Failure of output contacts

7.2 Failure of Opto-Isolated Inputs

The opto-isolated inputs are mapped onto the relay internal signals using the PSL. If an input does not appear to be recognized by the relay scheme logic the Commission Tests/Opto Status menu option can be used to verify whether the problem is in the opto-isolated input itself or the mapping of its signal to the scheme logic functions. If the opto-isolated input does appear to be read correctly then it will be necessary to examine its mapping within the PSL.

Ensure the voltage rating for the opto inputs has been configured correctly with applied voltage. If the opto-isolated input state is not being correctly read by the relay the applied signal should be tested. Verify the connections to the opto-isolated input using the correct wiring diagram and the correct nominal voltage settings in any standard or custom menu settings. Next, using a voltmeter verify that 80% opto setting voltage is present on the terminals of the opto-isolated input in the energized state. If the signal is being correctly applied to the relay then the failure may be on the input card itself. Depending on which opto-isolated input has failed this may require replacement of either the complete analog input module (the board within this module cannot be individually replaced without re-calibration of the relay) or a separate opto board.

7.3 Incorrect Analog Signals

The measurements may be configured in primary or secondary to assist. If it is suspected that the analog quantities being measured by the relay are not correct then the measurement function of the relay can be used to verify the nature of the problem. The measured values displayed by the relay should be compared with the actual magnitudes at the relay terminals. Verify that the correct terminals are being used (in particular the dual rated CT inputs) and that the CT and VT ratios set on the relay are correct. The correct 120 degree displacement of the phase measurements should be used to confirm that the inputs have been correctly connected.

7.4 PSL Editor Troubleshooting

A failure to open a connection could be because of one or more of the following:

- The relay address is not valid (note: this address is always 1 for the front port).
- Password is not valid
- Communication Set-up - COM port, Baud rate, or Framing - is not correct
- Transaction values are not suitable for the relay and/or the type of connection
- Modem configuration is not valid. Changes may be necessary when using a modem
- The connection cable is not wired correctly or broken. See MiCOM S1 connection configurations
- The option switches on any KITZ101/102 that is in use may be incorrectly set

7.4.1 Diagram Reconstruction after Recover from Relay

Although the extraction of a scheme from a relay is supported, the facility is provided as a way of recovering a scheme in the event that the original file is unobtainable.

The recovered scheme will be logically correct, but much of the original graphical information is lost. Many signals will be drawn in a vertical line down the left side of the canvas. Links are drawn orthogonally using the shortest path from A to B.

Any annotation added to the original diagram (titles, notes, etc.) are lost.

Sometimes a gate type may not be what was expected, e.g. a 1-input AND gate in the original scheme will appear as an OR gate when uploaded. Programmable gates with an inputs-to-trigger value of 1 will also appear as OR gates.

7.4.2 PSL Version Check

The PSL is saved with a version reference, time stamp and CRC check. This gives a visual check whether the default PSL is in place or whether a new application has been downloaded.

8 REPAIR AND MODIFICATION PROCEDURE

Please follow these steps to return an Automation product to us:

1. Get the Repair and Modification Authorization Form (RMA).

   A copy of the RMA form is shown at the end of this section.

2. Fill in the RMA form.

   Fill in only the white part of the form.

   Please ensure that all fields marked **(M)** are completed such as:

   Equipment model

   Model No. and Serial No.

   Description of failure or modification required (please be specific)

   Value for customs (in case the product requires export)

   Delivery and invoice addresses

   Contact details

3. Receive from local service contact, the information required to ship the product.

   Your local service contact will provide you with all the information:

   Pricing details

   RMA No

   Repair center address

   If required, an acceptance of the quote must be delivered before going to next stage.

4. Send the product to the repair center.

   Address the shipment to the repair center specified by your local contact.

   Ensure all items are protected by appropriate packaging: anti-static bag and foam protection.

   Ensure a copy of the import invoice is attached with the unit being returned.

   Ensure a copy of the RMA form is attached with the unit being returned.

   E-mail or fax a copy of the import invoice and airway bill document to your local contact.

Notes:

REPAIR/MODIFICATION RETURN AUTHORIZATION FORM

FIELDS IN GREY TO BE FILLED IN BY SCHNEIDER ELECTRIC PERSONNEL ONLY

Reference **RMA:**		Date:
Repair Center Address (for shipping)	**Service Type** ☐ Retrofit ☐ Warranty ☐ Paid service ☐ Under repair contract ☐ Wrong supply	LSC PO No.:
Schneider Electric - Local Contact Details Name: Telephone No.: Fax No.: E-mail:		

IDENTIFICATION OF UNIT

Fields marked (M) are mandatory, delays in return will occur if not completed.

Model No./Part No.: **(M)**	Site Name/Project:
Manufacturer Reference: **(M)**	Commissioning Date:
Serial No.: **(M)**	Under Warranty: ☐ Yes ☐ No
Software Version:	Additional Information:
Quantity:	Customer P.O (if paid):

FAULT INFORMATION

Type of Failure	**Found Defective**
Hardware fail ☐	During FAT/inspection ☐
Mechanical fail/visible defect ☐	On receipt ☐
Software fail ☐	During installation/commissioning ☐
Other:	During operation ☐
	Other:
Fault Reproducibility	
Fault persists after removing, checking on test bench ☐	
Fault persists after re-energization ☐	
Intermittent fault ☐	

Description of Failure Observed or Modification Required - *Please be specific* **(M)**

FOR REPAIRS ONLY

Would you like us to install an updated firmware version after repair?	☐	Yes	☐	No

CUSTOMS & INVOICING INFORMATION

Required to allow return of repaired items

Value for Customs (M)	
Customer Invoice Address ((M) if paid)	**Customer Return Delivery Address** **(full street address) (M)** Part shipment accepted ☐ Yes ☐ No **OR** Full shipment required ☐ Yes ☐ No
Contact Name: Telephone No.: Fax No.: E-mail:	Contact Name: Telephone No.: Fax No.: E-mail:

REPAIR TERMS

1. **Please ensure that a copy of the import invoice is attached with the returned unit, together with the airway bill document.** Please fax/e-mail a copy of the appropriate documentation **(M)**.
2. Please ensure the Purchase Order is released, for paid service, to allow the unit to be shipped.
3. Submission of equipment to Schneider Electric is deemed as authorization to repair and acceptance of quote.
4. Please ensure all items returned are marked as Returned for 'Repair/Modification' and **protected by appropriate packaging** (anti-static bag for each board and foam protection).

SCADA COMMUNICATIONS

CHAPTER 15

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Hardware Suffix:	M
Software Version:	B4 (P746_1) / C4 (P746_2)
Connection Diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

FIGURES

TABLES

Notes:

1 INTRODUCTION

This chapter describes the remote interfaces of the MiCOM relay in enough detail to allow integration in a substation communication network. The relay supports a choice of one of a number of protocols through the rear 2-wire EIA(RS)485 communication interface, selected using the model number when ordering. This is in addition to the front serial interface and second rear communications port, which supports the Courier protocol only. According to the protocol and hardware options selected, the interface may alternatively be presented over an optical fiber interface, or via an Ethernet connection.

The supported protocols include:

- Courier
- IEC-80870-5-103
- DNP3.0
- MODBUS
- IEC 61850 Ethernet Interface

The implementation of both Courier and IEC 60870-5-103 on RP1 can also, optionally, be presented over fiber as well as EIA(RS)485.

The DNP3.0 implementation is available via EIA(RS)485 port or over Ethernet port.

The rear EIA(RS)-485 interface is isolated and is suitable for permanent connection whichever protocol is selected. The advantage of this type of connection is that up to 32 relays can be daisy-chained together using a simple twisted-pair electrical connection.

Note	*The second rear Courier port and the fiber optic interface are mutually exclusive as they occupy the same physical slot.*

An outline of the connection details for each of the communications ports is provided here. The ports are configurable using settings - a description of the configuration follows the connections part. Details of the protocol characteristics are also shown.

For each of the protocol options, the supported functions and commands are listed with the database definition. The operation of standard procedures such as extraction of event, fault and disturbance records, or setting changes is also described.

The descriptions in this chapter do not aim to fully describe the protocol in detail. Refer to the relevant documentation protocol for this information. This chapter describes the specific implementation of the protocol in the relay.

1.1 Read Only Mode (Command Blocking)

A Read Only mode is available for the rear communication ports of the Px40 relays. When Read Only mode is enabled for a port, all setting changes and most commands/control actions are blocked (not accepted by the relay). The full functionality is described below. It is similar to the 'Command Blocking' setting of Px30 relays.

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 ("tunnelled")

Read Only mode is not currently required for IEC 61850, as there are no settings or controls implemented.

Read Only mode does not apply to the Front Port, that is intended for local connection only.

The following settings enable and disable the Read Only Mode:

- [09FB: CONFIGURATION, RP1 Read Only]
- [09FC: CONFIGURATION, RP2 Read Only]
- [09FD: CONFIGURATION, NIC Read Only]

Read Only mode can only be disabled from either the front panel User Interface or via the Front Port.

Read Only mode can be enabled/disabled in the PSL by using the DDB signals 'RP1 Read Only', 'RP2 Read Only', 'NIC Read Only'.

When Read Only mode is enabled, the commands that are blocked (not accepted by the relay) and the commands that are allowed (accepted by the relay) are as follows.

(1) IEC 60870-5-103 Protocol

Blocked:

INF16 auto-recloser on/off (ASDU20)
INF17 teleprotection on/off (ASDU20)
INF18 protection on/off (ASDU20)
INF19 LED reset (ASDU20)
private INFs e.g CB open/close, Control Inputs (ASDU20)

Allowed:

Poll Class 1 (read spontaneous events)
Poll Class 2 (read measurands)
General Interrogation (GI) sequence
Transmission of Disturbance Records sequence
Time Synchronisation (ASDU6)
INF23 activate characteristic 1 (ASDU20)
INF24 activate characteristic 2 (ASDU20)
INF25 activate characteristic 3 (ASDU20)
INF26 activate characteristic 4 (ASDU20)

(2) Courier Protocol

Blocked:

- All setting changes
- Reset Indication (Trip LED) command
- Operate Control Input commands
- CB operation commands
- Auto-reclose operation commands
- Reset demands / thermal etc... command
- Clear event / fault / maintenance / disturbance record commands
- Test LEDs & contacts commands

Allowed:

- Read settings, statuses, measurands
- Read records (event, fault, disturbance)
- Time Synchronization command
- Change active setting group command

2 CONNECTIONS TO THE COMMUNICATIONS PORTS

2.1 Front Port

The front communications port is not intended for permanent connection. The front communications port supports the Courier protocol and is implemented on an EIA(RS)232 connection. A 9-pin connector type, as described in the 'Getting Started' (GS) chapter of this manual, is used, and the cabling requirements are detailed in the 'Connection Diagrams' (CD) chapter of this manual.

2.2 Rear Communication Port EIA(RS)485

The rear EIA(RS)-485 communication port is provided by a 3-terminal screw connector on the back of the relay. See the Connection Diagrams chapter for details of the connection terminals. The rear port provides K-Bus/EIA(RS)-485 serial data communication and is intended for use with a permanently-wired connection to a remote control center. Of the three connections, two are for the signal connection, and the other is for the earth shield of the cable.

If the IEC60870-5-103, or the DNP3.0 protocols are specified as the interface for the rear port, then connections conform entirely to the EIA(RS)485 standards outline below. If, however, the Courier protocol is specified as the rear port protocol, then the interface can be set either to EIA(RS)485 or K-Bus. The configuration of the port as either EIA(RS)485 or K-Bus is described later together with K-Bus details, but as connection to the port is affected by this choice, the following points should be noted:

- Connection to an EIA(RS)485 device is polarity sensitive, whereas K-Bus connection is not.
- Whilst connection to between an EIA(RS)485 port and an EIA(RS)232 port on, say, a PC might be implemented using a general purpose EIA(RS)485 to EIA(RS)232 converter, connection between an EIA(RS)232 port and K-Bus requires a KITZ101, KITZ102 or KITZ201

If the IEC60870-5-103, or the DNP3.0 protocols are specified as the interface for the rear port, then connections conform entirely to the EIA(RS)485 standards outline below. If, however, the Courier protocol is specified as the rear port protocol, the interface can be set either to EIA(RS)485 or K-Bus. The configuration of the port as either EIA(RS)485 or K-Bus is described later together with K-Bus details, but as connection to the port is affected by this choice, you should note these points:

- Connection to an EIA(RS)485 device is polarity sensitive, whereas K-Bus connection is not. In all other respects (bus wiring, topology, connection, biasing, and termination) K-Bus can be considered the same as EIA(RS)485.
- Whilst connection to or between an EIA(RS)485 port and an EIA(RS)232 port on a PC can be implemented using a general purpose EIA(RS)485 to EIA(RS)232 converter. However, connection between an EIA(RS)232 port and K-Bus requires a KITZ101, KITZ102 or KITZ201.

The protocol provided by the relay is indicated in the relay menu in the **Communications** column. Using the keypad and LCD, first check that the **Comms. settings** cell in the **Configuration** column is set to **Visible**, then move to the **Communications** column. The first cell down the column shows the communication protocol that is being used by the rear port.

Note	*Unless the K-Bus option is chosen for the rear port, correct polarity must be observed for the signal connections. In all other respects (bus wiring, topology, connection, biasing and termination) K-Bus can be considered the same as EIA(RS)485.*

2.3 Second Rear Communication Port (RP2 (Courier))

Relays with Courier, MODBUS, IEC60870-5-103 or DNP3.0 protocol on the first rear communications port have the option of a second rear port, running the Courier language. The second port is intended typically for dial-up modem access by protection engineers or operators, when the main port is reserved for SCADA communication traffic. Communication is through one of three physical links: K-Bus, EIA(RS)-485 or EIA(RS)-232. The port supports full local or remote protection and control access using MiCOM S1 Studio.

When changing the port configuration between K-Bus, EIA(RS)-485 and EIA(RS)-232, reboot the relay to update the hardware configuration of the second rear port.

The EIA(RS)-485 and EIA(RS)-232 protocols can be configured to operate with a modem, using an IEC60870 10-bit frame.

If both rear communications ports are connected to the same bus, make sure their address settings are not the same to avoid message conflicts.

Port Configuration	Valid Communication Protocol
K-Bus	K-Bus
EIA(RS)-232	IEC60870 FT1.2, 11-bit frame IEC60870, 10-bit frame
EIA(RS)-485	IEC60870 FT1.2, 11-bit frame IEC60870, 10-bit frame

Table 1 - Port configurations and communication protocols

2.3.1 Courier Protocol

The second rear communications port is functionally the same as described in the previous section for a Courier rear communications port, with the following exceptions:

2.3.1.1 Event Extraction

Automatic event extraction is not supported when the first rear port protocol is Courier, MODBUS or CS103. It is supported when the first rear port protocol is DNP3.0.

2.3.1.2 Disturbance Record Extraction

Automatic disturbance record extraction is not supported when the first rear port protocol is Courier, MODBUS or CS103. It is supported when the first rear port protocol is DNP3.0.

2.3.2 Connection to the Second Rear Port

The second rear Courier port connects using the 9-way female D-type connector (SK4) in the middle of the card end plate (between the IRIG-B connector and lower D-type). The connection complies with EIA(RS)-574.

For IEC60870-5-2 over EIA(RS)-232			For K-bus or IEC60870-5-2 over EIA(RS)-485	
Pin	Connection		Pin*	Connection
1	No Connection			
2	RxD			
3	TxD			
4	DTR#		4	EIA(RS)-485 - 1 (+ ve)
5	Ground			
6	No Connection			
7	RTS#		7	EIA(RS)-485 - 2 (- ve)
8	CTS#			
9	No Connection			
# - These pins are control lines for use with a modem.			* - All other pins unconnected.	

Notes *Connector pins 4 and 7 are used by both the EIA(RS)-232and EIA(RS)-485 physical layers, but for different purposes. Therefore, the cables should be removed during configuration switches.*
When using the EIA(RS)-485 protocol, an EIA(RS)-485 to EIA(RS)-232 converter is needed to connect the relay to a modem or PC running MiCOM S1 Studio. A Schneider Electric CK222 is recommended.
EIA(RS)-485 is polarity sensitive, with pin 4 positive (+) and pin 7 negative (-).
The K-Bus protocol can be connected to a PC using a KITZ101 or 102.

Table 2 - Pin connections over EIA(RS)-232 and EIS(RS)-485

2.4 EIA(RS)485 Bus

The EIA(RS)-485 two-wire connection provides a half-duplex fully isolated serial connection to the product. The connection is polarized and while the product's connection diagrams show the polarization of the connection terminals, there is no agreed definition of which terminal is which. If the master is unable to communicate with the product and the communication parameters match, make sure the two-wire connection is not reversed.

EIA(RS)-485 provides the capability to connect multiple devices to the same two-wire bus. MODBUS is a master-slave protocol, so one device is the master, and the remaining devices are slaves. It is not possible to connect two masters to the same bus, unless they negotiate bus access.

2.4.1 Bus Termination

The EIA(RS)-485 bus must have 120 Ω (Ohm) ½ Watt terminating resistors fitted at either end across the signal wires, see the *EIA(RS)-485 bus connection arrangements* diagram below. Some devices may be able to provide the bus terminating resistors by different connection or configuration arrangements, in which case separate external components are not needed. However, this product does not provide such a facility, so if it is located at the bus terminus, an external termination resistor is needed.

2.4.2 Bus Connections & Topologies

The EIA(RS)-485 standard requires each device to be directly connected to the physical cable that is the communications bus. Stubs and tees are expressly forbidden, as are star topologies. Loop bus topologies are not part of the EIA(RS)-485 standard and are forbidden by it.

Two-core screened cable is recommended. The specification of the cable depends on the application, although a multi-strand 0.5 mm^2 per core is normally adequate. Total cable length must not exceed 1000 m. The screen must be continuous and connected at one end, normally at the master connection point. It is important to avoid circulating currents, especially when the cable runs between buildings, for both safety and noise reasons.

This product does not provide a signal ground connection. If the bus cable has a signal ground connection, it must be ignored. However, the signal ground must have continuity for the benefit of other devices connected to the bus. For both safety and noise reasons, the signal ground must never be connected to the cable's screen or to the product's chassis.

2.4.3 Biasing

It may also be necessary to bias the signal wires to prevent jabber. Jabber occurs when the signal level has an indeterminate state because the bus is not being actively driven. This can occur when all the slaves are in receive mode and the master is slow to switch from receive mode to transmit mode. This may be because the master purposefully waits in receive mode, or even in a high impedance state, until it has something to transmit. Jabber causes the receiving device(s) to miss the first bits of the first character in the packet, which results in the slave rejecting the message and consequentially not responding. Symptoms of this are poor response times (due to retries), increasing message error counters, erratic communications, and even a complete failure to communicate.

Biasing requires that the signal lines are weakly pulled to a defined voltage level of about 1 V. There should only be one bias point on the bus, which is best situated at the master connection point. The DC source used for the bias must be clean, otherwise noise is injected. Some devices may (optionally) be able to provide the bus bias, in which case external components are not required.

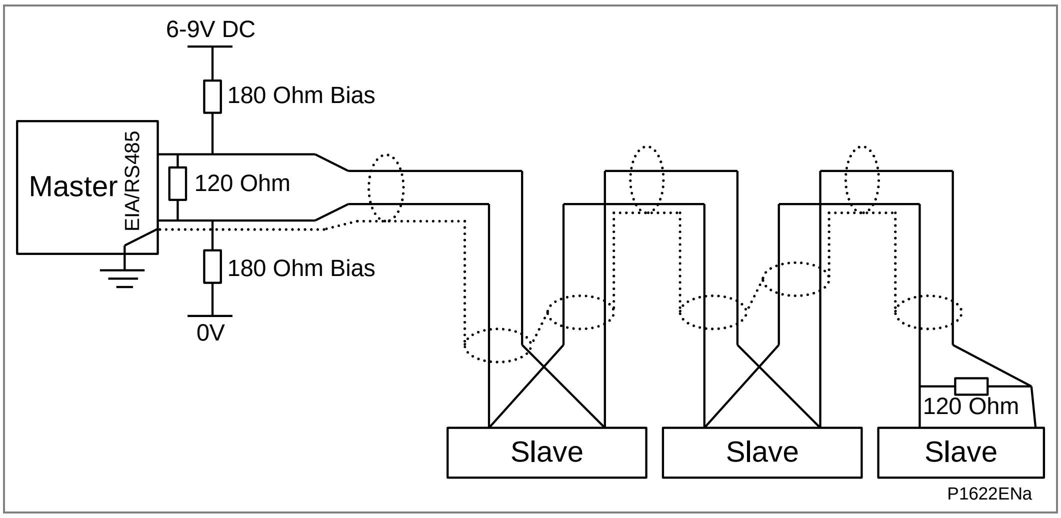


Figure 1 - EIA(RS)-485 bus connection arrangements

It is possible to use the product's field voltage output (48 V DC) to bias the bus using values of 2.2 k Ω (½W) as bias resistors instead of the 180 Ω resistors shown in the *EIA(RS)-485 bus connection arrangements* diagram. Note these warnings apply:

Warnings	**It is extremely important that the 120 Ω termination resistors are fitted. Otherwise the bias voltage may be excessive and may damage the devices connected to the bus.** **As the field voltage is much higher than that required, Schneider Electric cannot assume responsibility for any damage that may occur to a device connected to the network as a result of incorrect application of this voltage.** **Ensure the field voltage is not used for other purposes, such as powering logic inputs, because noise may be passed to the communication network.**

2.4.4 Courier Communication

Courier is the communication language developed to allow remote interrogation of its range of protection relays. Courier uses a master and slave. EIA(RS)-232 on the front panel allows only one slave but EIA(RS)-485 on the back panel allows up to 32 daisy-chained slaves. Each slave unit has a database of information and responds with information from its database when requested by the master unit.

The relay is a slave unit that is designed to be used with a Courier master unit such as MiCOM S1 Studio, MiCOM S10, PAS&T or a SCADA system. MiCOM S1 Studio is compatible is specifically designed for setting changes with the relay.

To use the rear port to communicate with a PC-based master station using Courier, a KITZ K-Bus to EIA(RS)-232 protocol converter is needed. This unit (and information on how to use it) is available from Schneider Electric. A typical connection arrangement is shown in the *K-bus remote communication connection arrangements* diagram below. For more detailed information on other possible connection arrangements, refer to the manual for the Courier master station software and the manual for the KITZ protocol converter. Each spur of the K-Bus twisted pair wiring can be up to 1000 m in length and have up to 32 relays connected to it.

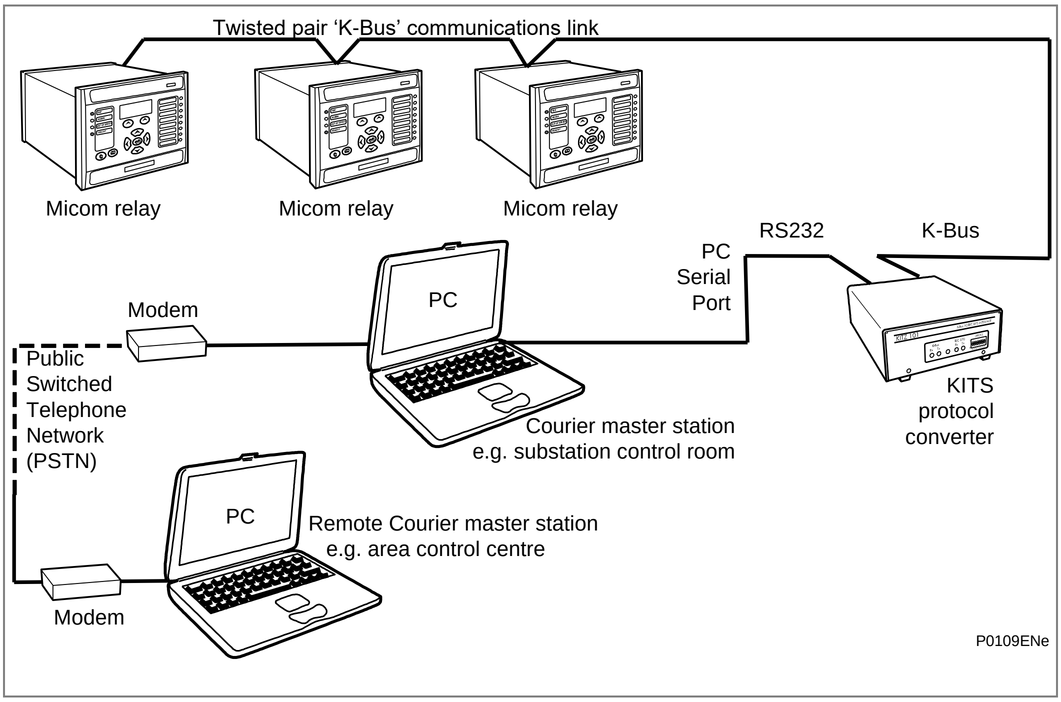


Figure 2 - K-bus remote communication connection arrangements

Once the physical connection is made to the relay, configure the relay's communication settings using the keypad and LCD user interface.

2.4.5 MODBUS Communication

Important	MODBUS is not available for all MiCOM products. MODBUS availability is shown in the *Supported Protocols* table.

MODBUS is a master/slave communication protocol that can be used for network control. In a similar way to Courier, the master device initiates all actions and the slave devices (the relays) respond to the master by supplying the requested data or by taking the requested action. MODBUS communication uses a twisted pair connection to the rear port and can be used over a distance of 1000 m with up to 32 slave devices.

To use the rear port with MODBUS communication, configure the relay's communication settings using the keypad and LCD user interface.

2.4.6 IEC 60870-5 CS 103 Communication

The IEC specification IEC 60870-5-103: Telecontrol Equipment and Systems, Part 5: Transmission Protocols Section 103 defines the use of standards IEC 60870-5-1 to IEC 60870-5-5 to perform communication with protection equipment. The standard configuration for the IEC 60870-5-103 protocol is to use a twisted pair connection over distances up to 1000 m. As an option for IEC 60870-5-103, the rear port can be specified to use a fiber optic connection for direct connection to a master station. The relay operates as a slave in the system, responding to commands from a master station. The method of communication uses standardized messages which are based on the VDEW communication protocol.

To use the rear port with IEC 60870-5-103 communication, configure the relay's communication settings using the keypad and LCD user interface.

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

- **Disabled**
  No blocking selected.
- **Monitor Blocking**
  When the monitor blocking DDB Signal is active high, either by energizing an opto input or control input, reading of the status information and disturbance records is not permitted. When in this mode the relay returns a “Termination of general interrogation” message to the master station.
- **Command Blocking**
  When the command blocking DDB signal is active high, either by energizing an opto input or control input, all remote commands are ignored, such as CB Trip/Close or change setting group. When in this mode the relay returns a **negative acknowledgement of command** message to the master station.

2.4.7 DNP3.0 Communication

Important	**DNP3.0 is not available for all MiCOM products. DNP3.0 availability is shown in the Supported Protocols table.**

The DNP3.0 protocol is defined and administered by the DNP User Group. Information about the user group, DNP3.0 in general and protocol specifications can be found on their website: www.dnp.org

The relay operates as a DNP3.0 slave and supports subset level 2 of the protocol plus some of the features from level 3. DNP3.0 communication is achieved using a twisted pair connection to the rear port and can be used over a distance of 1000 m with up to 32 slave devices.

2.5 SK5 Port Connection

The lower 9-way D-type connector (SK5) is currently unsupported.
Do not connect to this port.

3 CONFIGURING THE COMMUNICATIONS PORT

3.1 Introduction

Courier works on a master/slave basis where the slave units contain information in the form of a database, and respond with information from the database when it is requested by a master unit.

The relay is a slave unit that is designed to be used with a Courier master unit such as MiCOM S1 Studio, PAS&T or a SCADA system.

3.2 Configuring the Front Courier Port

The front EIA(RS)232 9-pin port supports the Courier protocol for one-to-one communication. It is designed for use during installation, commissioning and maintenance and is not suitable for permanent connection. Since this interface is not intended to link the relay to a substation communication system, not all of the features of the Courier interface are supported; the port is not configurable and the following parameters apply:

- Physical presentation EIA(RS)232 via 9-pin connector
- Frame format IEC60870-5 FT1.2 = 11-bit (8 Even 1)
- Address 1
- Baud rate 19200 bps

Note	*As part of the limited implementation of Courier on the front port, neither automatic extraction of event and disturbance records, nor busy response are supported.)*

3.3 Configuring the First Rear Courier Port (RP1)

Once the physical connection is made to the relay, configure the relay's communication settings using the keypad and LCD user interface.

1. In the relay menu, select the **Configuration** column, then check that the **Comms. settings** cell is set to **Visible**.
2. Select the **Communications** column. Only two settings apply to the rear port using Courier, the relay's address and the inactivity timer. Synchronous communication uses a fixed baud rate of 64 kbits/s.
3. Move down the **Communications** column from the column heading to the first cell down. This shows the communication protocol.

```
Protocol
Courier
```

4. The next cell down the column controls the address of the relay. As up to 32 relays can be connected to one K-Bus spur, each relay must have a unique address so messages from the master control station are accepted by one relay only. Courier uses an integer (from 0 to 254) for the relay address that is set with this cell. Important: no two relays should have the same Courier address. The master station uses the Courier address to communicate with the relay.

```
Address
1
```

5. The next cell down controls the inactivity timer.

```
Inactiv timer
10.00 mins.
```

The inactivity timer controls how long the relay waits without receiving any messages on the rear port before it reverts to its default state, including revoking any password access that was enabled. For the rear port this can be set between 1 and 30 minutes.

Note	*Protection and disturbance recorder settings that are modified using an on-line editor such as PAS&T must be confirmed with a write to the 'Save changes' cell of the 'Configuration' column. Off-line editors such as MiCOM S1 Studio do not require this action for the setting changes to take effect.*

The next cell down controls the physical media used for the communication.

```
Physical link
Copper
```

The default setting is to select the electrical (copper) connection. If the optional fiber optic interface is fitted to the relay, then this setting can be changed to '**Fiber optic**'. This cell is invisible if a second rear communications port or an Ethernet card is fitted, as they are mutually exclusive and occupy the same physical location.

6. If the Physical link selection is copper, the next cell down becomes visible to further define the configuration:

```
Port Config
KBus
```

The setting choice is between K-Bus and EIA(RS)485. Selecting K-Bus allows connection with K-series devices, but means that a KITZ converter must be used to make a connection. If the EIA(RS)485 selection is made, direct connections can be made to proprietary equipment such as MODEMs. If the EIA(RS)485 selection is made, then two further cells become visible to control the frame format and the communication speed:

7. The frame format is selected in the RP1 Comms mode setting:

```
Comms Mode
IEC60870 FT1.2
```

The standard default is the IEC 60870-FT1.2. This is an 11-bit framing. Alternatively, a 10-bit framing may be selected for use with MODEMs that do not support 11-bit framing.

8. The final RP1 cell controls the communication speed or baud rate:

```
Baud Rate
19200 bits/s
```

Courier communications is asynchronous and three baud rate selections are available to allow the relay communication rate to be matched to that of the connected equipment. Three baud rates are supported by the relay, '9600 bits/s', '19200 bits/s' and '38400 bits/s'.

Important	**If you modify protection and disturbance recorder settings using an on-line editor such as PAS&T, you must confirm them. To do this, from the Configuration column select the Save changes cell. Off-line editors such as MiCOM S1 Studio do not need this action for the setting changes to take effect.**

3.4 Configuring the MODBUS Communication

Important	MODBUS is not available for all MiCOM products. MODBUS availability is shown in the *Supported Protocols* table.

MODBUS is a master/slave communication protocol that can be used for network control. In a similar way to Courier, the master device initiates all actions and the slave devices (the relays) respond to the master by supplying the requested data or by taking the requested action. MODBUS communication uses a twisted pair connection to the rear port and can be used over a distance of 1000 m with up to 32 slave devices.

To use the rear port with MODBUS communication, configure the relay's communication settings using the keypad and LCD user interface.

1. In the relay menu firstly check that the '**Comms. settings**' cell in the '**Configuration**' column is set to '**Visible**'.
2. Select the '**Communications**' column. Four settings apply to the rear port using MODBUS, which are described below.
3. Move down the **Communications** column from the column heading to the first cell down which indicates the communication protocol.

```
Protocol
MODBUS
```

4. The next cell down controls the MODBUS address of the relay:

```
MODBUS address
23
```

   Up to 32 relays can be connected to one MODBUS spur, and therefore it is necessary for each relay to have a unique address so that messages from the master control station are accepted by one relay only. MODBUS uses an integer number between 1 and 247 for the relay address. It is important that no two relays have the same MODBUS address. The MODBUS address is then used by the master station to communicate with the relay.

5. The next cell down controls the inactivity timer:

```
Inactivity timer
10.00 mins.
```

   The inactivity timer controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state, including revoking any password access that was enabled. For the rear port this can be set between 1 and 30 minutes.

6. The next cell down the column controls the baud rate to be used:

```
Baud rate
9600 bits/s
```

7. MODBUS communication is asynchronous. Three baud rates are supported by the relay, '**9600 bits/s**', '**19200 bits/s**' and '**38400 bits/s**'. It is important that whatever baud rate is selected on the relay is the same as that set on the MODBUS master station.
8. The next cell down controls the parity format used in the data frames:

```
Parity
None
```

   The parity can be set to be one of '**None**', '**Odd**' or '**Even**'. It is important that whatever parity format is selected on the relay is the same as that set on the MODBUS master station.

9. The next cell down controls the IEC time format used in the data frames:

```
MODBUS IEC time
Standard
```

10. The MODBUS IEC time can be set to '**Standard**' or '**Reverse**'. For a complete definition see the Relay Menu Database (P14x/EN MD), datatype G12.

The format can be selected as either **Standard** (as for IEC60870-5-4 'Binary Time 2a') which is the default, or to **Reverse** for compatibility with MICOM Px20 and Px30 product ranges. For more information see the *Date and Time Format* section.

3.5 Configuring the IEC60870-5 CS 103 Rear Port RP1

The IEC specification IEC 60870-5-103: Telecontrol Equipment and Systems, Part 5: Transmission Protocols Section 103 defines the use of standards IEC 60870-5-1 to IEC 60870-5-5 to perform communication with protection equipment. The standard configuration for the IEC 60870-5-103 protocol is to use a twisted pair connection over distances up to 1000 m. As an option for IEC 60870-5-103, the rear port can be specified to use a fiber optic connection for direct connection to a master station. The relay operates as a slave in the system, responding to commands from a master station. The method of communication uses standardized messages which are based on the VDEW communication protocol.

To use the rear port with IEC 60870-5-103 communication, configure the relay's communication settings using the keypad and LCD user interface.

1. In the relay menu, select the **Configuration** column, then check that the **Comms. settings** cell is set to **Visible**.
2. Select the **Communications** column. Four settings apply to the rear port using IEC 60870-5-103 that are described below.

   Move down the 'COMMUNICATIONS' column from the column heading to the first cell to confirm the communication protocol:

   ```
   Protocol
   IEC60870-5-103
   ```

3. The next cell sets the address of the relay on the IEC 60870-5-103 network:

   ```
   Remote Address
   162
   ```

   Up to 32 relays can be connected to one IEC 60870-5-103 spur, and therefore it is necessary for each relay to have a unique address so that messages from the master control station are accepted by one relay only. IEC 60870-5-103 uses an integer number between 0 and 254 for the relay address. It is important that no two relays have the same address. The address is then used by the master station to communicate with the relay.
4. The next cell down the column controls the baud rate to be used:

   ```
   Baud rate
   9600 bits/s
   ```

   IEC 60870-5-103 communication is asynchronous. Two baud rates are supported by the relay, '9600 bits/s' and '19200 bits/s'. It is important that whatever baud rate is selected on the relay is the same as that set on the IEC 60870-5-103 master station.
5. The next cell down controls the period between IEC 60870-5-103 measurements:

   ```
   Measure't period
   30.00 s
   ```

   The IEC 60870-5-103 protocol allows the relay to supply measurements at regular intervals. The interval between measurements is controlled by this cell, and can be set between 1 and 60 seconds.
6. An optional fiber optic card is available in the relay to allow optical connection to the IEC 60870-5-103 communication to be made over an optical connection. When fitted, it converts between EIA(RS)485 signals and fiber optic signals and the following cell is visible in the menu column:

   ```
   Physical link
   Copper
   ```

The default setting is to select the electrical (copper) connection. If the optional fiber optic interface is fitted to the relay, then this setting can be changed to 'Fiber optic'. This cell is invisible if a second rear communications port or an Ethernet card is fitted, as they are mutually exclusive and occupy the same physical location.

7. The following cell which may be displayed, is not currently used but is available for future expansion.

```
InactivTimer
```

8. The next cell down can be used for monitor or command blocking:

```
CS103 Blocking
```

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

- **Disabled**
  No blocking selected.
- **Monitor Blocking**
  When the monitor blocking DDB Signal is active high, either by energizing an opto input or control input, reading of the status information and disturbance records is not permitted. When in this mode the relay returns a "Termination of general interrogation" message to the master station.
- **Command Blocking**
  When the command blocking DDB signal is active high, either by energizing an opto input or control input, all remote commands are ignored, such as CB Trip/Close or change setting group. When in this mode the relay returns a **negative acknowledgement of command** message to the master station.

3.6 Configuring the DNP3.0 Rear Port, RP1 and Optional DNP3.0 over Ethernet

Important	**DNP3.0 is not available for all MiCOM products. DNP3.0 availability is shown in the Supported Protocols table.**

The DNP3.0 protocol is defined and administered by the DNP User Group. Information about the user group, DNP3.0 in general and protocol specifications can be found on their website: www.dnp.org

The DNP3.0 implementation in the MiCOM P841 can be presented on an EIA(RS)485 physical layer, and/or on an Ethernet connection according to the options selected.

The relay operates as a DNP3.0 slave and supports subset Level 2 of the protocol plus some of the features from Level 3.

The settings applicable to the EIA(RS)485 implementation are described in section 3.7.

The settings applicable to the Ethernet implementation are described in section 5 - MODBUS Interface.

3.7 Configuring the DNP3.0 Communication Rear Port, RP1

Important	**DNP3.0 is not available for all MiCOM products. DNP3.0 availability is shown in the Supported Protocols table.**

The DNP3.0 protocol is defined and administered by the DNP User Group. Information about the user group, DNP3.0 in general and protocol specifications can be found on their website: www.dnp.org

The relay operates as a DNP3.0 slave and supports subset level 2 of the protocol plus some of the features from level 3. DNP3.0 communication is achieved using a twisted pair connection to the rear port and can be used over a distance of 1000 m with up to 32 slave devices.

1. To use the rear port with DNP3.0 communication, configure the relay's communication settings using the keypad and LCD user interface.
2. In the relay menu, select the **Configuration** column, then check that the **Comms. settings** cell is set to **Visible**.
3. Several settings apply to the rear port using DNP 3.0 that are described below.
4. Move down the 'COMMUNICATIONS' column from the column heading to the first cell that indicates the communications protocol:

```
Protocol
DNP 3.0
```

5. The next cell sets the device address on the DNP3.0 network:

```
DNP 3.0 Address
232
```

   Up to 32 devices can be connected to one DNP3.0 spur, and therefore it is necessary for each device to have a unique address so that messages from the master control station are accepted by only one device. DNP3.0 uses a decimal number between 1 and 65519 for the device address. It is important that no two devices have the same address. The address is then used by the DNP3.0 master station to communicate with the relay.
6. The next cell sets the baud rate to be used:

```
Baud Rate
9600 bits/s
```

   DNP3.0 communication is asynchronous. Six baud rates are supported by the relay '1200bits/s', '2400bits/s', '4800bits/s', '9600bits/s', '19200bits/s' and '38400bits/s'. It is important that whatever baud rate is selected on the relay is the same as that set on the DNP3.0 master station.
7. The next cell controls the parity format used in the data frames:

```
Parity
None
```

   The parity can be set to be one of **None**, **Odd** or **Even.** It is important that whatever parity format is selected on the relay is the same as that set on the DNP3.0 master station.

   An optional fiber optic card is available in the relay to allow optical connection to the IEC 60870-5-103 communication to be made over an optical connection. When fitted, it converts between EIA(RS)485 signals and fiber optic signals and the following cell is visible in the menu column.
8. The next cell down the column controls the physical media used for the communication.

```
Physical link
Copper
```

The default setting is to select the electrical (copper) connection. If the optional fiber optic interface is fitted to the relay, then this setting can be changed to **Fiber optic**. This cell is invisible if a second rear communications port or an Ethernet card is fitted, as they are mutually exclusive and occupy the same physical location.

9. The next cell down the column sets the time synchronization request from the master by the relay:

```
Time Sync.
Enabled
```

The time synchronization can be set to either enabled or disabled. If enabled it allows the DNP3.0 master to synchronize the time.

10. Analogue values can be set to be reported in terms of primary, secondary or normalized (with respect to the CT/VT ratio setting) values:

```
Meas Scaling
Primary
```

The setting for enabling/disabling DNP3.0 time synchronization is described above. When DNP3.0 time sync is enabled, the required rate of synchronization, known as the “need time”, needs to be set.

11. A setting allows different “need time” to be set with setting range from 1 - 30 minutes, step of 1 minute and default at 10 minutes:

```
DNP Need Time
10mins
```

The transmitted application fragment size can be set to ensure that a Master Station cannot be held too long before a complete reply is received and allow it to move on to next IED in a token ring polling setup.

12. The maximum overall response message length can be configured:

```
DNP App Fragment
2048
```

A single fragment size is 249. Depending on circumstances, a user may set the fragment size as a multiple of 249 in order to optimize segment packing efficiency in fragments. However it can also be useful to allow "odd" sizes for users to choose under specific circumstances, such as if sending data inside SMS frames, through packet radios, etc. In such cases it can be useful to select the fragment size such that each packet occupies a single "transmission media frame".

In some cases, communication to the outstation is made over slow, packet-switched networks which can add seconds to the communication latency.

13. A setting is provided to allow the application layer timeout to be set:

```
DNP App Timeout
2s
```

14. Select Before Operate (SBO) timeouts can be set.
If the DNP3.0 “Select a trip command” causes the relay’s internal logic to block automatic tripping, then a corruption of the DNP3.0 “Operate” message could delay the trip. The delay of tripping can be set:

```
DNP SBO Timeout
10s
```

15. The DNP link timeout can be set:

```
DNP Link Timeout
10s
```

3.8 Configuring the Second Rear Communication Port (RP2)

For relays with Courier, MODBUS, IEC60870-5-103 or DNP3.0 protocol on the first rear communications port there is the hardware option of a second rear communications port, which will run the Courier language. This can be used over one of three physical links: twisted pair K-Bus (non-polarity sensitive), twisted pair EIA(RS)485 (connection polarity sensitive) or EIA(RS)232.

The settings for this port are located immediately below the ones for the first port as described in the *Introduction* chapter.

1. Move down the settings until the following sub heading is displayed.

```
Rear Port 2 (RP2)
```

2. The next cell defines the protocol, which is fixed at Courier for RP2.

```
RP2 protocol
Courier
```

3. The following cell indicates the status of the hardware.

```
RP2 card status
EIA(RS)232 OK
```

4. The following cell allows for selection of the port configuration.

```
RP2 port config.
EIA(RS)232
```

5. The port can be configured for EIA(RS)232, EIA(RS)485 or K-Bus.
   As in the case of the first rear Courier port, if K-Bus is not selected certain other cells to control the communication mode and speed become visible. If either EIA(RS)232 or EIA(RS)485 is selected for the port configuration, the next cell is visible and selects the communication mode.

```
RP2 comms.  Mode
IEC60870 FT1.2
```

6. The standard default is the IEC 60870 FT1.2 for normal operation with 11-bit modems. Alternatively, a 10-bit framing with no parity bit can be selected for special cases.
7. The next cell down sets the communications port address.

```
RP2 address
255
```

   Since up to 32 devices can be connected to one K-bus spur, it is necessary for each device to have a unique address so that messages from the master control station are accepted by one device only. Courier uses an integer number between 0 and 254 for the device address that is set with this cell. It is important that no two devices have the same Courier address. The Courier address is then used by the master station to communicate with the device. The default value is 255 and must be changed to a value in the range 0 to 254 before use.

8. The following cell controls the inactivity timer.

```
RP2 InactivTimer
15 mins.
```

9. The inactivity timer controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state. This includes revoking any password access that was enabled. The inactivity timer can be set between 1 and 30 minutes.
10. In the case of EIA(RS)232 and EIA(RS)485 the next cell down controls the baud rate. For K-Bus the baud rate is fixed at 64kbit/second between the relay and the KITZ interface at the end of the relay spur.

```
RP2 baud rate
19200
```

Courier communications is asynchronous and three selections are available to allow the relay communication rate to be matched to that of the connected equipment. The three baud rates supported by the relay are: '9600 bits/s', '19200 bits/s' and '38400 bits/s'.

3.9 Fiber Optic Converter (option)

An optional fiber optic card is available in this product. This converts the EIA(RS)485 protocols into a fiber optic output. This communication card is available for use on Courier, MODBUS (for products listed in the *Supported Protocols* table), IEC60870-5-103 and DNP3.0 it adds the following setting to the communication column.

This controls the physical media used for the communication:

```
Physical link
Copper
```

The default setting is to select the electrical EIA(RS)485 connection. If the optional fiber optic connectors are fitted to the relay, then this setting can be changed to '**Fiber optic**'. This cell is also invisible if a second rear comms. port, or Ethernet card is fitted, as it is mutually exclusive with the fiber optic connectors, and occupies the same physical location.

Where this is used, connection should be made using either 50/125µm or 62.5/125µm multi-mode optical fibers terminated with BFOC/2.5 (ST) connectors.

3.10 Second Rear Port K-Bus Application

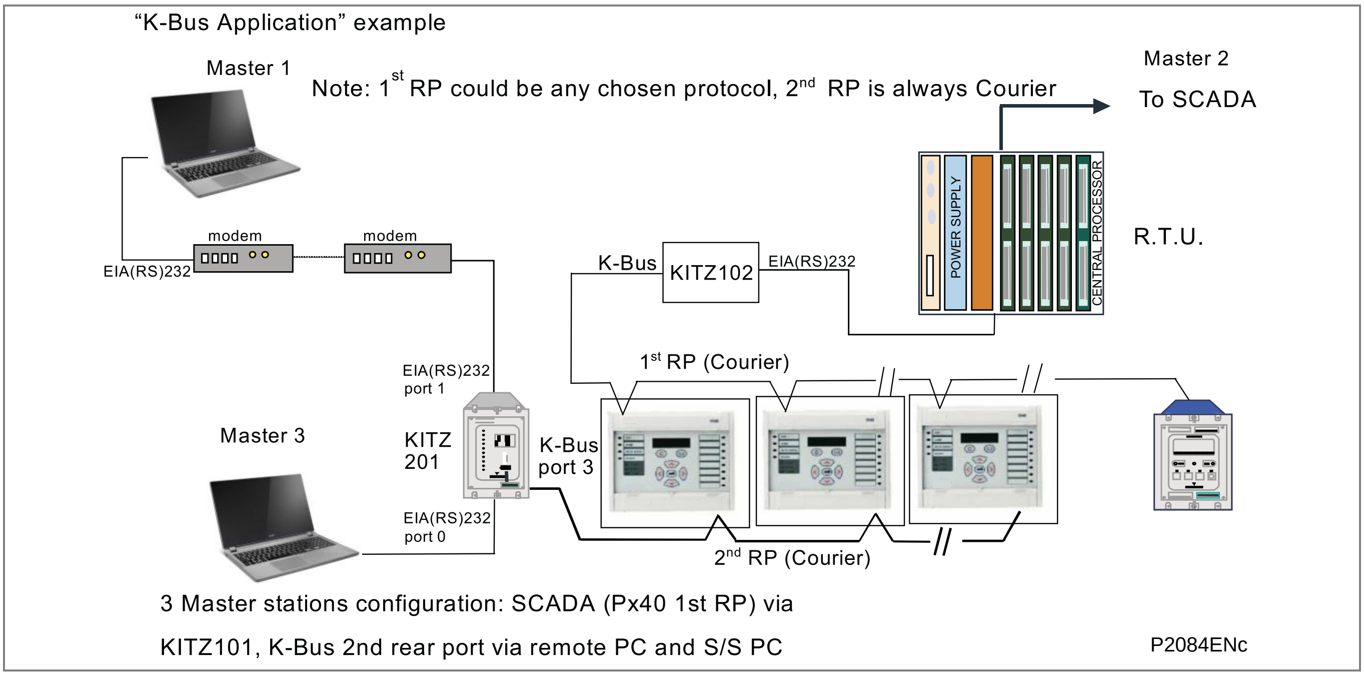


Figure 3 - Second rear port K-Bus application

3.11 Second Rear Port EIA(RS)485 Example

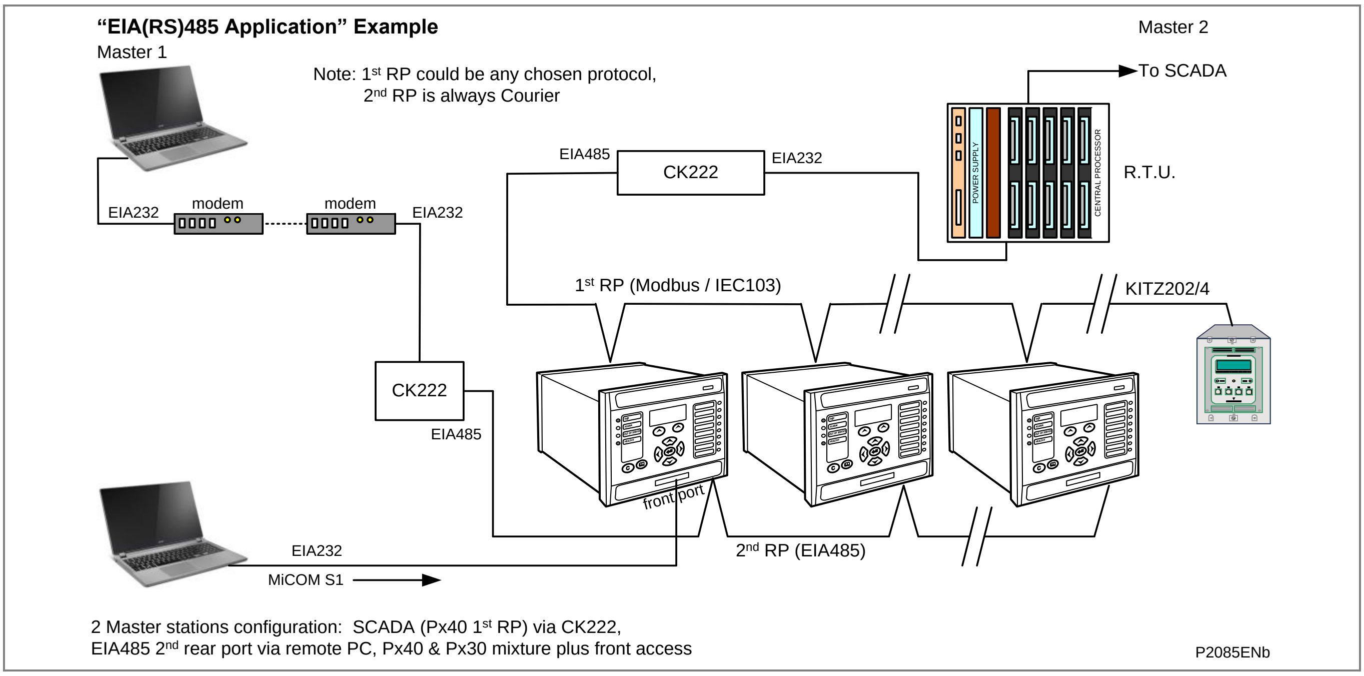


Figure 4 - Second rear port EIA(RS)485 example

3.12 Second Rear Port EIA(RS)232 Example

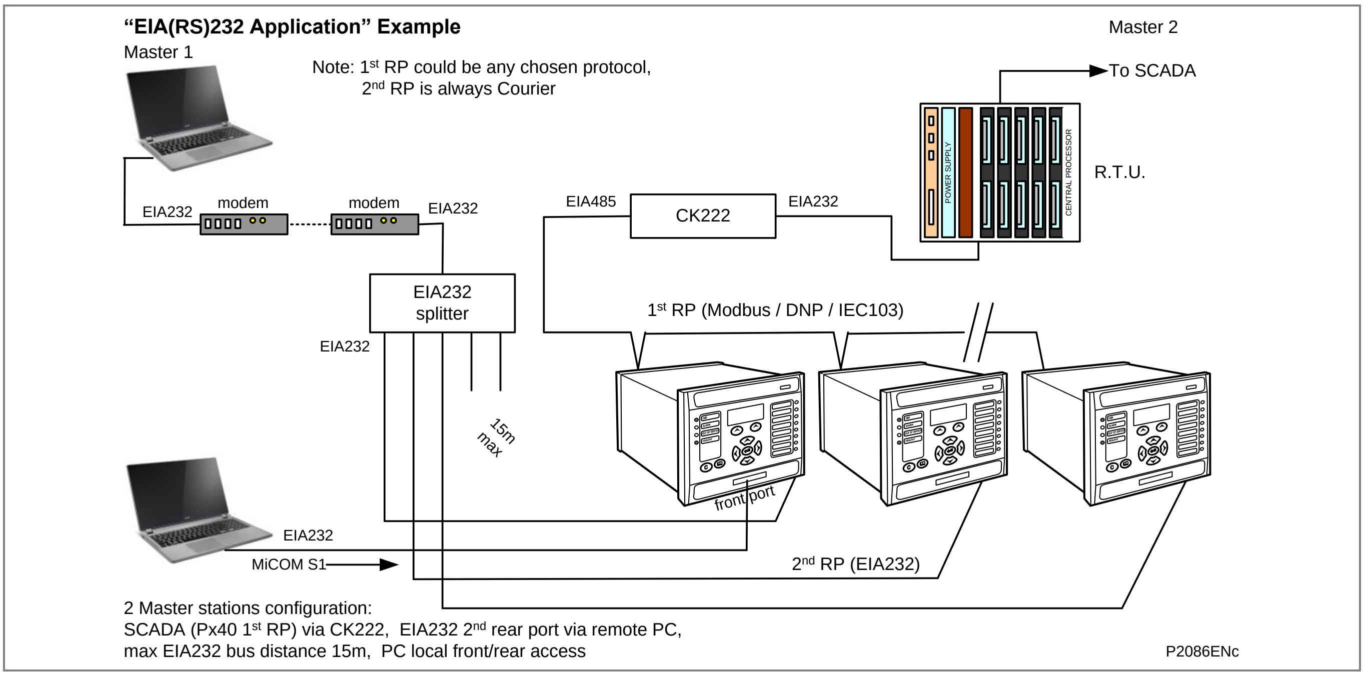


Figure 5 - Second rear port EIA(RS)232 example

3.13 SK5 Port Connection

The lower 9-way D-type connector (SK5) is the InterMiCOM port, which is based on the EIA232 standard.

3.14 Configuring the Ethernet Communication (option)

It is possible to communicate through an Ethernet network using a Schneider Electric I4XS4UE (refer to Px4x/EN REB user guide for Redundant Ethernet board connections).

Connection for Ethernet communication can be made either by standard RJ45 electrical connections or by multi-mode optical fibers suitable for 1310 nm transmission and terminated with LC connectors.

3.14.1 Legacy Protocols

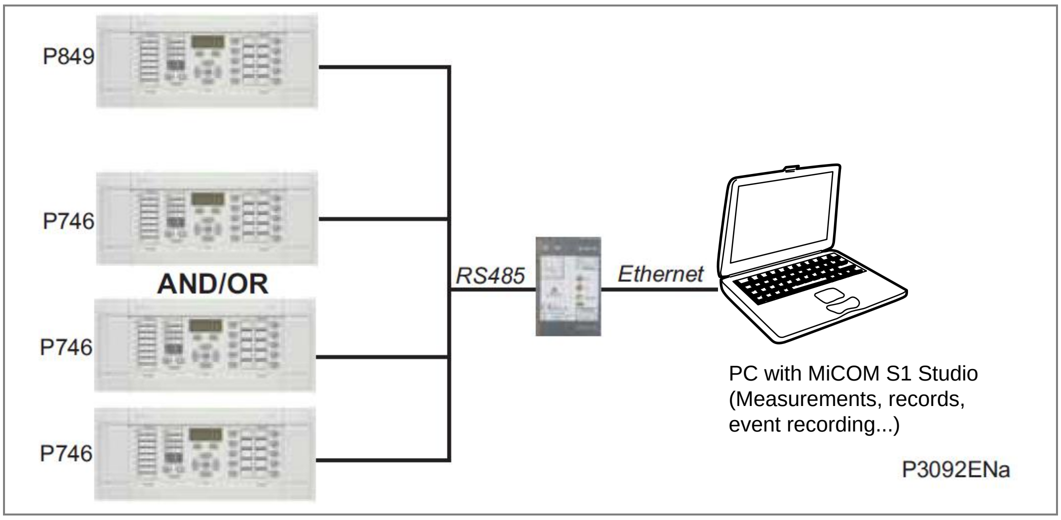


Figure 6 - Ethernet connection example

3.14.2 IEC 61850 Protocol

Using Ethernet hardware options, high-speed communication exchanges are possible through an Ethernet network.

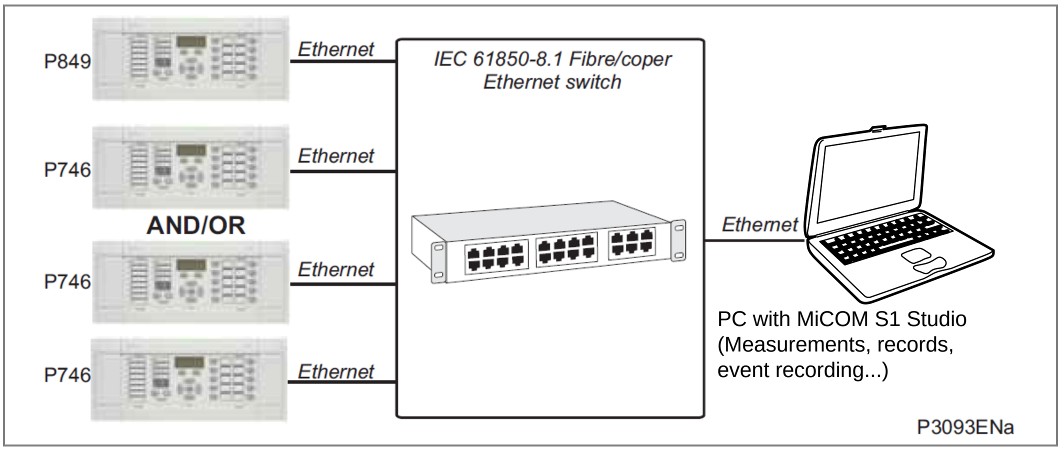


Figure 7 - Ethernet connection example

3.14.3 Redundant Ethernet Protocol

Redundant Ethernet connections are performed with Redundant Ethernet (Parallel Redundancy Protocol or High-availability Seamless Redundancy) options (refer to Px4x/EN REB user guide).

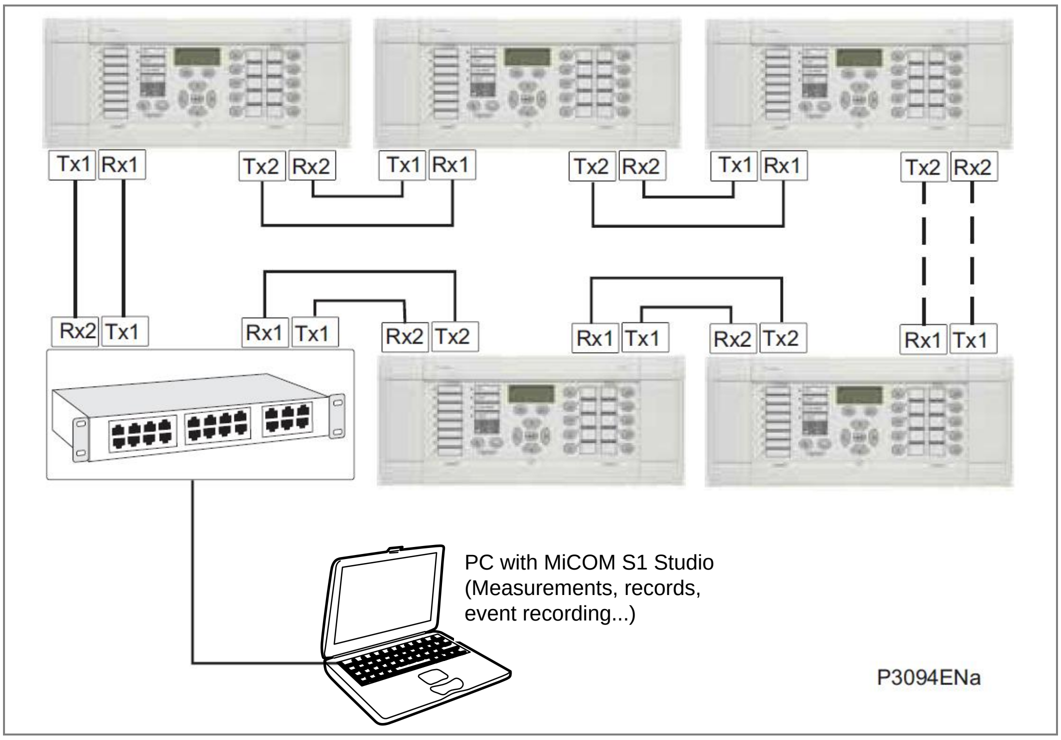


Figure 8 - Redundant Ethernet board connection

4 COURIER INTERFACE

4.1 Courier Protocol

Courier is a Schneider Electric communication protocol. The concept of the protocol is that a standard set of commands is used to access a database of settings and data in the relay. This allows a generic master to be able to communicate with different slave devices. The application-specific aspects are contained in the database rather than the commands used to interrogate it, so the master station does not need to be preconfigured.

The same protocol can be used through two physical links K-Bus or EIA(RS)-232.

K-Bus is based on EIA(RS)-485 voltage levels with HDLC FM0 encoded synchronous signaling and its own frame format. The K-Bus twisted pair connection is unpolarized, whereas the EIA(RS)-485 and EIA(RS)-232 interfaces are polarized.

The EIA(RS)-232 interface uses the IEC60870-5 FT1.2 frame format.

The relay supports an IEC60870-5 FT1.2 connection on the front-port. This is intended for temporary local connection and is not suitable for permanent connection. This interface uses a fixed baud rate, 11-bit frame, and a fixed device address.

The rear interface is used to provide a permanent connection for K-Bus and allows multi-drop connection. Although K-Bus is based on EIA(RS)-485 voltage levels, it is a synchronous HDLC protocol using FM0 encoding. It is not possible to use a standard EIA(RS)-232 to EIA(RS)-485 converter to convert IEC60870-5 FT1.2 frames to K-Bus. Also it is not possible to connect K-Bus to an EIA(RS)-485 computer port. A protocol converter, such as the KITZ101, should be used for this purpose.

For a detailed description of the Courier protocol, command-set and link description, see the following documentation:

R6509	K-Bus Interface Guide
R6510	IEC60870 Interface Guide
R6511	Courier Protocol
R6512	Courier User Guide

Alternatively for direct connections, the fiber optic converter card may be used to convert the rear EIA(RS)485 port into a fiber optic (ST) port. See the *Fiber Optic Converter (option)* section for more information.

4.2 Front Courier Port

The front EIA(RS)-232 9 pin port supports the Courier protocol for one-to-one communication. This port complies with EIA(RS)-574; the 9-pin version of EIA(RS)-232, see www.tiaonline.org. It is designed for use during installation and commissioning/maintenance and is not suitable for permanent connection. Since this interface is not used to link the relay to a substation communication system, some of the features of Courier are not implemented. These are as follows:

- Automatic extraction of Event Records:
  - Courier Status byte does not support the Event flag.
  - Send Event/Accept Event commands are not implemented.
- Automatic extraction of Disturbance records:
  - Courier Status byte does not support the Disturbance flag.
- Busy Response Layer:
  - Courier Status byte does not support the Busy flag, the only response to a request is the final data.
- Fixed Address:
  - The address of the front Courier port is always 1; the Change Device address command is not supported.
- Fixed Baud Rate:
  - 19200 bps.
  - Although automatic extraction of event and disturbance records is not supported, it is possible to manually access this data through the front port.

4.3 Supported Command Set

The following Courier commands are supported by the relay:

Protocol Layer:

- Reset Remote Link
- Poll Status
- Poll Buffer*

Low Level Commands:

- Send Event*
- Accept Event*
- Send Block
- Store Block Identifier
- Store Block Footer

Menu Browsing:

- Get Column Headings
- Get Column Text
- Get Column Values
- Get Strings
- Get Text
- Get Value
- Get Column Setting Limits

Setting Changes:

- Enter Setting Mode
- Preload Setting
- Abort Setting
- Execute Setting
- Reset Menu Cell
- Set Value

Control Commands:

- Select Setting Group
- Change Device Address*
- Set Real Time

Note *Commands marked with an asterisk (*) are not supported through the front Courier port.*

4.4 Courier Database

The Courier database is two-dimensional. Each cell in the database is referenced by a row and column address. Both the column and the row can take a range from 0 to 255. Addresses in the database are specified as hexadecimal values, for example, 0A02 is column 0A (10 decimal) row 02. Associated settings or data are part of the same column. Row zero of the column has a text string to identify the contents of the column and to act as a column heading.

The *Relay Menu Database document* contains the complete database definition for the relay. For each cell location the following information is stated:

- Cell Text
- Cell Data type
- Cell value
- Whether the cell is settable, if so
  - Minimum value
  - Maximum value
  - Step size
- Password Level required to allow setting changes
- String information (for Indexed String or Binary flag cells)

4.5 Setting Changes

(See R6512, Courier User Guide - Chapter 9)
Courier provides two mechanisms for making setting changes, both of these are supported by the relay. Either method can be used for editing any of the settings in the relay database.

4.5.1 Method 1

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

Enter Setting Mode	Checks that the cell is settable and returns the limits.
Preload Setting	Places a new value to the cell. This value is echoed to ensure that setting corruption has not taken place. The validity of the setting is not checked by this action.
Execute Setting	Confirms the setting change. If the change is valid, a positive response is returned. If the setting change fails, an error response is returned.
Abort Setting	This command can be used to abandon the setting change.

This is the most secure method. It is ideally suited to on-line editors because the setting limits are taken from the relay before the setting change is made. However, this method can be slow if many settings are being changed because three commands are required for each change.

4.5.2 Method 2

The **Set Value** command can be used to directly change a setting, the response to this command is either a positive confirm or an error code to indicate the nature of a failure. This command can be used to implement a setting more rapidly than the previous method, however the limits are not extracted from the relay. This method is most suitable for off-line setting editors such as MiCOM S1 Studio, or for issuing preconfigured (SCADA) control commands.

4.5.3 Relay Settings

There are three categories of settings in the relay database:

- Control and support
- Disturbance recorder
- Protection settings group

Setting changes made to the control and support settings are implemented immediately and stored in non-volatile memory. Changes made to either the Disturbance recorder settings or the Protection Settings Groups are stored in a ‘scratchpad’ memory and are not immediately implemented by the relay.

To action setting changes stored in the scratchpad the Save **Changes cell** in the **Configuration** column must be written to. This allows the changes to either be confirmed and stored in non-volatile memory, or the setting changes to be aborted.

4.5.4 Setting Transfer Mode

If it is necessary to transfer all of the relay settings to or from the relay, a cell in the **Communication System Data** column can be used. This cell (location BF03) when set to 1 makes all of the relay settings visible. Any setting changes made with the relay set in this mode are stored in scratchpad memory, including control and support settings. When the value of BF03 is set back to 0, any setting changes are verified and stored in non-volatile memory.

4.6 Event Extraction

Events can be extracted either automatically (rear port only) or manually (either Courier port). For automatic extraction all events are extracted in sequential order using the standard Courier event mechanism, this includes fault/maintenance data if appropriate. The manual approach allows the user to select events, faults, or maintenance data at random from the stored records.

4.6.1 Automatic Event Extraction

(See Chapter 7 Courier User Guide, publication R6512).

This method is intended for continuous extraction of event and fault information as it is produced. It is only supported through the rear Courier port.

When new event information is created, the Event bit is set in the Status byte. This indicates to the Master device that event information is available. The oldest, unextracted event can be extracted from the relay using the Send Event command. The relay responds with the event data, which is either a Courier Type 0 or Type 3 event. The Type 3 event is used for fault records and maintenance records.

Once an event has been extracted from the relay, the Accept Event can be used to confirm that the event has been successfully extracted. If all events have been extracted, the event bit is reset. If there are more events still to be extracted, the next event can be accessed using the **Send Event** command as before.

4.6.2 Event Types

Events are created by the relay under these circumstances:

- Change of state of output contact
- Change of state of opto input
- Protection element operation
- Alarm condition
- Setting change
- Password entered/timed-out
- Fault record (Type 3 Courier Event)
- Maintenance record (Type 3 Courier Event)

4.6.3 Event Format

The Send Event command results in these fields being returned by the relay:

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

The *Relay Menu Database* document for the relevant product, contains a table of the events created by the relay and indicates how the contents of the above fields are interpreted. Fault records and Maintenance records return a Courier Type 3 event, which contains the above fields with two additional fields:

- Event extraction column
- Event number

These events contain additional information that is extracted from the relay using the referenced extraction column. Row 01 of the extraction column contains a setting that allows the fault/maintenance record to be selected. This setting should be set to the event number value returned in the record. The extended data can be extracted from the relay by uploading the text and data from the column.

4.6.4 Manual Event Record Extraction

Column 01 of the database can be used for manual viewing of event, fault, and maintenance records. The contents of this column depend on the nature of the record selected. It is possible to select events by event number and to directly select a fault record or maintenance record by number.

Event Record selection (Row 01)

> This cell can be set to a value between 0 to 511 to select from 512 stored events. 0 selects the most recent record and 511 the oldest stored record. For simple event records, (Type 0) cells 0102 to 0105 contain the event details. A single cell is used to represent each of the event fields. If the event selected is a fault or maintenance record (Type 3), the remainder of the column contains the additional information.

Fault Record Selection (Row 05)

> This cell can be used to select a fault record directly, using a value between 0 and 4 to select one of up to five stored fault records. (0 is the most recent fault and 4 is the oldest). The column then contains the details of the fault record selected.

Maintenance Record Selection (Row F0)

> This cell can be used to select a maintenance record using a value between 0 and 4. This cell operates in a similar way to the fault record selection.

If this column is used to extract event information from the relay, the number associated with a particular record changes when a new event or fault occurs.

4.7 Disturbance Record Extraction

The stored disturbance records in the relay are accessible in a compressed format through the Courier interface. The records are extracted using column B4. Cells required for extraction of uncompressed disturbance records are not supported.

Select Record Number (Row 01)

> This cell can be used to select the record to be extracted. Record 0 is the oldest unextracted record, already extracted older records are assigned positive values, and negative values are used for more recent records. To help automatic extraction through the rear port, the Disturbance bit of the Status byte is set by the relay whenever there are unextracted disturbance records.

Once a record has been selected, using the above cell, the time and date of the record can be read from cell 02. The disturbance record can be extracted using the block transfer mechanism from cell B00B. The file extracted from the relay is in a compressed format. Use MiCOM S1 Studio to decompress this file and save the disturbance record in the COMTRADE format.

As has been stated, the rear Courier port can be used to extract disturbance records automatically as they occur. This operates using the standard Courier mechanism, see *Chapter 8 of the Courier User Guide*. The front Courier port does not support automatic extraction although disturbance record data can be extracted manually from this port.

4.8 Programmable Scheme Logic (PSL) Settings

The Programmable Scheme Logic (PSL) settings can be uploaded from and downloaded to the relay using the block transfer mechanism defined in the Courier User Guide.

These cells are used to perform the extraction:

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

The PSL settings can be uploaded and downloaded to and from the relay using this mechanism. If it is necessary to edit the settings, MiCOM S1 Studio must be used because the data is compressed. MiCOM S1 Studio also performs checks on the validity of the settings before they are downloaded to the relay.

5 MODBUS INTERFACE

The MODBUS interface is a master/slave protocol and is defined by: www.modbus.org

MODBUS Serial Protocol Reference Guide: PI-MBUS-300 Rev. E

5.1 Serial Interface

The MODBUS interface uses the first rear EIA(RS)-485 (RS485) two-wire port "RP1" (or converted fiber optic port). The port is designated "EIA(RS)-485/K-Bus Port" on the external connection diagrams.

The interface uses the MODBUS RTU communication mode rather than the ASCII mode since it provides for more efficient use of the communication bandwidth and is in widespread use. This communication mode is defined by the MODBUS standard.

5.1.1 Character Framing

The character framing is 1 start bit, 8 data bits, either 1 parity bit and 1 stop bit, or 2 stop bits. This gives 11 bits per character.

5.1.2 Maximum MODBUS Query and Response Frame Size

The maximum query and response frame size is limited to 260 bytes in total. (This includes the frame header and CRC footer, as defined by the MODBUS protocol.).

5.1.3 User Configurable Communication Parameters

The following parameters can be configured for this port using the product's front panel user interface (in the communications sub-menu):

- Baud rate: 9600, 19200, 38400 bps
- Device address: 1 - 247
- Parity: Odd, even, none.
- Inactivity time: 1 - 30 minutes

Note	*The inactivity timer is started (or restarted) whenever the active password level is reduced when a valid password is entered, or when a change is made to the setting scratchpad. When the timer expires, the password level is restored to its default level and any pending (uncommitted) setting changes on the scratch pad are discarded. The inactivity timer is disabled when the password level is at its default value and there are no settings pending on the scratchpad. See the Setting Changes section.*

The MODBUS interface communication parameters are not part of the product's setting file and cannot be configured with MiCOM S1 Studio.

5.2 Supported MODBUS Query Functions

The MODBUS protocol provides numerous query functions, of which the product supports the subset in the following table. The product responds with exception code 01 if any other query function is received by it.

Query Function Code	MODBUS Query Name	Application / Interpretation
01	Read Coil Status	Read status of output contacts (0x addresses)
02	Read Input Status	Read status of opto-isolated status inputs (1x addresses)
03	Read Holding Registers	Read setting values (4x addresses)
04	Read Input Registers	Read measurement values (3x addresses)
06	Preset Single Register	Write single setting value (4x addresses)
07	Read Exception Status	Read relay status, same value as register 3x1
08	Diagnostics	Application defined by the MODBUS protocol specification
11	Fetch Communication Event Counter	
12	Fetch Communication Event Log	
16	Preset Multiple Registers (127 max)	Write multiple setting values (4x addresses)

Table 3 - MODBUS query functions supported by the product

5.3 MODBUS Response Codes

Code	MODBUS response name	Product interpretation
01	Illegal Function Code	The function code transmitted is not supported.
02	Illegal Data Address	The start data address in the request is not an allowable value. If any of the addresses in the range cannot be accessed due to password protection, all changes in the request are discarded and this error response is returned. Note If the start address is correct but the range includes non-implemented addresses, this response is not produced.
03	Illegal Value	A value referenced in the data field transmitted by the master is not in range. Other values transmitted in the same packet are executed if they are in the range.
04	Slave Device Failure	An exception arose during the processing of the received query that is not covered by any of the other exception codes in this table.
05	Acknowledge	Not used.
06	Slave Device Busy	The write command cannot be implemented due to the product's internal database being locked by another interface. This response is also produced if the product is busy executing a previous request.

Table 4 - MODBUS response code interpretation

5.4 Maximum Query and Response Parameters

The following table shows the maximum amount of data that the product can process for each of the supported query functions (see the Supported MODBUS Query Functions section) and the maximum amount of data that can be sent in a corresponding response frame. The principal constraint is the maximum query and response frame size, as noted in the *Maximum MODBUS Query and Response Frame Size* section. Maximum MODBUS query and response frame size.

Query function code	MODBUS query name	Maximum query data request size	Maximum response data size
01	Read Coil Status	32 coils	32 coils
02	Read Input Status	32 inputs	32 inputs
03	Read Holding Registers	127 registers	127 registers
04	Read Input Registers	127 registers	127 registers
06	Preset Single Register	1 register	1 register
07	Read Exception Status	-	8 coils
08	Diagnostics	-	-
11	Fetch Communication Event Counter	-	-
12	Fetch Communication Event Log	-	70 bytes
16	Preset Multiple Registers	127 registers	127 registers

Table 5 - Maximum query and response parameters for supported queries

5.5 Register Mapping

5.5.1 Conventions

5.5.1.1 Memory Pages

The MODBUS specification associates a specific register address space to each query that has a data address field. The address spaces are often called memory pages because they are analogous to separate memory devices. A simplistic view of the queries in MODBUS is that a specified location in a specified memory device is being read from or written to. However, the product's implementation of such queries is not as a memory access but as a translation to an internal database query (see Note).

Note *One consequence of this is that the granularity of the register address space (in the 3x and 4x memory pages) is governed by the size of the data item being requested from the internal database. Since this is often more than the 16 bits of an individual register, not all register addresses are valid. See the Register Data Types section for more details.*

Each MODBUS memory page has a name and an ID. The *MODBUS "memory" pages reference and application* table provides a summary of the memory pages, their Ids, and their application in the product.

It is common practice to prefix a decimal register address with the page ID and generally this is the style used in this document.

Memory page ID	MODBUS memory page name	Product application
0xxxx	Coil Status	Read and write access of the Output Relays.
1xxxx	Input Status	Read only access of the Opto-Isolated Status Inputs.
3xxxx	Input Registers	Read-only data access, such as measurements and records.
4xxxx	Holding Registers	Read and write data access, such as product configurations settings and control commands.
6xxxx	Extended Memory File	Not used or supported.
Note	*xxxx represents the addresses available in the page (0 to 9999).*	

Table 6 - MODBUS "memory" pages reference and application

5.5.1.2 MODBUS Register Identification

The MODBUS convention is to document register identifiers with ordinal values (first, second, third…) whereas the actual protocol uses memory-page based register addresses that begin with address zero. Therefore the first register in a memory page is register address zero, the second register is register address 1 and so on. In general, one must be subtracted from a register's identifier to find its equivalent address. The page number notation is not part of the address.

Example:

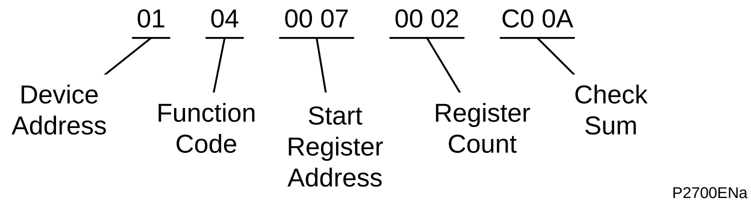
Task:

Obtain the status of the output contacts from the Schneider Electric MiCOM Pxxx device at address 1.

The output contact status is a 32-bit binary string held in input registers 3x8 and 3x9 (see the *Binary Status Information* section).

Select MODBUS function code 4 "Read input registers" and request two registers starting at input register address 7. Note the register address is one less than the required register ordinal.

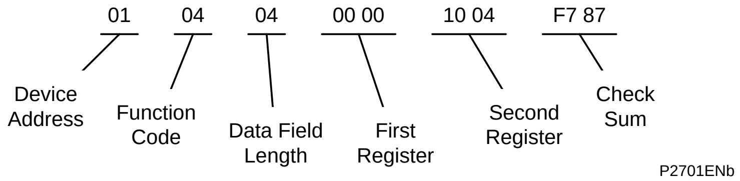
The MODBUS query frame is:



Note that the following frame data is shown in hexadecimal 8-bit bytes.

The frame is transmitted from left to right by the master device. The start register address, register count and check sum are all 16-bit numbers that are transmitted in a high byte - low byte order.

The query may elicit the following response: [4]



The frame was transmitted from left to right by the slave device. The response frame is valid because the eighth bit of the function code field is not set. The data field length is 4 bytes since the query was a read from two 16-bit registers. The data field consists of two pairs of bytes in a high byte - low byte order with the first requested register's data coming first. Therefore the request for the 32-bit output contact status starting at register 3x8 is 00001004h (1000000000100b), which shows that outputs 3 and 13 are energized and the remaining outputs are de-energized.

5.6 Register Map

For a complete map of the MODBUS addresses supported by the product, see the *Relay Menu Database document*.

The register map tables in this document include an Equivalent Courier Cell column. The cell identifiers relate to the product's internal Courier database and may be used in cross-reference with the Courier Protocol documentation or the product's front panel user interface documentation.

The Data Format column specifies the format of the data presented by the associated MODBUS register or registers. The *Register Data Types* section describes the formats used.

The right-hand columns in the tables show whether the register is used in a particular product model. An asterisk indicates that the model uses the register.

5.7 Event Extraction

The product can store up to 512 event records in battery backed-up memory. An event record consists of a time stamp, a record type, and a set of information fields. The record type and the information fields record the event that occurred at the time captured by the time stamp.

The product has several classes of event record:

- Alarm events
- Opto-isolated status input events
- Relay contact output events
- Protection/DDB operation events
- Fault data capture events
- General events

The *Relay Menu Database document* specifies the available events. The product provides an “event filtering” feature that may be used to prevent specific events from being logged. The event filter is configured in the **Record Control** section of the product’s menu database in the MiCOM S1 Studio configuration tool.

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

The product stores event, fault, and maintenance records in three separate queues. As entries are added to the fault and maintenance queues, a corresponding event is added to the event queue. Each queue is of different length and each queue may be individually cleared – see the *Event Record Delection* section. It is therefore possible to have a fault event or a maintenance event entry in the event queue with no corresponding entry in the associated queue because it has been overwritten or deleted.

The manual extraction procedure (see the *Manual Extraction Procedure section*) allows each of these three queues to be read independently.

The automatic extraction procedure (sss the *Automatic Extraction Procedure section*) reads records from the event queue. If the event record is a fault or a maintenance record, the record’s extended data is read also, if it is available from their queues.

Note	*Version 31 of the product introduced a new set of 3x registers for the presentation of the event and fault record data. These registers are used throughout the text of the following sub-sections. For legacy compatibility, the original registers are still provided. These are described as previous MODBUS addresses in the Relay Menu Database document. They should not be used for new installations. See the* ***Legacy Event Record Support*** *section for additional information.*

5.7.1 Manual Extraction Procedure

There are three registers used to manually select stored records. For each of these registers, zero represents the most-recent stored record. For example:

- 4x00100 - Select Event, 0 to 511
- 4x00101 - Select Fault, 0 to 4
- 4x00102 - Select Maintenance Record, 0 to 4

These registers can be read to indicate the numbers of the various types of record stored.

- 30100 - Number of stored records
- 30101 - Number of stored fault records
- 30102 - Number of stored maintenance records

Each fault or maintenance record logged causes an event record to be created by the relay. If this event record is selected the additional registers allowing the fault or maintenance record details will also become populated.

5.7.2 Automatic Extraction Procedure

Automatic event-record extraction allows records to be extracted as they occur. Event records are extracted in sequential order, including any fault or maintenance data that may be associated with an event.

The MODBUS master can determine whether the product has any events stored that have not yet been extracted. This is done by reading the product's status register 3x00001 (G26 data type). If the event bit of this register is set, the product contains event records that have not yet been extracted.

To select the next event for sequential extraction, the master station writes a value of one to the record selection register 4x00400 (G18 data type). The event data, plus any fault or maintenance data, can be read from the registers specified in the *Record Data* section. Once the data has been read, the event record is marked. This is done by writing a value of 2 to register 4x00400. The G18 data type consists of bit fields. Therefore it is also possible to both mark the current record as read and automatically select the next unread record. This is done by writing a value of 3 to the register.

When the last (most recent) record is accepted, the event flag in the status register (3x00001) resets. If the last record is accepted by writing a value of 3 to the record selection register (4x00400), a dummy record appears in the event-record registers with an "Event Type" value of 255. Selecting another record when none are available gives a MODBUS exception code 3, "Invalid value" (see the *MODBUS Response Code Interpretation* section).

One possible event record extraction procedure is shown in the following *Automatic event extraction procedure* diagram.

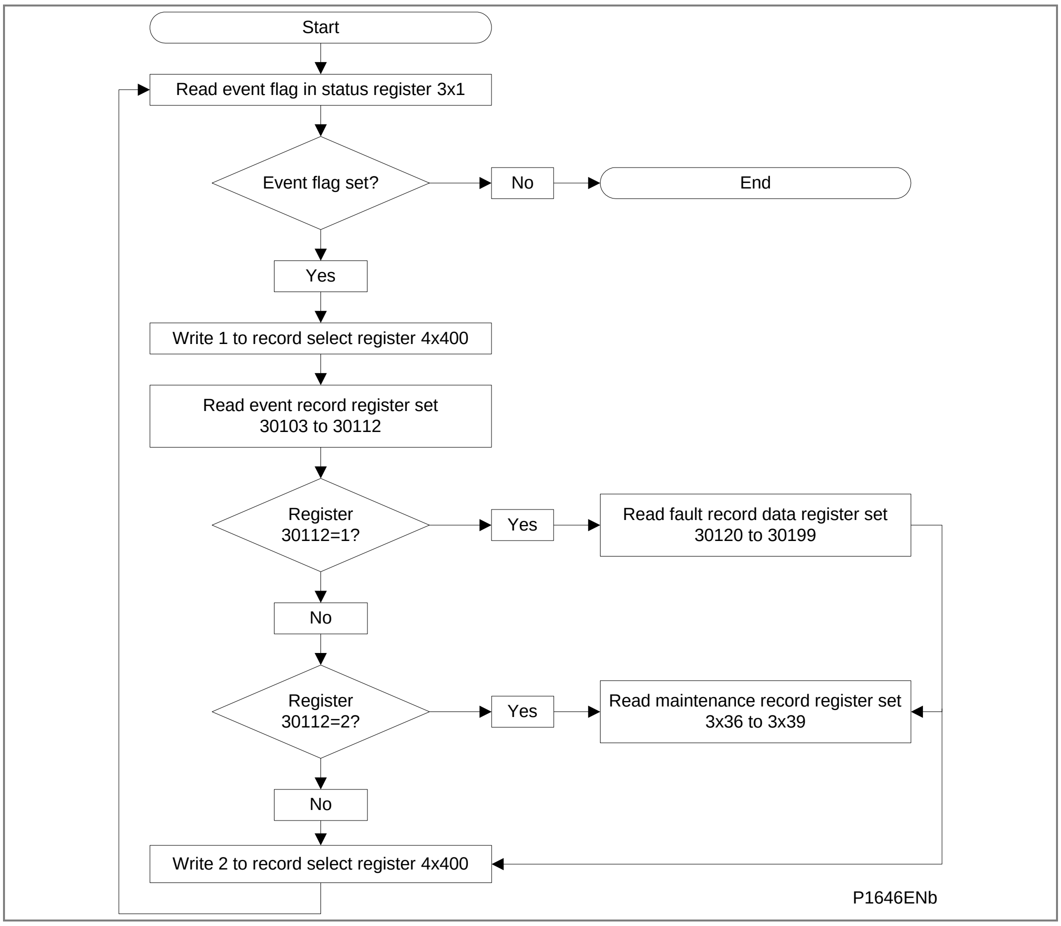


Figure 9 - Automatic event extraction procedure

5.7.3 Record Data

The location and format of the registers used to access the record data is the same whether they have been selected using manual or automatic extraction mechanisms, see the *Manual Extraction Procedure* and *Automatic Extraction Procedure* sections.

Event Description	MODBUS Address	Length (registers)	Comments
Time and Date	30103	4	See G12 data type description in section 5.10.
Event Type	30107	1	See G13 data type. Indicates type of event.
Event Value	30108	2	Nature of value depends on event type. This will contain the status as a binary flag for contact, opto, alarm, and protection events.
MODBUS Address	30110	1	The Event Original value indicates the MODBUS Register pair where the change occurred (see Note 2). Possible values are: 30011: Alarm Status 1 event 30013: Alarm Status 2 event 30015: Alarm Status 3 event 30723: Relay contact event (2 registers: DDB 0-31 status) 30725: Status input event (2 registers: DDB 32-63 status) 30727 to 30785: Protection events (Indicates the 32-bit DDB status word that was the origin of the event) For General events, Fault events, and Maintenance events, a value of zero is returned.
Event Index	30111	1	This register will contain the DDB ordinal for protection events or the bit number for alarm events. The direction of the change will be indicated by the most significant bit; 1 for 0 - 1 change and 0 for 1 - 0 change.
Additional Data Present	30112	1	0 means that there is no additional data. 1 means fault record data can be read from 30113 to 30199 (number of registers depends on the product). 2 means maintenance record data can be read from 30036 to 30039.

Note 1 *The protection-event status information is the value of the DDB status word that contains the protection DDB that caused the event.*

Note 2 *Subtracting 3000 from the Event Origin value results in the MODBUS 3x memory-page register ID, subtracting one from this results in the MODBUS register address - see section* ***Error! Reference source not found.****. The resultant register address can be used in a function code 4 MODBUS query.*

Note 3 *The exact number of fault record registers depends on the individual product - see Relay Menu Database.*

Table 7 - MODBUS Event record extraction registers

If a fault record or maintenance record is directly selected using the manual mechanism then the data can be read from the register ranges specified above. The event record data in registers 30103 to 30111 will not be available.

It is possible using register 40401(G6 data type) to clear independently the stored relay event/fault and maintenance records. This register also provides an option to reset the relay indications, which has the same effect on the relay as pressing the clear key within the alarm viewer using the front panel menu.

Event types 4 **Relay Contact Output Events** and 5 **Opto-Isolated Status Input Events** only provide the value of the input or output status register (as indicated by the Event Origin value) when the event occurred. If event transition information for each input or output is required, it must be deduced by comparing the event value with the previous event value (for identically-typed events records).

Event type 7 **General Event** events are solely identified by their **Event Value**.

Event types 8 **Fault Record** and 9 **Maintenance Record** require additional registers to be read when the associated additional data is available (see Note). The Fault record registers in the range 30120 to 30199 (the exact number of registers depends on the individual product) are documented in the 3x register-map in the *Relay Menu Database document*. The two additional 32-bit maintenance record register-pairs consist of a maintenance record type (register pair 3x36/7) and a type-specific error code (register pair 3x38/9). The *Maintenance record types* table lists the different types of maintenance record available from the product.

Note	*As noted at the beginning of the Event Extraction section, it should not be assumed that the additional data is available for fault and maintenance record events.*

Maintenance record	Front panel text	Record type 3x00036
Power on test errors (non-fatal)		
Watchdog 1 failure (fast)	Fast W'Dog Error	0
Battery fail	Battery Failure	1
Battery-backed RAM failure	BBRAM Failure	2
Field voltage failure	Field Volt Fail	3
Ribbon bus check failure	Bus Reset Error	4
Watchdog 2 failure (slow)	Slow W'Dog Error	5
Continuous self-test errors		
SRAM bus failure	SRAM Failure Bus	6
SRAM cell failure	SRAM Failure Blk.	7
Flash EPROM checksum failure	FLASH Failure	8
Program code verify failure	Code Verify Fail	9
Battery-backed RAM failure	BBRAM Failure	10
Battery fail	Battery Failure	11
Field Voltage failure	Field Volt Fail	12
EEPROM failure	EEPROM Failure	13
Fatal software exception	Software Failure	14
Incorrect hardware configuration	H/W Verify Fail	15
Software exception (typically non-fatal)	Non Standard	16
Analog module failure	Ana. Sample Fail	17
Ethernet card error	NIC Soft Error	18

Table 8 - Maintenance record types

5.7.4 Event Record Deletion

It is possible to independently delete (“clear”) the stored event, fault, and maintenance record queues. This is done by writing a value of 1, 2, or 3 to register 4x401 (G6 data type), respectively.

Register 4x401 also provides an option to reset the product’s front panel indications, which has the same effect as pressing the front panel “Clear” key when viewing alarm indications using the front panel user interface. This is done by writing a value of 4 to register 4x401.

See also the *Disturbance Record Deletion* section for details about deleting disturbance records.

5.7.5 Legacy Event Record Support

Version 57 of P24x and Version 31 of P34x product introduced a new set of 3x registers for the presentation of the event and fault record data. For legacy compatibility, the original registers are supported and are described in this section. They should not be used for new installations and they are correspondingly described as previous MODBUS address in the 3x-register table in the *Relay Menu Database document*.

The *Correspondence of obsolete event record 3x registers with their counterparts* table provides a mapping between the obsolete event record 3x-registers and the registers used in the event record discussions in the previous sub-sections.

The obsolete fault record data between registers 3x113 and 3x199, and 3x490 and 3x499, now exists between registers 3x10020 and 3x10999. In comparison with the obsolete fault record data, the data between registers 3x10020 and 3x10999 is ordered slightly differently and it contains new data values. These new values are not available in the obsolete fault-record register sets.

The maintenance-record registers 3x36 to 3x39 remain unaffected by this evolution.

Description	Obsolete register	Length (registers)	Corresponds to register
Number of stored event records	3x00100	1	3x10100
Number of stored fault records	3x00101	1	3x10101
Number of stored maintenance records	3x00102	1	3x10102
Time Stamp	3x00103	4	3x10103
Event Type	3x00107	1	3x10107
Event Value	3x00108	2	3x10108
Event Origin	3x00110	1	3x10110
Event Index	3x00111	1	3x10111
Additional Data Present	3x00112	1	3x10112

Table 9 – Correspondence of obsolete event record 3x registers with their counterparts record types

5.8 Disturbance Record Extraction

The product provides facilities for both manual and automatic extraction of disturbance records. The two methods differ only in the mechanism for selecting a disturbance record; the method for extracting the data and the format of the data are identical.

Records extracted are presented in IEEE COMTRADE format. This involves extracting two files: an ASCII text configuration file, and a binary data file.

Each file is extracted by repeatedly reading a data-page until all of the file’s data has been transferred. The data-page is made up of 127 registers; providing a maximum of 254 bytes for each register block request.

5.8.1 Interface Registers

The following set of registers is presented to the master station to support the extraction of uncompressed disturbance records:

MODBUS Register	Name	Description
3x00001	Status register	Provides the status of the relay as bit flags: b0 - Out of service b1 - Minor self test failure b2 - Event b3 - Time synchronization b4 - Disturbance b5 - Fault b6 - Trip b7 - Alarm b8 to b15 - Unused A ‘1’ on b4 indicates the presence of a disturbance.
3x00800	Nº of stored disturbances	Indicates the total number of disturbance records currently stored in the relay, both extracted and unextracted.
3x00801	Unique identifier of the oldest disturbance record	Indicates the unique identifier value for the oldest disturbance record stored in the relay. This is an integer value used in conjunction with the ‘Nº of stored disturbances’ value to calculate a value for manually selecting records.
4x00250	Manual disturbance record selection register	This register is used to manually select disturbance records. The values written to this cell are an offset of the unique identifier value for the oldest record. The offset value, which ranges from 0 to the Nº of stored disturbances - 1, is added to the identifier of the oldest record to generate the identifier of the required record.
4x00400	Record selection command register	This register is used during the extraction process and has a number of commands. These are: b0 - Select next event b1 - Accept event b2 - Select next disturbance record b3 - Accept disturbance record b4 - Select next page of disturbance data b5 - Select data file
3x00930 - 3x00933	Record time stamp	These registers return the timestamp of the disturbance record.
3x00802	Nº of registers in data page	This register informs the master station of the number of registers in the data page that are populated.
3x00803 - 3x00929	Data page registers	These 127 registers are used to transfer data from the relay to the master station. They are 16-bit unsigned integers.
3x00934	Disturbance record status register	The disturbance record status register is used during the extraction process to indicate to the master station when data is ready for extraction. See next table.
4x00251	Data file format selection	This is used to select the required data file format. This is reserved for future use.
Note		*Register addresses are provided in reference code + address format. E.g. 4x00001 is reference code 4x, address 1 (which is specified as function code 03, address 0x0000 in the MODBUS specification).*

Table 10 - Disturbance record extraction registers

The disturbance record status register will report one of the following values:

State		Description
Idle		This will be the state reported when no record is selected; such as after power on or after a record has been marked as extracted.
Busy		The relay is currently processing data.
Page ready		The data page has been populated and the master station can now safely read the data.
Configuration complete		All of the configuration data has been read without error.

State		Description
Record complete	4	All of the disturbance data has been extracted.
Disturbance overwritten	5	An error occurred during the extraction process where the disturbance being extracted was overwritten by a new record.
No unextracted disturbances	6	An attempt was made by the master station to automatically select the next oldest unextracted disturbance when all records have been extracted.
Not a valid disturbance	7	An attempt was made by the master station to manually select a record that did not exist in the relay.
Command out of sequence	8	The master station issued a command to the relay that was not expected during the extraction process.

Table 11 - Disturbance record status register (3x934) values

5.8.2 Extraction Procedure

The following procedure must be used to extract disturbance records from the product. The procedure is split into four sections:

1. Selection of a disturbance, either manually or automatically.
2. Extraction of the configuration file.
3. Extraction of the data file.
4. Accepting the extracted record (automatic extraction only).

5.8.2.1 Manual Extraction Procedure

The procedure used to extract a disturbance manually is shown in the following *Manual selection of a disturbance record* diagram. The manual method of extraction does not allow for the acceptance of disturbance records.

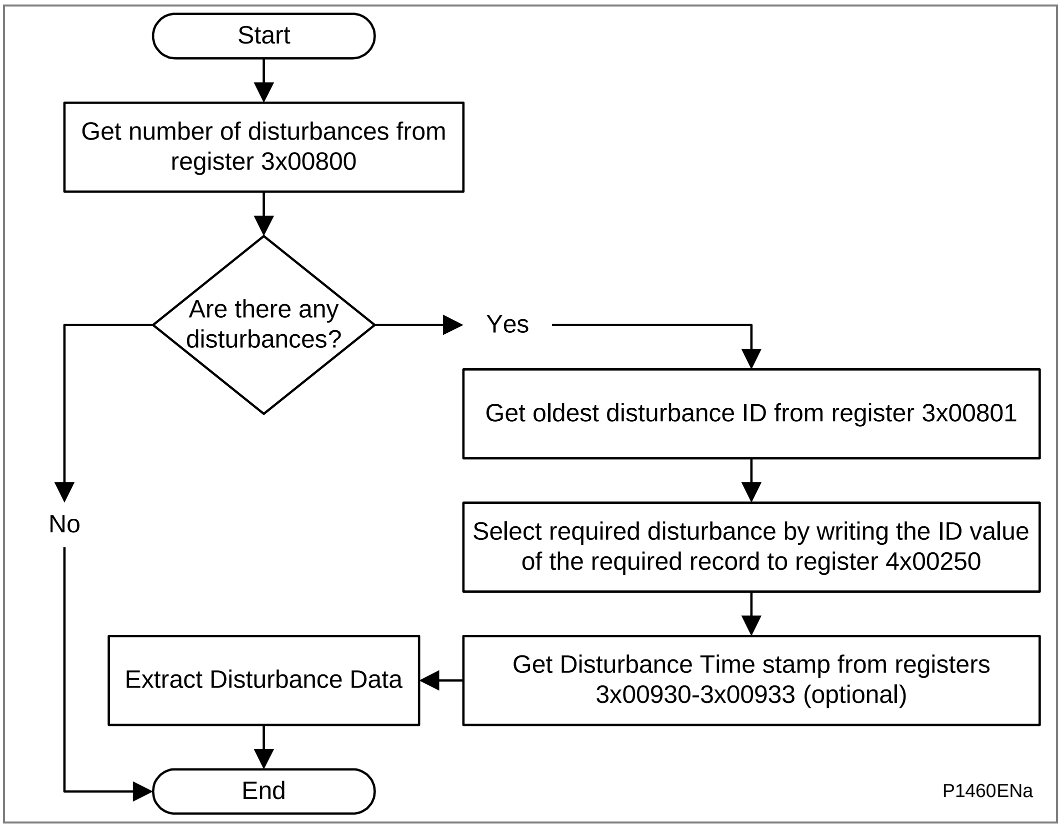


Figure 10 - Manual selection of a disturbance record

5.8.2.2 Automatic Extraction Procedure - Option 1

There are two methods that can be used for automatically extracting disturbances. The procedure for the first method is shown in the *Automatic selection of a disturbance - option 1* diagram. This also shows the acceptance of the disturbance record once the extraction is complete.

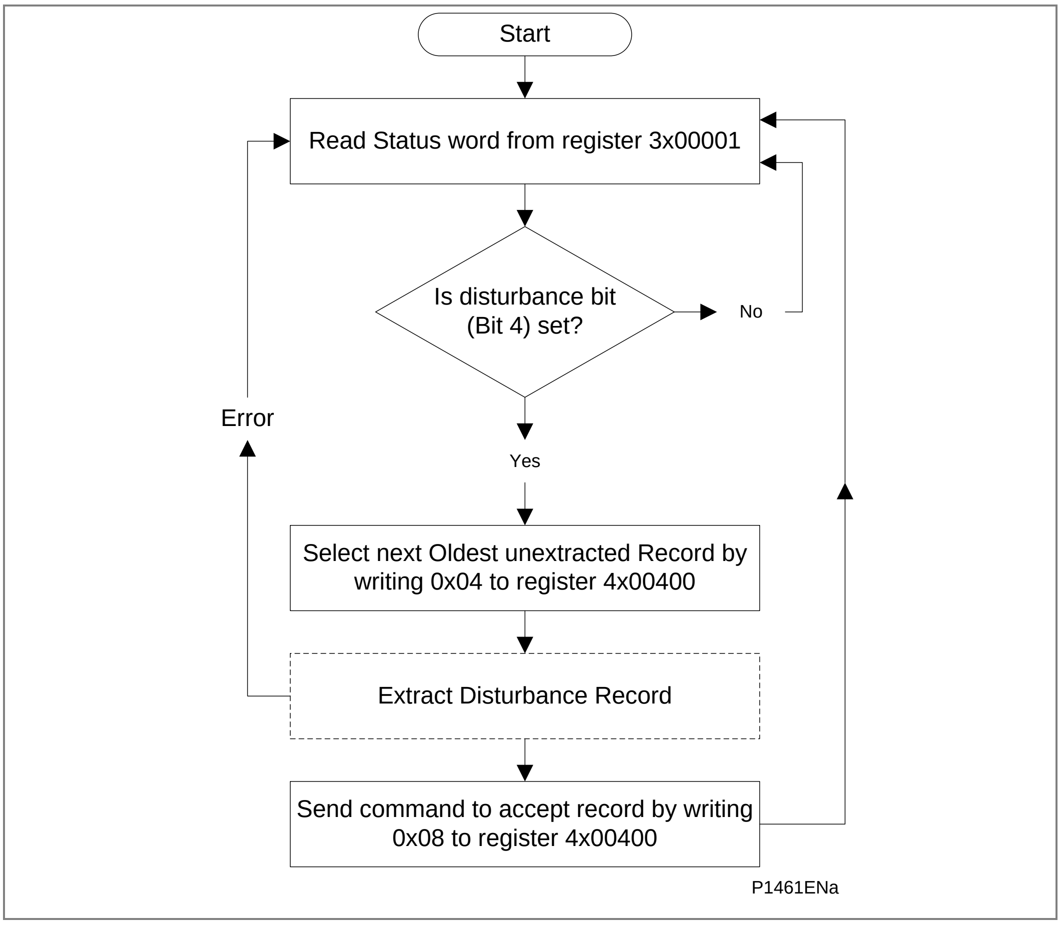


Figure 11 - Automatic selection of a disturbance - option 1

5.8.2.3 Automatic Extraction Procedure - Option 2

The second method that can be used for automatic extraction is shown in the *Automatic selection of a disturbance - option 2* diagram. This also shows the acceptance of the disturbance record once the extraction is complete.

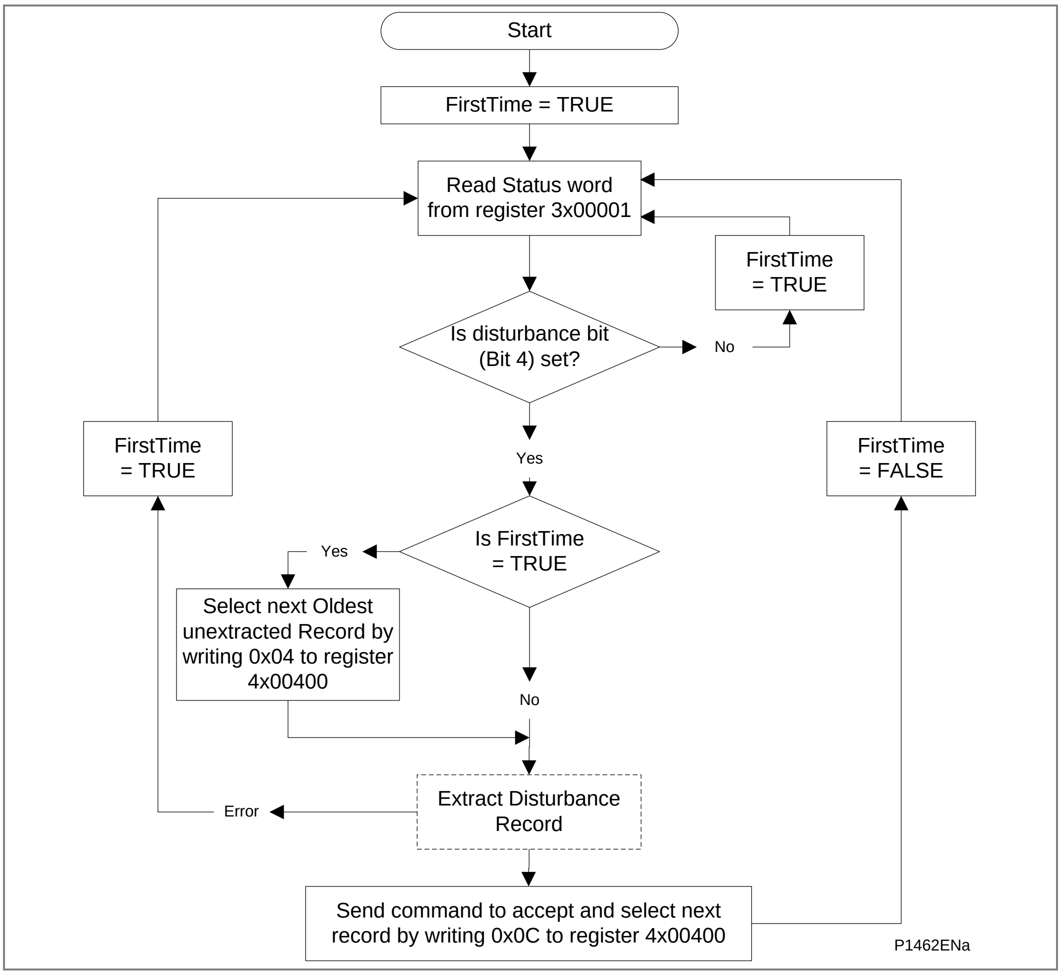


Figure 12 - Automatic selection of a disturbance - option 2

5.8.3 Extracting the Disturbance Data

Extraction of a selected disturbance record is a two-stage process. This involves first reading the configuration file, then the data file. The *Extracting the COMTRADE configuration file* diagram shows how the configuration file is read and *the Extracting the COMTRADE binary data file* diagram shows how the data file is extracted.

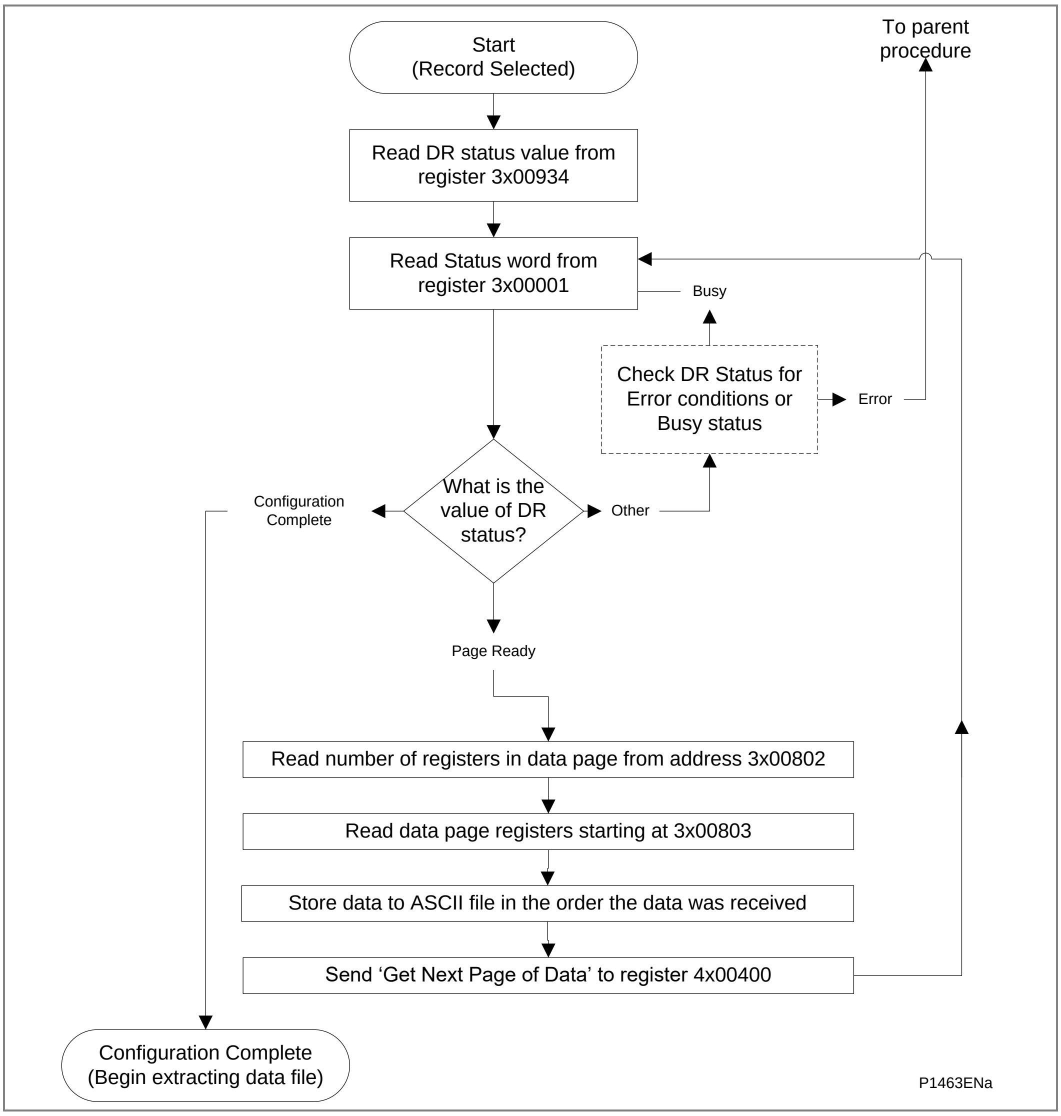


Figure 13 - Extracting the comtrade configuration file

The following figure shows how the data file is extracted:

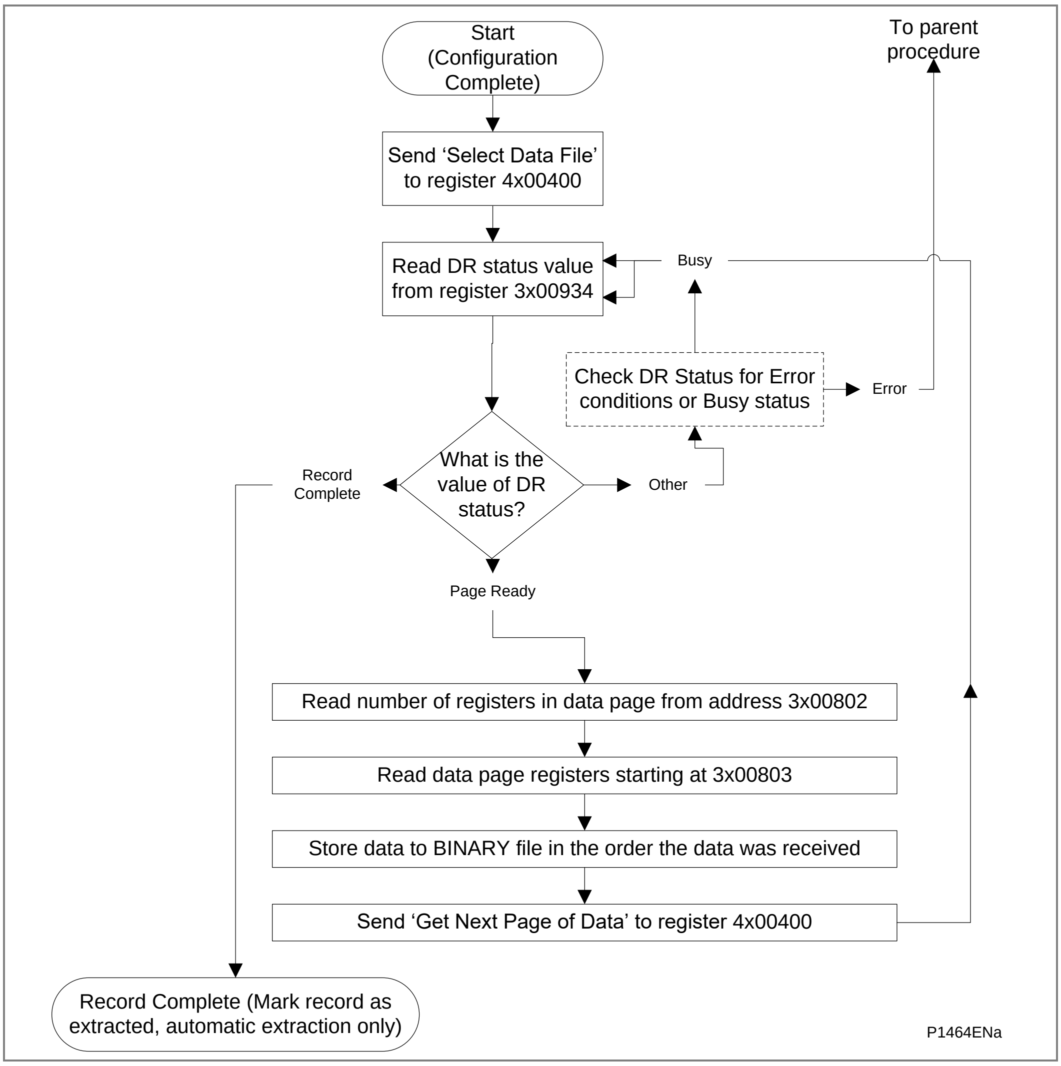


Figure 14 - Extracting the COMTRADE binary data file

During the extraction of a COMTRADE file, an error may occur that is reported in the disturbance record status register, 3x934. This can be caused by the product overwriting the record that is being extracted. It can also be caused by the master issuing a command that is not in the bounds of the extraction procedure.

5.8.4 Storage of Extracted Data

The extracted data needs to be written to two separate files. The first is the configuration file, which is in ASCII text format, and the second is the data file, which is in a binary format.

5.8.4.1 Storing the Configuration File

As the configuration data is extracted from the product, it should be stored to an ASCII text file with a '.cfg' file extension. Each register in the page is a G1 format 16-bit unsigned integer that is transmitted in big-endian byte order. The master must write the configuration file page-data to the file in ascending register order with each register's high order byte written before its low order byte, until all the pages have been processed.

5.8.4.2 Storing the Binary Data File

As the binary data is extracted from the product, it should be stored to a binary file with the same name as the configuration file, but with a '.dat' file extension instead of the '.cfg' extension. Each register in the page is a G1-format 16-bit unsigned integer that is transmitted in big-endian byte order. The master must write the page data to a file in ascending register order with each register's high order byte written before its low order byte until all the pages have been processed.

5.8.5 Disturbance Record Deletion

All of the disturbance records stored in the product can be deleted ("cleared") by writing 5 to the record control register 4x401 (G6 data type). See the *Event Record Deletion* section for details on event record deletion.

5.9 Setting Changes

The relay settings can be split into two categories:

- Control and support settings
- Disturbance record settings and protection setting groups

Changes to settings in the control and support area are executed immediately. Changes to the protection setting groups or the disturbance recorder settings are stored in a temporary 'scratchpad' area and must be confirmed before they are implemented. All the product settings are 4xxxx page registers; see the *Relay Menu Database document*. The following points should be noted when changing settings:

- Settings implemented using multiple registers must be written to using a multi-register write operation. The product does not support write access to sub-parts of multi-register data types.
- The first address for a multi-register write must be a valid address. If there are unmapped addresses in the range that is written to, the data associated with these addresses are discarded.
- If a write operation is performed with values that are out of range, an "illegal data" response code is produced. Valid setting values in the same write operation are executed.
- If a write operation is performed attempting to change registers that require a higher level of password access than is currently enabled, all setting changes in the write operation are discarded.

5.9.1 Authentication and Password Protection

Access to the product's settings is subject to authentication of a user who has the correct role. The authentication needed to change a setting is shown in the 4x register-map table in the *Relay Menu Database document, P64x/EN MD*.

5.9.2 Control and Support Settings

Control and support settings are committed immediately when a value is written to such a register. The MODBUS registers in this category are:

- 4x00000-4x00599
- 4x00700-4x00999
- 4x02049 to 4x02052
- 4x10000-4x10999

5.9.2.1 Time Synchronization

The value of the product's real time clock can be set by writing the desired time (see the *Date and Time Format (Data Type G12)* section) to registers 4x02049 through 4x02052. These registers are standard to Schneider Electric MiCOM products, which makes it easier to broadcast a time synchronization packet, being a block write to the time setting registers sent to slave address zero.

When the product's time has been set using these registers, the Time Synchronized flag in the MODBUS Status Register (3x1: type G26) is set. The product automatically clears this flag if more than five minutes has elapsed since these registers were last written to.

A "Time synchronization" event is logged if the new time value is more than two seconds different to the current value.

5.9.3 Protection and Disturbance Recorder Settings

Protection configuration-settings are written to a scratchpad memory area. A confirmation procedure is required to commit the contents of the scratchpad to the product's protection functions, which ensures that their configuration is consistent at all times. The contents of the scratchpad memory can be discarded with the abort procedure. The scratchpad confirmation and abort procedures are described in the *Scratchpad Management* section.

The product supports four groups of protection settings. One protection-group is active and the other three are either dormant or disabled. The active protection-group can be selected by writing to register 4x00404. An illegal data response is returned if an attempt is made to set the active group to one that has been disabled.

Group 1	41000 - 42999
Group 2	43000 - 44999
Group 3	45000 - 46999
Group 4	47000 - 48999

5.9.4 Scratchpad Management

In addition to the basic editing of the protection setting groups, the following functions are provided:

- Default values can be restored to a setting group or to all of the relay settings by writing to register 40402.
- It is possible to copy the contents of one setting group to another by writing the source group to register 40406 and the target group to 40407.

It should be noted that the setting changes performed by either of the two operations defined above are made to the scratchpad area. These changes must be confirmed by writing to register 40405.

The active protection setting groups can be selected by writing to register 40404. An illegal data response will be returned if an attempt is made to set the active group to one that has been disabled.

5.10 Register Data Types

The product maps one or more MODBUS registers to data-typed information contained in an internal database. These data-types are referred to as G-Types since they have a ‘G’ prefixed identifier. The *Relay Menu Database document* gives a complete definition of the all of the G-Types used in the product.

Generally the data types are transmitted in high byte to low byte order, also known as “Big Endian format”. This may require the MODBUS master to reorder the received bytes into a format that complies with its byte order and register order (for multi-register G-Types) conventions. Most MODBUS masters provide byte-swap and register-swap device (or data point) configuration to cope with the wide range of implementations.

The product’s data types cannot be broken into smaller parts. Therefore multi-register data types cannot be read from or written to on an individual register basis. All of the registers for a multi-register data-typed item must be read from or written to with a single block read or write command. The following subsections provide some additional notes for a few of the more complex G-Types.

5.11 Numeric Setting (Data Types G2 & G35)

Numeric settings are integer representations of real (non-integer) values. The register value is the number of setting increments (or steps) that the real value is away from the real minimum value. This is expressed by this formula:

$S_{real} = S_{min.} + (S_{inc.} \times S_{numeric})$

Where:

S_{real}	Setting real value
$S_{min.}$	Setting real minimum value
$S_{inc.}$	Setting real increment (step) value
$S_{numeric}$	Setting numeric (register) value

For example, a setting with a real value setting range of 0.01 to 10 in steps of 0.01 would have the following numeric setting values:

Real value (S_{real})	Numeric value ($S_{numeric}$)
0.01	0
0.02	1
1.00	99

Table 12 – Numeric settings

The G2 numeric data type uses 1 register as an unsigned 16-bit integer, whereas the G35 numeric data type uses 2 registers as an unsigned 32-bit integer. The G2 data type therefore provides a maximum setting range of $2^{16} \times S_{inc}$. Similarly the G35 data type provides a maximum setting range of $2^{32} \times S_{inc}$.

5.12 Date and Time Format (Data Type G12)

The date-time data type G12 allows real date and time information to be conveyed down to a resolution of 1 ms. The data-type is used for record time-stamps and for time synchronization (see the *Time Synchronization* section).

The structure of the data type is shown in the following table and complies with the IEC60870-5-4 Binary Time 2a format.

Byte	Bit Position							
	7	6	5	4	3	2	1	0
1	m^7	m^6	m^5	m^4	m^3	m^2	m^1	m^0
2	m^{15}	m^{14}	m^{13}	m^{12}	m^{11}	m^{10}	m^9	m^8
3	IV	R	I^5	I^4	I^3	I^2	I^1	I^0
4	SU	R	R	H^4	H^3	H^2	H^1	H^0
5	W^2	W^1	W^0	D^4	D^3	D^2	D^1	D^0
6	R	R	R	R	M^3	M^2	M^1	M^0
7	R	Y^6	Y^5	Y^4	Y^3	Y^2	Y^1	Y^0

Where:

m	=	0…59,999ms	Y	=	0…99 Years (year of century)
I	=	0…59 minutes	R	=	Reserved bit = 0
H	=	0…23 Hours	SU	=	Summertime: 0=standard time, 1=summer time
W	=	1…7 Day of week; Monday to Sunday, 0 for not calculated	IV	=	Invalid value: 0=valid, 1=invalid
D	=	1…31 Day of Month			
M	=	1…12 Month of year; January to December	range	=	0ms…99 years

Table 13 - G12 date & time data type structure

The seven bytes of the structure are packed into four 16-bit registers. Two packing formats are provided: standard and reverse. The prevailing format is selected by the G238 setting in the **Date and Time** menu column or by register 4x306 (Modbus IEC Time).

The standard packing format is the default and complies with the IEC60870-5-4 requirement that byte 1 is transmitted first. This is followed by byte 2 through to byte 7, followed by a null (zero) byte to make eight bytes in total. Since register data is usually transmitted in big-endian format (high-order byte followed by low-order byte), byte 1 is in the high-order byte position followed by byte 2 in the low-order position for the first register. The last register contains just byte 7 in the high-order position and the low-order byte has a value of zero.

The reverse packing format is the exact byte transmission order reverse of the standard format. The null (zero) byte is sent as the high-order byte of the first register and byte 7 as the register's low-order byte. The second register's high-order byte contains byte 6 and byte 5 in its low order byte.

Both packing formats are fully documented in the *Relay Menu Database document* for the G12 type.

The principal application of the reverse format is for date-time packet format consistency when a mixture of MiCOM Px20, Px30, and Px40 series products are being used. This is especially true when there is a requirement for broadcast time synchronization with a mixture of such MiCOM products.

The data type provides only the value for the year of the century. The century must be deduced. The century could be imposed as 20 for applications not dealing with dates stored in this format from the previous (20th) century. Alternatively, the century can be calculated as the one that produces the nearest time value to the current date. For example: 30-12-99 is 30-12-1999 when received in 1999 & 2000, but is 30-12-2099 when received in 2050. This technique allows 2-digit years to be accurately converted to 4 digits in a ±50 year window around the current datum.

The invalid bit has two applications:

- It can indicate that the date-time information is considered inaccurate, but is the best information available.
- Date-time information is not available.

The summertime bit is used to indicate that summertime (day light saving) is being used and, more importantly, to resolve the alias and time discontinuity which occurs when summertime starts and ends. This is important for the correct time correlation of time stamped records.

Note	*The value of the summertime bit does not affect the time displayed by the product.*

The day of the week field is optional and if not calculated is set to zero.

This data type (and therefore the product) does not cater for time zones so the end user must determine the time zone used by the product. UTC (universal co-ordinated time) is commonly used and avoids the complications of daylight saving timestamps.

5.13 Power and Energy Measurement Data Formats (G29 & G125)

The power and energy measurements are available in two data formats, G29 integer format and G125 IEEE754 floating point format. The G125 format is preferred over the older G29 format.

5.13.1 Data Type G29

Data type G29 consists of three registers. The first register is the per-unit power or energy measurement and is of type G28, which is a signed 16-bit quantity. The second and third registers contain a multiplier to convert the per-unit value to a real value.

The multiplier is of type G27, which is an unsigned 32-bit quantity. Therefore the overall value conveyed by the G29 data type must be calculated as G29 = G28 × G27.

The product calculates the G28 per unit power or energy value as

G28 = ((measured secondary quantity) / (CT secondary) × (110 V / (VT secondary)).

Since data type G28 is a signed 16-bit integer, its dynamic range is constrained to ±32768. This limitation should be borne in mind for the energy measurements, as the G29 value saturates a long time before the equivalent G125.

The associated G27 multiplier is calculated as

G27 = (CT primary) × (VT primary / 110 V)
when primary value measurements are selected,
and as
G27 = (CT secondary) × (VT secondary / 110 V)
when secondary value measurements are selected.

Due to the required truncations from floating point values to integer values in the calculations of the G29 component parts and its limited dynamic range, the use of the G29 values is only recommended when the MODBUS master cannot deal with the G125 IEEE754 floating point equivalents.

Note	*The G29 values must be read in whole multiples of three registers. It is not possible to read the G28 and G27 parts with separate read commands.*

Example:

For A-Phase Power (Watts) (registers 3x00300 - 3x00302) for a 110 V nominal,
In = 1 A, VT ratio = 110 V:110 V and CT ratio = 1 A : 1 A.

Applying A-phase 1A @ 63.51V

A-phase Watts = ((63.51 V × 1 A) / In=1 A) × (110/Vn=110 V) = 63.51 Watts

The G28 part of the value is the truncated per unit quantity, which is equal to 64 (40h).

The multiplier is derived from the VT and CT ratios set in the product, with the equation ((CT Primary) × (VT Primary) / 110 V)). Therefore the G27 part of the value equals 1 and the overall value of the G29 register set is 64×1 = 64 W.

The registers would contain:

3x00300 - 0040h
3x00301 - 0000h
3x00302 - 0001h

Using the previous example with a VT ratio = 110,000 V:110 V and CT ratio = 10,000 A : 1 A the G27 multiplier would be 10,000 A × 110,000 V / 110 = 10,000,000. The overall value of the G29 register set is 64 × 10,000,000 = 640 MW. (Note that there is an actual error of 49 MW in this calculation due to loss of resolution).

The registers would contain:

3x00300 - 0040h
3x00301 - 0098h
3x00302 - 9680h

5.13.2 Data Type G125

Data type G125 is a short float IEEE754 floating point format, which occupies 32 bits in two consecutive registers. The most significant 16 bits of the format are in the first (low order) register and the least significant 16 bits in the second register.

The value of the G125 measurement is as accurate as the product’s ability to resolve the measurement after it has applied the secondary or primary scaling factors as required. It does not suffer from the truncation errors or dynamic range limitations associated with the G29 data format.

6 IEC60870-5-103 INTERFACE

The IEC60870-5-103 interface is a master/slave interface with the relay as the slave device. The relay conforms to compatibility level 2; compatibility level 3 is not supported.

These IEC60870-5-103 facilities are supported by this interface:

- Initialization (Reset)
- Time Synchronization
- Event Record Extraction
- General Interrogation
- Cyclic Measurements
- General Commands
- Disturbance Record Extraction
- Private Codes

Note	*The RP1 Inactiv Timer is not currently used, but is available for future expansion*

6.1 Physical Connection and Link Layer

Two connection options are available for IEC60870-5-103, either the rear EIA(RS)-485 port or an optional rear fiber optic port. If the fiber optic port is fitted, the active port can be selected using the front panel menu or the front Courier port. However the selection is only effective following the next relay power up.

For either of the two connection modes, both the relay address and baud rate can be selected using the front panel menu or the front Courier port. Following a change to either of these two settings a reset command is required to re-establish communications, see the description of the reset command in the *Initialization* section.

6.2 Initialization

Whenever the relay has been powered up, or if the communication parameters have been changed, a reset command is required to initialize the communications. The relay responds to either of the two reset commands (Reset CU or Reset FCB). However, the Reset CU clears any unsent messages in the relay's transmit buffer.

The relay responds to the reset command with an identification message ASDU 5. The Cause Of Transmission (COT) of this response is either Reset CU or Reset FCB depending on the nature of the reset command. For information on the content of ASDU 5 see *section IEC60870-5-103 in the Relay Menu Database document*.

In addition to the ASDU 5 identification message, if the relay has been powered up it also produces a power-up event.

6.3 Time Synchronization

The relay time and date can be set using the time synchronization feature of the IEC60870-5-103 protocol. The relay corrects for the transmission delay as specified in IEC60870-5-103. If the time synchronization message is sent as a send / confirm message, the relay responds with a confirm. Whether the time-synchronization message is sent as a send / confirm or a broadcast (send / no reply) message, a time synchronization Class 1 event is generated.

If the relay clock is synchronised using the IRIG-B input, it is not possible to set the relay time using the IEC60870-5-103 interface. If the time is set using the interface, the relay creates an event using the current date and time from the internal clock, which is synchronised to IRIG-B.

6.4 Spontaneous Events

Events are categorized using the following information:

- Function Type
- Information Number

The IEC60870-5-103 profile in the *Relay Menu Database document*, contains a complete listing of all events produced by the relay.

6.5 General Interrogation (GI)

The General Interrogation (GI) request can be used to read the status of the relay, the function numbers, and information numbers that are returned during the GI cycle. See the IEC60870-5-103 profile in the *Relay Menu Database document*.

6.6 Cyclic Measurements

The relay produces measured values using ASDU 9 cyclically. This can be read from the relay using a Class 2 poll (note ADSU 3 is not used). The rate at which the relay produces new measured values can be controlled using the Measurement Period setting. This setting can be edited from the front panel menu or the front Courier port and is active immediately following a change.

The measurands transmitted by the relay are sent as a proportion of 2.4 times the rated value of the analog value.

6.7 Commands

A list of the supported commands is contained in the *Relay Menu Database document*. The relay responds to other commands with an ASDU 1, with a Cause of Transmission (COT) indicating ‘negative acknowledgement’.

6.8 Test Mode

Using either the front panel menu or the front Courier port, it is possible to disable the relay output contacts to allow secondary injection testing to be performed. This is interpreted as ‘test mode’ by the IEC60870-5-103 standard. An event is produced to indicate both entry to and exit from test mode. Spontaneous events and cyclic measured data transmitted while the relay is in test mode has a COT of ‘test mode’.

6.9 Disturbance Records

For Software Releases prior to B0 (i.e. 57 and earlier):

The disturbance records are stored in uncompressed format and can be extracted using the standard mechanisms described in IEC60870-5-103.

Note	*IEC60870-5-103 only supports up to 8 records.*

For Software Release B0 - A & B:

The disturbance records are stored in uncompressed format and can be extracted using the standard mechanisms described in IEC60870-5-103. The Enhanced Disturbance Recorder software releases mean the relay can store a minimum of 15 records, each of 1.5 seconds duration.

Using relays with IEC 60870-5 CS 103 communication means they can store the same total record length. However, the IEC 60870-5 CS 103 communication protocol dictates that only 8 records (of 3 seconds duration) can be extracted via the rear port.

For Other Software Releases:

The disturbance records are stored in uncompressed format and can be extracted using the standard mechanisms described in IEC60870-5-103.

Where available, the Enhanced Disturbance Recorder software releases mean the relay can store a minimum of 15 records, each of 3.0 seconds duration.

Using relays with IEC 60870-5 CS 103 communication means they can store the same total record length. However, the IEC 60870-5 CS 103 communication protocol dictates that only 8 records (of 3 seconds duration) can be extracted via the rear port.

6.10 Blocking of Monitor Direction

The relay supports a facility to block messages in the Monitor direction and in the Command direction. Messages can be blocked in the Monitor and Command directions using the menu commands, Communications - CS103 Blocking -
Disabled / Monitor Blocking / Command Blocking or DDB signals Monitor Blocked and Command Blocked.

6.11 Setting Changes through IEC103 Protocol

The IEC 870-5-103 Standard suggests using the generic services for read/write operations on the proprietary data of different manufacture protection equipments, the directory structure specified by the standard for accessing the generic data is the same as the Px40 setting structure. With the generic services selected in the Platform Software full access to the relay's database is possible over the first rear communications port using the IEC608070-5-103 protocol with Level 3 compatibility.

Each cell in the database has an attribute that defines whether it is included in the list of cells that are subject to a General Interrogation of Generic data.

The following Group 1,2,3 and 4 settings will be included in the GGI:

- Overcurrent, Neg Seq O/C, Broken Conductor, Earth Fault 1 and 2,
- SEF/REF Prot'n, Residual O/V NVD, Thermal Overload, NEG Sequence O/V,
- Cold Load Pickup, Selective Logic, Admit Protection, Power Protection,
- Volt Protection, Freq Protection, CB FAIL & I<, Supervision,
- Fault Locator, System Checks, Autoreclose, ADV.Frequency.

7 DNP3.0 INTERFACE

7.1 DNP3.0 Protocol

The DNP3.0 protocol is defined and administered by the DNP Users Group. For information on the user group, DNP3.0 in general and the protocol specifications, see www.dnp.org

The descriptions given here are intended to accompany the device profile document that is included in the *Relay Menu Database document.* The DNP3.0 protocol is not described here, please refer to the documentation available from the user group. The device profile document specifies the full details of the DNP3.0 implementation for the relay. This is the standard format DNP3.0 document that specifies which objects; variations and qualifiers are supported. The device profile document also specifies what data is available from the relay using DNP3.0. The relay operates as a DNP3.0 slave and supports subset level 2 of the protocol, plus some of the features from level 3.

DNP3.0 communication uses the EIA(RS)-485 communication port at the rear of the relay. The data format is 1 start bit, 8 data bits, an optional parity bit and 1 stop bit. Parity is configurable (see menu settings below).

7.2 DNP3.0 Menu Setting

The following settings are in the DNP3.0 menu in the ***Communications*** column.

Settings	Range	Description
Remote Address	0 - 65519	DNP3.0 address of relay (decimal)
Baud Rate	1200, 2400, 4800, 9600, 19200, 38400	Selectable baud rate for DNP3.0 serial communication
Parity	None, Odd, Even	Parity setting
DNP Time Sync	Disabled, Enabled	If set to 'Enabled' the DNP3.0 master station can be used to synchronize the time on the IED. If set to 'Disabled' either the internet free running clock, or IRIG-B input are used.
Meas Scaling	Primary, Secondary or Normalised	Setting to report analog values in terms of primary, secondary or normalized (with respect to the CT/VT ratio setting) values.
Message Gap (ms)	0-50	DNP3.0 versions only. This setting allows the master station to have an interframe gap.
DNP Need Time	1 - 30 mins	The length of time waited before requesting another time sync from the master.
DNP App Fragment	100 - 2048 bytes	The maximum message length (application fragment size) transmitted by the relay.
DNP App Timeout	1 - 120 s	The length of time waited after sending a message fragment and waiting for a confirmation from the master.
DNP SBO Timeout	1 - 10 s	The length of time waited after receiving a select command and waiting for an operate confirmation from the master.
DNP Link Timeout	0 - 120 s	The length of time the relay waits for a Data Link Confirm from the master. A value of 0 means data link support disabled and 1 to 120 seconds is the timeout setting.

Table 14 - DNP3.0 menu settings

7.3 Object 1 Binary Inputs

Object 1, binary inputs, contains information describing the state of signals in the relay, which mostly form part of the Digital Data Bus (DDB). In general these include the state of the output contacts and input optos, alarm signals and protection start and trip signals. The 'DDB number' column in the device profile document provides the DDB numbers for the DNP3.0 point data. These can be used to cross-reference to the DDB definition list. See the *Relay Menu Database document*. The binary input points can also be read as change events using object 2 and object 60 for class 1-3 event data.

7.4 Object 10 Binary Outputs

Object 10, binary outputs, contains commands that can be operated using DNP3.0. Therefore the points accept commands of type pulse on [null, trip, close] and latch on/off as detailed in the device profile in the *Relay Menu Database document* and execute the command once for either command. The other fields are ignored (queue, clear, trip/close, in time and off time).

There is an additional image of the control inputs. Described as alias control inputs, they reflect the state of the control input, but with a dynamic nature.

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

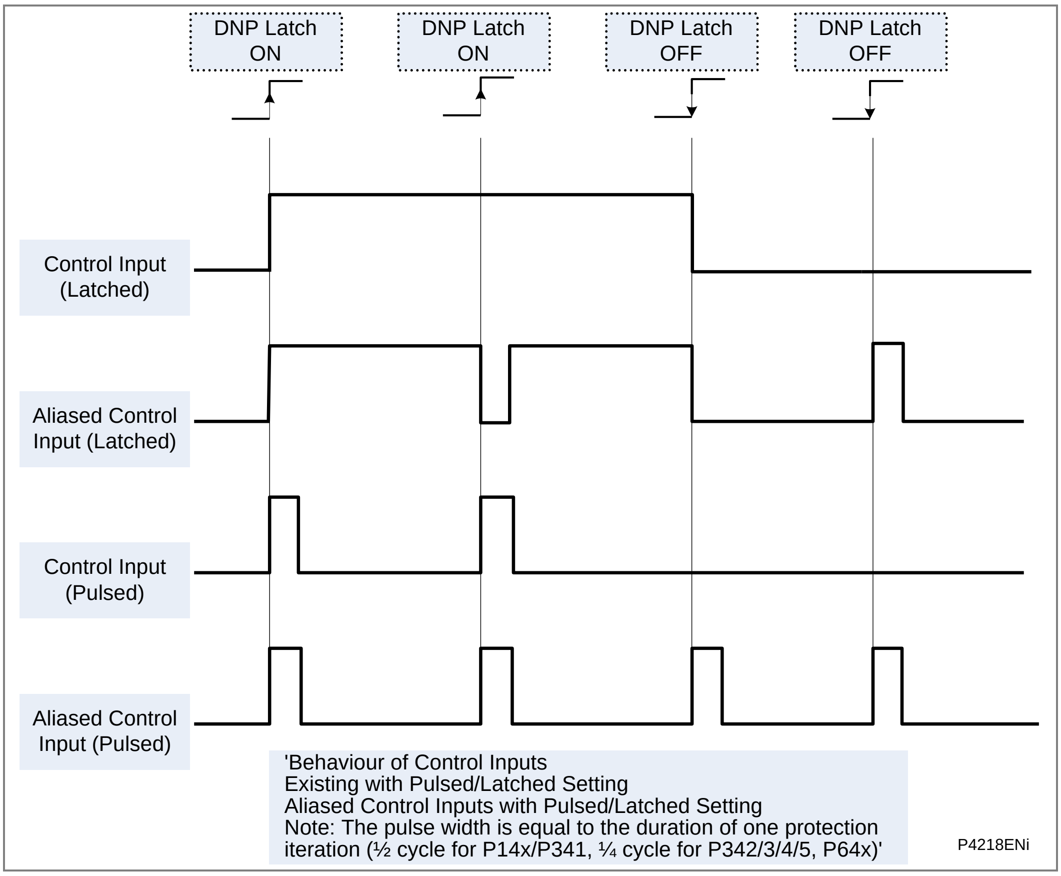


Figure 15 - Behavior when control input is set to pulsed or latched

Many of the relay's functions are configurable so some of the object 10 commands described in the following sections may not be available. A read from object 10 reports the point as off-line and an operate command to object 12 generates an error response.

Examples of object 10 points that maybe reported as off-line are:

- Activate setting groups — Ensure setting groups are enabled
- CB trip/close — Ensure remote CB control is enabled
- Reset NPS thermal — Ensure NPS thermal protection is enabled
- Reset thermal O/L — Ensure thermal overload protection is enabled
- Reset RTD flags — Ensure RTD Inputs is enabled
- Control inputs — Ensure control inputs are enabled

7.5 Object 20 Binary Counters

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

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

7.6 Object 30 Analog Input

Object 30, analog inputs, contains information from the relay's measurements columns in the menu. All object 30 points are reported as fixed-point values although they are stored inside the relay in a floating-point format. The conversion to fixed-point format requires the use of a scaling factor, which differs for the various types of data within the relay e.g. current, voltage, phase angle etc. The data types supported are listed at the end of the device profile document with each type allocated a 'D number', i.e. D1, D2, etc. In the object 30 point List each data point has a D number data type assigned to it which defines the scaling factor, default deadband setting and the range and resolution of the deadband setting. The deadband is the setting used to determine whether a change event should be generated for each point. The change events can be read via object 32 or object 60 and will be generated for any point whose value has changed by more than the deadband setting since the last time the data value was reported.

Any analog measurement that is unavailable at the time it is read will be reported as offline, e.g. the frequency when the current and voltage frequency is outside the tracking range of the relay or the thermal state when the thermal protection is disabled in the configuration column. Note that all object 30 points are reported as secondary values in DNP3.0 (with respect to CT and VT ratios).

Beside the measurements described above, the latest fault record can also be retrieved over DNP3.0. The fault data defined in Object 30 table are:

- Fault voltages and Fault currents
- Operating time of relay and Operating time of breaker
- Fault time, Fault data, etc...

The following fault data can be mapped in DNP3.0 protocol in serial and Ethernet connections:

- Fault voltages
- Fault currents
- Operating time of relay
- Operating time of breaker
- Fault time
- Fault date

The latest fault records only will be retrieved over DNP3.0.

7.7 Object 40 Analog Output

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

7.8 DNP3.0 Configuration using Easergy Studio

A PC support package for DNP3.0 is available as part of Easergy Studio to allow configuration of the relay’s DNP3.0 response. The PC is connected to the relay using a serial cable to the 9-pin connector on the front of the relay, see the *Introduction* chapter.

The configuration data is uploaded from the relay to the PC in a block of compressed format data and downloaded to the relay in a similar manner after modification. The new DNP3.0 configuration takes effect in the relay after the download is complete. To restore the default configuration at any time, from the **Configuration** column, select the **Restore Defaults** cell then select **All Settings**.

In Easergy Studio, the DNP3.0 data is shown in four main folders, one folder each for the point configuration, integer scaling, default variation (data format) and DNP over Ethernet. The point configuration also includes screens for binary inputs, binary outputs, counters and analogue input configuration. Note that if the DNP3.0 over Ethernet plus IEC61850 option is chosen, DNP over Ethernet configuration will be used to configure DNP3.0 over Ethernet, and this part of configuration will be ignored by DNP3.0 serial.

For the IP configuration of DNP over Ethernet, please refer to the *DNP3.0 over Ethernet runs concurrently with IEC61850* section.

Please refer to the DNP3.0 Configurator Tool User guide (S1V2DNP/EN HI/A11) for details regarding the configuration of binary points, analogues and reporting format.

DNP3.0 over Ethernet includes support for unsolicited responses. For the Unsolicited Responses configuration of DNP over Ethernet, please refer to this table:

Setting Name	Explanation
unsolAllowed	Determines whether unsolicited responses are allowed. If unsolAllowed is set to disabled, no unsolicited responses will be generated. Requests to enable or disable unsolicited responses will fail and the master station will reply indicating bad function information. If it is configured to allow unsolicited mode (enabled), the relay will be able to send event data in an unsolicited response after it receives a request from the master station containing function code ENABLE_UNSOLICITED(0x14) that enables some or all points to initiate unsolicited responses.
unsolMaxRetries	Specify the maximum number of unsolicited retries before changing to the 'offline' retry period (30 seconds).
unsolRetryDelay	Specifies the time, in seconds, to delay after an unsolicited confirm timeout before retrying the unsolicited response.
unsolClass1MaxDelay unsolClass2MaxDelay unsolClass3MaxDelay	If unsolicited responses are enabled, unsolClassXMaxDelay specifies the maximum amount of time in seconds after an event in the corresponding class is received before an unsolicited response will be generated. A configured value of 0 indicates that responses are not delayed.
unsolClass1MaxEvents unsolClass2MaxEvents unsolClass3MaxEvents	If unsolicited responses are enabled, unsolClassXMaxEvents specifies the maximum number of events in the corresponding class to be allowed before an unsolicited response will be generated.

Important	***At most 8 clients are supported to connect to device at the same time in DNP3.0 over Ethernet protocol.***

7.8.1 Object 1

For every point included in the device profile document there is a check box for membership of class 0 and radio buttons for class 1, 2 or 3 membership. Any point that is in class 0 must be a member of one of the change event classes 1, 2 or 3.

Points that are configured out of class 0 are by default not capable of generating change events. Furthermore, points that are not part of class 0 are effectively removed from the DNP3.0 response by renumbering the points that are in class 0 into a contiguous list starting at point number 0. The renumbered point numbers are shown at the left-hand side of the screen in S1 and can be printed out to form a revised device profile for the relay. This mechanism allows best use of available bandwidth by only reporting the data points required by the user when a poll for all points is made.

7.8.2 Object 20

The running counter value of object 20 points can be configured to be in or out of class 0. Any running counter that is in class 0 can have its frozen value selected to be in or out of the DNP3.0 response, but a frozen counter cannot be included without the corresponding running counter. As with object 1, the class 0 response will be renumbered into a contiguous list of points based on the selection of running counters. The frozen counters will also be renumbered based on the selection; note that if some of the counters that are selected as running are not also selected as frozen then the renumbering will result in the frozen counters having different point numbers to their running counterparts. For example, object 20 point 3 (running counter) might have its frozen value reported as object 21 point 1.

7.8.3 Object 30

For the analog inputs, object 30, the same selection options for classes 0, 1, 2 and 3 are available as for object 1. In addition to these options, which behave in exactly the same way as for object 1, it is possible to change the deadband setting for each point. The minimum and maximum values and the resolution of the deadband settings are defined in the device profile document; MiCOM S1 will allow the deadband to be set to any value within these constraints.

7.8.4 DNP3.0 over Ethernet runs concurrently with IEC61850

DNP3.0 over Ethernet can run concurrently with IEC61850 if DNP3.0 over Ethernet plus IEC61850 option is chosen. Below table describes the different cases of the usage of DNP3.0 over Ethernet service and IEC61850 service. IEC61850 service will always run under this situation, but DNPoE service only runs when certain requirements are met.

Board Type	Dual or PRP/HSR	Configuration file	Interface 1		Interface 2		Invalid DNPoE IP Alarm
			IP address	DNP3oE	IP address	DNP3oE	
Q or R	Doesn't matter	Default IEC61850 configuration No DNP setting or IP_DNP is 0.0.0.0	DEF_IP_1	Disabled	DEF_IP_2	Disabled	No
	Dual	Default IEC61850 configuration Customized DNP setting with valid IP_DNP	IP_DNP	Run	DEF_IP_2	N/A	No
	PRP/HSR		DEF_IP_1	N/A	IP_DNP	Run	No
	Doesn't matter	Customized IEC61850 configuration No DNPoE setting or IP_DNP is 0.0.0.0	IP_1	Disabled	IP_2	Disabled	No
	Doesn't matter	Customized IEC61850 configuration Customized DNPoE setting where IP_DNP = IP_1	IP_1	Run	IP_2	N/A	No
	Doesn't matter	Customized IEC61850 configuration Customized DNPoE setting where IP_DNP = IP_2	IP_1	N/A	IP_2	Run	No
	Doesn't matter	Customized IEC61850 configuration Customized DNPoE setting where IP_DNP ≠ IP_1 and IP_DNP ≠ IP_2	IP_1	Disabled	IP_2	Disabled	Yes
S	N/A	Default IEC61850 configuration No DNPoE setting or IP_DNP is 0.0.0.0	DEF_IP_1	Disabled	N/A	N/A	No
	N/A	Default IEC61850 configuration Customized DNPoE setting with valid IP_DNP	IP_DNP	Run	N/A	N/A	No
	N/A	Customized IEC61850 configuration No DNPoE setting or IP_DNP is 0.0.0.0	IP_1	Disabled	N/A	N/A	No
	N/A	Customized IEC61850 configuration Customized DNPoE setting where IP_DNP = IP_1	IP_1	Run	N/A	N/A	No
	N/A	Customized IEC61850 configuration Customized DNPoE setting where IP_DNP ≠ IP_1	IP_1	Disabled	N/A	N/A	Yes

Note *For detailed information about different interfaces please refer to the* ***Dual IP in MiCOM*** *section in the Dual Redundant Ethernet Board (DREB) chapter.*

Table 15 - Protocol running options for different board types

For these IP abbreviations please refer to this table:

Abbreviation	Description
DEF_IP_1	Default IP of interface 1 with default IEC61850 configuration
DEF_IP_2	Default IP of interface 2 with default IEC61850 configuration
IP_1	IP of interface 1 configured in a IEC61850 configuration file
IP_2	IP of interface 2 configured in a IEC61850 configuration file
IP_DNP	IP configured in DNP over Ethernet setting

Table 16 - Abbreviations of Different IP

Note	*Running DNP3.0 serial and DNP3.0 over Ethernet concurrently is not recommended.*

8 IEC 61850 ETHERNET INTERFACE

8.1 Introduction

IEC 61850 is the international standard for Ethernet-based communication in substations. It enables integration of all protection, control, measurement and monitoring functions in a substation, and provides the means for interlocking and inter-tripping. It combines the convenience of Ethernet with the security which is essential in substations today.

The MiCOM protection relays can integrate with the PACiS substation control systems, to complete Schneider Electric's offer of a full IEC 61850 solution for the substation. The majority of MiCOM Px3x and Px4x relay types can be supplied with Ethernet, in addition to traditional serial protocols. Relays which have already been delivered with UCA2.0 on Ethernet can be easily upgraded to IEC 61850.

8.2 What is IEC 61850?

IEC 61850 is a 14-part international standard, which defines a communication architecture for substations. It is more than just a protocol and provides:

- Standardized models for IEDs and other equipment in the substation
- Standardized communication services (the methods used to access and exchange data)
- Standardized formats for configuration files
- Peer-to-peer (for example, relay to relay) communication

The standard includes mapping of data onto Ethernet. Using Ethernet in the substation offers many advantages, most significantly including:

- High-speed data rates (currently 100 Mbits/s, rather than tens of kbits/s or less used by most serial protocols)
- Multiple masters (called “clients”)
- Ethernet is an open standard in every-day use

Schneider Electric has been involved in the Working Groups which formed the standard, building on experience gained with UCA2.0, the predecessor of IEC 61850.

8.2.1 Interoperability

A major benefit of IEC 61850 is interoperability. IEC 61850 standardizes the data model of substation IEDs which simplifies integration of different vendors’ products. Data is accessed in the same way in all IEDs, regardless of the vendor, even though the protection algorithms of different vendors’ relays may be different.

IEC 61850-compliant devices are not interchangeable, you cannot replace one device with another (although they are interoperable). However, the terminology is predefined and anyone with knowledge of IEC 61850 can quickly integrate a new device without mapping all of the new data. IEC 61850 improves substation communications and interoperability at a lower cost to the end user.

8.2.2 Data Model

To ease understanding, the data model of any IEC 61850 IED can be viewed as a hierarchy of information. The categories and naming of this information is standardized in the IEC 61850 specification.

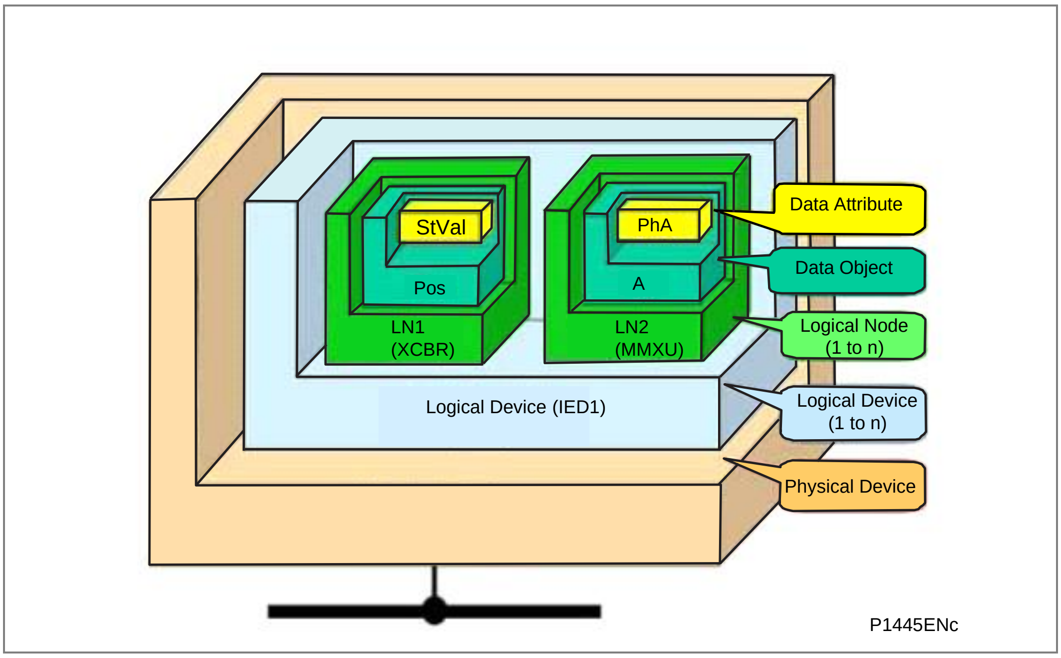


Figure 16 - Data model layers in IEC 61850

The levels of this hierarchy can be described as follows:

- Physical Device — Identifies the actual IED in a system. Typically the device's name or IP address can be used (for example **Feeder_1** or **10.0.0.2**).
- Logical Device — Identifies groups of related Logical Nodes inthe Physical Device. For the MiCOM relays, five Logical Devices exist: **Control, Measurements, Protection, Records, System**.
- Wrapper/Logical Node Instance — Identifies the major functional areas in the IEC 61850 data model. Either 3 or 6 characters are used as a prefix to define the functional group (wrapper) while the actual functionality is identified by a 4 character Logical Node name, suffixed by an instance number. For example, XCBR1 (circuit breaker), MMXU1 (measurements), FrqPTOF2 (overfrequency protection, stage 2).
- Data Object — This next layer is used to identify the type of data presented. For example, **Pos** (position) of Logical Node type **XCBR**.
- Data Attribute — This is the actual data (such as measurement value, status, and description). For example, **stVal** (status value) indicates the actual position of the circuit breaker for Data Object type **Pos** of Logical Node type **XCBR**.

8.3 IEC 61850 in MiCOM relays

IEC 61850 is implemented in MiCOM relays by use of a separate Ethernet card. This card manages the majority of the IEC 61850 implementation and data transfer to avoid any impact on the performance of the protection.

To communicate with an IEC 61850 IED on Ethernet, it is necessary only to know its IP address. This can then be configured into either:

- An IEC 61850 **client** (or **master**), for example a PACiS computer (MiCOM C264) or HMI, or
- An **MMS browser**, with which the full data model can be retrieved from the IED, without any prior knowledge

8.3.1 Capability

The IEC 61850 interface provides these capabilities:

- Read access to measurements

  All measurands are presented using the measurement Logical Nodes, in the **Measurements** Logical Device. Reported measurement values are refreshed by the relay once per second, in line with the relay user interface.

The following fault data have been mapped in LN RFLO1 of LD Records of IEC61850 data model:

- Fault voltages, Fault currents and Fault location
- Operating time of relay and Operating time of breaker
- Fault time, Fault date, etc…

Only the latest fault record can be retrieved over IEC61850.

- Generation of unbuffered reports on change of status/measurement

  Unbuffered reports, when enabled, report any change of state in statuses and measurements (according to deadband settings).
- Support for time synchronization over an Ethernet link

  Time synchronization is supported using SNTP (Simple Network Time Protocol). This protocol is used to synchronize the internal real time clock of the relays.
- GOOSE peer-to-peer communication

  GOOSE communications of statuses are included as part of the IEC 61850 implementation. See *Peer-to-Peer (GSE) Communications* for more details.
- Disturbance record extraction

  Disturbance records can be extracted from MiCOM relays by file transfer, as ASCII format COMTRADE files.
- Controls

  The following control services are available:
  - Direct Control
  - Direct Control with enhanced security
  - Select Before Operate (SBO) with enhanced security
  - Controls are applied to open and close circuit breakers using XCBR.Pos and DDB signals ‘Control Trip’ and ‘Control Close’.
  - System/LLN0. LLN0.LEDRs are used to reset any trip LED indications.

Setting changes (e.g. of protection settings) are not supported in the current IEC 61850 implementation. To keep this process as simple as possible, such setting changes are done using Easergy Studio settings & records program. This can be done as previously using the front port serial connection of the relay, or now optionally over the Ethernet link if preferred (this is known as “tunneling”).

- Reports
  Reports only include data objects that have changed and not the complete dataset. The exceptions to this are a General Interrogation request and integrity reports.
- Buffered Reports
  Eight Buffered Report Control Blocks, (BRCB), are provided in SYSTEM/LLN0 in Logical Device 'System'.
  Buffered reports are configurable to use any configurable dataset located in the same Logical device as the BRCB (SYSTEM/LLN0).
- Unbuffered Reports
  Sixteen Unbuffered Report Control Blocks (URCB) are provided in SYSTEM/LLN0 in Logical Device 'System'.
  Unbuffered reports are configurable to use any configurable dataset located in the same Logical device as the URCB (SYSTEM/LLN0).
- Configurable Data Sets
  It is possible to create and configure datasets in any Logical Node using the IED Configurator. The maximum number of datasets will be specified in an IED's ICD file. An IED is capable of handling 100 datasets.
- Published GOOSE message
  Eight GOCBs are provided in SYSTEM/LLN0.
- Uniqueness of control
  The Uniqueness of control mechanism is implemented to be consistent with the PACiS mechanism. This requires the relay to subscribe to the OrdRun signal from all devices in the system and be able to publish such a signal in a GOOSE message.
- Select Active Setting Group
  Functional protection groups can be enabled or disabled using private mod/beh attributes in the Protection/LLN0.OcpMod object. Setting groups are selectable using the Setting Group Control Block class, (SGCB). The Active Setting Group can be selected using the System/LLN0.SP.SGCB.ActSG data attribute in Logical Device 'System'.
- Quality for GOOSE
  It is possible to process the quality attributes of any Data Object in an incoming GOOSE message. Devices that do not support IEC61850 quality flags send quality attributes as all zeros. The supported quality attributes for outgoing GOOSE messages are described in the Protocol Implementation eXtra Information for Testing (PIXIT) document.
- Address List
  An Address List document (to be titled ADL) is produced for each IED which shows the mapping between the IEC61850 data model and the internal data model of the IED. It includes a mapping in the reverse direction, which may be more useful. This document is separate from the PICS/MICS document.
- Originator of Control
  Originator of control mechanism is implemented for operate response message and in the data model on the ST of the related control object, consistent with the PACiS mechanism.
- Scaled Measurements
  The Unit definition, as per IEC specifies an SI unit and an optional multiplier for each measurement. This allows a magnitude of measurement to be specified e.g. mA, A, kA, MA.

The multiplier will always be included in the Unit definition and will be configurable in SCL, but not settable at runtime. It will apply to the magnitude, rangeC.min & rangeC.max attributes. rangeC.min & rangeC.max will not be settable at runtime to be more consistent with Px30 and to reduce configuration problems regarding deadbands.

Setting changes, such as changes to protection settings, are done using MiCOM S1 Studio. These changes can also be done using the relay's front port serial connection or the relay's Ethernet link, and is known as "tunneling".

8.3.2 IEC 61850 Configuration

One of the main objectives of IEC 61850 is to allow IEDs to be directly configured from a configuration file generated at system configuration time. At the system configuration level, the capabilities of the IED are determined from an IED capability description file (ICD), which is provided with the product. Using a collection of these ICD files from different products, the entire protection of a substation can be designed, configured and tested (using simulation tools) before the product is even installed into the substation.

To help this process, the MiCOM S1 Studio Support Software provides an IEC61850 IED Configurator tool. Select **Tools > IEC61850 IED Configurator**. This tool allows the preconfigured IEC 61850 configuration file (SCD or CID) to be imported and transferred to the IED. The configuration files for MiCOM relays can also be created manually, based on their original IED Capability Description (ICD) file.

Other features include the extraction of configuration data for viewing and editing, and a sophisticated error-checking sequence. The error checking ensures the configuration data is valid for sending to the IED and ensures the IED functions correctly in the substation.

To help the user, some configuration data is available in the **IED CONFIGURATOR** column of the relay user interface, allowing read-only access to basic configuration data.

8.3.2.1 Configuration Banks

To promote version management and minimize down-time during system upgrades and maintenance, the MiCOM relays have incorporated a mechanism consisting of multiple configuration banks. These configuration banks are categorized as:

- Active Configuration Bank
- Inactive Configuration Bank

Any new configuration sent to the relay is automatically stored in the inactive configuration bank, therefore not immediately affecting the current configuration. Both active and inactive configuration banks can be extracted at any time.

When the upgrade or maintenance stage is complete, the IED Configurator tool can be used to transmit a command to a single IED. This command authorizes the activation of the new configuration contained in the inactive configuration bank, by switching the active and inactive configuration banks. This technique ensures that the system down-time is minimized to the start-up time of the new configuration. The capability to switch the configuration banks is also available using the **IED CONFIGURATOR** column.

For version management, data is available in the **IED CONFIGURATOR** column in the relay user interface, displaying the SCL Name and Revision attributes of both configuration banks.

8.3.2.2 Network Connectivity

Note	*This section presumes a prior knowledge of IP addressing and related topics. Further details on this topic may be found on the Internet (search for IP Configuration) and in numerous relevant books.*

Configuration of the relay IP parameters (IP Address, Subnet Mask, Gateway) and SNTP time synchronization parameters (SNTP Server 1, SNTP Server 2) is performed by the IED Configurator tool. If these parameters are not available using an SCL file, they must be configured manually.

If the assigned IP address is duplicated elsewhere on the same network, the remote communications do not operate in a fixed way. However, the relay checks for a conflict at power up and every time the IP configuration is changed. An alarm is raised if an IP conflict is detected.

Use the **Gateway** setting to configure the relay to accept data from networks other than the local network.

8.4 Data Model of MiCOM Relays

The data model naming adopted in the Px30 and Px40 relays has been standardized for consistency. The Logical Nodes are allocated to one of the five Logical Devices, as appropriate, and the wrapper names used to instantiate Logical Nodes are consistent between Px30 and Px40 relays.

The data model is described in the Model Implementation Conformance Statement (MICS) document, which is available separately. The MICS document provides lists of Logical Device definitions, Logical Node definitions, Common Data Class and Attribute definitions, Enumeration definitions, and MMS data type conversions. It generally follows the format used in Parts 7-3 and 7-4 of the IEC 61850 standard.

8.5 Communication Services of MiCOM Relays

The IEC 61850 communication services which are implemented in the Px30 and Px40 relays are described in the Protocol Implementation Conformance Statement (PICS) document, which is available separately. The PICS document provides the Abstract Communication Service Interface (ACSI) conformance statements as defined in Annex A of Part 7-2 of the IEC 61850 standard.

8.6 Peer-to-Peer (GOOSE) Communications

The implementation of IEC 61850 Generic Object Oriented Substation Event (GOOSE) sets the way for cheaper and faster inter-relay communications. The generic substation event model provides fast and reliable system-wide distribution of input and output data values. The generic substation event model is based on autonomous decentralization This provides an efficient method of allowing simultaneous delivery of the same generic substation event information to more than one physical device, by using multicast services.

The use of multicast messaging means that IEC 61850 GOOSE uses a publisher-subscriber system to transfer information around the network*. When a device detects a change in one of its monitored status points, it publishes (sends) a new message. Any device that is interested in the information subscribes (listens) to the data message.

*Note**	*Multicast messages cannot be routed across networks without specialized equipment.*

Each new message is retransmitted at user-configurable intervals until the maximum interval is reached, to overcome possible corruption due to interference and collisions. In practice, the parameters which control the message transmission cannot be calculated. Time must be allocated to the testing of GOOSE schemes before or during commissioning; in just the same way a hardwired scheme must be tested.

8.6.1 Scope

Virtual outputs and virtual inputs are available within the PSL. These can be mapped directly to a published dataset in a GOOSE message (only 1 fixed dataset is supported). All published GOOSE signals are BOOLEAN values. The maximum number of virtual outputs and inputs depends on the software version and the product. The virtual output and input numbers (and their DDB Numbers) are shown in the *Logic Nodes* table in the *Programmable Logic* chapter.

Note	*Analogue Goose subscribing: A new GGIO3 is provided for analogue value subscribing, the received analogue values will not be sent to the main card. The values will be stored only on the IEC 61850 data mode.*

Each GOOSE signal contained in a subscribed GOOSE message can be mapped to any of the virtual outputs and virtual inputs within the PSL. The virtual inputs allow the mapping to internal logic functions for protection control, directly to output contacts or LEDs for monitoring.

The MiCOM relay can subscribe to all GOOSE messages but only these data types can be decoded and mapped to a virtual input:

- BOOLEAN
- BSTR2
- INT16
- INT32
- INT8
- UINT16
- UINT32
- UINT8

The MiCOM relay on Ed2 mode can also subscribe analogue GOOSE messages with Float32 data type. The received analogue values can not apply to any application function, these values will be stored only on the IEC 61850 data model.

The MiCOM relay also can subscribe to analogue GOOSE messages with Float32 data type. The received analogue values can not apply to any application function, these values will be stored only on the IEC 61850 data mode.

8.6.2 Simulation GOOSE Configuration

From MiCOM S1 Studio select Tools > IEC 61850 IED Configurator (Ed.2). Make sure the configuration is correct as this ensures efficient GOOSE scheme operation.

The relay can be set to publish/subscribe simulation/test GOOSE; it is important that this setting is returned to publish/receive normal GOOSE messages after testing to permit normal operation of the application and GOOSE messaging.

The relay provides a single setting to receive Simulated GOOSE, however it manages each subscribed GOOSE signal independently when the setting is set to simulated GOOSE. Each subscription (virtual input) will continue to respond to GOOSE messages without the simulation flag set; however once the relay receives a GOOSE for a subscription with the simulation flag set, it will respond to this and ignore messages without the simulation flag set. Other subscriptions (virtual inputs) which have not received a GOOSE message with the simulation flag will continue to operate as before. When the setting is reset back to normal GOOSE messaging the relay will ignore all GOOSE messages with the simulation flag set and act on GOOSE messages without the simulation flag.

WARNING	**If you set the GOOSE in Simulation Mode, you MUST set it back to normal GOOSE after testing.** **IT IS POTENTIALLY EXTREMELY UNSAFE TO ATTEMPT TO USE ANY RELAY WHICH IS STILL IN GOOSE SIMULATION MODE.**

8.6.3 High Performance GOOSE

In addition, the Px40 device is designed to provide maximum performance through an optimized publishing mechanism. This optimized mechanism is enabled so that the published GOOSE message is mapped using only the data attributes rather than mapping a complete data object. If data objects are mapped, the GOOSE messaging will operate correctly; but without the benefit of the optimized mechanism.

A pre-configured dataset named as "HighPerformGOOSE" is available in Ed.2 ICD template, which include all data attributes of the first 32 virtual outputs. The optimized mechanism also applies to Ed.1 but without such a pre-configured dataset.

8.7 Ethernet Functionality

Settings relating to a failed Ethernet link are available in the 'COMMUNICATIONS' column of the relay user interface.

Note	*Setting relating to the failed link is removed for the new Ethernet and the behaviour is fixed as Event.*

8.7.1 Ethernet Disconnection

IEC 61850 'Associations' are unique and made to the relay between the client (master) and server (IEC 61850 device). If the Ethernet is disconnected, such associations are lost and must be re-established by the client. The TCP_KEEPALIVE function is implemented in the relay to monitor each association and terminate any which are no longer active.

8.7.2 Redundant Ethernet Communication Ports

For information regarding the Redundant Ethernet communication ports, refer to the stand alone document *Px4x/EN REB/B11*.

8.7.3 Loss of Power

If the relay's power is removed, the relay allows the client to re-establish associations without a negative impact on the relay's operation. As the relay acts as a server in this process, the client must request the association. Uncommitted settings are cancelled when power is lost. Reports requested by connected clients are reset and must be re-enabled by the client when the client next creates the new association to the relay.

8.7.4 Courier Tunneling via Secure Ethernet Communications

8.7.4.1 Introduction

When the IED and Easergy Studio are connected via the Ethernet port they will communicate securely using TLS.
The benefits of secure communication are:

- Help in the prevention of unwanted eavesdropping between Easergy Studio (MiCOM S1 Studio) and the IED
- Help in the prevention of modification of data between Easergy Studio (MiCOM S1 Studio) and the IED
- Ensure integrity of data
- Prevent replay of data at a later data

Note	*The communication will be done using port 4422, ensure this port is left unblocked on your network.*

8.7.4.2 Setting up a Connection

As a quick guide, you need to do the following:

1. In Easergy Studio, click the Quick Connect… button
2. Select the relevant Device Type in the Quick Connect dialog box.
3. Select Ethernet port
4. Enter the relevant data i.e. IP address of IED
5. Click Finish
6. Easergy Studio will attempt to communicate with the device

Note	*When attempting to connect to the IED via Ethernet, Easergy Studio will first try to communicate with the IED via secure communication. If this is not possible, it will use open communication with no encryption.* *For secure communication, please ensure port 4422 is left unblocked on the firewalls on which Easergy Studio is running.*

INSTALLATION

CHAPTER 16

Date (month/year):	11/2016			
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.			
Hardware suffix:	P141/P142/P143	J/L	P44y (P443/P446)	K/M
	P145	J/M	P547	K
	P241	J	P54x (P543/P544/P545/P546)	K/M
	P242/P243	K	P642	J/L
	P342	J	P643	K/M
	P343/P344/P345	K	P645	K/M
	P391	A	P74x (P741/P742/P743)	J/K
	P445	J/L	P746	K/M
	P44x (P441/P442/P444)	J/K	P841	K/M
	P44x (P442/P444)	M	P849	K/M
Software version:	P14x (P141/P142/P143/P145)	43/44/46/ B0/B1/B2	P44y (P443/P446) P547	55/H4 57
	P24x (P241/P242/P243):	57	P54x (P543/P544/P545/P546)	45/55/H4
	P342/P343/P344/P345/P391	36	P64x (P642/P643/P645)	04/A0/B1/B2
	P445	35/36/J4	P74x (P741/P742/P743)	51/A0/B1
	P44x (P441/P442/P444)	C7.x/D4.x/ D5.x/D6.x/	P746	A0/B1/B2/B3/ C1/C2/C3
	P44x (P442/P444)	E0/E1	P841	45/55/G4/H4
			P849	A0/B1
Connection diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P445: 10P445xx (xx = 01 to 04) P44x (P441, P442 & P444): 10P44101 (SH 1 & 2) 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)		P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 1 to 10) 10P643xx (xx = 1 to 6) 10P645xx (xx = 1 to 9) P74x (P741, P742 & P743): 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)	

CONTENTS

TABLES

FIGURES

1 INTRODUCTION TO MICOM RANGE

About MiCOM Range

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

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

The components within MiCOM are:

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

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

For up-to-date information, please see:

www.schneider-electric.com

MiCOM Px4x Products

The MiCOM Px4x series of protection devices provide a wide range of protection and control functions and meet the requirements of a wide market segment.

Different parts of the Px4x range provide different functions. These include:

- **P14x** **Feeder Management** relay suitable for MV and HV systems
- **P24x** **Motors** and rotating machine management relay for use on a wide range of synchronous and induction machines
- **P34x** **Generator Protection** for small to sophisticated generator systems and interconnection protection
- **P445** Full scheme **Distance Protection** relays for MV, HV and EHV systems
- **P44x** Full scheme **Distance Protection** relays for MV, HV and EHV systems
- **P44y** Full scheme **Distance Protection** relays for MV, HV and EHV systems
- **P54x** **Line Differential** protection relays for HV/EHV systems with multiple communication options and phase comparison protection for use with PLC
- **P547** **Line Differential** protection relays for HV/EHV systems with multiple communication options and phase comparison protection for use with PLC
- **P64x** **Transformer Protection Relays**
- **P74x** **Numerical Busbar Protection** for use on MV, HV and EHV busbars
- **P746** **Numerical Busbar Protection** for use on MV, HV and EHV busbars
- **P84x** **Breaker Failure** protection relays

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

2 RECEIPT, HANDLING, STORAGE AND UNPACKING RELAYS

2.1 Receipt of Relays

Protective relays, although generally of robust construction, require careful treatment prior to installation on site.

Upon receipt, relays should be examined immediately to ensure no external damage has been sustained in transit. If damage has been sustained, a claim should be made to the transport contractor and Schneider Electric should be promptly notified.

Relays that are supplied unmounted and not intended for immediate installation should be returned to their protective polythene bags and delivery carton. See the *Storage* section for more information about the storage of relays.

2.2 Handling of Electronic Equipment

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

A person's normal movements can easily generate electrostatic potentials of several thousand volts. Discharge of these voltages into semiconductor devices when handling electronic circuits can cause serious damage which, although not always immediately apparent, will reduce the reliability of the circuit. This is particularly important to consider where the circuits use Complementary Metal Oxide Semiconductors (CMOS), as is the case with these relays.

The electronic circuits inside the relay are protected from electrostatic discharge when housed in the case. Do not expose them to risk by removing the front panel or Printed Circuit Boards (PCBs) unnecessarily.

Each PCB incorporates the highest practicable protection for its semiconductor devices. However, if it becomes necessary to remove a PCB, the following precautions should be taken to preserve the high reliability and long life for which the relay has been designed and manufactured.

- Before removing a PCB, ensure that you are at the same electrostatic potential as the equipment by touching the case.
- Handle analogue input modules by the front panel, frame or edges of the circuit boards. PCBs should only be handled by their edges. Avoid touching the electronic components, printed circuit tracks or connectors.
- Do not pass the module to another person without first ensuring you are both at the same electrostatic potential. Shaking hands achieves equipotential.
- Place the module on an anti-static surface, or on a conducting surface which is at the same potential as yourself.
- If it is necessary to store or transport printed circuit boards removed from the case, place them individually in electrically conducting anti-static bags.

In the unlikely event that you are making measurements on the internal electronic circuitry of a relay in service, it is preferable that you are earthed to the case with a conductive wrist strap. Wrist straps should have a resistance to ground between 500kΩ to 10MΩ. If a wrist strap is not available you should maintain regular contact with the case to prevent a build-up of electrostatic potential. Instrumentation which may be used for making measurements should also be earthed to the case whenever possible.

More information on safe working procedures for all electronic equipment can be found in IEC 61340-5-1. It is strongly recommended that detailed investigations on electronic circuitry or modification work should be carried out in a special handling area such as described in the aforementioned Standard document.

2.3 Storage

If relays are not to be installed immediately upon receipt, they should be stored in a place free from dust and moisture in their original cartons. Where de-humidifier bags have been included in the packing they should be retained. The action of the de-humidifier crystals will be impaired if the bag is exposed to ambient conditions and may be restored by gently heating the bag for about an hour prior to replacing it in the carton.

To prevent battery drain during transportation and storage a battery isolation strip is fitted during manufacture. With the lower access cover open, presence of the battery isolation strip can be checked by a red tab protruding from the positive side.

Care should be taken on subsequent unpacking that any dust which has collected on the carton does not fall inside. In locations of high humidity the carton and packing may become impregnated with moisture and the de-humidifier crystals will lose their efficiency.

Prior to installation, relays should be stored at a temperature of between -40°C to +70°C (-13°F to +158°F).

2.4 Unpacking

Care must be taken when unpacking and installing the relays so that none of the parts are damaged and additional components are not accidentally left in the packing or lost. Make sure that any user's CDROM or technical documentation is NOT discarded, and accompanies the relay to its destination substation.

Note	*With the lower access cover open, the red tab of the battery isolation strip will be seen protruding from the positive side of the battery compartment. Do not remove this strip because it prevents battery drain during transportation and storage and will be removed as part of the commissioning tests.*

Relays must only be handled by skilled persons.

The site should be well lit to facilitate inspection, clean, dry and reasonably free from dust and excessive vibration. This particularly applies to installations which are being carried out at the same time as construction work.

3 RELAY MOUNTING

MiCOM relays are dispatched either individually or as part of a panel/rack assembly. Individual relays are normally supplied with an outline diagram showing the dimensions for panel cut-outs and hole centres. This information can also be found in the product publication.
Secondary front covers can also be supplied as an option item to prevent unauthorised changing of settings and alarm status. They are available in sizes 40TE and 60TE. The 60TE cover also fits the 80TE case size of the relay.
The old GN0037/GN0038 part numbers are now obsolete.
They have been replaced by the GN0242/GN0243 versions as shown below.

Product	Size	Part No (obsolete)	Replacement Part No
P40	**40TE 60TE / 80TE**	**GN0037 001 GN0038 001**	**GN0242 001 GN0243 001**
P14x	40TE 60TE / 80TE	GN0037 001 GN0038 001	GN0242 001 GN0243 001
P24xxxxxxxxxxxA P24xxxxxxxxxxxC	40TE 60TE / 80TE	GN0037 001 GN0038 001	GN0242 001 GN0243 001
P24xxxxxxxxxxxJ P24xxxxxxxxxxxK	40TE 60TE / 80TE		GN0242 001 GN0243 001
P34xxxxxxxxxxxA P34xxxxxxxxxxxC	40TE 60TE / 80TE	GN0037 001 GN0038 001	GN0242 001 GN0243 001
P34xxxxxxxxxxxJ P34xxxxxxxxxxxK	40TE 60TE / 80TE		GN0242 001 GN0243 001
P44x	40TE 60TE / 80TE	GN0037 001 GN0038 001	GN0242 001 GN0243 001
P44y	60TE / 80TE	GN0038 001	GN0243 001
P445	40TE 60TE / 80TE	GN0037 001 GN0038 001	GN0242 001 GN0243 001
P54x	60TE / 80TE	GN0038 001	GN0243 001
P547	60TE / 80TE	GN0038 001	GN0243 001
P64xxxxxxxxxxxA/B/C	40TE 60TE / 80TE	GN0037 001 GN0038 001	GN0242 001 GN0243 001
P64xxxxxxxxxxxJ/K	40TE 60TE / 80TE		GN0242 001 GN0243 001
P74x P74x	40TE 60TE	GN0037 001 GN0038 001	GN0242 001 GN0243 001
P746	80TE	GN0038 001	GN0243 001
P841	60TE / 80TE	GN0038 001	GN0243 001
P849	80TE	GN0038 001	GN0243 001

Note *Part Numbers suitable for rack-mounting have an "N" as the 10th digit.*
Part Numbers suitable for panel-mounting have an "M" as the 10th digit.
Size 40TE may be GN0242 001 and 60TE/80TE as GN0243 001.

Table 1 - Products, sizes and part numbers

The design of the relay is such that the fixing holes in the mounting flanges are only accessible when the access covers are open and hidden from sight when the covers are closed.
If a MiCOM P991 or Easergy test block is to be included with the relays, we recommend you position the test block on the right-hand side of the associated relays (when viewed from the front). This minimises the wiring between the relay and test block, and allows the correct test block to be easily identified during commissioning and maintenance tests.

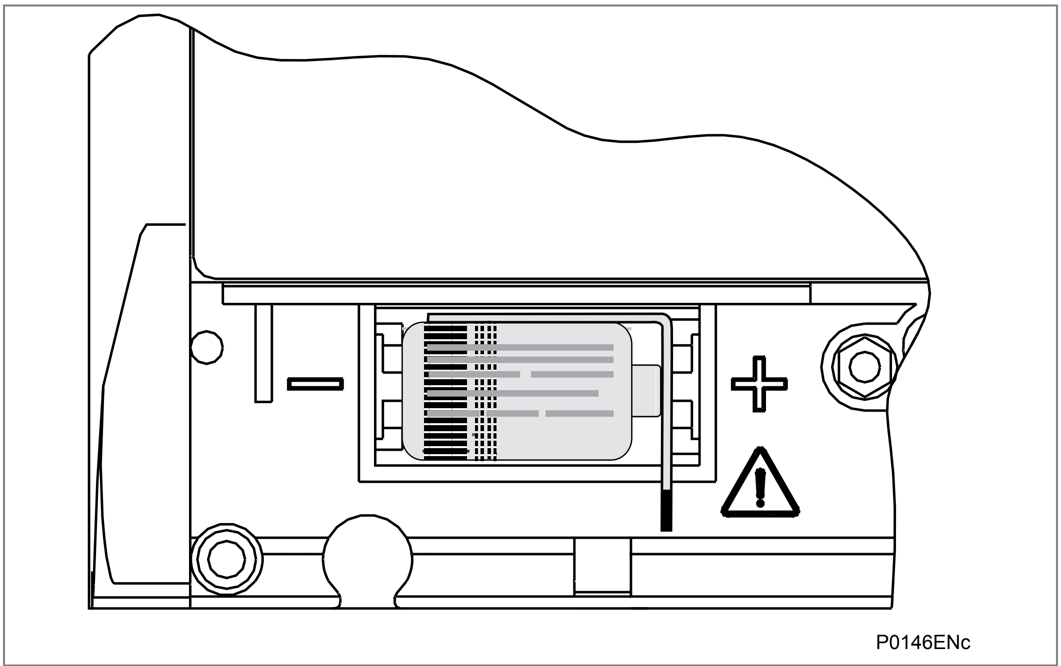


Figure 1 - Location of battery isolation strip

If you need to test correct relay operation during the installation, the battery isolation strip can be removed but should be replaced if commissioning of the scheme is not imminent. This will prevent unnecessary battery drain during transportation to site and installation. The red tab of the isolation strip can be seen protruding from the positive side of the battery compartment when the lower access cover is open. To remove the isolation strip, pull the red tab whilst lightly pressing the battery to prevent it falling out of the compartment. When replacing the battery isolation strip, ensure that the strip is refitted as shown in the *Location of battery isolation strip* diagram, i.e. with the strip behind the battery with the red tab protruding.

3.1 Rack Mounting

Virtually all MiCOM relays can be rack mounted using single tier rack frames (part number FX0021 101), see the ***Rack mounting of relays*** diagram below. These frames have dimensions in accordance with IEC 60297 and are supplied pre-assembled ready to use. On a standard 483 mm rack this enables combinations of case widths up to a total equivalent of size 80TE to be mounted side-by-side.
The two horizontal rails of the rack frame have holes drilled at approximately 26 mm intervals and the relays are attached via their mounting flanges using M4 Taptite self-tapping screws with captive 3 mm thick washers (also known as a SEMS unit). These fastenings are available in packs of 5 (part number ZA0005 104).

Warning	**Risk of damage to the front cover moulding. Do not use conventional self-tapping screws, including those supplied for mounting other relays because they have slightly larger heads.**

Once the tier is complete, the frames are fastened into the racks using mounting angles at each end of the tier.

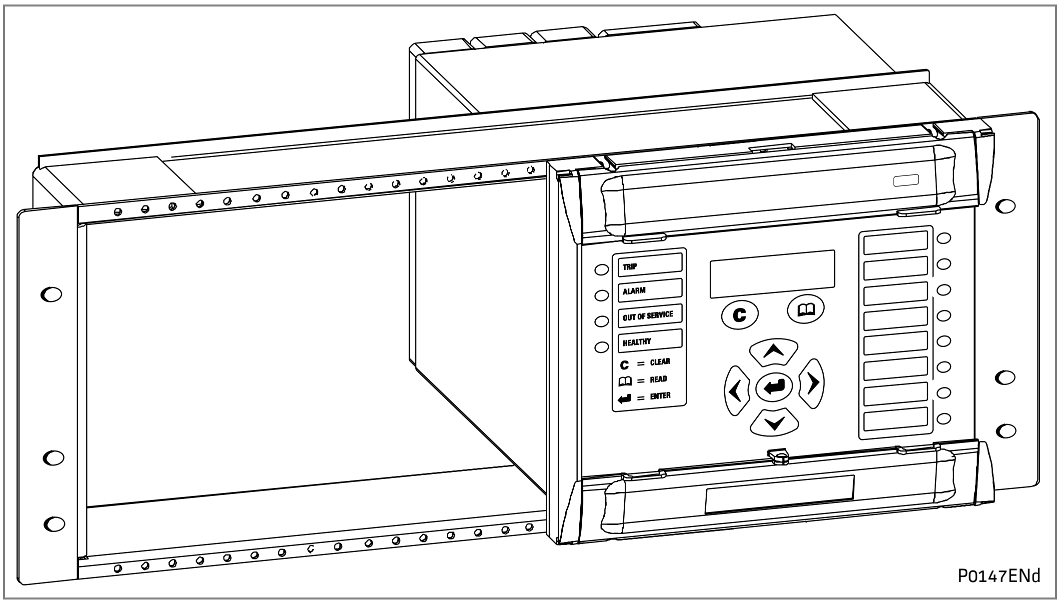


Figure 2 - Rack mounting of relays

Relays can be mechanically grouped into single tier (4U) or multi-tier arrangements by the rack frame. This enables schemes using MiCOM products to be pre-wired together prior to mounting.

Use blanking plates if there are empty spaces. The spaces may be for future installation of relays or because the total size is less than 80TE on any tier. Blanking plates can also be used to mount ancillary components. The following ***Blanking plates*** table shows the sizes that can be ordered.

Note	*Blanking plates are only available in grey.*

Case size summation	Blanking plate part number
10TE	GJ2028 102
20TE	GJ2028 104
30TE	GJ2028 106
40TE	GJ2028 108

Table 2 - Blanking plates

3.2 Panel Mounting

The relays can be flush mounted into panels using M4 SEMS Taptite self-tapping screws with captive 3 mm thick washers (also known as a SEMS unit). These fastenings are available in packs of 5 (part number ZA0005 104).

Warning	**Risk of damage to the front cover moulding. Do not use conventional self-tapping screws, including those supplied for mounting other relays because they have slightly larger heads.**

Alternatively tapped holes can be used if the panel has a minimum thickness of 2.5 mm. If several relays are mounted in a single cut-out in the panel, mechanically group them together horizontally or vertically to form rigid assemblies prior to mounting in the panel.

Note	*Fastening MiCOM relays with pop rivets is not advised because this does not allow easy removal if repair is necessary.*

Rack-mounting panel-mounted versions: it is possible to rack-mount some relay versions which have been designed to be panel-mounted. The relay is mounted on a single-tier rack frame, which occupies the full width of the rack. To make sure a panel-mounted relay assembly complies with BS EN60529 IP52, fit a metallic sealing strip between adjoining relays (Part No GN2044 001) and a sealing ring from the following ***IP52 sealing rings*** table around the complete assembly.

Width	Single tier	Double tier
40TE	GJ9018 008	GJ9018 024
45TE	GJ9018 009	GJ9018 025
50TE	GJ9018 010	GJ9018 026
55TE	GJ9018 011	GJ9018 027
60TE	GJ9018 012	GJ9018 028
65TE	GJ9018 013	GJ9018 029
70TE	GJ9018 014	GJ9018 030
75TE	GJ9018 015	GJ9018 031
80TE	GJ9018 016	GJ9018 032

Table 3 - IP52 sealing rings

4 RELAY WIRING

This section serves as a guide to selecting the appropriate cable and connector type for each terminal on the MiCOM relay.

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

4.1 Medium and Heavy Duty Terminal Block Connections

Key:

Heavy duty terminal block: CT and VT circuits, terminals with “C”,“D”,“E” or “F” prefix (depending on the relay)

Medium duty: All other terminal blocks (grey color)

Loose relays are supplied with sufficient M4 screws for making connections to the rear mounted terminal blocks using ring terminals, with a recommended maximum of two ring terminals per relay terminal.

If required, Schneider Electric can supply M4 90° crimp ring terminals in three different sizes depending on wire size (see the *M4 90° crimp ring terminals* table). Each type is available in bags of 100.

Part number	Wire size	Insulation colour
ZB9124 901	0.25 – 1.65mm^2 (22 – 16AWG)	Red
ZB9124 900	1.04 – 2.63mm^2 (16 – 14AWG)	Blue
ZB9124 904	2.53 – 6.64mm^2 (12 – 10AWG)	Uninsulated*

Note — ** To maintain the terminal block insulation requirements for safety, fit an insulating sleeve over the ring terminal after crimping.*

Table 4 - M4 90° crimp ring terminals

The following minimum wire sizes are recommended:

- Current Transformers 2.5mm^2
- Auxiliary Supply Vx 1.5mm^2
- RS485 Port See separate section
- Rotor winding to P391 1.0mm^2
- Other circuits 1.0mm^2

Due to the limitations of the ring terminal, the maximum wire size that can be used for any of the medium or heavy duty terminals is 6.0mm^2 using ring terminals that are not pre-insulated. Where it required to only use pre-insulated ring terminals, the maximum wire size that can be used is reduced to 2.63mm^2 per ring terminal. If a larger wire size is required, two wires should be used in parallel, each terminated in a separate ring terminal at the relay.

The wire used for all connections to the medium and heavy duty terminal blocks, except the RS485 port, should have a minimum voltage rating of 300Vrms.

It is recommended that the auxiliary supply wiring should be protected by a 16A maximum High Rupture Capacity (HRC) fuse of type NIT or TIA. For safety reasons, current transformer circuits must never be fused. Other circuits should be appropriately fused to protect the wire used.

Note	*The high-break contacts optional fitted to P44y (P443/P446) and P54x relays are polarity sensitive. External wiring must respect the polarity requirements which are shown on the external connection diagram to ensure correct operation.*

Each opto input has selectable filtering. This allows use of a pre-set filter of ½ cycle which renders the input immune to induced noise on the wiring: although this method is secure it can be slow, particularly for intertripping. This can be improved by switching off the ½ cycle filter in which case one of the following methods to reduce ac noise should be considered. The first method is to use double pole switching on the input, the second is to use screened twisted cable on the input circuit. The recognition time of the opto inputs without the filtering is <2 ms and with the filtering is <12 ms.

4.2 EIA(RS)485 Port

Connections to the first rear EIA(RS)485 port use ring terminals. 2-core screened cable is recommended with a maximum total length of 1000m or 200nF total cable capacitance. A typical cable specification would be:

Each core:	16/0.2mm copper conductors. PVC insulated
Nominal conductor area:	0.5mm^2 per core
Screen:	Overall braid, PVC sheathed

See the SCADA Communications chapter for details of setting up an EIA(RS)485 bus.

4.3 Current Loop Input Output (CLIO) Connections (if applicable)

Where current loop inputs and outputs are available on a MiCOM relay, the connections are made using screw clamp connectors, as per the RTD inputs, on the rear of the relay which can accept wire sizes between 0.1 mm^2 and 1.5 mm^2. It is recommended that connections between the relay and the current loop inputs and outputs are made using a screened cable. The wire should have a minimum voltage rating of 300 Vrms.

4.4 IRIG-B Connections (if applicable)

The IRIG-B input and BNC connector have a characteristic impedance of 50Ω. It is recommended that connections between the IRIG-B equipment and the relay are made using coaxial cable of type RG59LSF with a halogen free, fire retardant sheath.

4.5 EIA(RS)232 Port

Short term connections to the RS232 port, located behind the bottom access cover, can be made using a screened multi-core communication cable up to 15m long, or a total capacitance of 2500pF. The cable should be terminated at the relay end with a 9-way, metal shelled, D-type male plug. The Getting Started chapter of this manual details the pin allocations.

4.6 Optical Fiber Connectors (when applicable)


Warning **LASER LIGHT RAYS: Where fibre optic communication devices are fitted, never look into the end of a fiber optic due to the risk of causing serious damage to the eye. Optical power meters should be used to determine the operation or signal level of the device. Non-observance of this rule could possibly result in personal injury.**

If electrical to optical converters are used, they must have management of character idle state capability (for when the fibre optic cable interface is "Light off").
Specific care should be taken with the bend radius of the fibres, and the use of optical shunts is not recommended as these can degrade the transmission path over time.
The relay uses 1310nm multi mode 100BaseFx and BFOC 2.5 - (ST/LC according to the MiCOM model) connectors (one Tx – optical emitter, one Rx – optical receiver).

4.7 Ethernet Port for IEC 61850 and/or DNP3.0 (where applicable)

4.7.1 Fiber Optic (FO) Port

The relays can have 100 Mbps Ethernet port. Fibre Optic (FO) connection is recommended for use in permanent connections in a substation environment. The 100 Mbit port uses a type LC connector (according to the MiCOM model), compatible with fiber multimode 50/125 µm or 62.5/125 µm to 1310 nm.

Note	*The new LC fiber optical connector can be used with the Px40 Enhanced Ethernet Board.*

4.7.2 RJ-45 Metallic Port

Due to possibility of noise and interference on this part, it is recommended that this connection type be used for short-term connections and over short distance. Ideally, where the relays and switches are located in the same cubicle.

The connector for the Ethernet port is a shielded RJ-45. The following ***Signals on the Ethernet connector*** table shows the signals and pins on the connector.

Pin	Signal name	Signal definition
1	TXP	Transmit (positive)
2	TXN	Transmit (negative)
3	RXP	Receive (positive)
4	-	Not used
5	-	Not used
6	RXN	Receive (negative)
7	-	Not used
8	-	Not used

Table 5 - Signals on the Ethernet connector

4.8 RTD Connections (if applicable)

Where RTD inputs are available on a MiCOM relay, the connections are made using screw clamp connectors on the rear of the relay that can accept wire sizes between 0.1 mm^2 and 1.5 mm^2. The connections between the relay and the RTDs must be made using a screened 3-core cable with a total resistance less than 10 Ω. The cable should have a minimum voltage rating of 300 Vrms.

A 3-core cable should be used even for 2-wire RTD applications, as it allows for the cable's resistance to be removed from the overall resistance measurement. In such cases the third wire is connected to the second wire at the point the cable is joined to the RTD.

The screen of each cable must only be earthed at one end, preferably at the relay end and must be continuous. Multiple earthing of the screen can cause circulating current to flow along the screen, which induces noise and is unsafe.

It is recommended to minimize noise pick-up in the RTD cables by keeping them close to earthed metal casings and avoiding areas of high electromagnetic and radio interference. The RTD cables should not be run adjacent to or in the same conduit as other high voltage or current cables.

A typical cable specification would be:

Each core: 7/0.2 mm copper conductors heat resistant PVC insulated

Nominal conductor area: 0.22 mm^2 per core

Screen: Nickel-plated copper wire braid heat resistant PVC sheathed

The extract below may be useful in defining cable recommendations for the RTDs:

Noise pick-up by cables can be categorized in to three types:

- Resistive
- Capacitive
- Inductive

Resistive coupling requires there to be an electrical connection to the noise source. So assuming that the wire and cable insulation is sound and that the junctions are clean then this can be dismissed.

Capacitive coupling requires there to be sufficient capacitance for the impedance path to the noise source to be small enough to allow for significant coupling. This is a function of the dielectric strength between the signal cable on the noise source and the potential (i.e. power) of the noise source.

Inductive coupling occurs when the signal cable is adjacent to a cable/wire carrying the noise or it is exposed to a radiated EMF.

Standard screened cable is normally used to protect against capacitively coupled noise, but in order for it to be effective the screen must only be bonded to the system ground at one point, otherwise a current could flow and the noise would be coupled in to the signal wires of the cable. There are different types of screening available, but basically there are two types: aluminum foil wrap and tin-copper braid.

Foil screens are good for low to medium frequencies and braid is good for high frequencies. High-fidelity screen cables provide both types.

Protection against magnetic inductive coupling requires very careful cable routing and magnetic shielding. The latter can be achieved with steel-armored cable and the use of steel cable trays. It is important that the armor of the cable is grounded at both ends so that the EMF of the induced current cancels the field of the noise source and hence shields the cables conductors from it. (However, the design of the system ground must be considered and care taken to not bridge two isolated ground systems since this could be hazardous and defeat the objectives of the original ground design). The cable should be laid in the cable trays as close as possible to the metal of the tray and under no circumstance should any power cable be in or near to the tray. (Power cables should only cross the signal cables at 90 degrees and never be adjacent to them).

Both the capacitive and inductive screens must be contiguous from the RTD probes to the relay terminals.

The best types of cable are those provided by the RTD manufactures. These tend to be three conductors (a so-called "triad") which are screened with foil. Such triad cables are available in armored forms as well as multi-triad armored forms.

4.9 Download/Monitor Port

Short term connections to the download/monitor port, located behind the bottom access cover, can be made using a screened 25-core communication cable up to 4m long. The cable should be terminated at the relay end with a 25-way, metal shelled, D-type male plug.

The Getting Started and Commissioning chapters this manual details the pin allocations.

4.10 Second EIA(RS)232/485 Port

Relays with Courier, MODBUS, IEC 60870-5-103 or DNP3 protocol on the first rear communications port have the option of a second rear port, running Courier protocol. The second rear communications port can be used over one of three physical links:

- twisted pair K-Bus (non-polarity sensitive),
- twisted pair EIA(RS)485 (connection polarity sensitive) or
- EIA(RS)232. This EIA(RS)232 port is actually compliant to EIA(RS)574; the 9-pin version of EIA(RS)232, see www.tiaonline.org.

4.10.1 Connection to the Second Rear Port

The second rear Courier port connects via a 9-way female D-type connector (SK4) in the middle of the card end plate (in between IRIG-B connector and lower D-type). The connection is compliant to EIA(RS)574.

4.10.1.1 For IEC 60870-5-2 over EIA(RS)232/574

Pin	Connection
1	No Connection
2	RxD
3	TxD
4	DTR#
5	Ground
6	No Connection
7	RTS #
8	CTS #
9	No Connection
# - These pins are control lines for use with a modem.	

Table 6 - Pin connections for IEC 60870-5-2 over EIA(RS)232/574

Connections to the second rear port configured for EIA(RS)232 operation can be made using a screened multi-core communication cable up to 15 m long, or a total capacitance of 2500 pF. The cable should be terminated at the relay end with a 9-way, metal shelled, D-type male plug. The table above details the pin allocations.

4.10.1.2 For K-bus or IEC 60870-5-2 over EIA(RS)485

Pin*	Connection
4	EIA(RS)485 - 1 (+ ve)
7	EIA(RS)485 - 2 (- ve)
* - All other pins unconnected.	

Note *Connector pins 4 and 7 are used by both the EIA(RS)232/574 and EIA(RS)485 physical layers, but for different purposes. Therefore, the cables should be removed during configuration switches.*
For the EIA(RS)485 protocol an EIA(RS)485 to EIA(RS)232/574 converter will be required to connect a modem or PC running MiCOM S1 Studio, to the relay. A Schneider Electric CK222 is recommended.
EIA(RS)485 is polarity sensitive, with pin 4 positive (+) and pin 7 negative (-).
The K-Bus protocol can be connected to a PC via a KITZ101 or 102.
It is recommended that a 2-core screened cable be used. To avoid exceeding the second communications port flash clearances it is recommended that the length of cable between the port and the communications equipment should be less than 300 m. This length can be increased to 1000 m or 200nF total cable capacitance if the communications cable is not laid in close proximity to high current carrying conductors. The cable screen should be earthed at one end only.

Table 7 - Pin connections for K-bus or IEC 60870-5-2 over EIA(RS)485

A typical cable specification would be:

Each core:	16/0.2mm copper conductors. PVC insulated
Nominal conductor area:	0.5mm^2 per core
Screen:	Overall braid, PVC sheathed

4.11 Earth Connection (Protective Conductor)

Every relay must be connected to the local earth bar using the M4 earth studs in the bottom left hand corner of the relay case. The minimum recommended wire size is 2.5mm^2 and should have a ring terminal at the relay end.
Due to the limitations of the ring terminal, the maximum wire size that can be used for any of the medium or heavy duty terminals is 6.0mm^2 per wire. If a greater cross-sectional area is required, two parallel connected wires, each terminated in a separate ring terminal at the relay, or a metal earth bar could be used.

Note	*To prevent any possibility of electrolytic action between brass or copper earth conductors and the rear panel of the relay, precautions should be taken to isolate them from one another. This could be achieved in a number of ways, including placing a nickel-plated or insulating washer between the conductor and the relay case, or using tinned ring terminals.*

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

4.12 P391 Rotor Earth Fault Unit (REFU) Mounting

Under rotor earth fault conditions, DC currents of up to 29mA can appear in the earth circuit. Accordingly, the P391 must be permanently connected to the local earth via the protective conductor terminal provided.
This section serves as a guide to selecting the appropriate cable and connector type for each terminal on the P391 unit.

Caution	**You must be familiar with all safety statements listed in the Commissioning chapter and the Safety Information section SFTY/4LM/G11 (or later issue) before undertaking any work on the P391.**

Caution	**Under no circumstances should the high voltage DC rotor winding supply be connected via Easergy or P99x test blocks. Both Easergy and P990 test blocks are not rated for continuous working voltages greater than 300 Vrms. These test blocks are not designed to withstand the inductive EMF voltages which will be experienced on disconnection or de-energization of the DC rotor winding supply.**

4.12.1 Medium Duty Terminal Block Connections

Information about the medium duty terminal block connections is described in the ***Medium and Heavy Duty Terminal Block Connections*** section.

> **Caution** **Wiring between the DC rotor winding and the P391 must be suitably rated to withstand at least twice the rotor winding supply voltage to earth. This is to ensure that the wiring insulation can withstand the inductive Electro Motive Force (EMF) voltage which will be experienced on disconnection or de-energization of the DC rotor winding supply.**

Due to the limitations of the ring terminal, the maximum wire size that can be used for any of the medium terminals is 6.0 mm^2 using ring terminals that are not pre-insulated (protective conductor terminal (PCT) only). All P391 terminals, except PCT shall be pre-insulated ring terminals, the maximum wire size that can be used is reduced to 2.63 mm^2 per ring terminal.

Wiring between the DC rotor winding and the P391 shall be suitably rated to withstand at least twice the rotor winding supply voltage to earth. The wire used for other P391 connections to the medium duty terminal blocks should have a minimum voltage rating of 300 Vrms.

The dielectric withstand of P391 injection resistor connections (A16, B16, A8, B8) to earth is 5.8 kV rms, 1 minute.

It is recommended that the auxiliary supply wiring should be protected by a High Rupture Capacity (HRC) fuse of type NIT or TIA, rated between 2 A and 16 A. Other circuits should be appropriately fused to protect the wire used.

5 CASE DIMENSIONS

The MiCOM range of products are available in a series of different case sizes.
The case sizes available for each product are shown here:

Range	Case Size		
	40TE	60TE	80TE
P14x	P141, P142	P143, P145	P143
P24x	P241	P242	P243
P34x	P341, P342	P341, P342, P343	P343, P344, P345
P441	P441		
P44x		P442	P444
P44y			P443, P446
P445	P445	P445	
P541	P541		
P542		P542	
P54x		P543, P544	P545, P546
P547			P547
P64x	P642	P643, P645	P645
P74x	P742	P743	P741
P746			P746
P841		P841	P841
P849			P849

Table 8 - Products and case sizes

5.1 40TE Case Dimensions

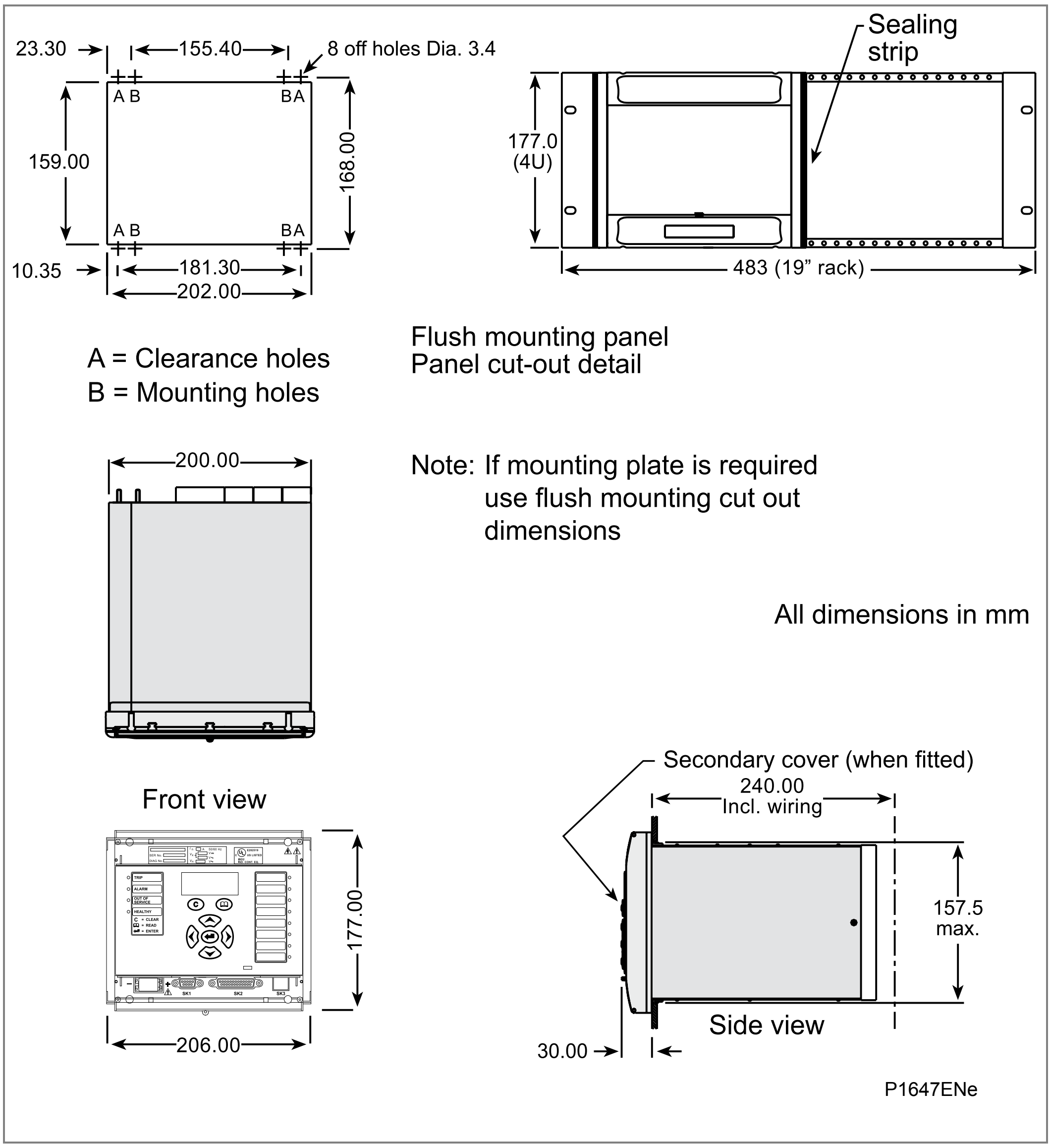


Figure 3 - 40TE Case Dimensions

5.2 60TE Case Dimensions

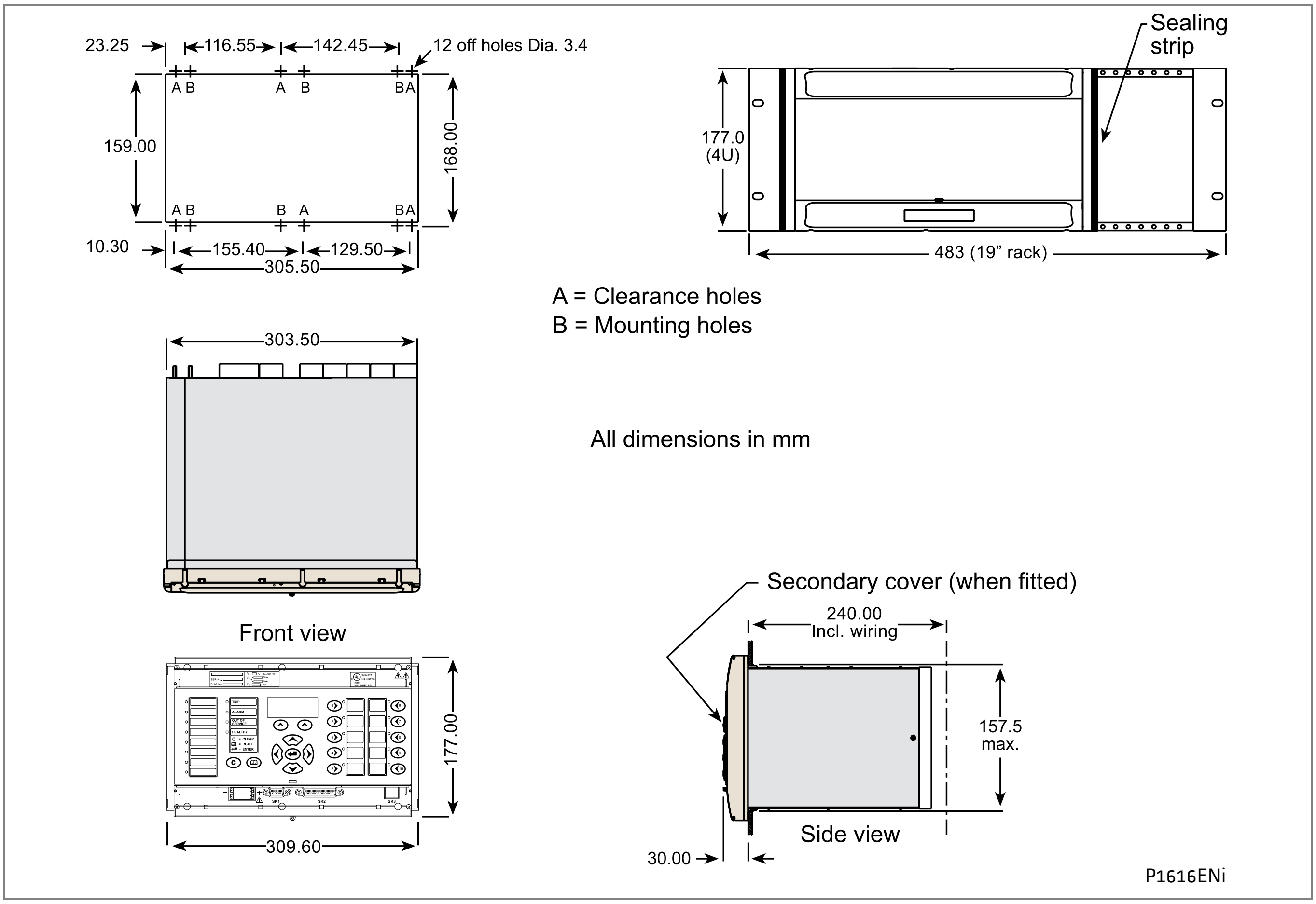


Figure 4 - 60TE Case Dimensions

5.3 80TE Case Dimensions

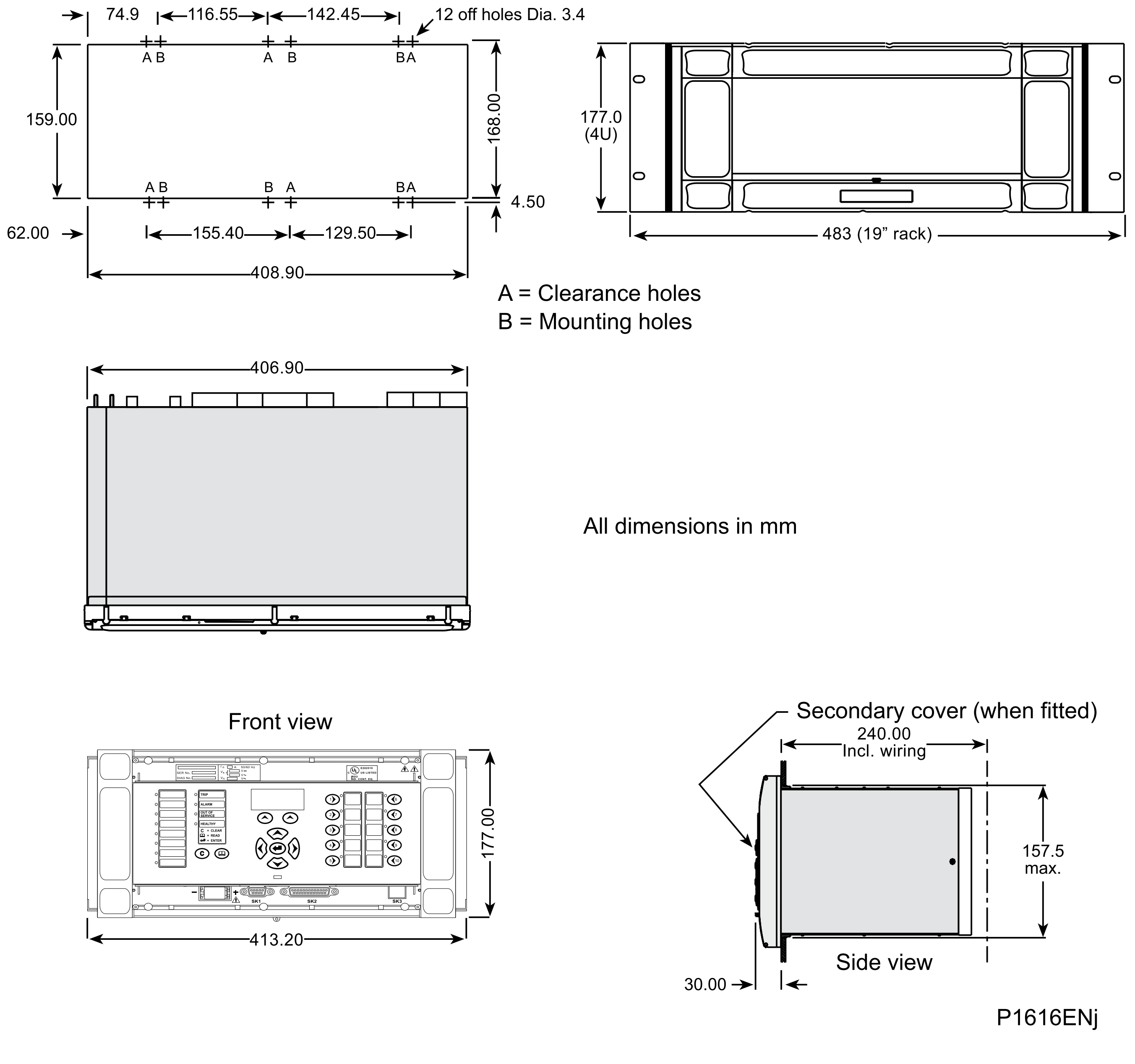


Figure 5 - 80TE Case Dimensions

CONNECTION DIAGRAMS

CHAPTER 17

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Software Version:	B4 (P746_1) / C4 (P746_2)
Hardware Suffix:	M
Connection Diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

Page (CD) 17-

FIGURES

Page (CD) 17-

Notes:

1 INTRODUCTION TO THE CONNECTION DIAGRAMS

The Installation chapter contains general information about the MiCOM unit. The Installation chapter covers many MiCOM P40 products. It includes items such as:

- Receiving, Handling, Storing and Unpacking the Relays
- Mounting the Relay
- Wiring the Relay
- Case Dimensions

This Connection Diagrams chapter is specific to this particular relay, and includes the detailed wiring diagrams which relate only to this particular relay.

Important	***You must be familiar with the contents of the Installation chapter, before using the information in this Connection Diagrams chapter.***

2 COMMUNICATION OPTIONS MICOM PX40 PLATFORM

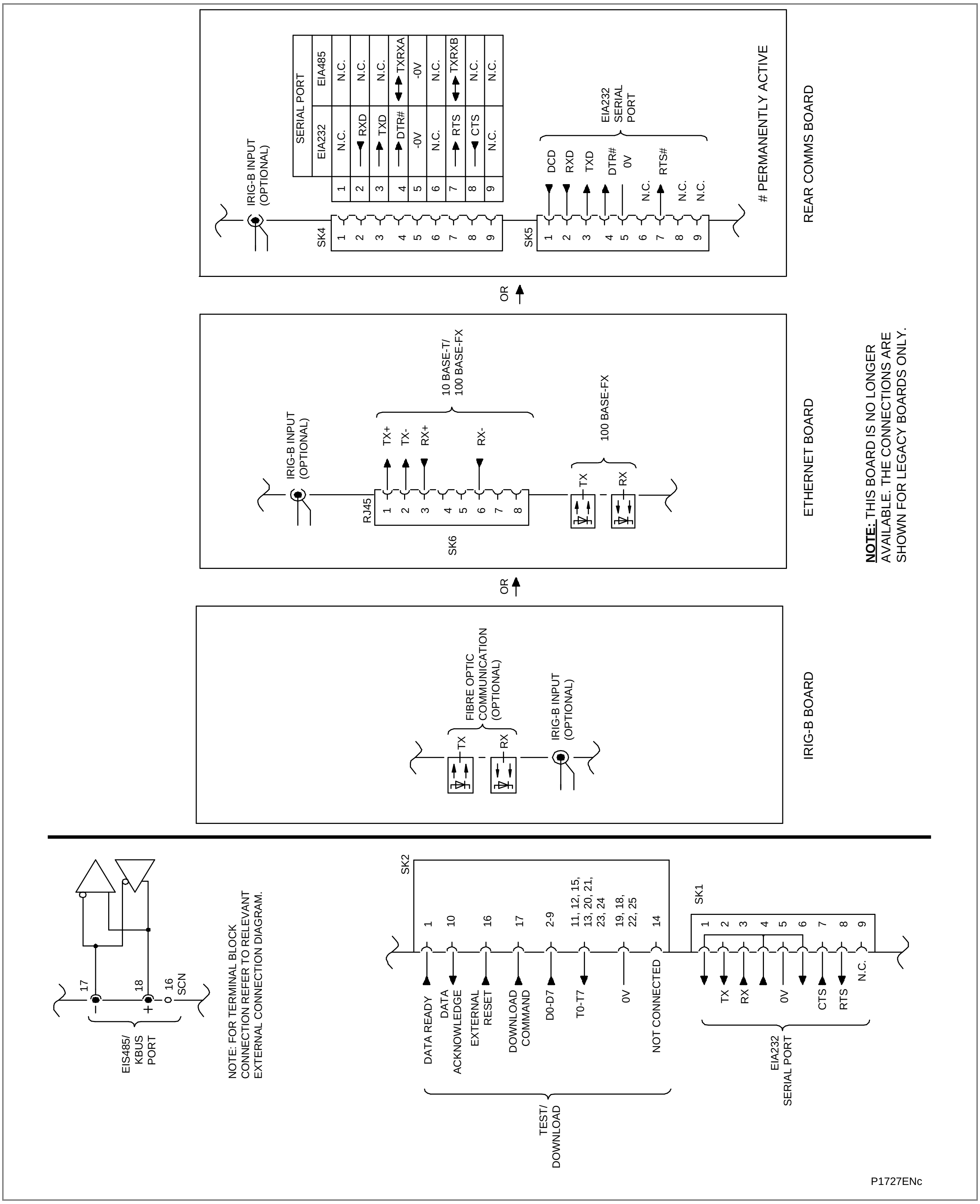


Figure 1 - Serial Communications Options MiCOM Px40 platform

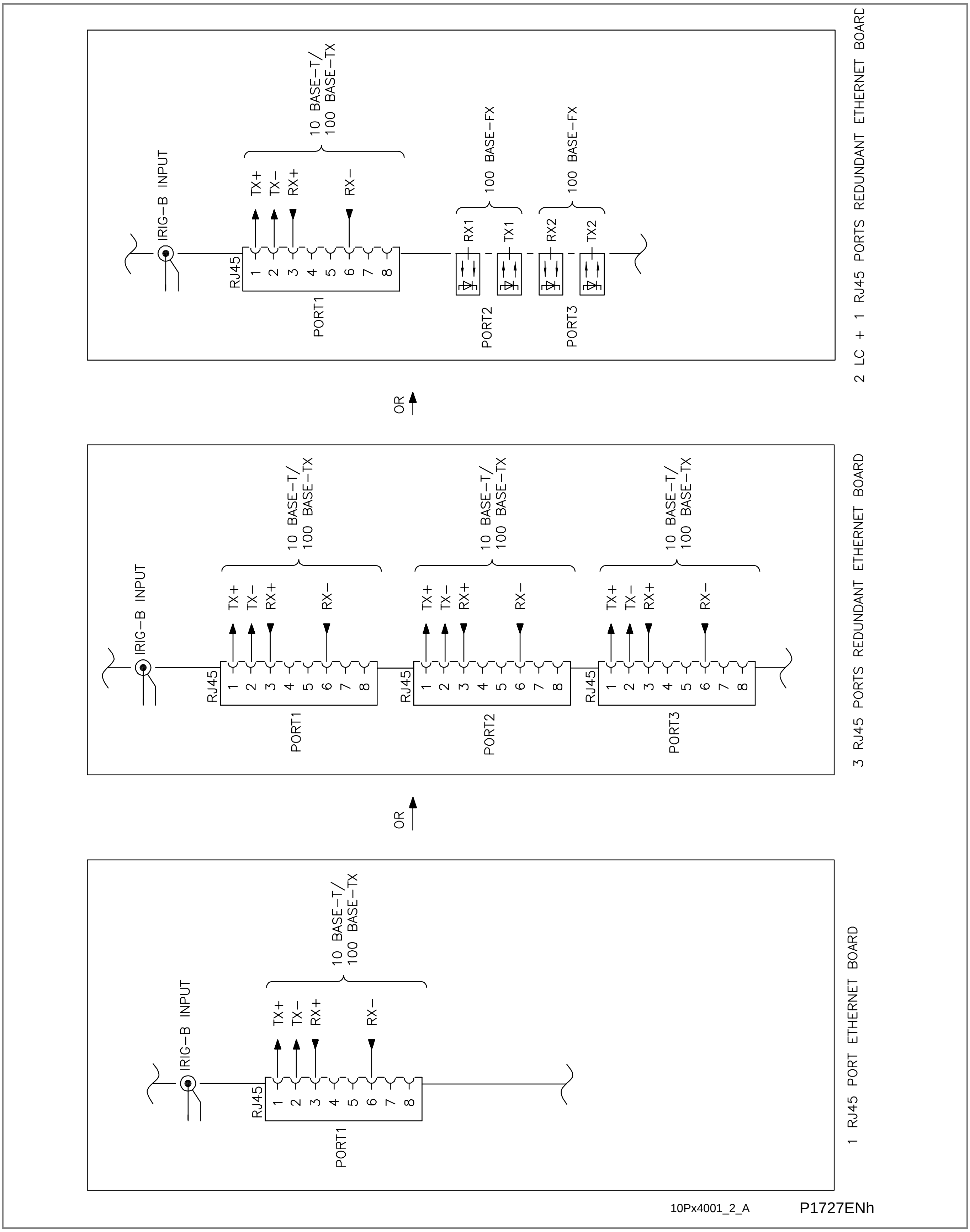
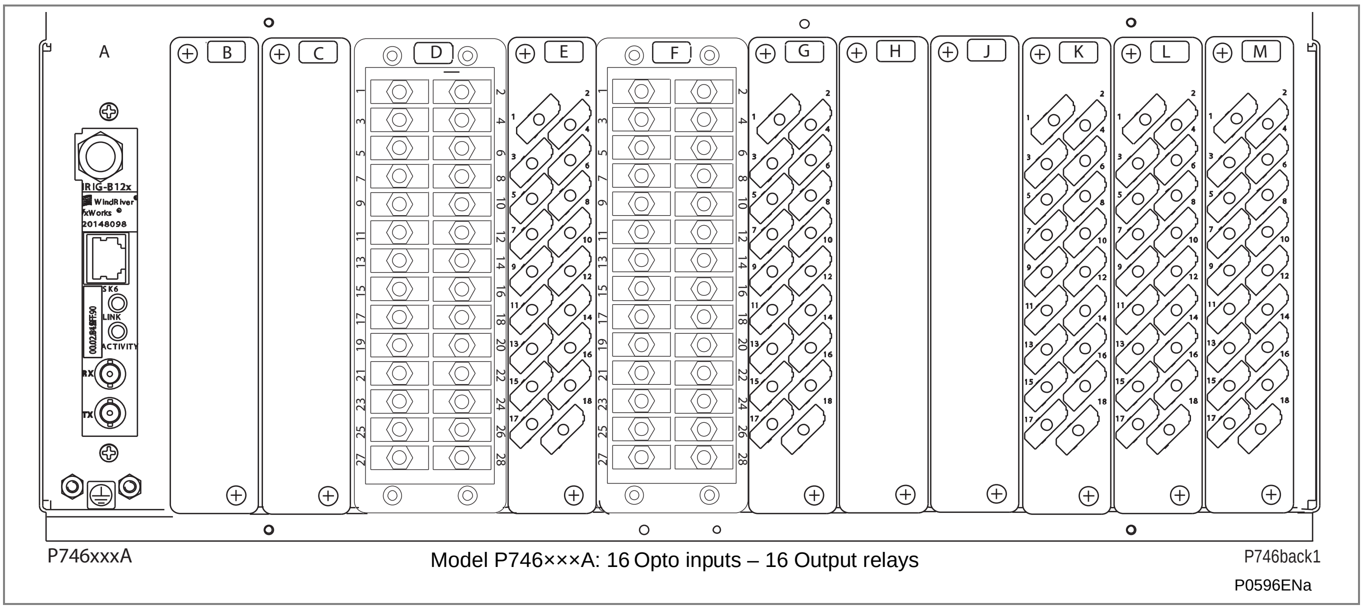


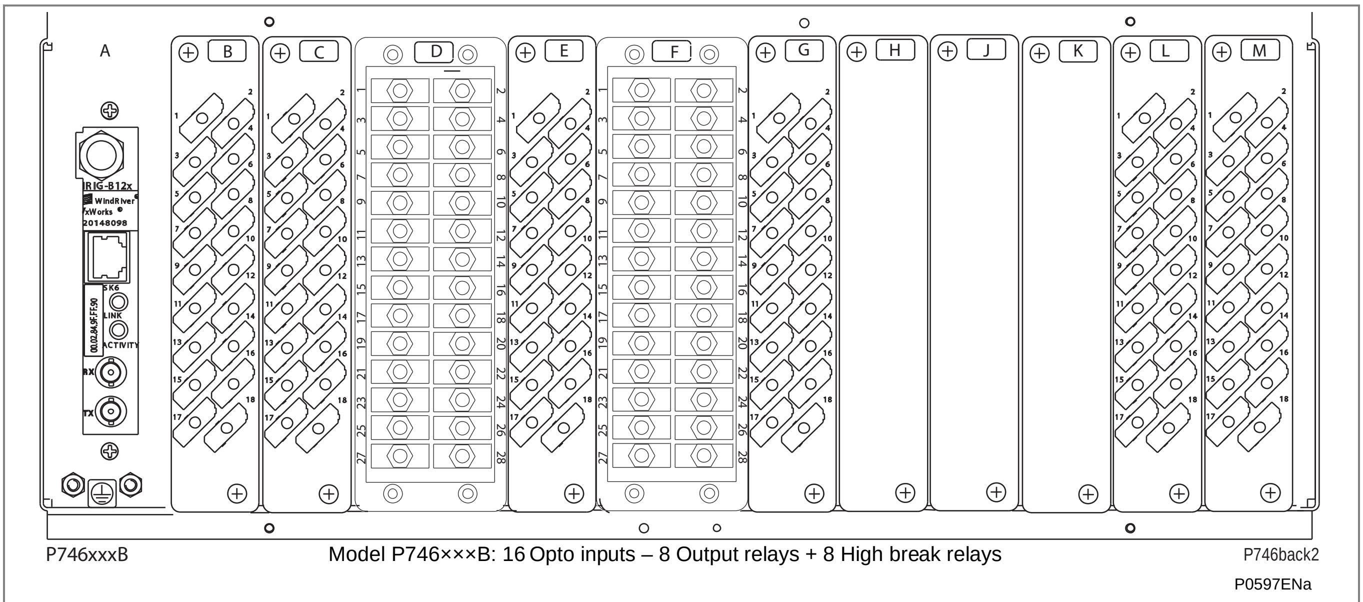
Figure 2 - Ethernet communications options MiCOM Px40 platform

3 EXTERNAL CONNECTION DIAGRAMS



Model P746×××A: 16 Opto inputs - 16 Output relays

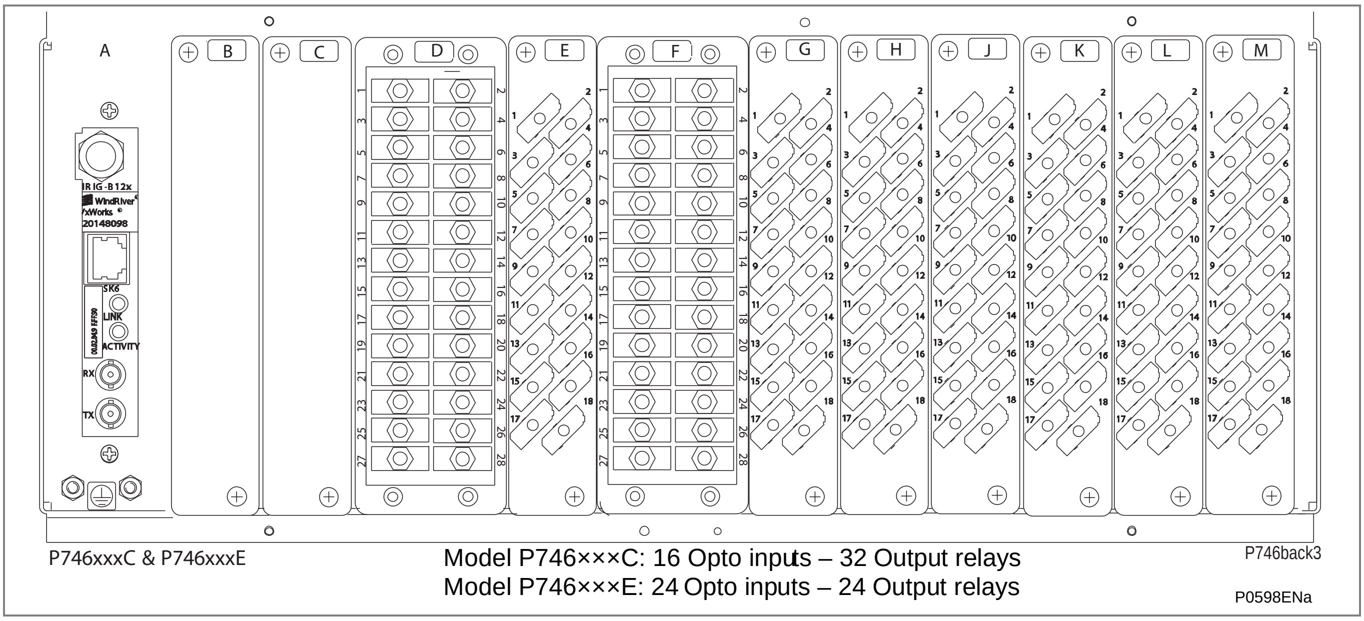
A - Optional board (1)
D - Current and voltage input board
E - Sigma Delta input Board
F - Current and voltage input board
G - Sigma Delta input Board
K - Relay board
L - Relay board
M - Power supply board



Model P746×××B: 16 Opto inputs - 8 Output relays + 8 High break relays

A - Optional board (1)
B - High break relay output board
C - High break relay output board
D - Current and voltage input board
E - Sigma Delta input Board
F - Current and voltage input board
G - Sigma Delta input Board
L - Relay board
M - Power supply board

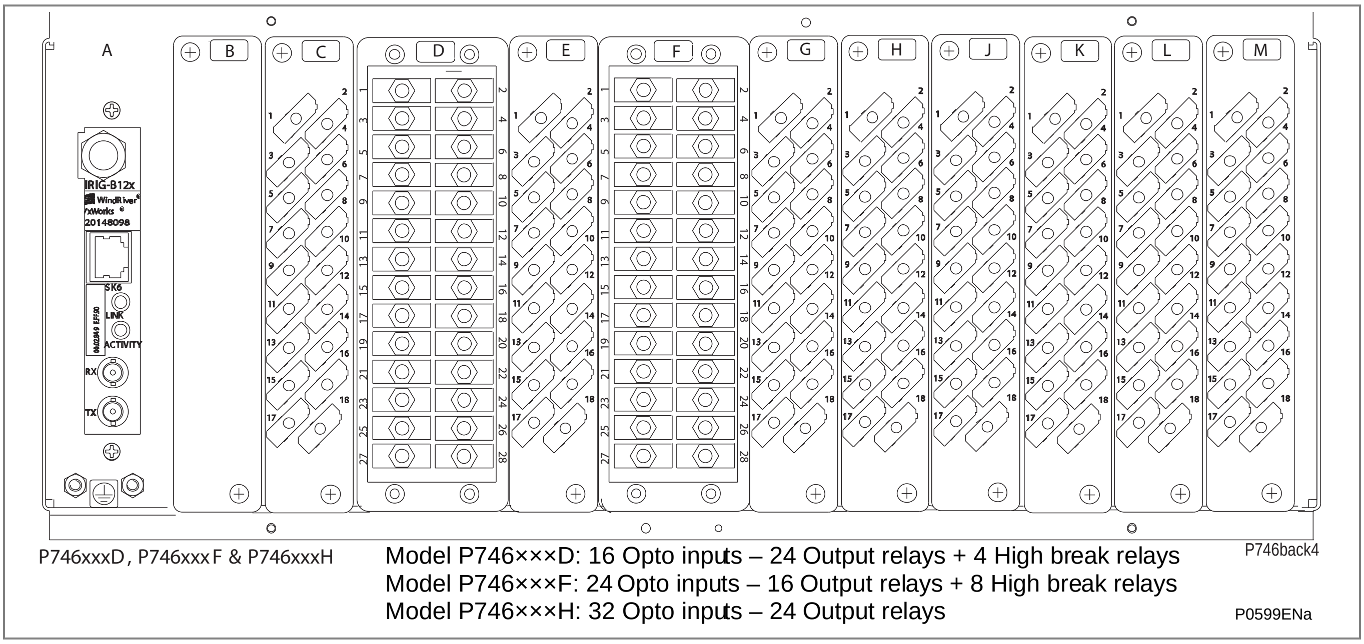
Figure 3 - P746 (80TE) - Rear View (1/3)



Model P746×××C: 16 Opto inputs - 32 Output relays
Model P746×××E: 24 Opto inputs - 24 Output relays

A - Optional board (1)
D - Current and voltage input board
E - Sigma Delta input Board
F - Current and voltage input board
G - Sigma Delta input Board

H - Relay board (P746×××C) \ Opto-input board (P746×××E)
J - Relay board
K - Relay board
L - Relay board
M - Power supply board



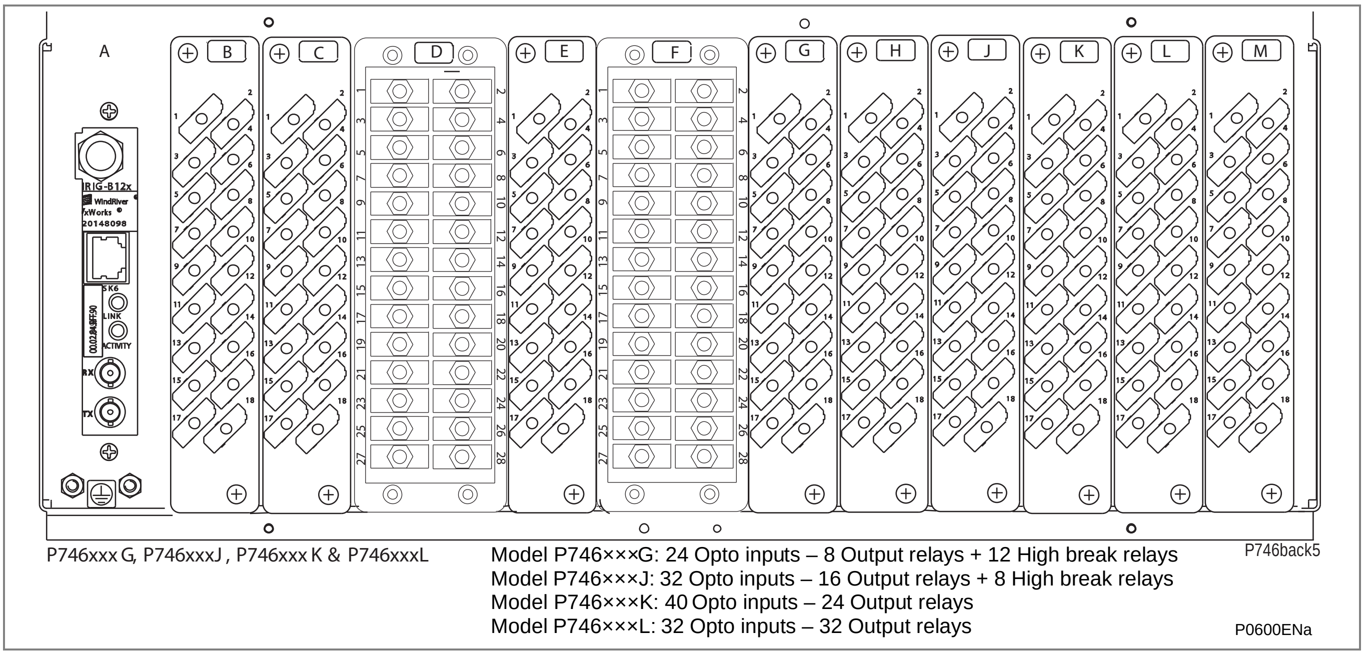
Model P746×××D: 16 Opto inputs - 24 Output relays + 4 High break relays
Model P746×××F: 24 Opto inputs - 16 Output relays + 8 High break relays
Model P746×××H: 32 Opto inputs - 24 Output relays

A - Optional board (1)
C - Empty (P746×××D) \ High break relay output board (P746×××F) \ Opto input board (P746×××H) \
D - Current and voltage input board

H - High break relay output board (P746×××D) \ Opto input board (P746×××F and H)
J - Relay board (P746×××D and H) \ High break relay output board

E - Sigma Delta input Board
F - Current and voltage input board
G - Sigma Delta input Board
(P746×××F)
K - Relay board
L - Relay board
M - Power supply board

Figure 4 - P746 (80TE) - Rear View (2/3)

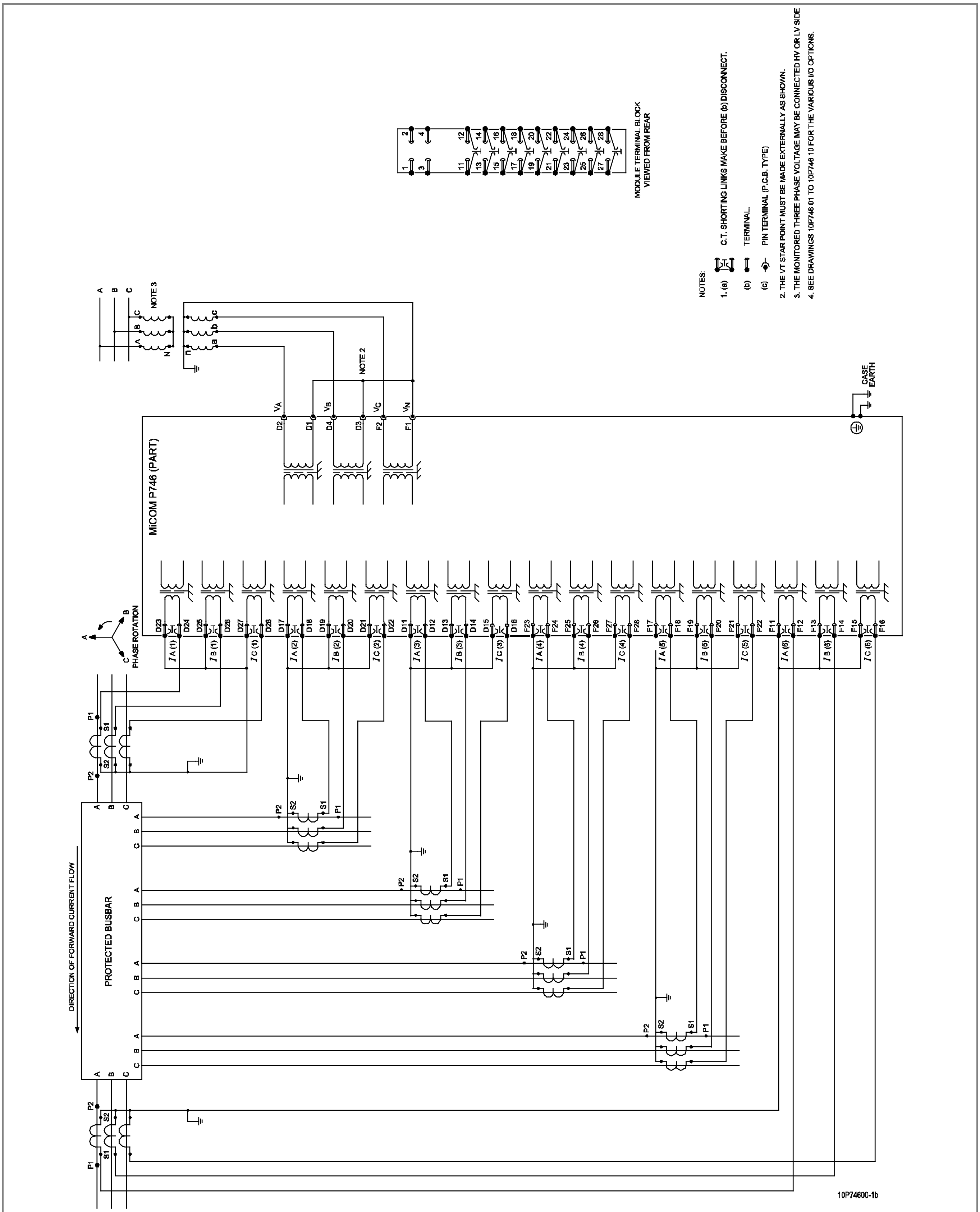


Model P746×××G: 24 Opto inputs - 8 Output relays + 12 High break relays
Model P746×××J: 32 Opto inputs - 16 Output relays + 8 High break relays
Model P746×××K: 40 Opto inputs - 24 Output relays
Model P746×××L: 32 Opto inputs - 32 Output relays

- A - Optional board [1]
- B - Empty (P746×××G) \ High break \ relay output board (P746×××J) \ Opto input board (P746×××K) \ Relay board (P746×××L) \
- C - High break relay output board (P746×××G) \ Opto input board (P746×××J, K and L)
- D - Current and voltage input board
- E - Sigma Delta input Board
- F - Current and voltage input board
- G - Sigma Delta input Board
- H - Opto input board
- J - High break relay output board (P746×××G and J) \ Relay board (P746×××K and L)
- K - High break relay output board (P746×××G) \ Relay board (P746×××J, K and L)
- L - Relay board
- M - Power supply board

Figure 5 - P746 (80TE) - Rear View (3/3)

(1) Hardware options:	Product Code
Standard version	P746××1
IRIG-B Only (Modulated)	P746××2
Fibre Optic Converter only	P746××3
IRIG-B modulated + Fibre optic Converter	P746××4
Second Rear Comms (Courier EIA232 / EIA485 / KBUS)	P746××7
Second Rear Comms (Courier EIA232 / EIA485 / KBUS) + IRIG-B modulated	P746××8
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 2LC ports + 1 RJ45 port + Modulated/Un-modulated IRIG-B	P746xxQ
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 3 RJ45 port + Modulated/Un-modulated IRIG-B	P746xxR
Ethernet (100Mbit/s), 1 RJ45 port + Modulated/Un-modulated IRIG-B	P746xxS



(wiring diagrams are represented relay not energized)

P2791ENa

Figure 6 - P746_1 (80TE) - Connection diagram 10P74600 - one box mode

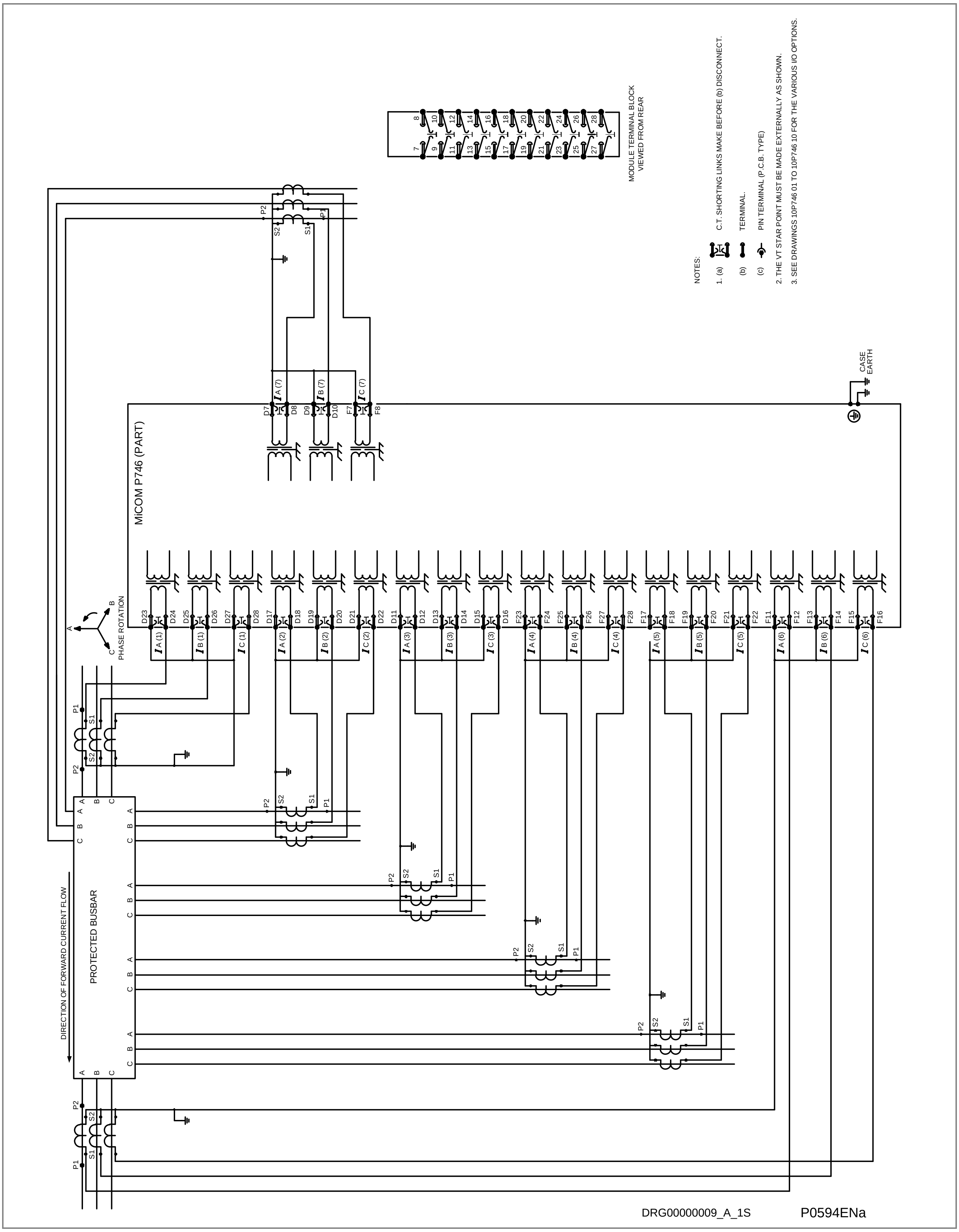
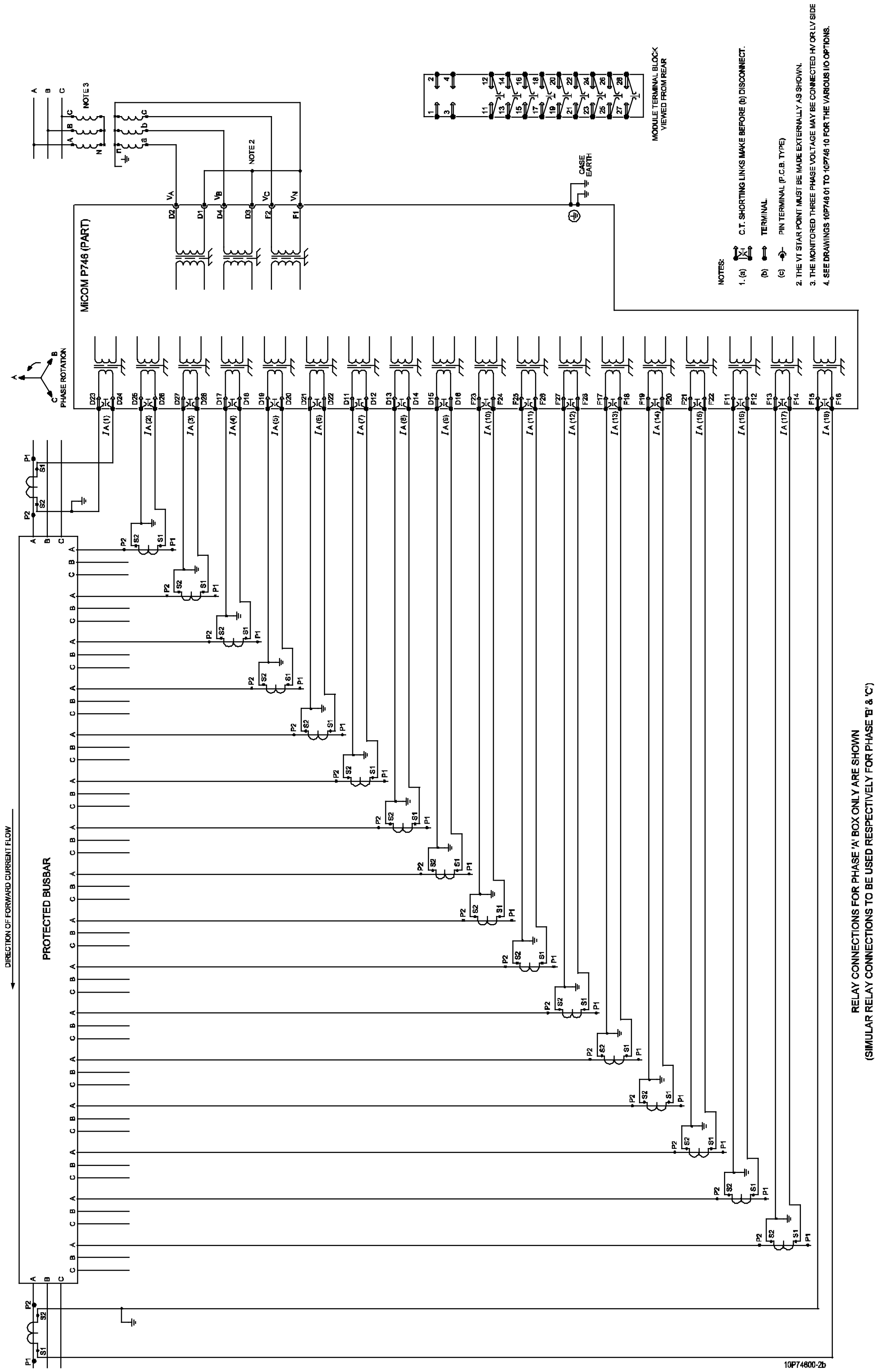


Figure 7 - P746_2 (80TE) - Connection diagram 10P74600 - one box mode



(wiring diagrams are represented relay not energized)

P2792ENa

Figure 8 - P746 (80TE) - Connection diagram 10P74600 - three box mode

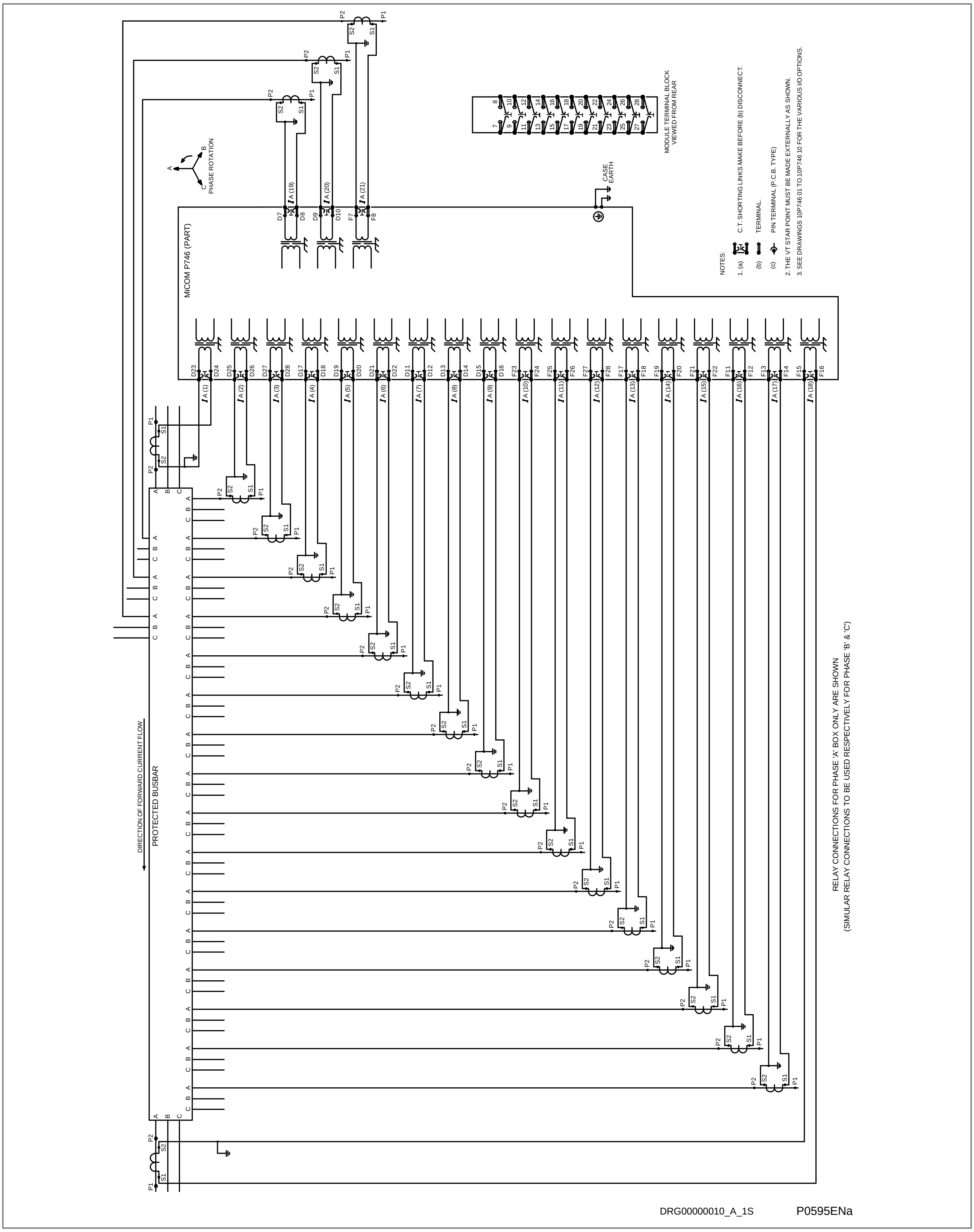


Figure 9 - P746_2 (80TE) - Connection diagram 10P74600 - three box mode

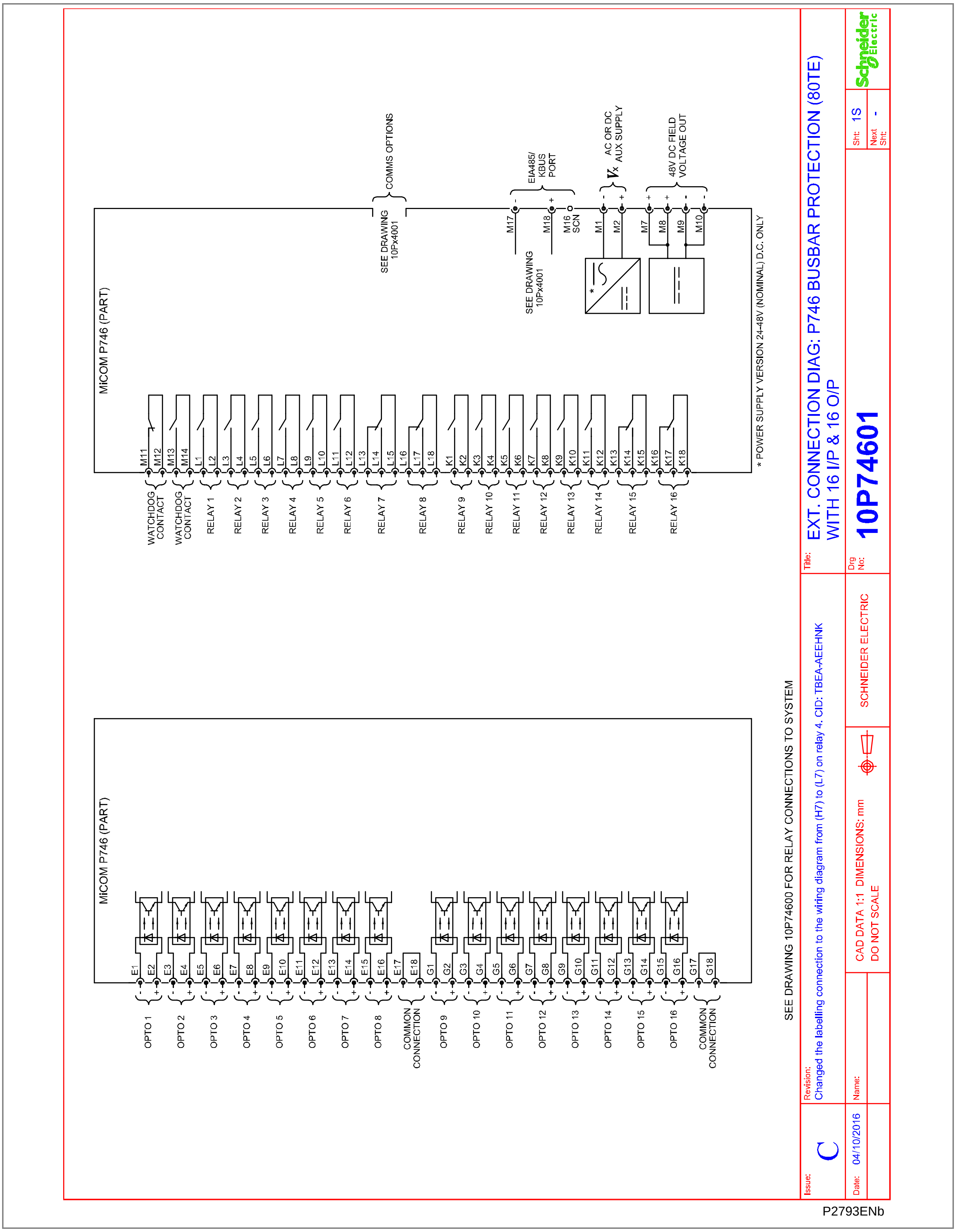


Figure 10 - P746 (80TE) - wiring description (P746xxxA)

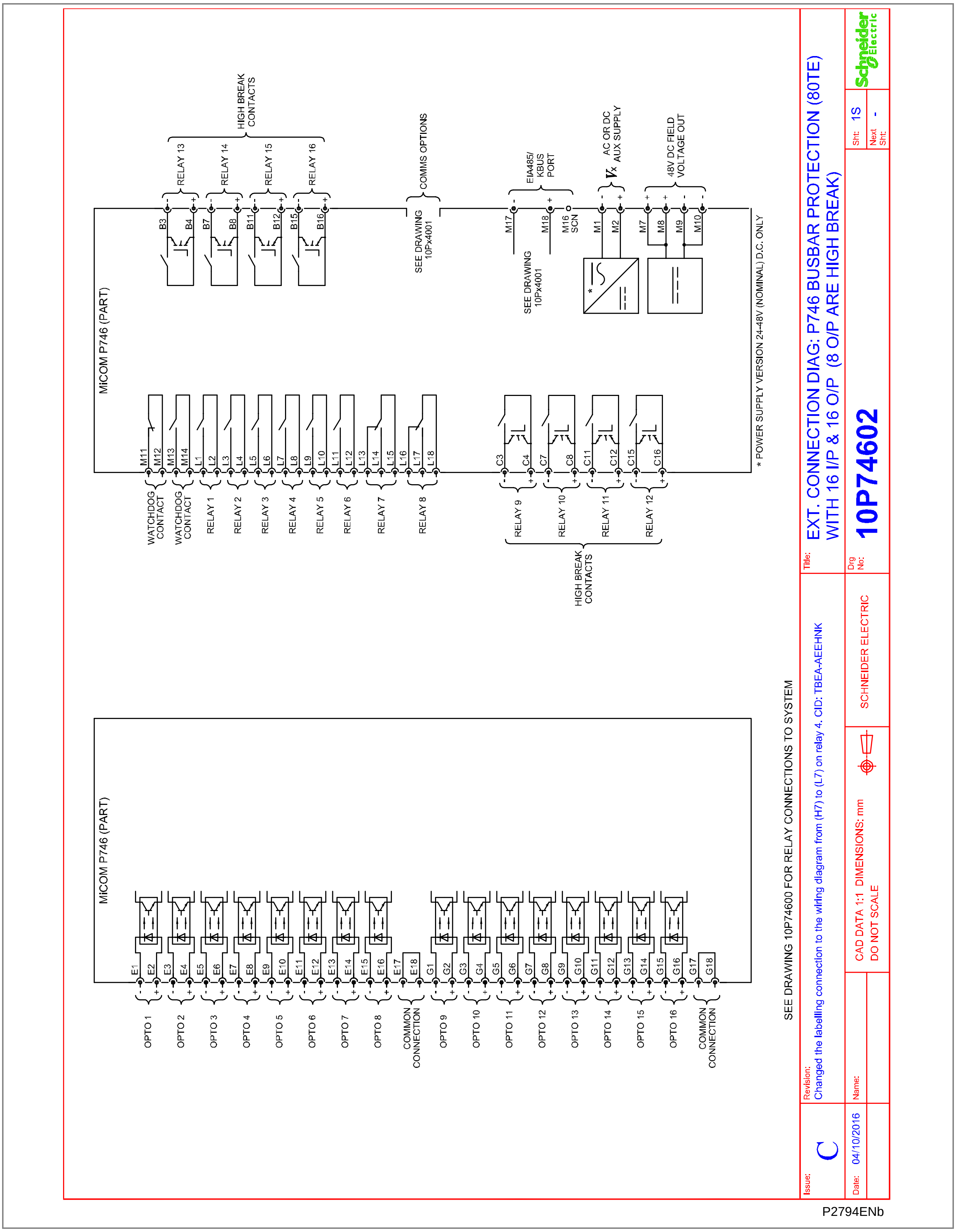


Figure 11 - P746 (80TE) - wiring description (P746xxxB)

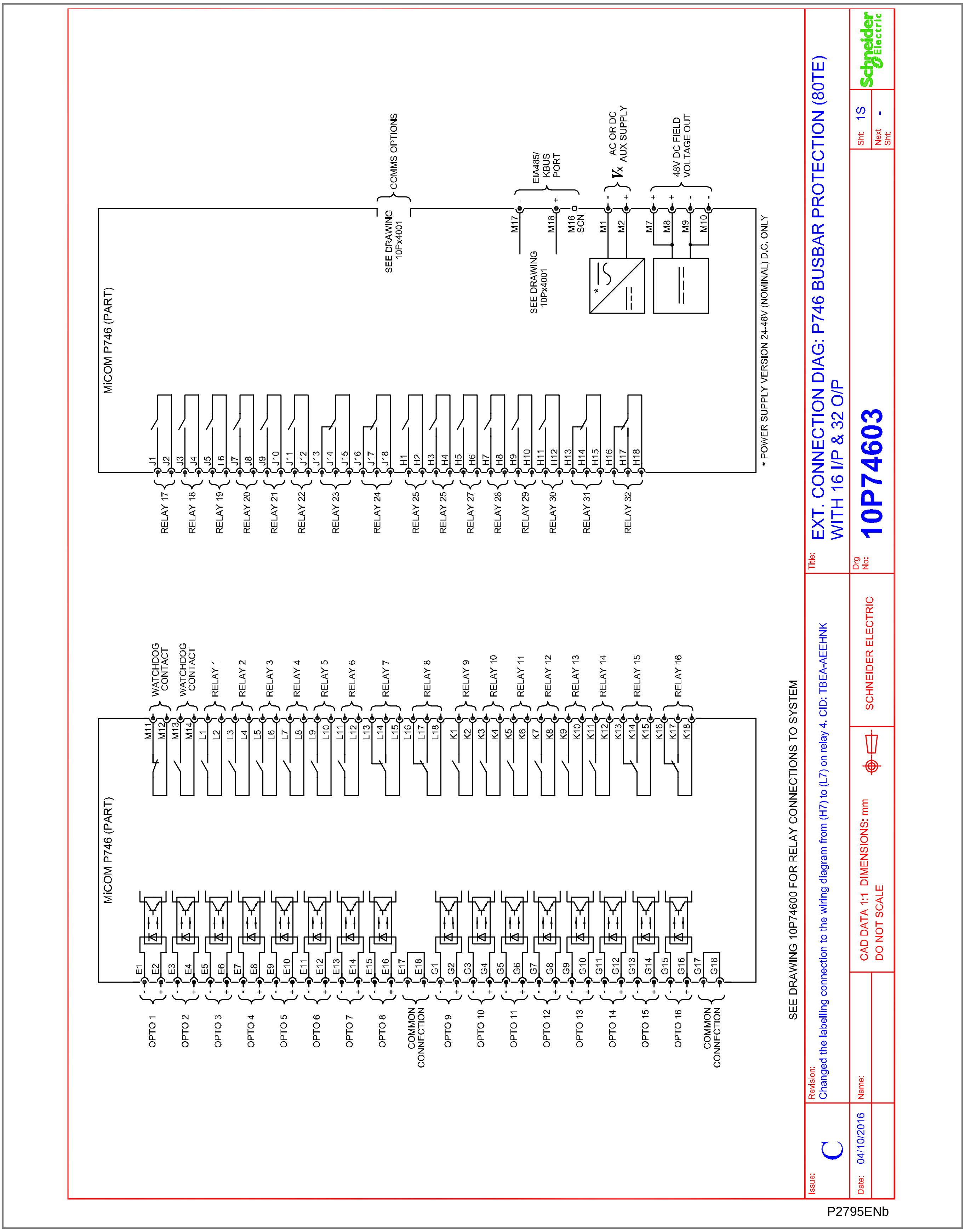


Figure 12 - P746 (80TE) - wiring description (P746xxxC)

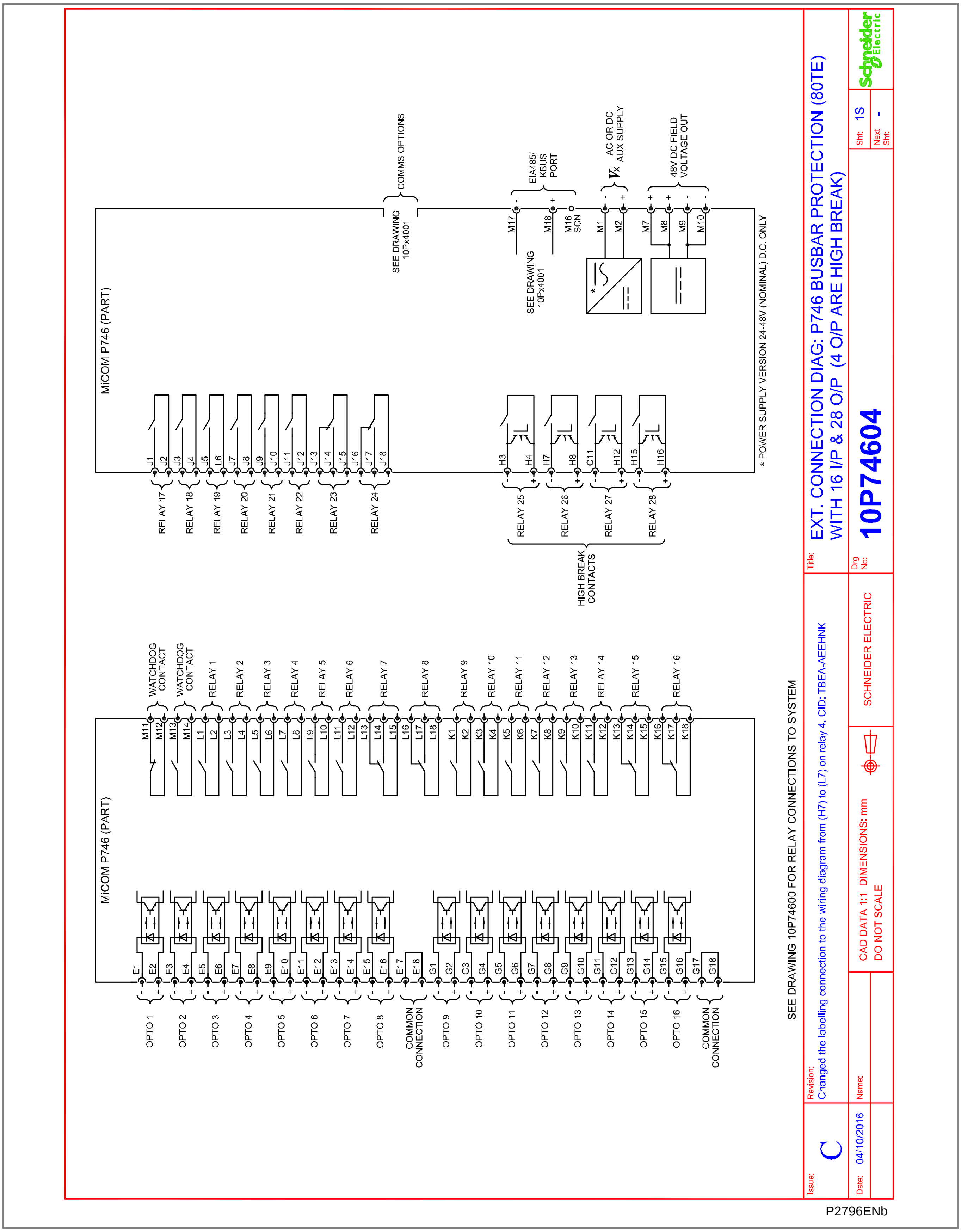


Figure 13 - P746 (80TE) - wiring description (P746xxxD)

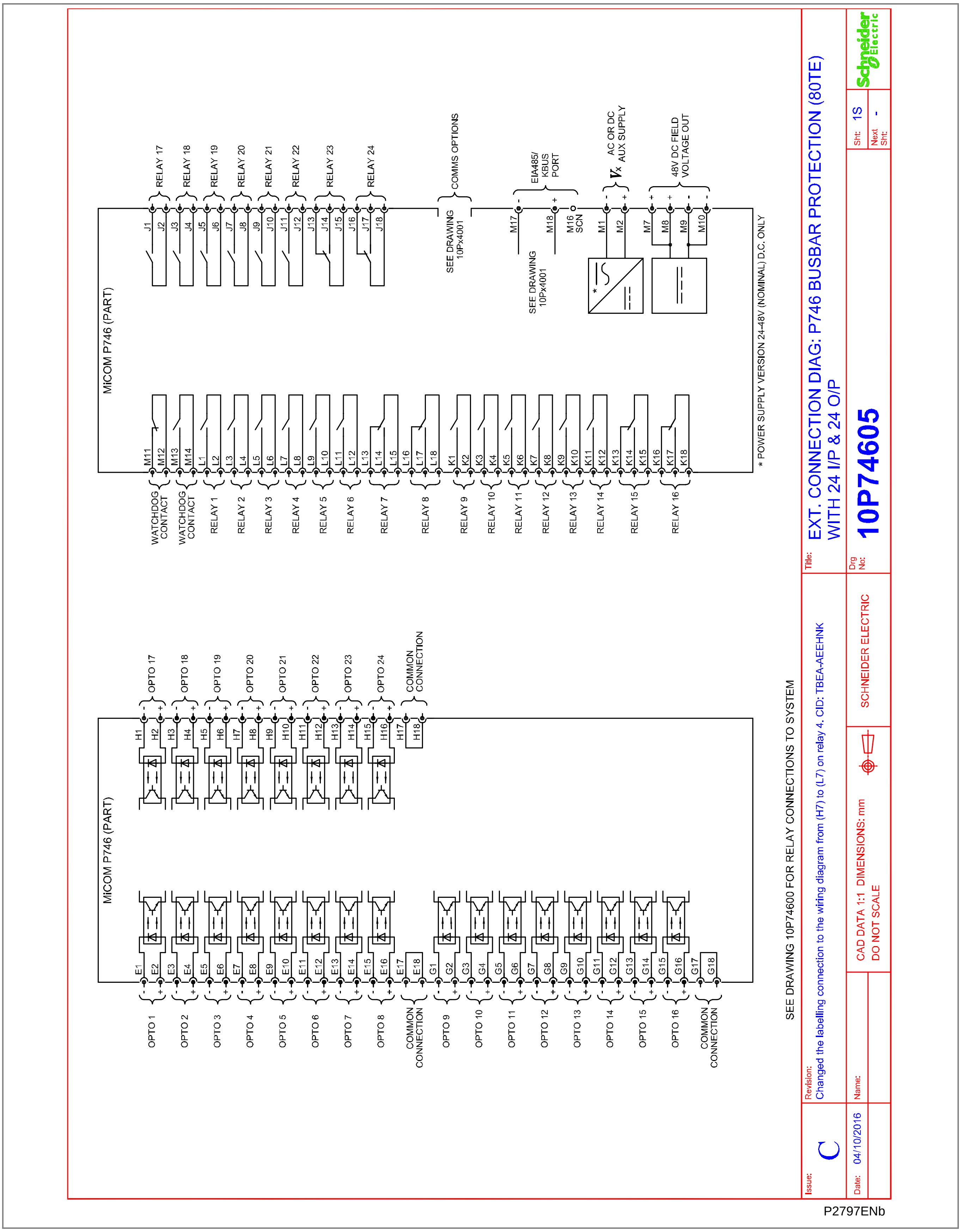


Figure 14 - P746 (80TE) - wiring description (P746xxxE)

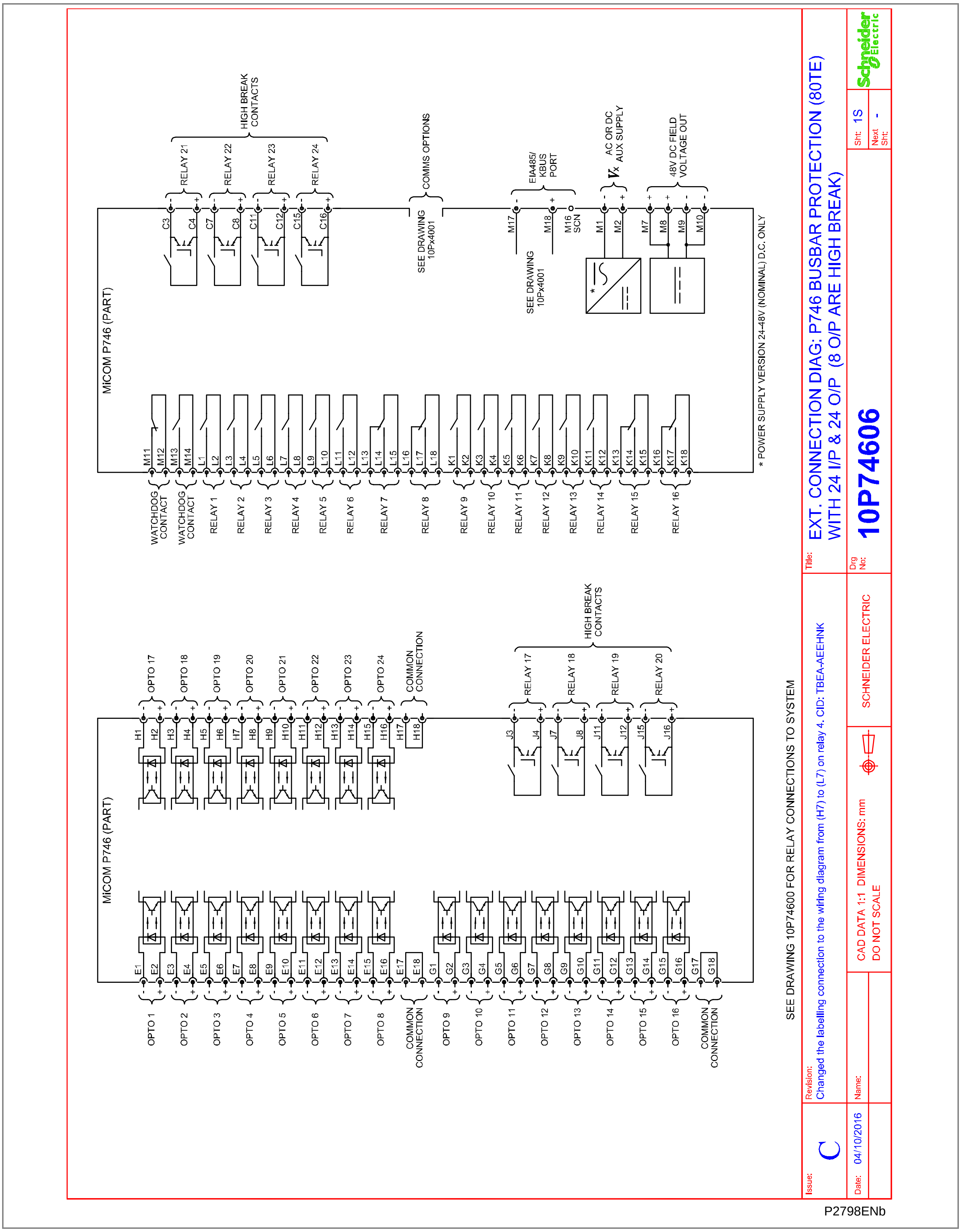


Figure 15 - P746 (80TE) - wiring description (P746xxxF)

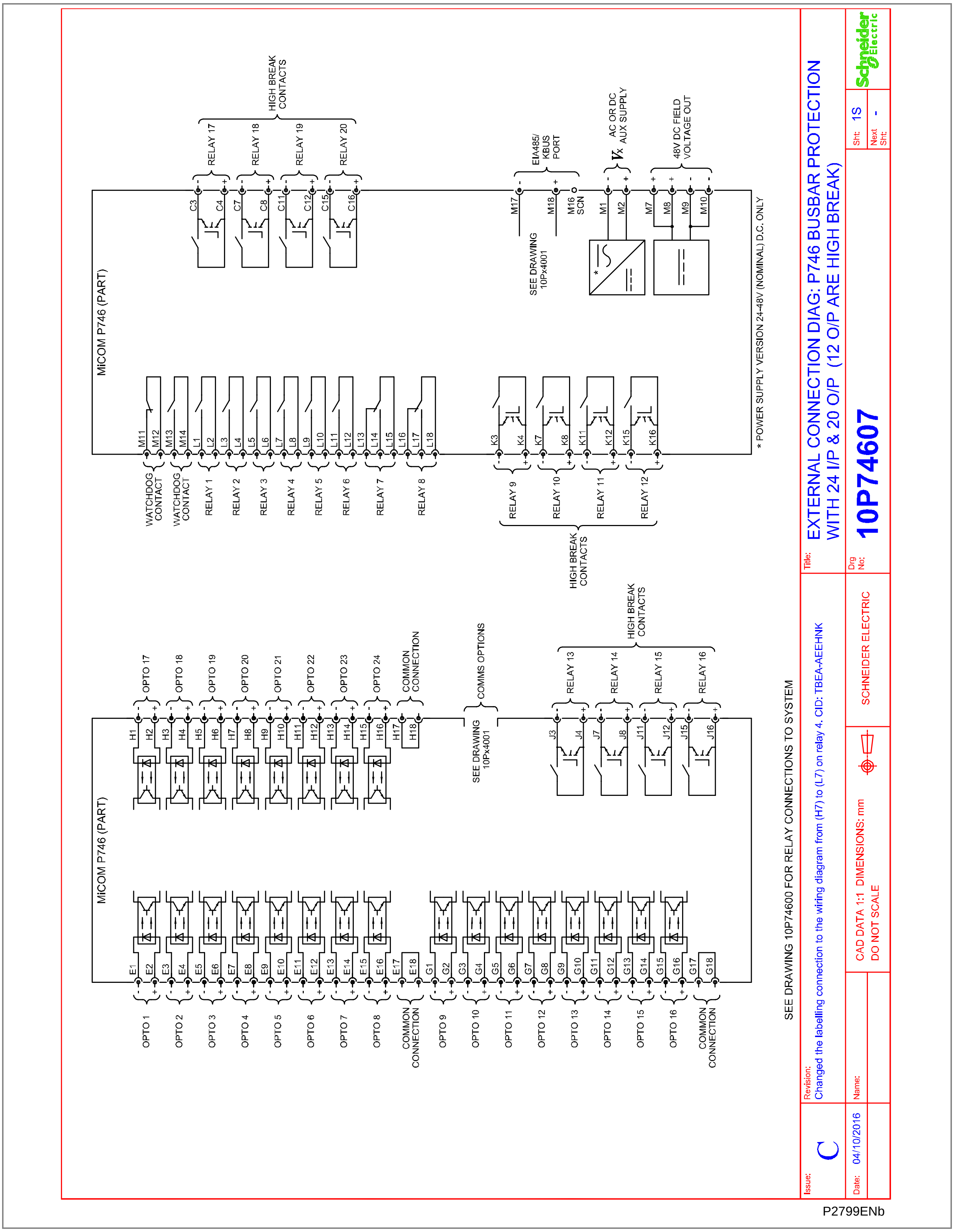


Figure 16 - P746 (80TE) - wiring description (P746xxxG)

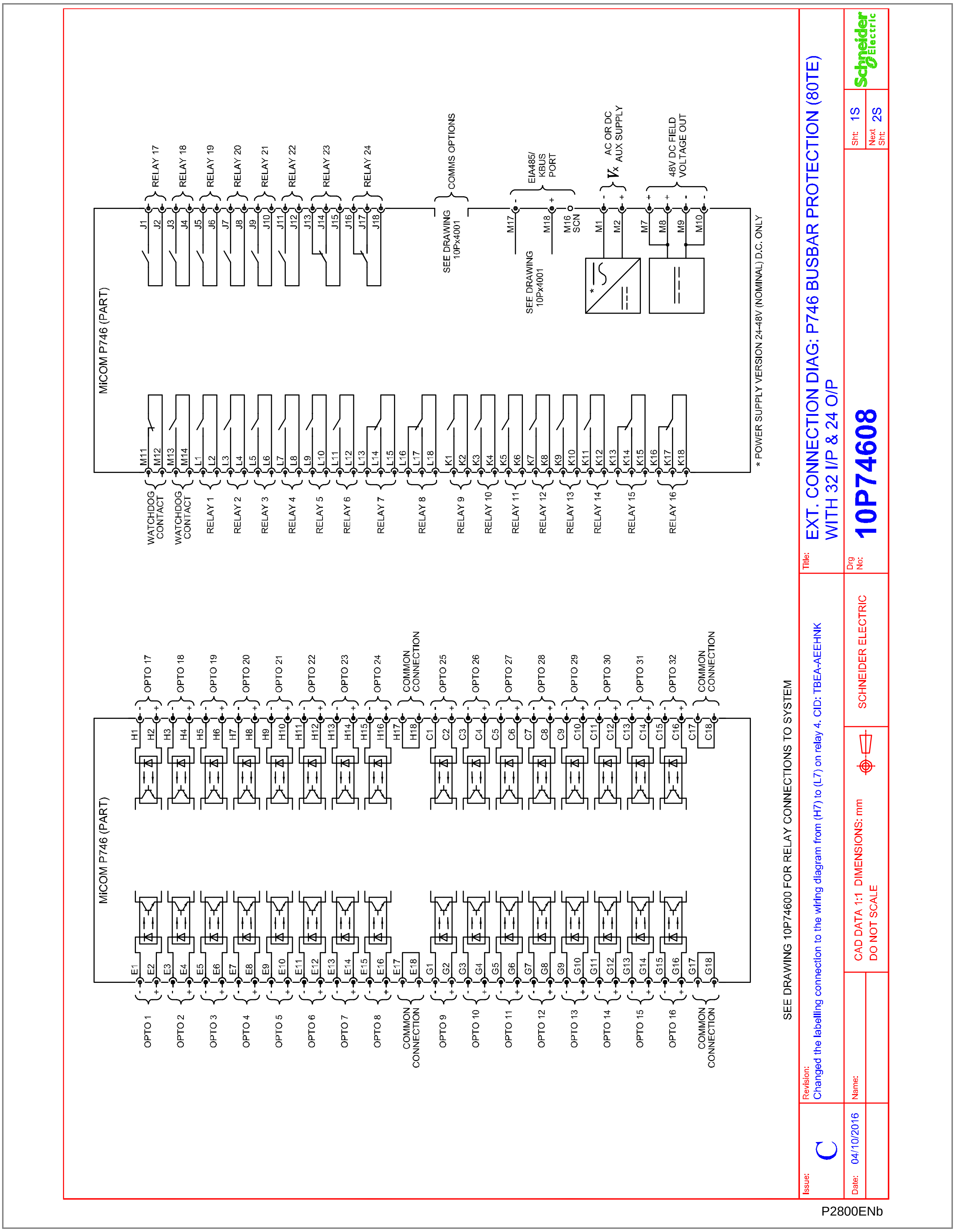


Figure 17 - P746 (80TE) - wiring description (P746xxxH)

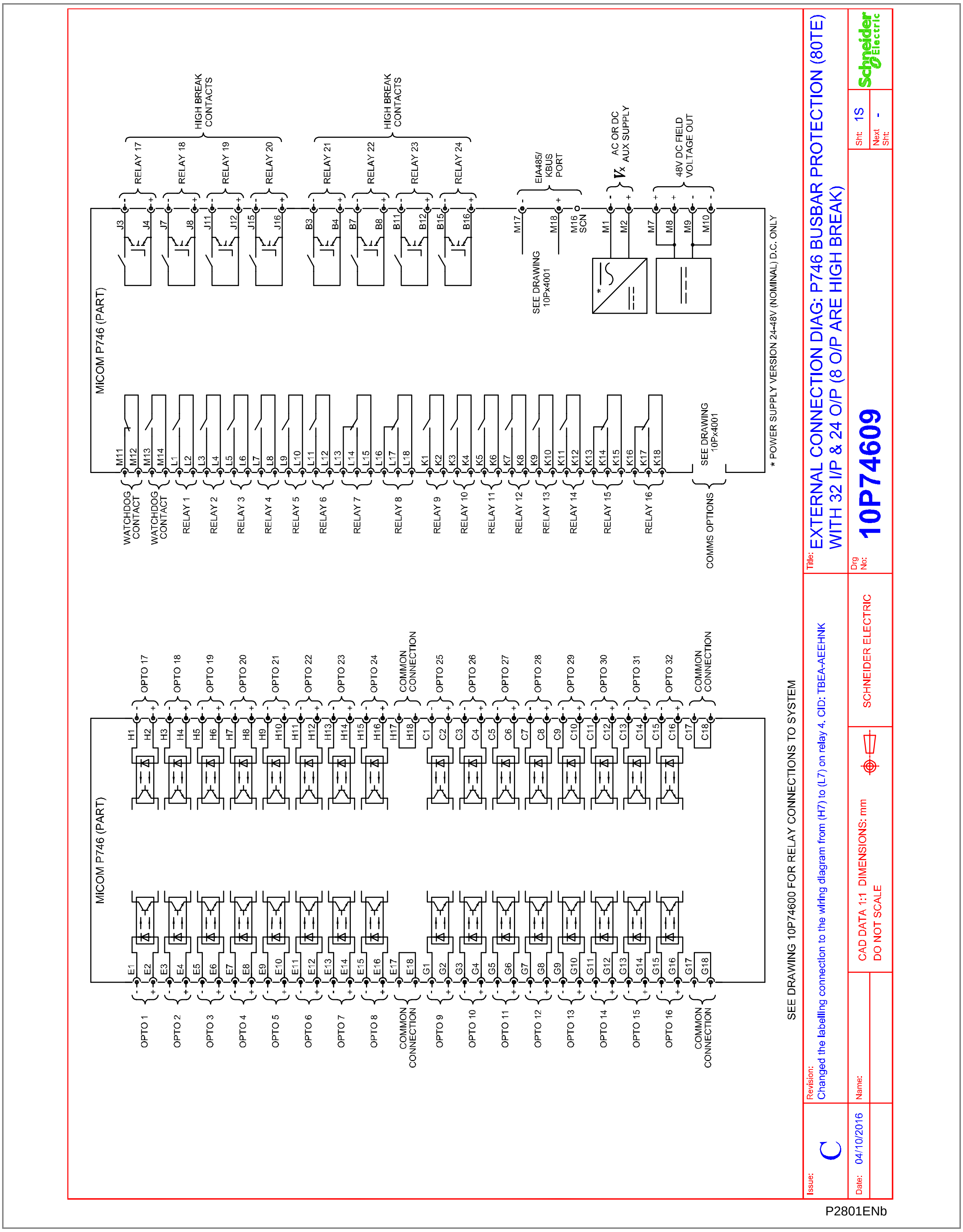


Figure 18 - P746 (80TE) - wiring description (P746xxxJ)

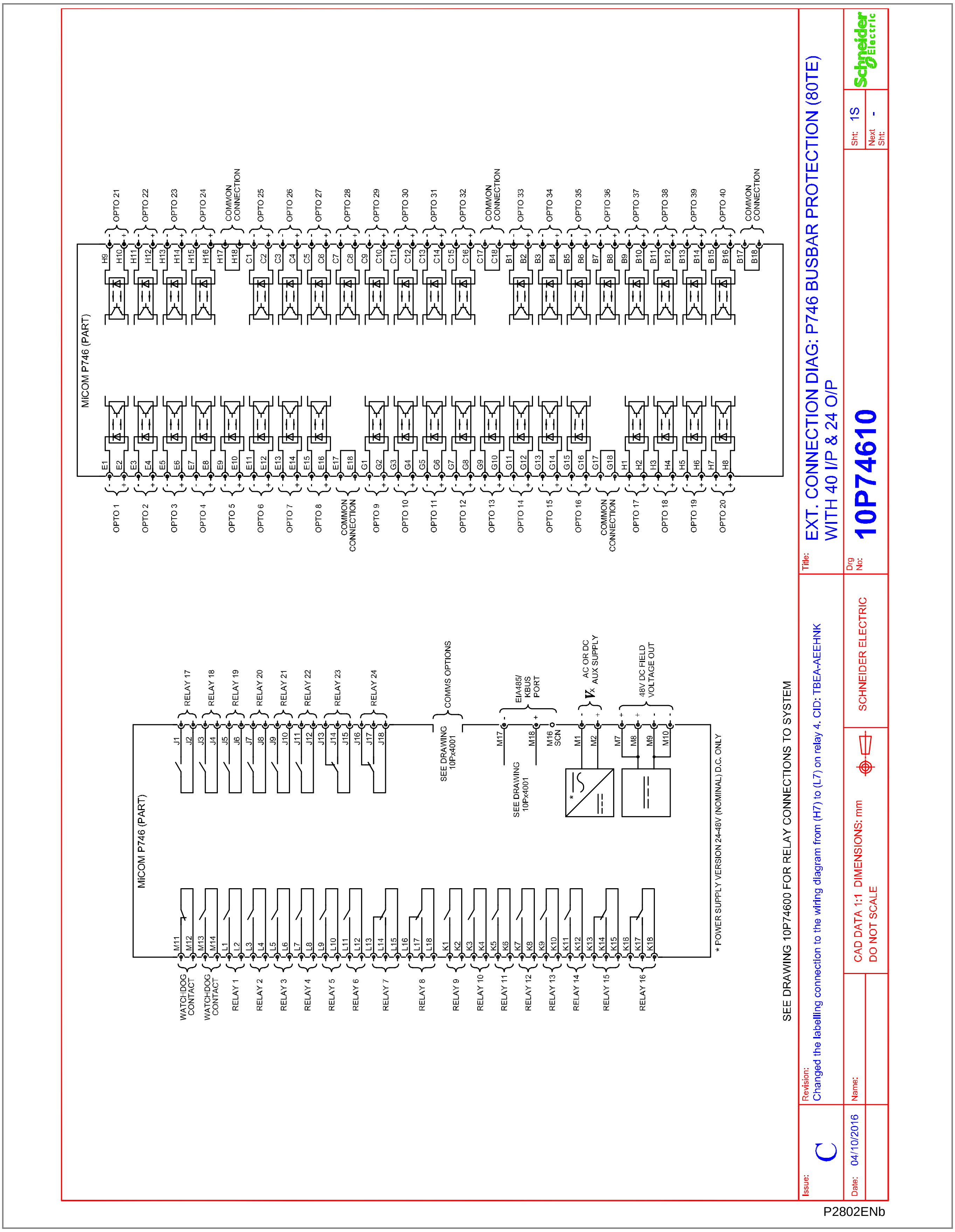


Figure 19 - P746 (80TE) - wiring description (P746xxxK)

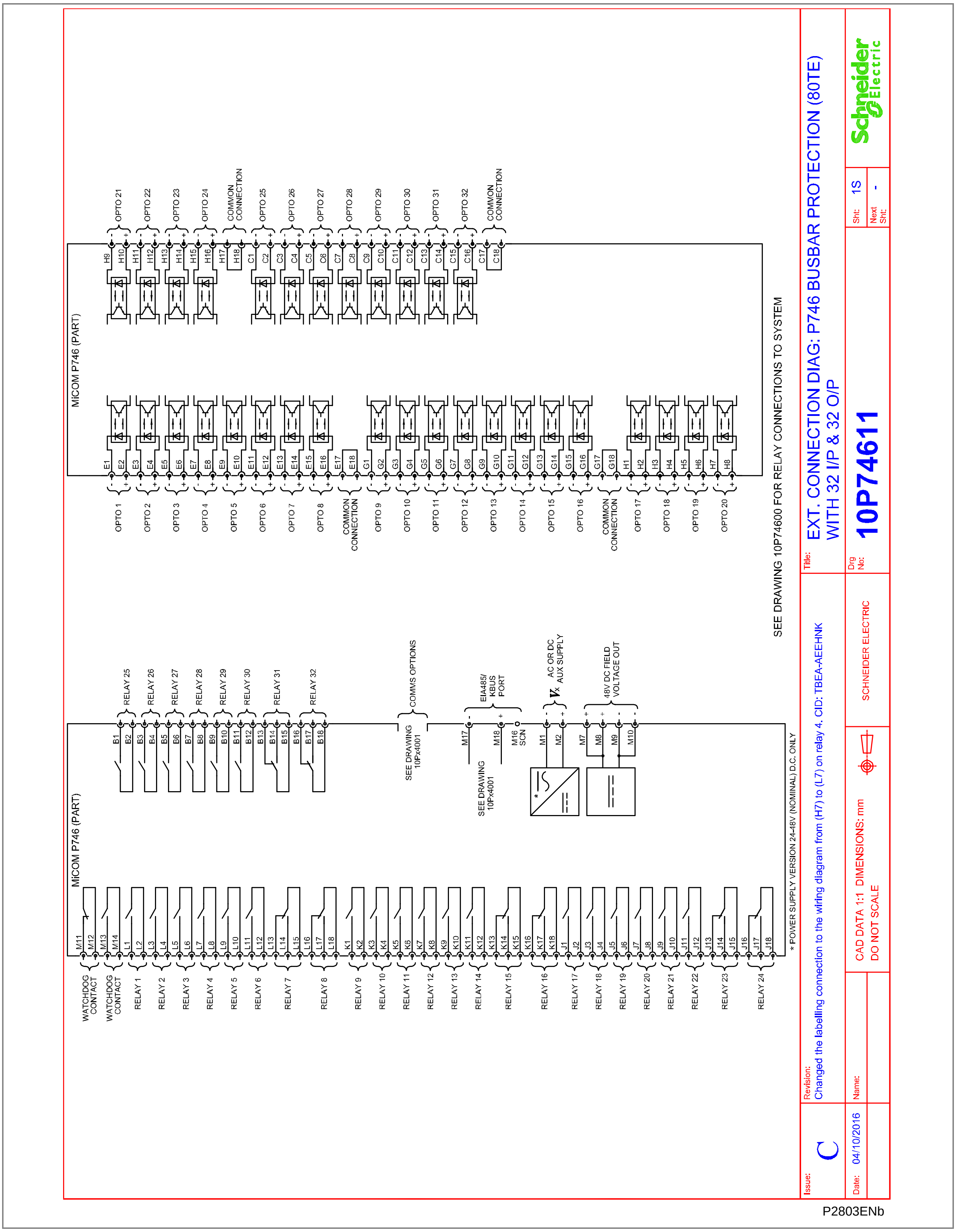


Figure 20 - P746 (80TE) - wiring description (P746xxxL)

CYBER SECURITY

CHAPTER 18

Date (month/year):	01/2017	
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.	
Hardware Suffix:	P141/P142/P143 L P145 M P445 L P44x (P442/P444) M P44y (P443/P446) M	P54x (P543/P544/P545/P546) M P642 L P643/P645 M P746 M P841A (one circuit breaker) M P841B (two circuit breakers) M P849 M
Software Version:	P14x (P141/P142/P143/P145) B2 P445 J4/J6 P44x (P442/P444) E1 P44y (P443/P446) H4	P54x (P543/P544/P545/P546) H4 P64x (P642/P643/P645) B2 P746 B3/C3 P841A (one circuit breaker) G4 P841B (two circuit breakers) H4 P849 B1
Connection Diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P445: 10P445xx (xx = 01 to 04) P44x (P442 & P444): 10P44101 (SH 1 & 2) 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)	P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P64x (P642, P643 & P645): 10P642xx (xx = 1 to 10) 10P643xx (xx = 1 to 6) 10P645xx (xx = 1 to 9) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)
	Note *This chapter covers the combinations of Products, Software Versions and Hardware Suffixes identified here. If you are using earlier software or hardware, please refer to the Schneider Electric Customer Care Centre (www.schneider-electric.com/ccc) for details of which version of this chapter to refer to.*	

CONTENTS

Page (CS) 18-

TABLES

FIGURES

1 OVERVIEW

1.1 Definition

Cyber security is a domain that addresses attacks on or by computer systems and through computer networks that can result in accidental or intentional disruptions. Cyber security addresses not only deliberate attacks, such as from disgruntled employees, industrial espionage, and terrorists, but also inadvertent compromises of the information infrastructure due to user errors, equipment failures, and natural disasters.

1.2 Introduction to Cyber Security

The objective of cyber security is to provide increased levels of protection for information and physical assets from theft, corruption, misuse, or accidents while maintaining access for their intended users.

To achieve this objective the owner of the grid must take into account Cyber Security at every level of his organization by the management of an ongoing process that encompasses procedures, policies, technical (software, and hardware asset) and regulatory constraints.

The following diagram outlines some of the associated topics.

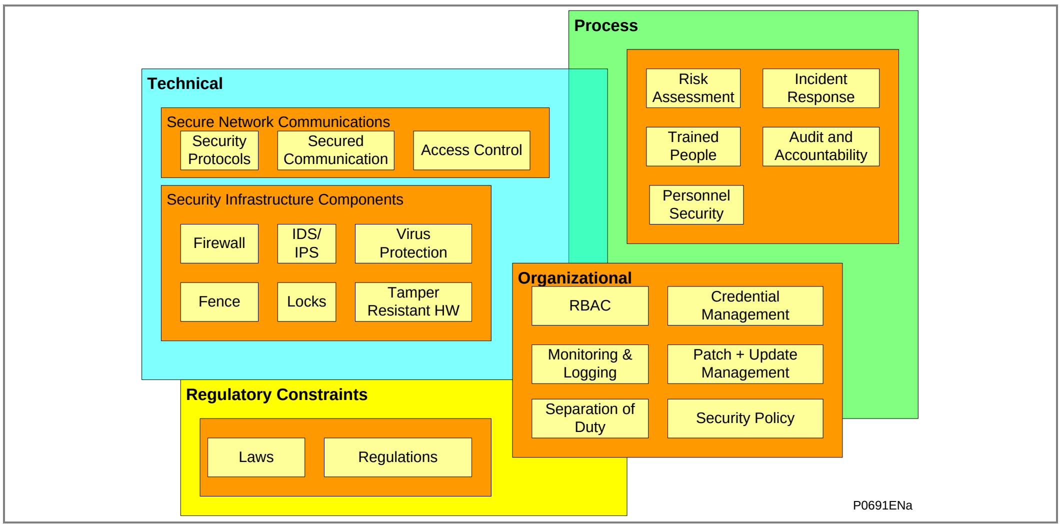


Figure 1 – Associated topics

The asset owner needs to run a continuous improvement process as outlined here:

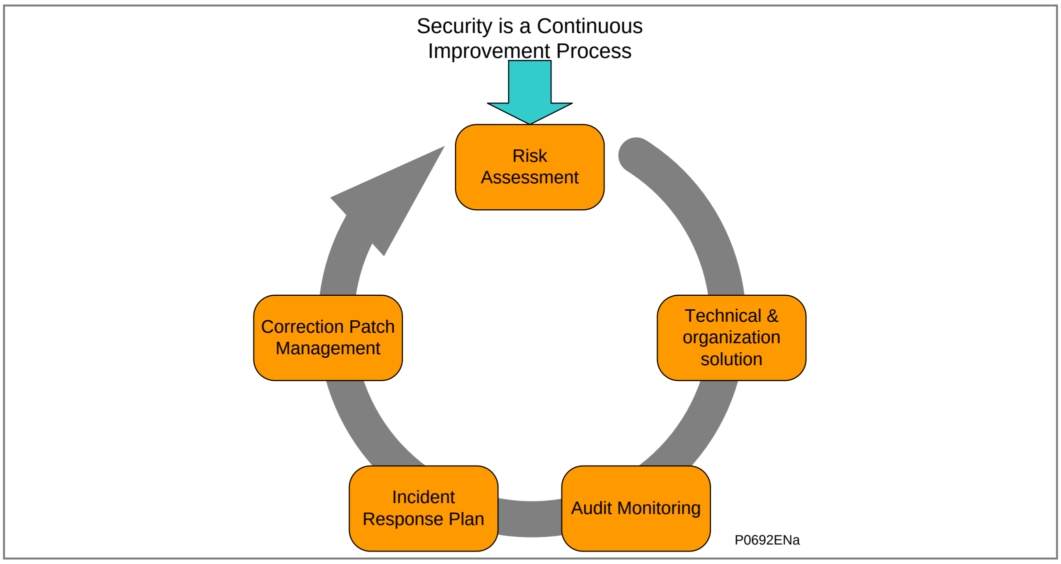


Figure 2 – Continuous improvement process

No single solution can provide adequate protection against all cyber attacks on the control network. Schneider Electric recommends employing a "defense in depth" approach using multiple security techniques to help mitigate risk.

A secured system is to offer:

- Detective controls: Monitor and record specific types of events: Security logs, Intrusion, detection systems, Video Surveillance etc.
- Preventive controls: Help blocking or controlling specific event : Antivirus, White listing, Firewall etc.
- Recovery controls: Help achieve Business continuity and Disaster recovery planning objectives in case of an incident: Backup and Restore solution.

As protective relay vendor, Schneider Electric helps the grid owner to achieve by providing technical features inside the IED, described in the next chapters.

Important	**This product contains a cyber-security function, which manages the encryption of the data exchanged through some of the communication channels. The aim is to protect the data (configuration and process data) from any corruption, malice, attack. Subsequently, this product might be subject to control from customs authorities. It might be necessary to request special authorization from these customs authorities before any export/import operation. For any technical question relating to the characteristics of this encryption please contact your Customer Care Centre - www.schneider-electric.com/ccc.**

1.3 Roles, Rights and relationship between IEC62351 and MiCOM Px4x

1.3.1 Role Based Access Control (RBAC)

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

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

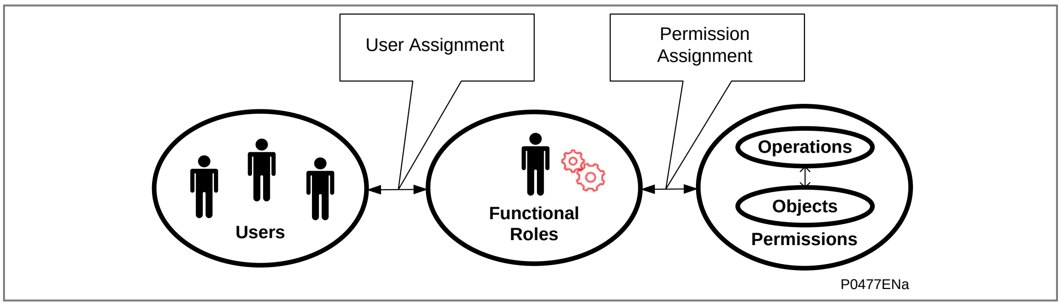


Figure 3 - RBAC Role structure

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

RBAC defines four different concepts:

RBAC Standard Definition	Description
Object	An ***object*** can represent information containers (e.g. files, directories in an operating system, tables and views in a database management system) or device resources, such as IEDs.
Subject	A ***subject*** is a user of the system. Note that a subject can be a person, or an automated agent / device.
Right	A ***right*** is the ability to access an object in order to perform certain operations (e.g. setting a data or reading a file)
Role	A ***role*** defines a certain authority level in the system. Rights are assigned to roles.

Table 1 – RBAC object, subject, rights and roles definitions

RBAC defines three primary rules:

RBAC Rule	Description
Role assignment	A subject can exercise a permission only if the subject has selected or been assigned a role.
Role authorization	A subject's active role must be authorized for the subject. With rule 1 above, this rule ensures that users can take on only roles for which they are authorized.
Permission authorization	A subject can exercise permission only if the permission is authorized for the subject's active role. With rules 1 and 2, this rule ensures that users can exercise only permissions for which they are authorized.

Table 2 – RBAC permission and authorization rules

1.3.2 User Roles

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

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

The default user roles for MiCOM Px4x are shown here:

Role	Description
VIEWER	Can View what objects are present within a Logical-Device by presenting the type ID of those objects.
OPERATOR	An Operator can view what objects and values are present within a Logical-Device by presenting the type ID of those objects as well as perform control actions.
ENGINEER	An Engineer can view what objects and values are present within a Logical-Device by presenting the type ID of those objects. Moreover, an engineer has full access to Datasets and Files and can configure the server locally or remotely.
SECADM	Security Administrator can change subject-to-role assignments (outside the device) and role-to-right assignment (inside the device) and security policy setting; change security setting such as certificates for subject authentication and access token verification.
SECAUD	Security Auditor can view audit logs

Table 3 – Default user roles summary for MiCOM Px4x

Each authorized user must be placed into at least ONE of these roles that most suits their job description. It is possible to assign a user into a different role; and/or to change the rights associated with a particular role. This means that the administrator can change the access rights for one role; and this will affect ALL the users who are assigned to that role.

It is possible for MiCOM Px4x to create the customized user roles.

1.3.3 Rights

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

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

A list of the pre-defined Rights for IEC 62351-8 is given here:

Right	Description
VIEW	Allows the subject/role to discover what objects are present within a Logical-Device by presenting the type ID of those objects. If this right is not granted to a subject/role, the Logical-Device for which the View right has not been granted shall not appear
READ	Allows the subject/role to obtain all or some of the values in addition to the type and ID of objects that are present within a Logical-Device;
DATASET	Allows the subject/role to have full management rights for both permanent and non-permanent Datasets;
REPORTING	Allows a subject/role to use buffered reporting as well as un-buffered reporting;
FILEREAD	Allows the subject/role to have read rights for file objects;
FILEWRITE	Allows the subject/role to have write rights for file objects. This right includes the FILEREAD right
CONTROL	Allows a subject to perform control operations;
CONFIG	Allows a subject to locally or remotely configure certain aspects of the server;
SETTINGGROUP	Allows a subject to remotely configure Settings Groups;
FILEMNGT	Allows the role to transfer files to the Logical-Device, as well as delete existing files on the Logical-Device;
SECURITY	Allows a subject/role to perform security functions at both a Server/Service Access Point and Logical-Device basis. To add Information about the concept of Rights.

Table 4 – Pre-defined rights for IEC 62351-8

The specific Rights for MiCOM Px4x are listed below. These are dependent on the IED data type. Please refer to each product MD file (Menu Database) for the IED data type.

Rights	Authorized Actions to IED	IED_DESC	IED_DATA	DISPLAY	IED_CONFIG	PROT_CONFIG	IEC_COMMAND	AUDIT	IED_FN_KEY	IED_CLEAR
Read Only (SAT default_access_right)	Read	x	x	x	x		x			
	Write	x								
IED Configuration (SAT configuration_right)	Read/write/upload/download				x					
HMI Display Settings (SAT display_action_right)	Read/write/select			x						
Protection Configuration (SAT protection_configuration_right)	Read/write					x				
IED Commands (SAT control_right)	Read/write/clear/reset/select						x			
Reading of Records & Events (SAT audit_read_right)	Read/select/upload							x		
Extraction of Records and Events (SAT audit_write_right)	Send/accept							x		
IED Function Key (SAT fn_key_access_right)	Write								x	
IED Records Clear (SAT clear_right)	Read/write/clear									x

Table 5 – Specific rights for MiCOM Px4x

1.3.4 Roles and their Access Rights

A complete list of the Roles and their access Rights is shown in this table:

Rights \ Roles		VIEWER	OPERATOR	ENGINEER	SECADM	SECAUD
Pre-defined Rights for IEC 62351	VIEW	X	X	X	X	X
	READ		X	X	X	X
	DATASET			X		
	REPORTING	X	X	X		X
	FILEREAD					X
	FILEWRITE			X	X	
	FILEMNGT			X	X	
	CONTROL		X		X	
	CONFIG			X	X	
	SETTINGGROUP				X	
	LOGS				X	X
	SECURITY				X	
Specific Rights for MiCOM Px4x	Read Only	X	X	X		X
	IED Configuration			X		
	HMI Display Settings		X	X		
	Protection Configuration			X		
	IED Commands		X	X		
	Reading of Records and Events	X	X	X		X
	Extraction of Records and Events		X	X		X
	IED Function Key		X	X		
	IED Clear			X		

Table 6 – Pre-defined roles (and rights) for IEC 62351-8 and MiCOM Px4x

Important	**The reason why these are described as Default, is that it is possible to change the definitions of Roles and Rights, using the full version of the SAT software. Depending on the work done by the system administrator, it is possible that your own situation may vary from these initial recommendations.**

1.4 Security Administration Tool (SAT) Software

Important	**This can only be used with Px4x relays with cyber security CSL1 features.**

Important	**For Dual Ethernet cards the SAT functionality is available from communication interface 1. The connection to the SAT would be available from interface 2 only when interface 1 is disconnected from the network.**

The Security Administration Tool (SAT) is the security configuration tool of MiCOM Px4x equipment. It allows the security administrator to define the security policy to the IEDs.

The Security Administrator manages RBAC and security policies data. Security Administrator defines needs to protect devices in accordance with user privileges. Thus, the system security can be configured easily and precisely.

The SAT is used by the Security Administrator to manage the system's security database and deploys security configurations to IED(s).

The SAT allows to Manage User Accounts, Roles, Permission, Elements to Secure (ETS) and Security Server parameters without connection with devices. Information is store on the MS SQL database. This is the Offline mode. SAT allows devices management connected on network. This is the online mode.

The Role Based Access Control (RBAC) is a method to restrict resource access to authorized users. Please refer to this documentation on section "*System RBAC Management*" for more details.

The following table contains the main user main functions of the SAT:

Category	User Function	Note
Offline General Administration	User Accounts Management	User Account Functions: * Creation * Edition * Suppress * Viewing * Sorting * Filtering
	Server Configuration	
	Users Accounts & Roles association Management	Associate a role to the user account
Offline Advanced Administration	Roles Management	Roles Functions: * Creation * Edition * Suppress * Viewing * Sorting
	Element To Secure (ETS) Management	Define ETS which are in fact the PACiS assets present in the project (C264, PACiS Gateway, ECOSUI, IED and SAM). Add, Suppress and Sort permissions associated with the ETS.
	Global Security Management	The Global Security allows scope(s) and associate or disassociate role(s) management for each user account. The security administrator manages the current scope by the Roles: * View Roles List, User Account List and associations User-Roles or Role-Users * Associate / dissociate role(s) for each User Account * Add / Suppress User account(s) for each Role
	Permission access	Define parameters: * Password validity * Inactivity period * Automatic logout period * Maximum attempts of login and lockout period
Communication	Refresh IED list	
	Display IED Logs	
	Display SAM Logs	
	Push RBAC and Security Policies	Send Security Configuration to all Devices integrating Security features.

Table 7 – Main SAT user functions

The details of how to use the SAT are provided in the SAT documentation:

SAT (Security Administration Tool) Documentation - User Guide

This is available from the Schneider Electric website: www.schneider-electric.com.

2 MICOM PX4X CYBER SECURITY IMPLEMENTATION

Schneider Electric MiCOM Px4x IEDs have always been and will continue to be equipped with state-of-the-art security measures. Due to the ever-evolving communication technology and new threats to security, this requirement is not static. Hardware and software security measures are continuously being developed and implemented to mitigate the associated threats and risks.

Considered some users may not want to use the cyber security, Schneider Electric offers MiCOM Px4x relays with CSL0 and CSL1 as below:

CSL0: Simple password management, No SAT required.

CSL1: Advanced cyber security, SAT required.

This depends on the model number, as CSL1 is depend on the Ethernet communication. Hence if the IED if supports only legacy protocol this will be CLS0 default as. The digit position number 9 (protocol options) in the Cortec / model number is used to distinguish it.

Protocol Option Number	Protocol options	Cyber Security options
1	K-Bus/Courier	CSL0
2	Modbus	CSL0
3	IEC 60870 -5 - 103	CSL0
4	DNP3.0	CSL0
6	IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485	CSL0
7	IEC 61850 Edition 1 / 2 and CS103 via rear port RS485	CSL0
B	IEC 61850 Edition 1 / 2 and DNP3oE and DNP Serial	CSL0
G	IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485	CSL1
H	IEC 61850 Edition 1 / 2 and CS103 via rear port RS485	CSL1
L	IEC 61850 Edition 1 / 2 and DNP3oE and DNP3 serial	CSL1

Table 8 – MiCOM Px4x protocol options for cyber security options

2.1 MiCOM Px4x with CSL1 - Advanced Cyber Security

For MiCOM Px4x IEDs which support CSL1, this means the IED supports advanced user account right management. Moreover, the IED supports security logs/events and secure administration capability.

If you want to use cyber security, you need to order the IED that supports CSL1. In this case, the Security Administration Tool (SAT) is required for RBAC configuration.

At the IED level, these cyber security features have been implemented:

- Passwords management (via the SAT)
- RBAC Management (via the SAT)
- User Locking
- Inactivity Timer
- RBAC recovery
- Port Disablement (via S1 Studio or the front panel)
- Simple Network Management Protocol (SNMP)
- Security Logs

2.1.1 Password Management (via the SAT)

For the IED if CSL1 supported, there are two types of password possible for the IED access: alphanumeric password or Arrow Key password.

The alphanumeric password is only settable via the SAT:

- Passwords may be any length between 1 and 32 characters long
- Passwords may contain any ASCII character in the range ASCII code 33 (21 Hex) to ASCII code 122 (7A Hex) inclusive
- Passwords may or may not be NERC/IEEE 1686 compliant
- The alphanumeric password will used for courier client access

For more details about NERC/IEEE 1686 password compliant, please check the standard.

The Arrow Key password is only settable via the SAT:

- The Arrow Key password is a combination of the four arrow keys on the front panel
- The Arrow Key password may be any length between 1 and 8 of arrow keys long
- The Arrow Key password can only used in the front panel
- The user also can disable the Arrow Key password by not setting it

Important	**If the Arrow Key password is not configured, the alphanumeric password will be used for the front panel access. In this case, alphanumeric passwords longer than 16 characters are not allowed.** **MiCOM S1 Studio and the front panel are not allowed to change the password.**

2.1.2 RBAC Management (via the SAT)

By default, the IED includes a factory RBAC which has three users, and for each user, the Rights depend on the user Role. Please refer to the *Roles and their Access Rights* section for more details.

Username	Role	Default password
SecurityAdmin	SECADM	AAAAAAAA
EngineerLevel	ENGINEER	AAAA
OperatorLevel	OPERATOR	AAAA

Table 9 – Factory RBAC

A Local Default Access function also available for the default RBAC, with the VIEWER role, which allows everyone login the IED in the front panel with VIEWER role. For more details about the Local Default Access function, please refer to the *Local Default Access* section.

For more information about how the SAT management the RBAC and cyber security policies, please see the *Security Administration Tool (SAT)* section.

2.1.3 User Locking

The user is locked out temporarily, after a defined number of failed password entry attempts.

Important	If a user is locked out, the block is applied to that named user and to the all IED interfaces. The blocking of one user, does not apply blocks to others. If the user entry is blocked, recover the RBAC or push a new RBAC will not reset the blocked user entry, but IED reboot will reset the blocking time and attempts count, so the user entry will be unblocked.

An invalid password entry will display a 'Login Failed PW Incorrect' message for 2s. It also reduces the Attempts Remaining Counter (Attempts Remain) by 1 and it remains at this level until the interface inactivity timer expires (CSL0 models) or until the Password Attempts Timer configured in SAT expires (CSL1 models) or another password entry is made. If Attempts Remain equals 1 then a '1 Attempt Left' warning will also be issued for 2s. When Attempts Remain equals 0 then a 'USER LOCKED OUT' warning is displayed for 2s and access for that user is blocked. If the Blocking Timer expires, or the correct password is entered before Attempts Remain reaches zero, then the Attempts Remain is reset to the Attempts Limit.

Once the user entry is blocked, the Blocking Timer is initiated. If the locked out user is selected whilst the Attempts Remain is zero a 'USER LOCKED OUT' error message is displayed.

2.1.4 Inactivity Timer

The MiCOM device runs an inactivity timer, which means that it records the last time an action was taken by a user who was logged in.

If the user does not perform an action within a pre-defined interval, the user will be logged off. This is to reduce the risk that a device can accidentally be left open to access by unauthorized people.

The inactivity timer is separate for each interface.

The inactivity timer is configurable by using the SAT.

Important	In case of a connection through an Ethernet interface, the actual inactive time depends on the setting value of both "Minimum inactivity period" & "[0E A7] ETH Tunl Timeout", the smaller value of both timers will be applied.

Refer to the Table 12 for more details about the settings.

2.1.5 RBAC Recovery

RBAC recovery is the means by which the device can be reset to the factory RBAC settings if required. To obtain the recovery password, the customer must go to www.schneider-electric.com/ccc to raise a recovery password request and supply the IED *Security Code*.

Caution	**The "recovery" password gives you access to the Factory RBAC Configuration. This action deletes all existing users (and their passwords), and restores to Factory RBAC Configuration. Recover the RBAC does not affect relay proper settings and does not provoke reboot of the relay - the protection functions of the relay are always maintained.**

2.1.5.1 Generate Security Code

The security code is a 16-character ASCII string. It is a read-only parameter. The IED generates its own random security code. This is when a new code is generated:

- On power up
- On expiry of validity timer (see below)
- When the recovery password is entered

As soon as the security code is ***first*** displayed on the LCD display, a validity timer is started. This validity timer is set to 120 hours and is not configurable. The validity timer is not reset if you request a subsequent code within the 120 hour period.

To prevent accidental reading of the IED security code the cell will initially display a warning message on the front panel of the IED:

```
PRESS ENTER TO
READ SEC. CODE
```

The security code will be displayed on confirmation, whereupon the validity timer will be started. Note that the security code can only be read from the front panel.

Important	**The recover password will be invalid once the new Security Code is generated, so please make sure the IED is always powered on before you get the reover password, and make sure you input the recover password within 120 hours.**

2.1.5.2 Entry of the Recovery Password

The "recovery" password is intended for recovery only. It is not a replacement password that can be used continually. It can only be used once – for password recovery.

Entry of the recovery password is done at the local front panel and it causes the IED to reset the RBAC back to default.

On this action, the following message is displayed on the front panel of the IED:

```
RBAC reset done
Press any key
```

2.1.6 Port Disabling (Equipment Hardening)

The availability of unused ports could provide a security risk. Hence, unused ports can be disabled (also known as equipment hardening) – either via the front panel or by MiCOM S1 Studio. An Engineer role is needed to perform this action.

These physical ports and logical ports can be enabled/disabled:

Port types	Menu text	Col	Row	Default Setting	Available Value
Physical Ports	Front port	25	05	Enable	Enable/Disable
	Rear Port 1	25	06	Enable	Enable/Disable
	Rear Port 2	25	07	Enable	Enable/Disable
	Ethernet Port 1	25	08	Enable	Enable/Disable
	Ethernet Port 1/2	25	09	Enable	Enable/Disable
	Ethernet Port 2/3	25	0A	Enable	Enable/Disable
	Ethernet Port 3	25	0B	Enable	Enable/Disable
Logical Ports	Courier Tunnel	25	0C	Enable	Enable/Disable
	IEC61850	25	0D	Enable	Enable/Disable
	DNP3oE	25	0E	Enable	Enable/Disable

Table 10 - Port hardening settings

Note	*The port disabling setting cells are not provided in the settings file. In addition, it is not possible to disable simultaneously more than one physical port or Logical port.* *New redundant Ethernet boards have three physical ports but total two interfaces. The actual disabled physical port is depended on the redundant communication mode (PRP, HSR or Dual IP). Refer to the Dual Redundant Ethernet Board (Upgrade) (DREB) chapter (Px4x/EN EB) for more details.*

When the Ethernet board related physical ports or logical ports are disabled or enabled, the Ethernet card will reboot. The status of the ports will be available after reboot of the Ethernet board.

For more details about how to disable/enable the unused ports, please see sections:

- How to Disable a Physical Port
- How to Disable a Logical Port

2.1.7 Simple Network Management Protocol (SNMP)

Simple Network Management Protocol (SNMP) allows security monitoring of events and alarms. Standard third-party SNMP client software can be used to access the log of these events and alarms. Access to the SNMP MIB is given on a read-only basis. For further details of gaining access to the MIB, please contact Schneider Electric.

2.1.8 Security Logs

The Security Logs needs to store logs from each item of equipment. These logs are generated by the system, and cannot be edited by the user. A variety of different items are recorded, including: bad/faulty access attempts, login attempts, authentication errors, changes to roles, users and access control lists, network backup and configuration changes, communication failures and so on.

Security logs emissions depend on the security standards that are configurable by the SAT.

The security logs will push to a Syslog server if the Syslog server IP address and Syslog server IP port are configured and connected.

SAT also can be used to explore the security logs but MiCOM S1 studio is not supported.

The settings for the security log standards and Syslog server IP address and ports are listed in the *Configurable cyber security settings* table. For more detail about the security log configuration, please refer to the SAT documentation.

Note	*The Security logs time stamp may be time shifted by several milliseconds compared with local event log.* *The security logs will not be generated if the Ethernet card is starting up.* *If the Syslog server is unavailable, the new logs will be stored and overwriting the oldest logs.*

This table lists the security logs categories available for each standard.

Log ID	Additional field	Explanation	Level	Standards					
				BDEW	E3	NERC CIP	IEEE 1686	IEC 62351	CS Phase 1
CONNECTION_SUCCESS	The additional field will contain the issuer of the connection: LOCAL or NETWORK	Successful connection	INFO	x	x	x	x		x
CONNECTION_FAILURE		Failed connection (wrong credentials)	WARNING	x	x	x	x		x
CONNECTION_FAILURE_ AND_BLOCK		Failed connection (wrong credentials) triggering the blocking of the account on the IED	DANGER	x	x	x	x		x
CONNECTION_FAILURE_ ALREADY_BLOCKED		Failed connection because of a blocked userID on this IED	DANGER	x	x	x	x		x
DISCONNECTION		Disconnection triggered by the peer /user	INFO	x	x	x	x		x
DISCONNECTION_TIMEOUT		Disconnection triggered by a timeout	INFO	x	x	x	x		x
CONTROL_OPERATION	Type & Data associated to the control	Trace and control / override of real data from a peer	INFO				x		
CONFIGURATION_ DOWNLOAD	Version	Download of the configuration file from the device - Files include PSL, Courier setting, DNP setting, MCL/CID and user curves (crv)	INFO				x		
CONFIGURATION_UPLOAD	Version	Upload of a new configuration file into the device - Files include PSL, Courier setting, DNP setting, MCL and user curves (crv)	INFO				x		
RBAC_UPDATE	Version	Update of the RBAC cache in the IED	INFO				x		x
SEC_LOGS_RETRIEVAL	Version	Retrieval of the security logs of the IED	INFO				x		
TIME_CHANGE	New & Old time	Modification of the time of the IED	INFO				x		
REBOOT_ORDER	None	Reboot order sent to the IED / IED start up	DANGER				x		x
PORT_MANAGEMENT	Port, action (enable / disable)	Any comms port enabled / disabled	INFO						x
AUTHORIZATION_REQ	Action, object	Any authorization request sent to the CS brick	INFO			x		x	x

Table 11 – Security logs recorded

2.1.9 Common Cyber Security Settings

The System Administrator can customize the cyber security settings at the SAT. The following table shows the common cyber security settings. Parts of settings also are visible on the IED with specific Courier cells but not editable in IED or MiCOM S1 Studio. These are shown in the right hand columns of this table:

Setting in SAT	Default Setting	Available Value	Menu in IED	Col	Row
Minimum inactivity period	15	1 to 99 Minutes	-	-	-
If the user does not perform any action within this interval, the user will be logged off.					
Allow user locking	Yes	Yes/No	-	-	-
Option allows user account locking					
Maximum login attempts	5	1 to 99	Attempts Limit	25	02
The maximum failed password entry attempts, the user will lock once the attempts reached.					
Password attempts timer	3	1 to 30 Minutes	Attempts timer	25	03
The time for reset the attempts count to 0. The user got to maximum login attempts.					
Automatic user account unlocking	Yes	Yes/No	-	-	-
Enable/disable the attempts times aromatic reset function.					
Locking period duration	240	1 to 86400 Seconds	Blocking timer	25	04
The Locking period duration (seconds)					
Password Complexity	None	None / IEEE1686/ NERC	-	-	-
Set the password compliant standard.					
Log and monitoring standard	BDEW	BDEW / E3 /NERC-CIP / IEE1686 / IEC62351/ CS_PH1	-	-	-
Setup security log emission standard					
Syslog server IP address	0.0.0.0		-	-	-
Syslog server IP address					
Syslog server IP port	601	1 to 65535	-	-	-
Syslog server IP port					
SNMP client IP address	0.0.0.0		-	-	-
SNMP client IP address					

Table 12 – Configurable cyber security settings

These settings show some common information about cyber security, which are not configurable whether by SAT, or MiCOM S1 Studio or the front panel.

Menu in IED	Col	Row	Description
User Banner	25	01	Show user banner information: ACCESS ONLY FOR AUTHORITY USERS
Attempts remain	25	11	Show the remains attempt times for user login.
Blk time remain	25	12	Show the remains time for blocked user to unlock
User Name	25	21~2F	Configured user name (in SAT)
Security Code	25	FE	The security code used to recovery the password.
RBAC Password	25	FF	Enter 16 characters recover password to recovery password

Table 13 – Un-configurable cyber security settings

2.1.10 Local Default Access

Local Default Access function can be disabled/enabled in the SAT.
The intention for Local Default Access function is to allow the user easy to access the IED from the front panel and without any authorization required. This means if the Local Default Access function is enabled, everyone will be authorized to access the front panel with associated Rights.

By default, the Local Default Access has the VIEWER role, it is also possible to associate the other Roles to the Local Default Access, which is configurable in the SAT.
Local Default Access function is only available in the front panel.
The Local Default Access login/logout process is invisible for the user.

2.2 MiCOM Px4x with CSL0- Simple Password Management

For MiCOM Px4x IED with CSL0, as the Security Administration Tool (SAT) is not supported, all the cyber security features which need SAT support will not be available.

This section describes the different implementations by comparing with CLS1.

The cyber security features that are not mentioned in this section will default to be the same as CSL1.

2.2.1 Password Management

For MiCOM Px4x IED with CSL0, SAT is not supported for the configuration, so only the alphanumeric password can be used.

- The alphanumeric password is settable via MiCOM S1 Studio and the Front panel
- Passwords may be any length between 1 and 16 characters long
- Passwords may contain any ASCII character in the range ASCII code 33 (21 Hex) to ASCII code 122 (7A Hex) inclusive
- No password compliance is required
- The alphanumeric password will used for Courier access and the front panel access

Arrow key password is not available for IED with CLS0.

2.2.2 Fixed Factory RBAC

For MiCOM Px4x IED with CSL0, the user list and its role/right will be fixed as factory RBAC and not configurable. Refer to the *Factory RBAC* table for more details.

2.2.3 Security Logs/SNMP Services

The security logs/SNMP services are not available for MiCOM Px4x IED with CSL0.

2.2.4 Cyber Security Settings

For MiCOM Px4x IED with CSL0, all cyber security settings are fixed as default setting and un-configurable. Refer to the *Configurable cyber security settings* table for the default settings.

2.2.5 Disable/Blank Password

For MiCOM Px4x IED with CSL0, it is possible to remove the user password. In MiCOM S1 Studio, this is achieved by click the BOX “Disable the password”. In the IED, this is achieved by setting the password as blank.

Once the password is disabled/blank, the user can login to the IED directly and there is no need to enter the password.

3 HOW TO USE CYBER SECURITY FEATURES

These sections shows the most common tasks associated with Cyber Security features.

For many of these tasks, the steps you take are the same as you have performed previously; with the main changes being in the steps you use to login and/or logout.

3.1 How to Login

3.1.1 Local Default Access

If the Local Default Access is enabled, the user may login to the front panel with associated roles.

See Table 14 for the applied cases.

3.1.2 Auto Login

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

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

Table 14 – Auto Login process

For more details about the Factory RBAC, please refer to Table 9.

3.1.3 Login with Prompt User List

This login process will happen if:

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

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

3.2 How to Logout

3.2.1 How to Logout at the IED

For security consideration, it would be better to “logout' the IED once the configuration done. You can do this by going up to the default display. When you are at the default display and you press the ‘Cancel’ button, you may be prompted to log out with the following display:

```
ENTER TO LOGOUT
CLEAR TO CANCEL
```

You will be asked this question if you are logged in.

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

```
LOGGED OUT
User Name
```

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

```
LOGOUT CANCELLED
User Name
```

Note	*The MiCOM IED runs a timer, which logs the user out after a period of inactivity. For more details, refer to the Inactivity Timer section.*

3.2.2 How to Logout at MiCOM S1 Studio

- Right-click on the device name and select Log Off.
- In the Log Off confirmation dialog click Yes.

3.3 How to Disable a Physical Port

Using MiCOM S1 Studio or the front panel it is possible to disable unused physical ports. This can not be done by the SAT. By default, an Engineer-role is needed to perform this action.

To prevent accidental disabling of a port, a warning message is displayed according to whichever port is required to be disabled. For example if rear port 1 is to be disabled, the following message appears:

```
REAR PORT 1 TO BE
DISABLED.CONFIRM
```

There are between two and four ports eligible for disablement:

- Front port
- Rear port 1
- Rear port 2 (available in the specific models)
- Ethernet port (available in the specific models)

Important	**It is not possible to disable a port from which the disabling port command originates.**

3.4 How to Disable a Logical Port

Using MiCOM S1 Studio or the front panel it is possible to disable unused logical ports. This can't be done by the SAT. An Engineer-role is needed to perform this action.

Caution	**Disabling the Ethernet port will disable all Ethernet based communications.**

If it is not desirable to disable the Ethernet port, it is possible to disable selected protocols on the Ethernet card and leave others functioning.

These protocols can be disabled:

- IEC61850 (available in the specific models)
- Courier Tunnelling (available in the specific models)
- IEC61850 + DNPoE (available in the specific models)

3.5 How to Secure a Function Key (When Available)

In cyber security implementation, this function has been linked to the front panel authorization.

- When the function key pressed, if there is no user login in the front panel or the logged- in user is not authorized, a prompt message will be raised in the front panel to ask the user to login. Once the user is logged-in, they need to press the function key again to execute the command.
- If the user is already logged in and the authorization is OK, the command will be executed immediately.
- By default, the OPERATOR or ENGINEER Roles are able to operate the function keys.
- The function key will be executed immediately if the auto login process is applied and the user is authorized.
- If unauthorized users press the Function Key during the setting change, they need to commit the changes first then login with authorized user to operate the function key.

4 GLOSSARY FOR CYBER SECURITY

Term	Meaning
CIP Standards	Critical Infrastructure Protection standards. NERC CIP standards have been given the force of law by the Federal Energy Regulatory Commission (FERC)
DCS	Distributed Control System
HMI	Human Machine Interface
IED	Intelligent Electronic Device. It is a power industry term to describe microprocessor-based controllers of power system equipments (e.g. Circuit breaker, transformer, etc)
LOGS	All the operations related to the security (connection, configuration…) are automatically caught in events that are logged in order to provide a good visibility of the previous actions to the security administrators.
MIB	Management Information Base
NERC	North American Electric Reliability Corporation
RBAC	Role Based Access Control. Authentication and authorization mechanism based on roles granted to a user. Roles are made of rights, themselves being actions that can be applied on objects. Each user's action is authorized or not based on his roles
Roles	A role is a logical representation of a person activity. This activity authorizes or forbids operations within the tool suite thanks to permissions that are associated to the role. A role needs to be attached to a user account to have a real purpose.
SAM	Security Administration Module. Device in charge of security management on an IP-over-Ethernet network.
SAT	Security Administration Tool TSF based application used to define and create security configuration
Secured IED	Devices embedding security mechanisms defined in the security architecture document
Security Administrator	A user of the system granted to manage its security
SNMP	Simple Network Management Protocol (SNMP) is an "Internet-standard protocol for managing devices on IP networks
TAT	Transfer Administration Tool
Unsecured IED	Relay/IEDs with no security mechanisms.

Table 15 – Glossary for cyber security

DUAL REDUNDANT ETHERNET BOARD (DREB)

CHAPTER 19

Date (month/year):	01/2017			
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.			
Hardware Suffix:	P141/P142/P143 P145 P241 P242/P243 P342 P343/P344/P345 P445 P44x (P442/P444) P44y (P443/P446)	L M L M L M L M M	P54x (P543/P544/P545/P546) P642 P643/P645 P741/P743 P742 P746 P841A (one circuit breaker) P841B (two circuit breakers) P849	M L M M L M M M M
Software Version:	P14x (P141/P142/P143/P145) P24x (P241/P242/P243) P341 P34x (P342/P343/P344/P345) P445 P44x (P442/P444) P44y (P443/P446)	B0/B2 D0 B1/E1 B0/B1 B0/B1/E0/E1/J4/J6 E0/E1 H4	P54x (P543/P544/P545/P546) P64x (P642/P643/P645) P746 P74x (P741/P742/P743) P841A P841B P849	H4 B1/B2 B1/B2/B3 C1/C2/C3 B0 G4 H4 B0/B1
Connection Diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P44x (P442 & P444): 10P44101 (SH 1 & 2) 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2) P445: 10P445xx (xx = 01 to 04)		P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 1 to 10) 10P643xx (xx = 1 to 6) 10P645xx (xx = 1 to 9) P74x (P741, P742 & P743): 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)	

CONTENTS

Page (EB) 19-

FIGURES

TABLES

Notes:

1 INTRODUCTION

The redundant Ethernet board assures redundancy at IED level. It is fitted into the following MiCOM IEDs from Schneider Electric.

- P141, P142, P143, P145
- P241, P242, P243
- P341, P342, P343, P344, P345
- P442, P443, P444, P445, P446
- P543, P544, P545, P546, P547
- P642, P643, P645
- P741, P743, P746
- P841, P849

1.1 Standard Safety Statements

For safety information please see the Safety Information chapter of the relevant Px4x Technical Manual.

2 HARDWARE DESCRIPTION

IEC 61850 work over Ethernet. Three boards are available:

- 1RJ45 Port Ethernet Board
- 3RJ45 Ports Redundant Ethernet Board
- 2LC+1RJ45 Ports Redundant Ethernet Board.

All are required for communications but 3RJ45 Ports and 2LC+1RJ45 Ports Redundant Ethernet Board allow an alternative path to be always available, providing bumpless redundancy.

Industrial network failure can be disastrous. Redundancy provides increased security and reliability, but also devices can be added to or removed from the network without network downtime.

The following list shows Schneider Electric's implementation of Ethernet redundancy, which has two variants with embedded IEC 61850 over Ethernet, plus PRP and HSR redundancy protocols.

- Parallel Redundancy Protocol (PRP)/High-availability Seamless Redundancy (HSR) with 1310 nm multi mode 100BaseFx fiber optic Ethernet ports (LC connector) and modulated/un- modulated IRIG-B input. Part number 2072069A01.

Note	*The board offers compatibility with any PRP/HSR device.*

- Parallel Redundancy Protocol (PRP)/High-availability Seamless Redundancy (HSR) with 100BaseTx Ethernet ports (RJ45) and modulated/un- modulated IRIG-B input. Part number 2072071A01.

Note	*The board offers compatibility with any PRP/HSR device.*

The redundant Ethernet board is fitted into Slot A of the IED, which is the optional communications slot. Each Ethernet board has three MAC addresses for two groups, one group (PORT 1) including one host MAC address, the other group (PORT 2 & 3) used for redundant application, including one host MAC address and one redundant agency device MAC address. Two host MAC addresses of the IED are printed on the rear panel of the IED.

In additional above for HSR/PRP redundant protocols, the redundant Ethernet board also can be operate on Dual IP mode. In this case, each Ethernet board has two host MAC addresses.

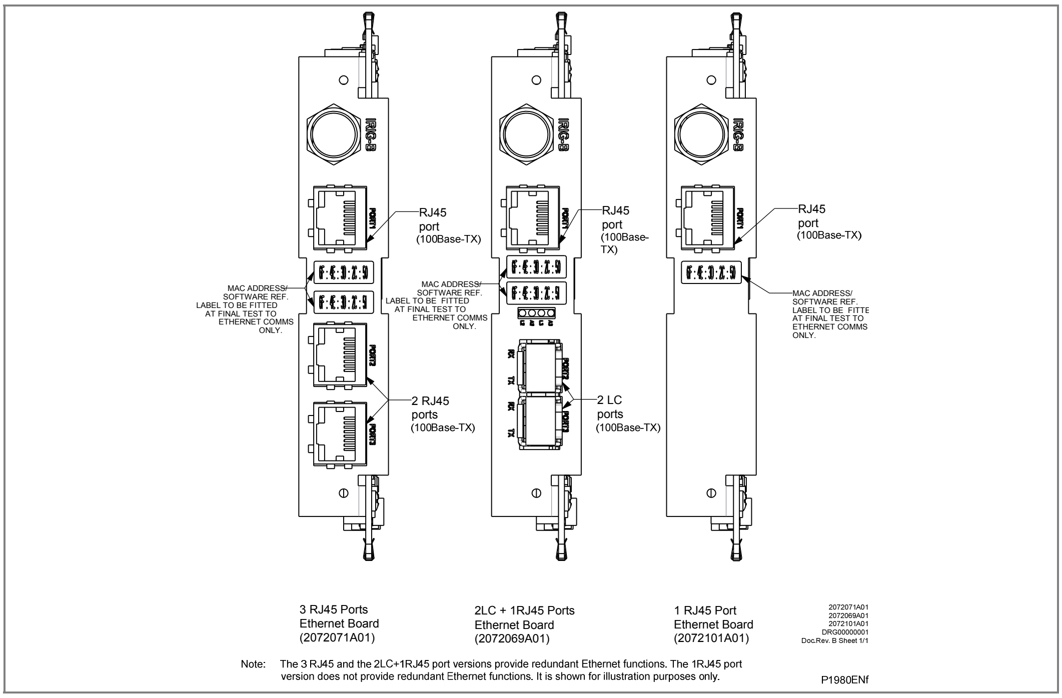


Figure 1 - Ethernet board connectors (3 RJ45 or 2 LC + RJ45 or 1 RJ45)

2.1 IRIG-B Connector

This is available as a modulated/un-modulated input.
See section 6.1.

2.2 LEDs

LED	Function	On	Off	Flashing
Green	Link	Link ok	Link broken	
Yellow	Activity			Traffic activity

Table 1 - LED functionality

2.3 Optical Fiber Connectors

Use 1310 nm multi mode 100BaseFx and LC connectors.
See Figure 1 and section 6.1.

Connector	PRP	HSR
2	Rx	Rx
2	Tx	Tx
3	Rx	Rx
3	Tx	Tx

Table 2 - Optical fiber connector functionality

3 REDUNDANCY PROTOCOLS

There are two redundancy protocols available:

- PRP (Parallel Redundancy Protocol)
- HSR (High-availability Seamless Redundancy)

3.1 Parallel Redundancy Protocol (PRP)

When the upper protocol layers send a data packet, the PRP interface creates a “twin packet” from this. The PRP interface then transmits redundant data packet of the twin pair to each participating LAN simultaneously. As they are transmitted via different LANs, the data packets may have different run times.
The receiving PRP interface forwards the first packet of a pair towards the upper protocol layers and discards the second packet. When viewed from the application, a PRP interface functions like a standard Ethernet interface.
The PRP interface or a Redundancy Box (RedBox) injects a Redundancy Control Trailer (RCT) into each packet. The RCT is a 48-bit identification field and is responsible for the identification of duplicates. This field contains, LAN identification (LAN A or B), information about the length of the payload, and a 16-bit sequence number. The PRP interface increments the sequence number for each packet sent. Using the unique attributes included in each packet, such as Physical MAC source address and sequence number, the receiving RedBox or Double Attached Node (DAN) interface identifies and discards duplicates.
Depending on the packet size, with PRP it attains a throughput of 93 to 99% of the available bandwidth.

3.1.1 PRP Network Structure

PRP uses two independent LANs. The topology of each of these LANs is arbitrary, and ring, star, bus and meshed topologies are possible.
The main advantage of PRP is loss-free data transmission with an active (transit) LAN. When the terminal device receives no packets from one of the LANs, the second (transit) LAN maintains the connection. As long as 1 (transit) LAN is available, repairs and maintenance on the other (transit) LAN have no impact on the data packet transmission.
The elementary devices of a PRP network are known as RedBox (Redundancy Box) and DANP (Double Attached Node implementing PRP).
Both devices have one connection each to the (transit) LANs.
The devices in the (transit) LAN are conventional switches that do not require any PRP support. The devices transmit PRP data packets transparently, without evaluating the RCT information.
Terminal devices that are connected directly to a device in the (transit) LAN are known as SAN (Single Attached Node). If there is an interruption, these terminal devices cannot be reached via the redundant line. To use the uninterruptible redundancy of the PRP network, you integrate your device into the PRP network via a RedBox.

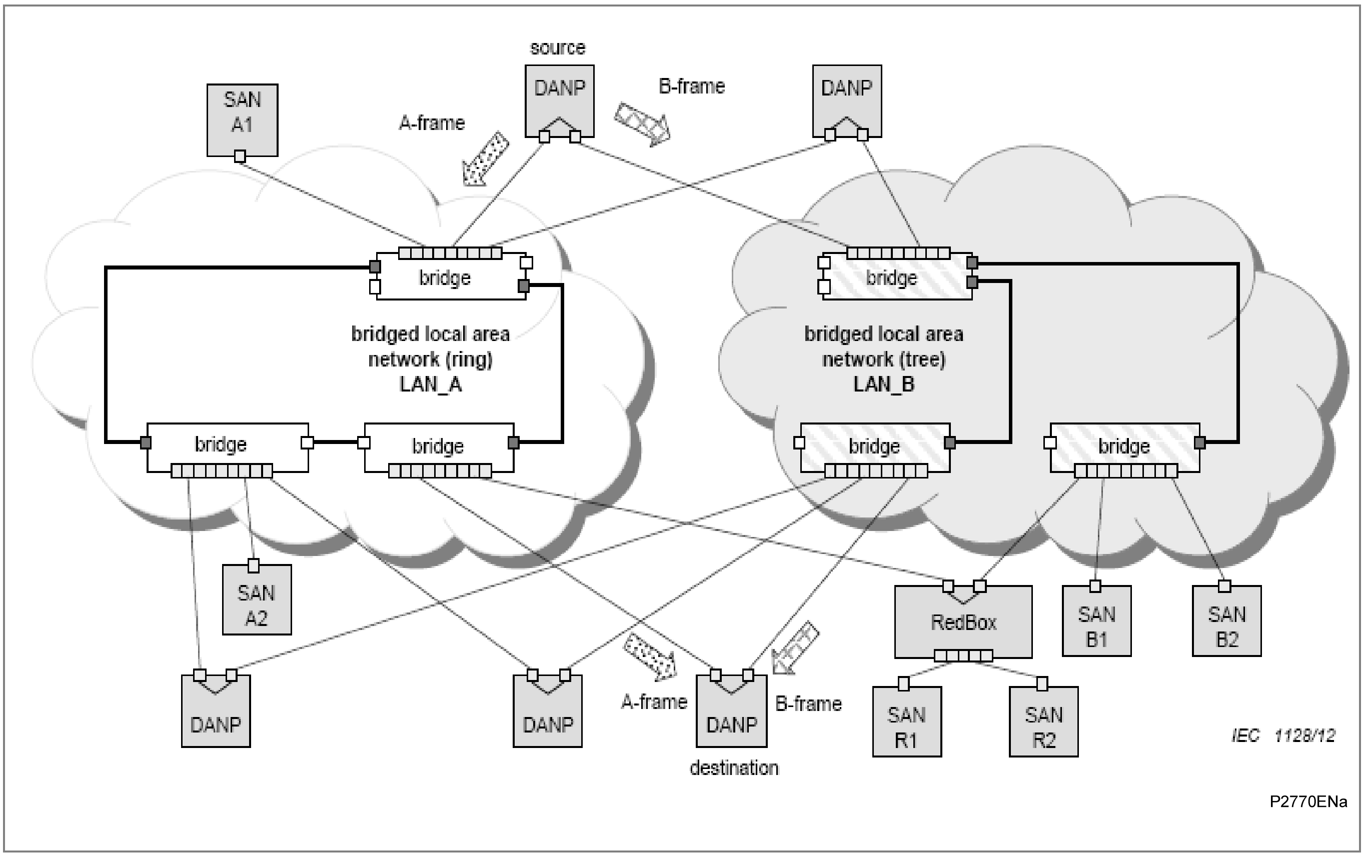


Figure 2 - PRP example of general redundant network

3.1.2 Example Configuration

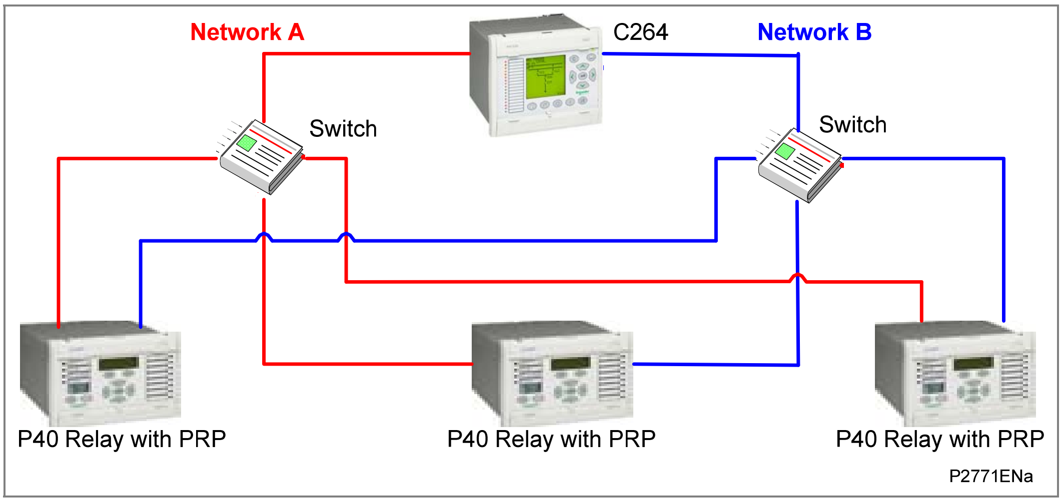


Figure 3 - PRP Relay Configuration

3.2 High-availability Seamless Redundancy (HSR)

High-availability Seamless Redundancy (HSR) can only be used in a ring topology, This section describes the application of the PRP principles (IEC 62439-3- Clause 4) to implement a High-availability Seamless Redundancy (HSR), retaining the PRP property of zero recovery time, applicable to rings. With respect to PRP, HSR allows you to greatly reduce the network infrastructure. With respect to rings based on IEEE 802.1D (RSTP), IEC 62439-2 (MRP), IEC 62439-6 (DRP) or IEC 62439-7 (RRP), the available network bandwidth for network traffic is somewhat reduced depending on the type of traffic. Nodes within the ring are restricted to be HSR-capable bridging nodes, thus avoiding the use of dedicated bridges. Singly Attached Nodes (SANs) such as laptops or printers cannot be attached directly to the ring, but need attachment through a RedBox (redundancy box).

3.2.1 HSR Network Structure

As in PRP, a node has two ports operated in parallel; it is a DANH (Doubly Attached Node with HSR protocol).
A simple HSR network consists of doubly-attached bridging nodes, each having two ring ports, interconnected by full-duplex links, as shown in these examples for a ring topology:

- Figure 4 (multicast)
- Figure 5 (unicast)

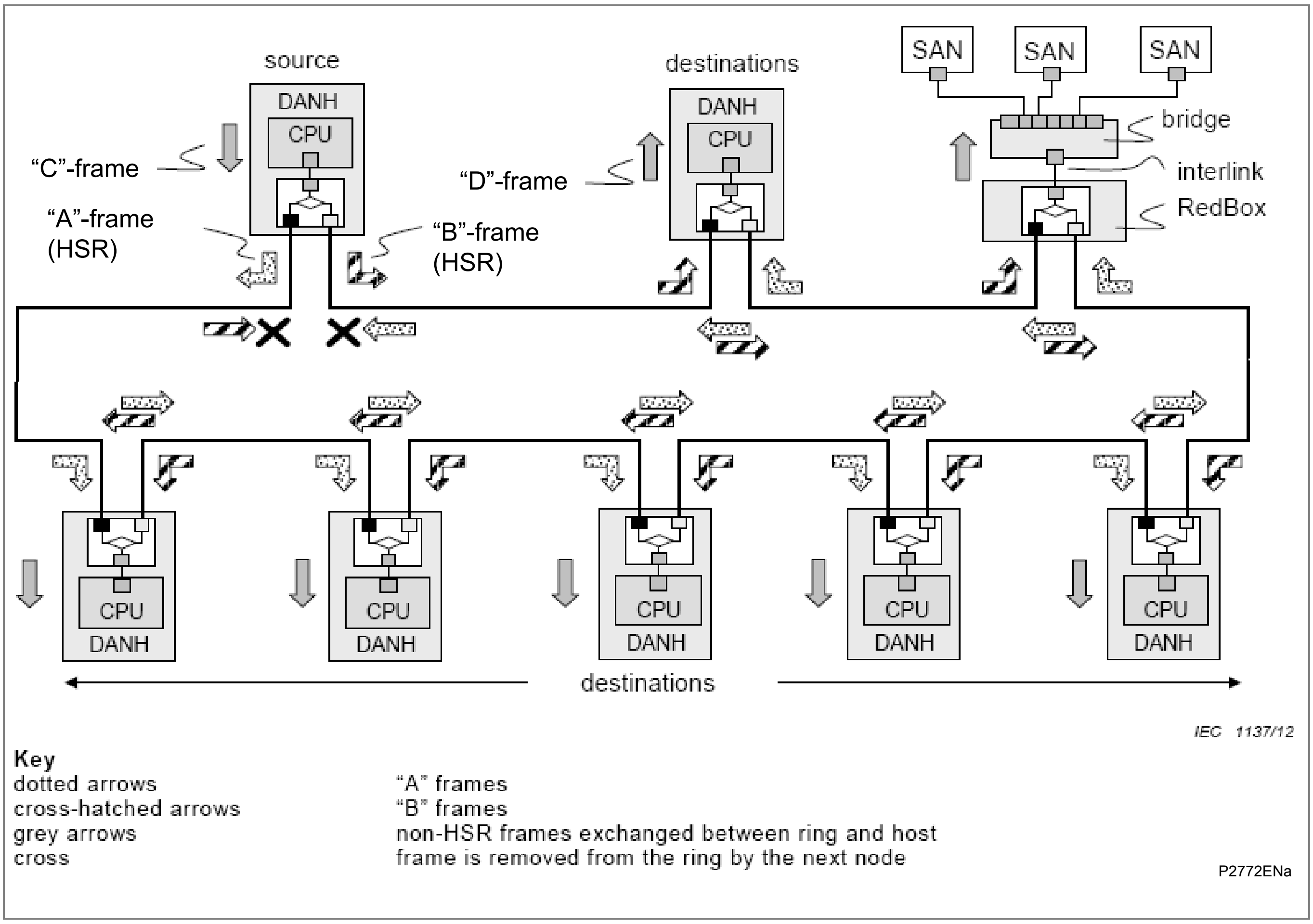


Figure 4 - HSR example of ring configuration for multicast traffic

A source DANH sends a frame passed from its upper layers (“C” frame), prefixes it by an HSR tag to identify frame duplicates and sends the frame over each port (“A”-frame and “B”-frame). A destination DANH receives, in the fault-free state, two identical frames from each port within a certain interval, removes the HSR tag of the first frame before passing it to its upper layers (“D”-frame) and discards any duplicate.
The nodes support the IEEE 802.1D bridge functionality and forward frames from one port to the other, except if they already sent the same frame in that same direction.
In particular, the node will not forward a frame that it injected into the ring.

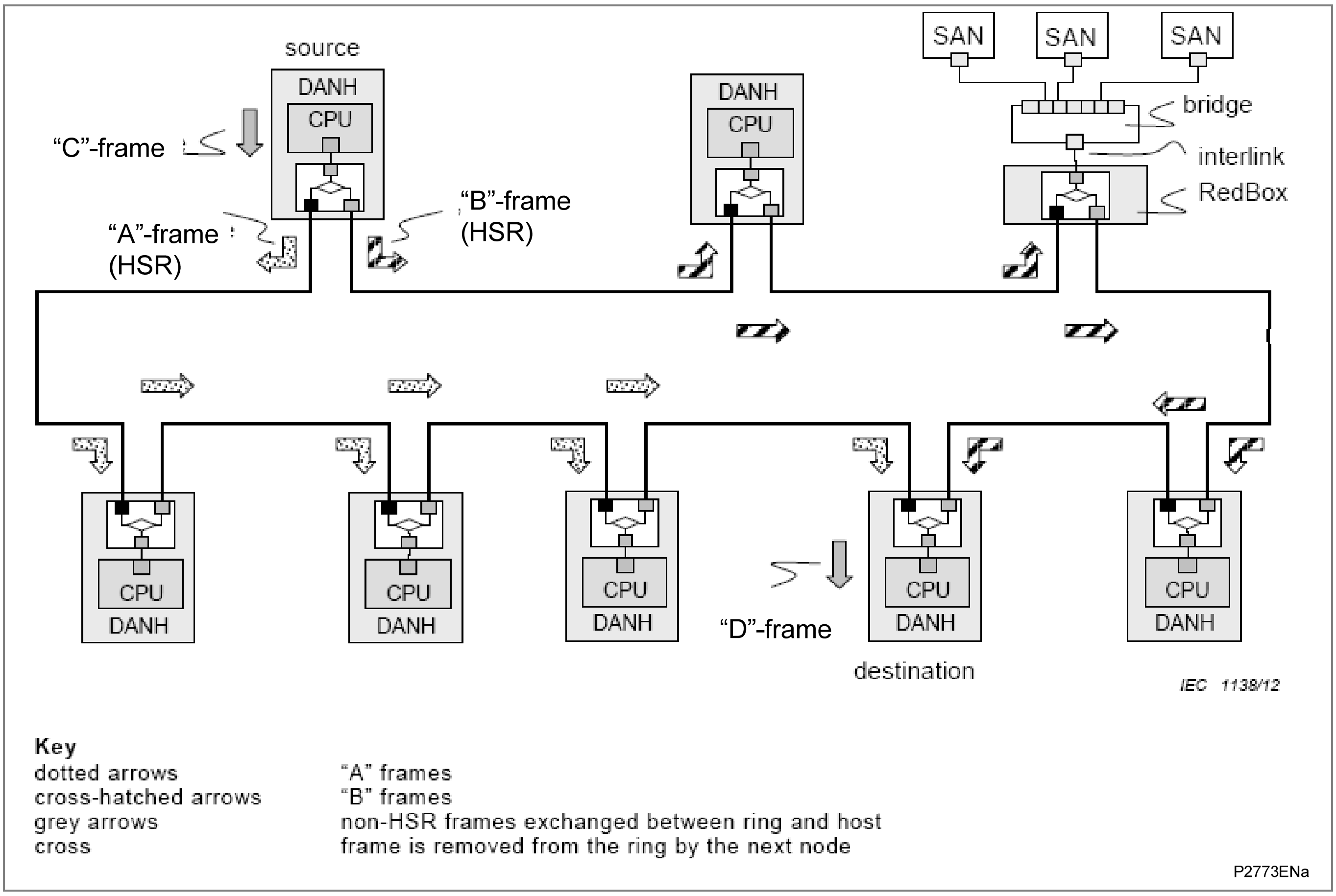


Figure 5 - HSR example of ring configuration for unicast traffic

A destination node of a unicast frame does not forward a frame for which it is the only destination, except for testing.
Frames circulating in the ring carry the HSR tag inserted by the source, which contains a sequence number. The doublet {source MAC address, sequence number} uniquely identifies copies of the same frame.
Singly Attached Nodes (SANs), for instance maintenance laptops or printers cannot be inserted directly into the ring since they have only one port and cannot interpret the HSR tag in the frames. SANs communicate with ring devices through a RedBox (redundancy box) that acts as a proxy for the SANs attached to it, as shown in the diagram.
Connecting non-HSR nodes to ring ports, breaking the ring, is allowed to enable configuration. Non-HSR traffic within the closed ring is supported in an optional mode.

3.2.2 Example Configuration

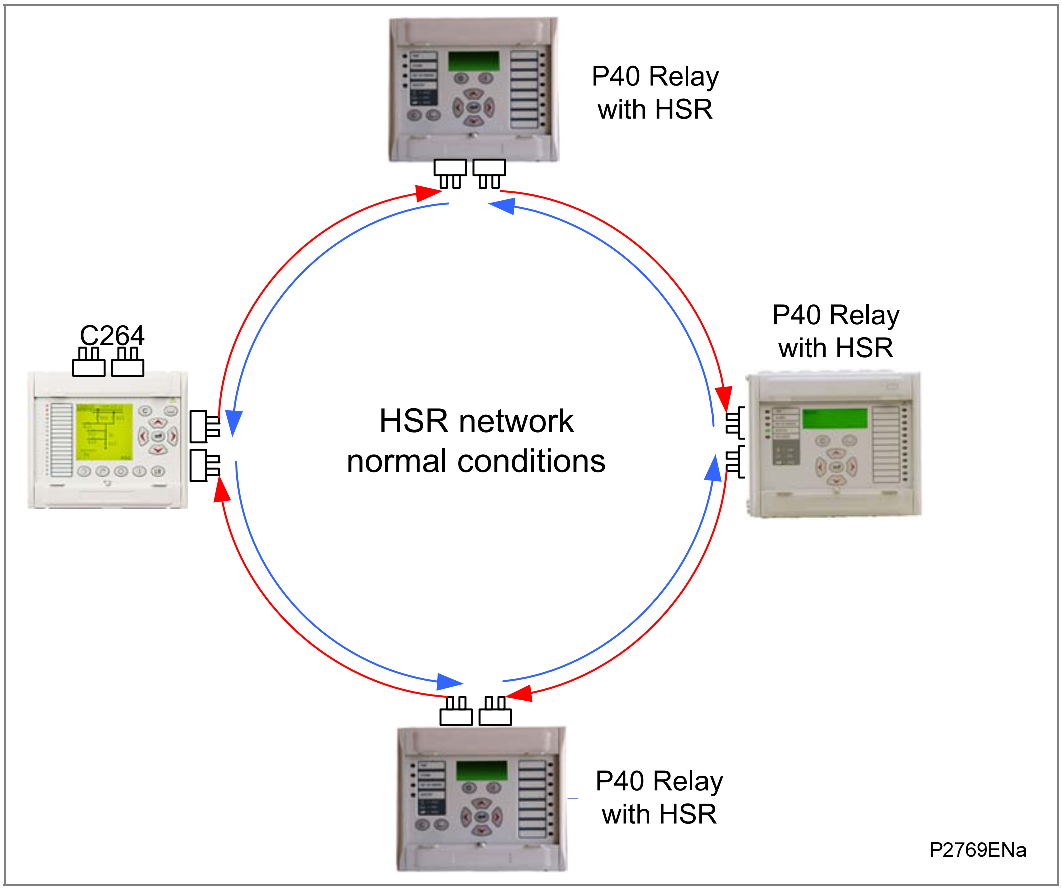


Figure 6 - HSR Relay Configuration

3.3 Generic Functions for all Redundant Ethernet Boards

The following apply to the redundant Ethernet protocols (PRP and HSR).

3.3.1 Priority Tagging

802.1p priority is enabled on all ports.

3.3.2 Simple Network Management Protocol (SNMP)

Simple Network Management Protocol (SNMP) is the network protocol developed to manage devices in an IP network. SNMP relies on a Management Information Base (MIB) that contains information about parameters to supervise. The MIB format is a tree structure, with each node in the tree identified by a numerical Object IDentifier (OID). Each OID identifies a variable that can be read or set using SNMP with the appropriate software. The information in the MIBs is standardized.

3.3.2.1 Redundant Ethernet Board MIB Structure

The IEC 62439-3 MIB provides the following objects available at the OID = .1.0.62439:

SNMP OID	Parameter name	Description
1	iso	
1	std	
1.0.62439	iec62439	
1.0.62439.2	prp	
1.0.62439.2.0	linkRedundancyEntityNotifications	
1.0.62439.2.1	linkRedundancyEntityObjects	
1.0.62439.2.1.0	lreConfiguration	
1.0.62439.2.1.0.0	lreConfigurationGeneralGroup	
1.0.62439.2.1.0.0.1	lreManufacturerName	Specifies the name of the LRE device manufacturer
1.0.62439.2.1.0.0.2	lreInterfaceCount	Total number of LREs present in this system
1.0.62439.2.1.0.1	lreConfigurationInterfaceGroup	
1.0.62439.2.1.0.1.0	lreConfigurationInterfaces	
1.0.62439.2.1.0.1.0.1	lreInterfaceConfigTable	List of PRP/HSR LREs. Each entry corresponds to one PRP/HSR Link Redundancy Entity (LRE), each representing a pair of LAN ports A and B. Basic devices supporting PRP/HSR may have only one LRE and thus one entry in the table, while more complex devices may have several entries for multiple LREs
1.0.62439.2.1.0.1.0.1.1	lreInterfaceConfigEntry	Each entry contains management information
1.0.62439.2.1.0.1.0.1.1.1	lreInterfaceConfigIndex	A unique value for each LRE
1.0.62439.2.1.0.1.0.1.1.2	lreRowStatus	Indicates the status of the LRE table entry
1.0.62439.2.1.0.1.0.1.1.3	lreNodeType	Specifies the operation mode of the LRE: PRP mode 1 (1) HSR mode (2). Note: PRP mode 0 is considered deprecated and is not supported by this revision of the MIB
1.0.62439.2.1.0.1.0.1.1.4	lreNodeName	Specifies this LRE's node name
1.0.62439.2.1.0.1.0.1.1.5	lreVersionName	Specifies the version of this LRE's software
1.0.62439.2.1.0.1.0.1.1.6	lreMacAddress	Specifies the MAC address to be used by this LRE. MAC addresses are identical for all ports of a single LRE
1.0.62439.2.1.0.1.0.1.1.7	lrePortAdminStateA	Specifies whether the port A shall be active or not Active through administrative action (Default: active)
1.0.62439.2.1.0.1.0.1.1.8	lrePortAdminStateB	Specifies whether the port B shall be active or not Active through administrative action (Default: active)
1.0.62439.2.1.0.1.0.1.1.9	lreLinkStatusA	Shows the actual link status of the LRE's port A
1.0.62439.2.1.0.1.0.1.1.10	lreLinkStatusB	Shows the actual link status of the LRE's port B

SNMP OID	Parameter name	Description
1.0.62439.2.1.0.1.0.1.1.11	lreDuplicateDiscard	Specifies whether a duplicate discard algorithm is used at reception (Default: discard)
1.0.62439.2.1.0.1.0.1.1.12	lreTransparentReception	If removeRCT is configured, the RCT is removed when forwarding to the upper layers, only applicable for PRP LRE (Default: removeRCT)
1.0.62439.2.1.0.1.0.1.1.13	lreHsrLREMode	This enumeration is only applicable if the LRE is an HSR bridging node or RedBox. It shows the mode of the HSR LRE: (1) Default mode: The HSR LRE is in mode h and bridges tagged HSR traffic (2) Optional mode: The HSR LRE is in mode n and bridging between its HSR ports is disabled. Traffic is HSR tagged (3) Optional mode: The HSR LRE is in mode t and bridges non-tagged HSR traffic between its HSR ports (4) Optional mode: The HSR LRE is in mode u and behaves like in mode h, except it does not remove unicast messages (5) Optional mode: The HSR LRE is configured in mixed mode. HSR frames are handled according to mode h. Non-HSR frames are handled according to 802.1D bridging rules
1.0.62439.2.1.0.1.0.1.1.14	lreSwitchingEndNode	This enumeration shows which feature is enabled in this particular LRE: (1): an unspecified non-bridging node, e.g. SRP. (2): an unspecified bridging node, e.g. RSTP. (3): a PRP node/RedBox. (4): an HSR RedBox with regular Ethernet traffic on its interlink. (5): an HSR switching node. (6): an HSR RedBox with HSR tagged traffic on its interlink. (7): an HSR RedBox with PRP traffic for LAN A on its interlink. (8): an HSR RedBox with PRP traffic for LAN B on its interlink.
1.0.62439.2.1.0.1.0.1.1.15	lreRedBoxIdentity	Applicable to RedBox HSR-PRP A and RedBox HSR-PRP B. One ID is used by one pair of RedBoxes (one configured to A and one configured to B) coupling an HSR ring to a PRP network. The integer value states the value of the path field a RedBox inserts into each frame it receives from its interlink and injects into the HSR ring. When interpreted as binary values, the LSB denotes the configuration of the RedBox (A or B), and the following 3 bits denote the identifier of a RedBox pair.
1.0.62439.2.1.0.1.0.1.1.16	lreEvaluateSupervision	True if the LRE evaluates received supervision frames. False if it drops the supervision frames without evaluating. Note: LREs are required to send supervision frames, but reception is optional. Default value is dependent on implementation.
1.0.62439.2.1.0.1.0.1.1.17	lreNodesTableClear	Specifies that the Node Table is to be cleared
1.0.62439.2.1.0.1.0.1.1.18	lreProxyNodeTableClear	Specifies that the Proxy Node Table is to be cleared
1.0.62439.2.1.1	lreStatistics	
1.0.62439.2.1.1.1	lreStatisticsInterfaceGroup	
1.0.62439.2.1.1.1.0	lreStatisticsInterfaces	
1.0.62439.2.1.1.1.0.1	lreInterfaceStatsTable	List of PRP/HSR LREs. Each entry corresponds to one PRP/HSR Link Redundancy Entity (LRE), each representing a pair of LAN ports A and B and a port C towards the application/interlink. Basic devices supporting PRP/HSR may have only one LRE and thus one entry in the table, while more complex devices may have several entries for multiple LREs.
1.0.62439.2.1.1.1.0.1.1	lreInterfaceStatsEntry	An entry containing management information applicable to a particular LRE
1.0.62439.2.1.1.1.0.1.1.1	lreInterfaceStatsIndex	A unique value for each LRE
1.0.62439.2.1.1.1.0.1.1.2	lreCntTxA	Number of frames sent over port A that are HSR tagged or fitted with a PRP Redundancy Control Trailer. Only frames that are HSR tagged or do have a PRP RCT are counted. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.3	lreCntTxB	Number of frames sent over port B that are HSR tagged or fitted with a PRP Redundancy Control Trailer. Only frames that are HSR tagged or do have a PRP RCT are counted. Initial value = 0.

SNMP OID	Parameter name	Description
1.0.62439.2.1.1.1.0.1.1.4	lreCntTxC	Number of frames sent towards the application interface of the DANP or DANH or over the interlink of the RedBox. All frames (with our without PRP RCT or HSR tag) are counted. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.5	lreCntErrWrongLanA	Number of frames with the wrong LAN identifier received on LRE port A. Initial value = 0. Only applicable to PRP ports.
1.0.62439.2.1.1.1.0.1.1.6	lreCntErrWrongLanB	Number of frames with the wrong LAN identifier received on LRE port B. Initial value = 0. Only applicable to PRP ports
1.0.62439.2.1.1.1.0.1.1.7	lreCntErrWrongLanC	Number of frames with the wrong LAN identifier received on the interlink of a RedBox. Only applicable to HSR RedBoxes in HSR-PRP configuration (hsrredboxprpa and hsrredboxprpb).
1.0.62439.2.1.1.1.0.1.1.8	lreCntRxA	Number of frames received on a LRE port A. Only frames that are HSR tagged or fitted with a PRP Redundancy Control Trailer are counted. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.9	lreCntRxB	Number of frames received on a LRE port B. Only frames that are HSR tagged or fitted with a PRP Redundancy Control Trailer are counted. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.10	lreCntRxC	Number of frames received from the application interface of a DANP or DANH or the number of number of frames received on the interlink of a RedBox. All frames (with our without PRP RCT or HSR tag) are counted. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.11	lreCntErrorsA	Number of frames with errors received on this LRE port A. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.12	lreCntErrorsB	Number of frames with errors received on this LRE port B. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.13	lreCntErrorsC	Number of frames with errors received on the application interface of a DANP or DANH or on the interlink of a RedBox. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.14	lreCntNodes	Number of nodes in the Nodes Table
1.0.62439.2.1.1.1.0.1.1.15	lreCntProxyNodes	Number of nodes in the Proxy Node Table. Only applicable to RedBox. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.16	lreCntUniqueRxA	Number of entries in the duplicate detection mechanism on port A for which no duplicate was received. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.17	lreCntUniqueRxB	Number of entries in the duplicate detection mechanism on port B for which no duplicate was received. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.18	lreCntUniqueRxC	Number of entries in the duplicate detection mechanism on the application interface of the DAN or the interlink of the RedBox for which no duplicate was received. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.19	lreCntDuplicateRxA	Number of entries in the duplicate detection mechanism on port A for which one single duplicate was received. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.20	lreCntDuplicateRxB	Number of entries in the duplicate detection mechanism on port B for which one single duplicate was received. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.21	lreCntDuplicateRxC	Number of entries in the duplicate detection mechanism on the application interface of the DAN or the interlink of the RedBox for which one single duplicate was received. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.22	lreCntMultiRxA	Number of entries in the duplicate detection mechanism on port A for which more than one duplicate was received. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.23	lreCntMultiRxB	Number of entries in the duplicate detection mechanism on port B for which more than one duplicate was received. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.24	lreCntMultiRxC	Number of entries in the duplicate detection mechanism on the application interface of the DAN or the interlink of the RedBox for which more than one duplicate was received. Initial value = 0
1.0.62439.2.1.1.1.0.1.1.25	lreCntOwnRxA	Number of HSR tagged frames received on Port A that originated from this device. Frames originate from this device if the source MAC matches the MAC of the LRE, or if the source MAC appears in the proxy node table (if implemented). Applicable only to HSR. Initial value = 0.
1.0.62439.2.1.1.1.0.1.1.26	lreCntOwnRxB	Number of HSR tagged frames received on Port B that originated from this device. Frames originate from this device if the source MAC matches the MAC of the LRE, or if the source MAC appears in the proxy node table (if implemented). Applicable only to HSR. Initial value = 0.

SNMP OID	Parameter name	Description
1.0.62439.2.1.1.1.0.2	lreNodesTable	The node table (if it exists on that node) contains information about all remote LRE, which advertised themselves through supervision frames
1.0.62439.2.1.1.1.0.2.1	lreNodesEntry	Each entry in the node table (if it exists) contains information about a particular remote LRE registered in the node table, which advertised itself through supervision frames.
1.0.62439.2.1.1.1.0.2.1.1	lreNodesIndex	Unique value for each node in the LRE's node table
1.0.62439.2.1.1.1.0.2.1.2	lreNodesMacAddress	Each MAC address corresponds to a single Dual Attached Node
1.0.62439.2.1.1.1.0.2.1.3	lreTimeLastSeenA	Time in TimeTicks (1/100s) since the last frame from this remote LRE was received over LAN A. Initialized with a value of 0 upon node registration in the node table
1.0.62439.2.1.1.1.0.2.1.4	lreTimeLastSeenB	Time in TimeTicks (1/100s) since the last frame from this remote LRE was received over LAN B. Initialized with a value of 0 upon node registration in the node table.
1.0.62439.2.1.1.1.0.2.1.5	lreRemNodeType	DAN type, as indicated in the received supervision frame
1.0.62439.2.1.1.1.0.3	lreProxyNodeTable	The proxy node table (if implemented) contains information about all nodes, for which the LRE acts as a connection to the HSR/PRP network.
1.0.62439.2.1.1.1.0.3.1	lreProxyNodeEntry	Each entry in the proxy node table contains information about a particular node for which the LRE acts as a connection to the HSR/PRP network.
1.0.62439.2.1.1.1.0.3.1.1	lreProxyNodeIndex	A unique value for each node in the LRE's proxy node table.
1.0.62439.2.1.1.1.0.3.1.2	lreProxyNodeMacAddress	Each entry contains information about a particular node for which the LRE acts as a proxy for the HSR/PRP network.
1.0.62439.2.2	linkRedundancyEntityConformance	

Table 3 - Redundant Ethernet board MIB Structure

*Port number: 1 to 6 for the RJ45, port 7 management, port 8 ring

Various SNMP client software tools can be used with the MiCOM Px4x, C264 and Hx8x range. Schneider Electric recommends using an SNMP MIB browser which can perform the basic SNMP operations such as GET, GETNEXT, and RESPONSE.

Redundant agency device configuration will be required to access SNMP, refer to section 4.4 for more details.

3.3.3 Simple Network Time Protocol (SNTP)

Simple Network Time Protocol (SNTP) is supported by both the IED and the redundant Ethernet switch. SNTP is used to synchronize the clocks of computer systems over packet-switched, variable-latency data networks. A jitter buffer is used to reduce the effects of variable latency introduced by queuing in packet switched networks, ensuring a continuous data stream over the network.

The IED receives the synchronization from the SNTP server. This is done using the IP address of the SNTP server entered into the IED from the IED Configurator software.

3.3.4 Dual Ethernet Communication (Dual IPs)

3.3.4.1 Dual IP Introduction

Dual IP means the IED provides two independent IEC 61850 interfaces, and both these interfaces support MMS and Goose message.

The IED which supports Dual IP can provide the customer with more flexible network connections: two fully segregated Station BUS networks, or one Station Bus and one Process Bus (for Goose message transmission).

Dual IP is not mutually exclusive with PRP/HSR - Dual IP is automatically supported even if the IED is operate under HSR/PRP mode.

3.3.4.2 Dual IP in MiCOM

Dual IP is only supported for devices with the new Ethernet board assembly. This is shown by the model number, where the 7th digit is either hardware option Q or R. These boards have three Ethernet ports, as shown in Figure 1.

A setting is provided in the HMI to switch the operation mode between PRP/HSR/Dual IP.

Operation mode	Port 1	Port 2	Port3
PRP	Interface 1	Interface 2 (PRP)	Interface 2 (PRP)
HSR	Interface 1	Interface 2 (HSR)	Interface 2 (HSR)
Dual IP	* Interface 1 on Port 1 or Port 2		Interface 2

** Note* *In Dual IP mode, interface 1 can be available on port 1 or port 2. If both of port 1 and port 2 are connected, only port 1 will work.*

Table 4 - Ethernet ports operation mode

For each interface, the fully IEC 61850 functions (GOOSE and MMS services) are supported independently.

For outgoing GOOSE messages, you need to configure whether a message is to be transmitted across one or both Ethernet connections. You also need to configure the destination parameters such as multicast MAC address, AppID, VLAN, etc.

Two communication parameters also need to be configured for each interface (IP address, MAC address, subnet mask). For the CID which is exported from SCD file, the second interface communication parameters are not configured. This needs to be done by manually editing in the IED configurator (this being invisible by the SCD file). This process needs to be completed before the exported CID file is downloaded to the IED. (this being invisible by the SCD file).

3.3.4.3 Typical User Cases

Below for Interface 1 and Interface 2, from a functional point of view it is same. The customer has flexibility to define the functionality according their requirements.

- Both for Station Bus to have duplicated network for DCS.
- One for Station Bus and one for process bus (Goose message)

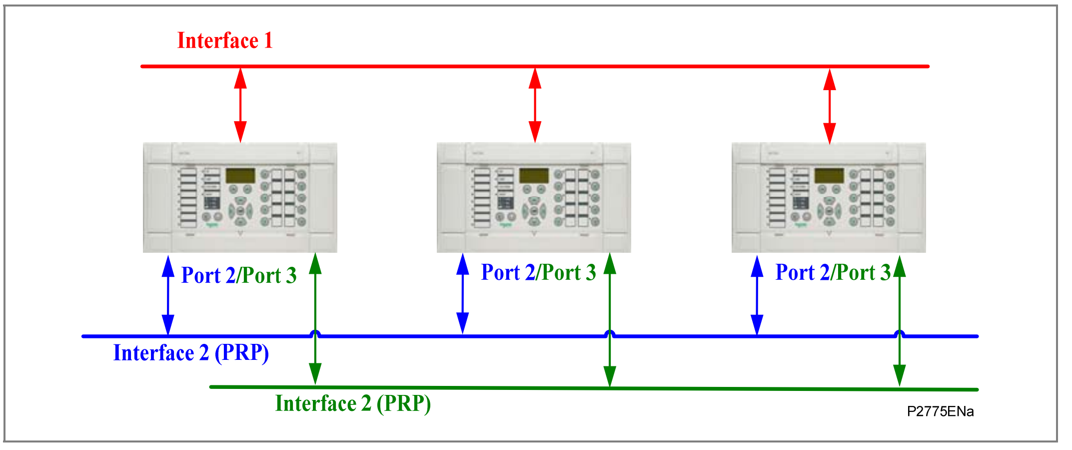


Figure 7 - PRP + Dual IP (Ethernet Mode PRP)

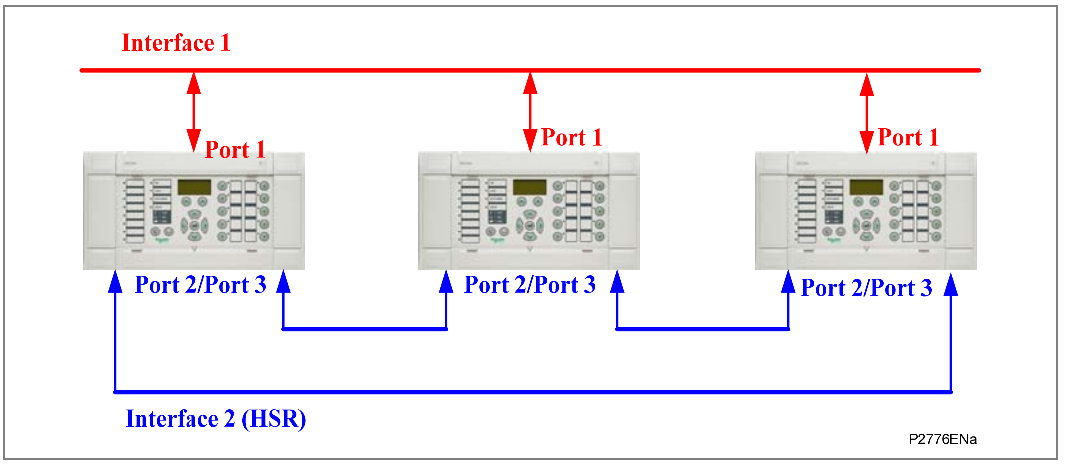


Figure 8 - HSR + Dual IP (Ethernet Mode HSR)

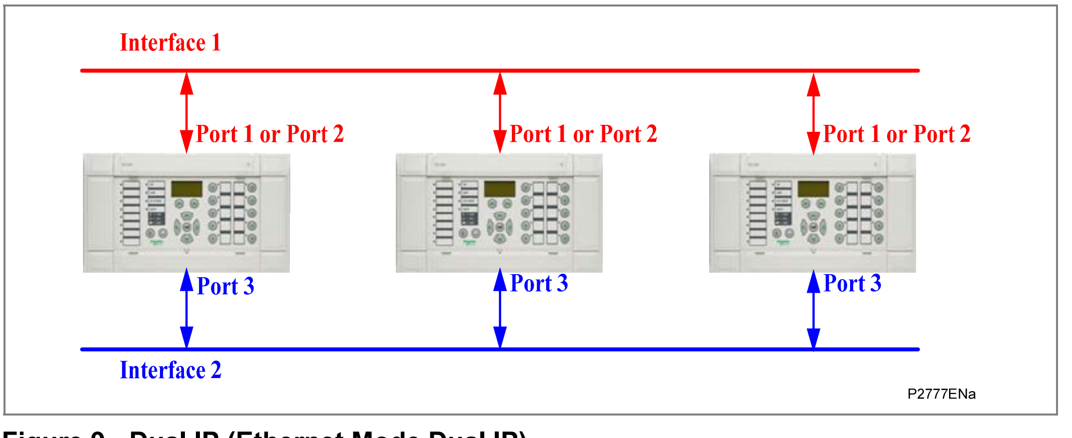


Figure 9 - Dual IP (Ethernet Mode Dual IP)

4 CONFIGURATION

The new redundant Ethernet board supports three communication operation modes. These can be achieved by change the setting in HMI. It is not necessary to flash the firmware.

Also for the two interfaces, the communication parameters need to be configured. These include the IP address, MAC address, and subnet mask, etc.

For redundant protocols, the communication parameters for redundant agency device also need to be configured.

4.1 Configuring Ethernet Communication Mode

Menu Text	Cell Add.	Default Setting	Available Setting
ETH COMM Mode	0016	Dual IP	Dual IP, PRP, HSR
This setting can only be change using the HMI, and the setting change will cause the Ethernet board reboot. Restore default setting does not apply to this setting.			

Table 5 - Ethernet communication mode setting

4.2 Configuring the IED Communication Parameters

The communication parameter for each interface is configured using the IED Configurator software in MiCOM S1 Studio. **Customers can configure these parameters according to their needs, but the IP address for these two interfaces should not be in the same subnet.**

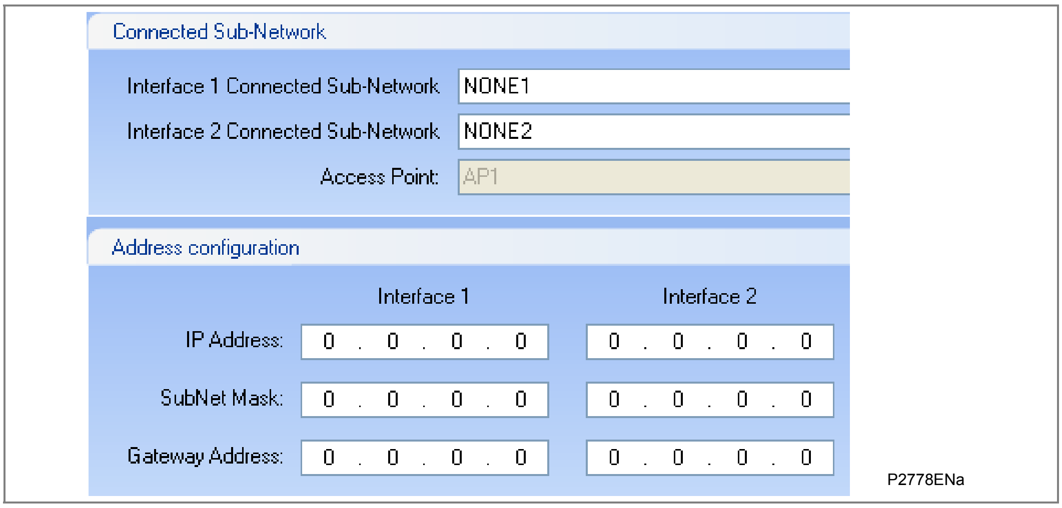


Figure 10 - Communication Parameters for two Interfaces

To use the device configuration with Courier Tunneling, for each interface, a default IP address has been applied. The default IP address for the first three bytes is fixed for each interface as below,

Interface	First three Bytes for IP address
Interface 1	169.254.0.xxx
Interface 2	169.254.1.yyy
Note *xxx = Mod(The last byte MAC1 address, 128) + 1* *yyy = Mod(The last byte MAC2 address, 128) + 1*	

Table 6 - First three bytes for default IP address

The default IP address can be found in the ***IED CONFIGURATOR*** column. Also, you can also calculate it according the MAC address label which is mounted on the rear panel of the Ethernet card.

4.3 Configuring GOOSE Publish Parameters

For outgoing GOOSE messages, you need to configure whether a message is to be transmitted over one or both Ethernet connections. You also need to configure the destination parameters including multicast MAC address, AppID, VLAN, etc.

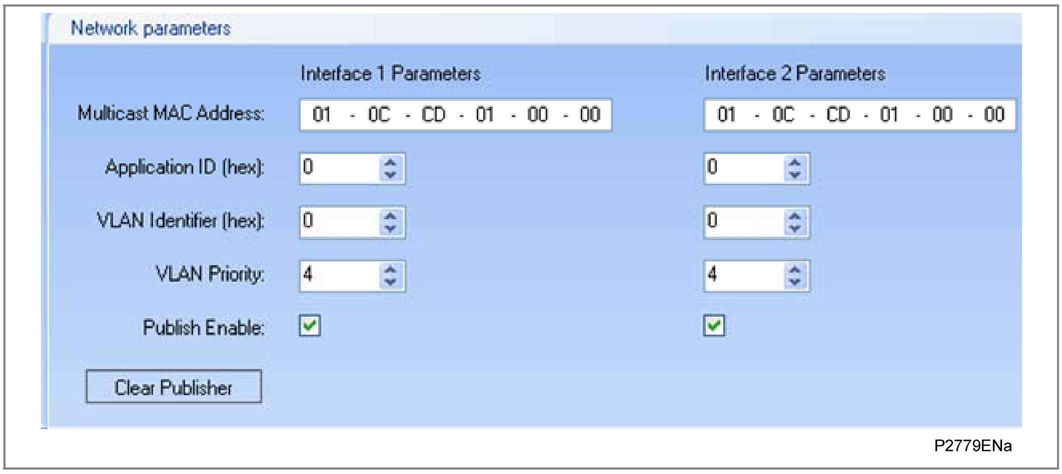


Figure 11 - Goose Publish Parameters for two Interfaces

4.4 Redundant Agency Device Configuration

The redundant agency device configuration is used by the SNMP server and only available for the device which works on PRP/HSR mode. The SNMP server can only be connected with Interface 2 (HSR/PRP port).

The following settings need to be configured in setting files:

- IP address
- Subnet Mask
- Gateway.

The MAC address is set when the device is manufactured. Also, the default IP is applied and linked to the MAC address. This default IP address can be seen in the HMI, in the Communication settings section.

The default IP address is 169.254.2.zzz.

zzz = Mod (The last byte MAC3 address, 128) + 1

5 COMMISSIONING

5.1 PRP Star Connection

The following diagram shows the Px4x IEDs with the PRP variant of Redundant Ethernet boards connected in a STAR topology. The STAR topology can have one or more high-end PRP-enabled Ethernet switches to interface with another network. The Ethernet switch is an HSR-enabled switch with a higher number of ports, which should be configured as the root bridge.

The number of IEDs that can be connected in the STAR can be up to 128.

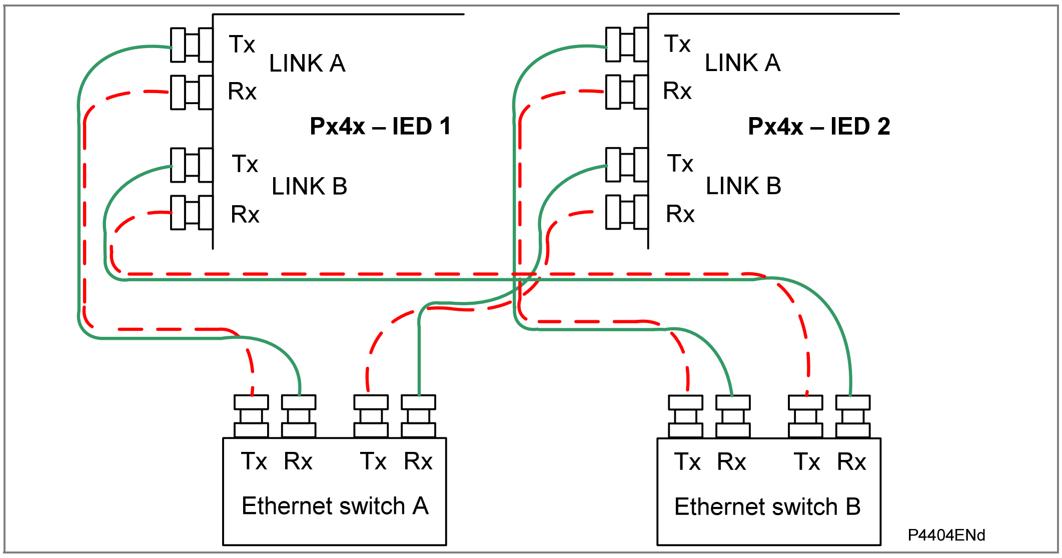


Figure 12 - PRP star connection

5.2 HSR Ring Connection

The following diagram shows the Px4x IEDs (Px4x - IED 1 to IED N) with the HSR variant of redundant Ethernet boards connected in a ring topology. The ring topology can have one or more high-end HSR-enabled Ethernet switches to interface with another network or a control center. The Ethernet switch is an HSR enabled switch with a higher number of ports.

The Ethernet switch, which is connected to the controlling PC, should be configured as the root bridge.

The number of IEDs that can be connected in the ring can be up to 128.

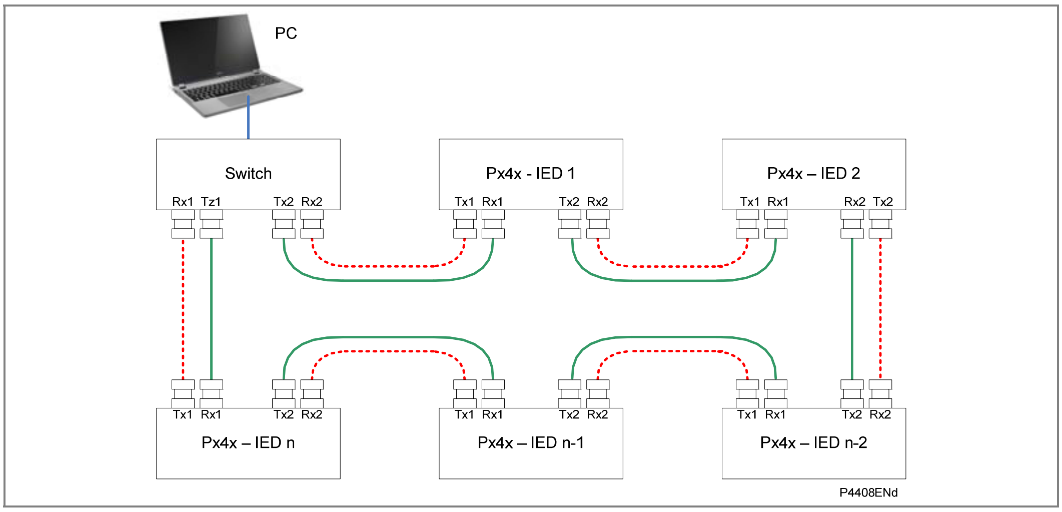


Figure 13 - HSR ring topology

The number of IEDs that can be connected in the ring can be up to 128.

6 TECHNICAL DATA

The technical data applies to a Redundant Ethernet board fitted into these MiCOM products.

- P141, P142, P143, P145
- P241, P242, P243
- P341, P342, P343, P344, P345
- P442, P443, P444, P445, P446
- P543, P544, P545, P546, P547
- P642, P643, P645
- P741, P743, P746
- P841, P849

6.1 Board Hardware

6.1.1 100 Base TX Communications Interface (in accordance with IEEE802.3 and IEC 61850)

Cable type	Screened Twisted Pair (STP)
Connector type	RJ45
Maximum distance	100m
Full Duplex	100 Mbps

Table 7 - 100 Base TX interface

6.1.2 100 Base FX Communications Interface (in accordance with IEEE802.3 and IEC 61850)

Optical fiber cable	Multi-mode 50/125 µm or 62.5/125 µm
Center wavelength	1310 nm
Connector type	LC
Maximum distance	2 km
Full Duplex	100 Mbps

Table 8 - 100 Base FX interface

6.1.3 Transmitter Optical Characteristics

(TA = -40° C to 85° C)

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

Table 9 - Tx optical characteristics

6.1.4 Receiver Optical Characteristics

(TA = -40° C to 85° C)

Parameter	Sym	Min.	Typ.	Max.	Unit
Input Optical Power	PIN	-31		-14	dBm avg.

Table 10 - Rx optical characteristics

6.1.5 IRIG-B and Real-Time Clock

6.1.5.1 Performance

Year 2000:	Compliant
Real time accuracy:	< ±2 seconds / day
External clock synchronization:	Conforms to IRIG standard 200-98, format B

6.1.5.2 Features

Real time 24 hour clock settable in hours, minutes and seconds
Calendar settable from January 1994 to December 2092
Clock and calendar maintained via battery after loss of auxiliary supply
Internal clock synchronization using IRIG-B Interface for IRIG-B signal is BNC

6.1.5.3 Self-adapted Rear IRIG-B interface (Modulated or Unmodulated)

BNC plug
Isolation to SELV level
50 ohm coaxial cable

6.2 Type Tests

6.2.1 Insulation

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

6.2.2 Creepage Distances and Clearances

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

6.2.3 High Voltage (Dielectric) Withstand

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

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

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

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

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

6.2.4 Impulse Voltage Withstand Test

As for EN / IEC 60255-27:

(i) Front time: 1.2 μs, Time to half-value: 50 μs,
Peak value: 5 kV, 0.5 J
Between all independent circuits.
Between independent circuits and case earth ground.

(ii) Front time: 1.2 μs, Time to half-value: 50 μs,
Peak value: 1.5kV, 0.5 J
Between RJ45 ports and the case earth (ground).
EIA(RS)-232 & EIA(RS)-485 ports and normally open contacts of output relays excepted.

6.3 ElectroMagnetic Compatibility (EMC)

6.3.1 1 MHz Burst High Frequency Disturbance Test

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

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

(EIA(RS)-232 ports excepted).

6.3.2 100 kHz and 1MHz Damped Oscillatory Test

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

6.3.3 Immunity to Electrostatic Discharge

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

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

6.3.4 Electrical Fast Transient or Burst Requirements

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

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

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

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

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

6.3.5 Surge Withstand Capability

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

6.3.6 Surge Immunity Test

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

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

6.3.7 Conducted/Radiated Immunity

For RTDs used for tripping applications the conducted and radiated immunity performance is guaranteed only when using totally shielded RTD cables (twisted leads).

6.3.8 Immunity to Radiated Electromagnetic Energy

Per EN / IEC 61000-4-3 and EN / IEC 60255-22-3, Class 3
Test field strength, frequency band 80 to 1000 MHz and
1.4 GHz to 2.7GHz: 10 V/m,
Test using AM: 1 kHz / 80%, Spot tests at 80, 160, 450, 900, 1850, 2150 MHz
Per IEEE/ANSI C37.90.2:
80MHz to 1000MHz, zero and 100% square wave modulated.
Field strength of 35V/m.

6.3.9 Radiated Immunity from Digital Communications

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

6.3.10 Radiated Immunity from Digital Radio Telephones

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

6.3.11 Immunity to Conducted Disturbances Induced by Radio Frequency Fields

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

6.3.12 Power Frequency Magnetic Field Immunity

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

6.3.13 Conducted Emissions

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

6.3.14 Radiated Emissions

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

6.4 Environmental Conditions

6.4.1 Ambient Temperature Range

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

6.4.2 Ambient Humidity Range

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

6.4.3 Corrosive Environments

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

6.5 EU Directives

6.5.1 EMC Compliance

As for 2004/108/EC:
Compliance to the European Commission Directive on EMC is demonstrated using a Technical File. Product Specific Standards were used to establish conformity:
EN 60255-26

6.5.2 Product Safety

Per 2006/95/EC:

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

CE EN 60255-27

6.5.3 R&TTE Compliance

Radio and Telecommunications Terminal Equipment (R&TTE) directive 99/5/EC.

Compliance demonstrated by compliance to both the EMC directive and the Low voltage directive, down to zero volts.

Applicable to rear communications ports.
Compliance demonstrated by Notified Body certificates of compliance.

6.5.4 Other Approvals

For ATEX Potentially Explosive Atmospheres directive 94/9/EC compliance, consult Schneider Electric.
For other approvals such as UL / CUL / CSA, consult Schneider Electric.

6.6 Mechanical Robustness

6.6.1 Vibration Test

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

6.6.2 Shock and Bump

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

6.6.3 Seismic Test

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

7 CORTEC

This is a generic Cortec to cover all IEDs using the **Redundant Ethernet** boards.
It does not necessarily include all the possible options for all products in the MiCOM Px4x range. Likewise, it is possible that options shown in this list, may not be available for all products

Variants / Order Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MiCOM Protection	P														
Application/Platform:															
Feeder Management:		1	4	*											
Motor Protection:		2	4	*											
Generator Protection Relay:		3	4	*											
Distance Protection Relay:		4	4	*											
Current Differential:		5	4	*											
Transformer:		6	4	*											
Busbar:		7	4	*											
Breaker Fail:		8	4	*											
Vx Aux Rating:															
24 - 32 Vdc					9										
48 - 110 Vdc					2										
110 - 250 Vdc (100 - 240 Vac)					3										
In/Vn Rating (model dependent):															
Product Dependent						*									
Hardware Options (model dependent):															
Standard - no options							1								
IRIG-B only (modulated)							2								
Fibre optic converter only							3								
IRIG-B (modulated) & fibre optic converter							4								
Ethernet with 100Mits/s fibre-optic port							6								
Second Rear Comms Port (Courier EIA232/EIA485/k-bus)							7								
Second Rear Comms Port + IRIG-B (modulated) (Courier EIA232/EIA485/k-bus)							8								
InterMiCOM + Courier Rear Port							E								
InterMiCOM + Courier Rear Port + IRIG-B modulated							F								
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 2 LC ports + 1 RJ45 port + Modulated/Unmodulated IRIG-B							Q								
Redundant Ethernet (100Mbit/s) PRP or HSR and Dual IP, 3 RJ45 ports + Modulated/Unmodulated IRIG-B							R								
Ethernet (100Mbit/s), 1 RJ45 port + Modulated/Unmodulated IRIG-B							S								
Product Specific Options (model dependent):															
Product Dependent								*							
Protocol Options:															
K-Bus/Courier									1						
Modbus									2						
IEC60870-5-103 (VDEW)									3						
DNP3.0									4						
IEC 61850 over Ethernet and Courier via rear K-Bus/RS485 OR IEC 61850 Edition 1 and Edition 2 and Courier via rear K-Bus/RS485									6						
IEC 61850 over ethernet with CS103 rear port RS485 protocol OR IEC 61850 Edition 1 and Edition 2 and CS103 via rear port RS485									7						
IEC 61850 Edition 1 / 2 and DNPoE and DNP3 Serial with simple password management - (CSL0)									B						
IEC 61850 Edition 1 / 2 and Courier via rear K-Bus/RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required									G						
IEC 61850 Edition 1 / 2 and CS103 via rear port RS485 with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required									H						
IEC 61850 Edition 1 / 2 and DNPoE and DNP3 Serial with advanced Cyber Security - CSL1 - Security Administration Tool (SAT) required									L						
Mounting Options:															
Flush Panel Mounting										M					

Rack Mounting (80TE only)	N
Language Options:	
English, French, German, Spanish	0
English, French, German, Russian	5
Chinese, English or French via HMI, with English or French only via Communications port	C
Software Version:	
	* *
Customisation:	
Default	8
Customer Specific	9
Design Suffix:	
Phase 3 CPU	L
Extended Phase 3 CPU	M

PRP NOTES

CHAPTER 20

Date (month/year):	12/2016			
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.			
Hardware Suffix:	P141/P142/P143	L	P54x (P543/P544/P545/P546)	M
	P145	M	P642	L
	P241	L	P643/P645	M
	P242/P243	M	P741/P743	M
	P342	L	P742	L
	P343/P344/P345	M	P746	M
	P445	L	P841A (one circuit breaker)	M
	P44x (P442/P444)	M	P841B (two circuit breakers)	M
	P44y (P443/P446)	M	P849	M
Software Version:	P14x (P141/P142/P143/P145)	B0/B2	P54x (P543/P544/P545/P546)	H4
	P24x (P241/P242/P243)	D0	P64x (P642/P643/P645)	B1/B2
	P341	B1/E1	P746	B1/B2/B3 C1/C2/C3
	P34x (P342/P343/P344/P345)	B0/B1	P74x (P741/P742/P743)	B0
	P445	J4/B0/B1/E0/E1	P841A	G4
	P44x (P442/P444)	E0/E1	P841B	H4
	P44y (P443/P446)	H4	P849	B0/B1
Connection Diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P445: 10P445xx (xx = 01 to 04) P44x(P442 & P444): 10P44101 (SH 1 & 2) 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)		P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 1 to 10) 10P643xx (xx = 1 to 6) 10P645xx (xx = 1 to 9) P74x (P741, P742 & P743): 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)	

CONTENTS

TABLES

FIGURES

Notes:

1 PARALLEL REDUNDANCY PROTOCOL (PRP) NOTES

1.1 Introduction to PRP

This section gives an introduction to the Parallel Redundancy Protocol (PRP); and how it is implemented on MiCOM-based products manufactured by Schneider Electric.

1.2 Protocols

Industrial real-time Ethernets typically need much better levels of availability and uninterrupted operation than normal office-type Ethernet solutions. For power networks, even a short loss of connectivity may result in a significant loss of functionality or impaired safety. To recover from a network failure, various redundancy schemes have been considered, including: Rapid Spanning Tree Protocol (RSTP), Media Redundancy Protocol (MRP) and Parallel Redundancy Protocol (PRP). The key properties of these are as follows:

RSTP this uses mesh-based topologies or ring topology and computes a tree, based on path costs and priorities. In case of network failure, a typical reset time for RSTP-based system is normally a few seconds.

MRP This uses ring-based topologies. In case of network failure, the network is broken into two separate lines, which are reconnected by de-blocking the previously blocked part. The guaranteed reset time for MRP protocol-based systems is typically around 100ms.

PRP this does not change the active topology as it uses two independent networks. Each message is replicated and sent over both networks. The first network node to receive it acts on it, with all later copies of the message being discarded. Importantly, these details are controlled by the low-level PRP layer of the network architecture, with the two networks being hidden from the higher level layers. Consequently, PRP-based networks are continuously available.

Power networks need to be able to respond to problems very quickly (typically in less than 10ms), and PRP is an available protocol which is robust enough to achieve this. The PRP protocol used in the MiCOM relay/IEDs is defined in the IEC62439-3 (2012) standard and is configured using the existing redundant Ethernet card(s).

1.3 PRP Summary (IEC 62439-3 Clause 4)

A summary of the main PRP features is given below:

- Ethernet redundancy method independent of any Ethernet protocol or topology (tree, ring or mesh)
- Seamless switchover and recovery in case of failure, which supports real-time communication
- Supervises redundancy continuously for better management of network devices
- Suitable for hot swap - 24 hour/365 day operation in substations
- Allows the mixing of devices with single and double network attached nodes on the same Local Area Network (LAN)
- Allows laptops and workstations to be connected to the network with standard Ethernet adapters (on double or single attached nodes)
- Particularly suited for substation automation, high-speed drives and transportation

1.4 Example of a PRP Network

Essentially a PRP network is a pair of similar Local Area Networks (LANs) which can be any topology (tree, ring or mesh). An example of a PRP network is shown in Figure 1:

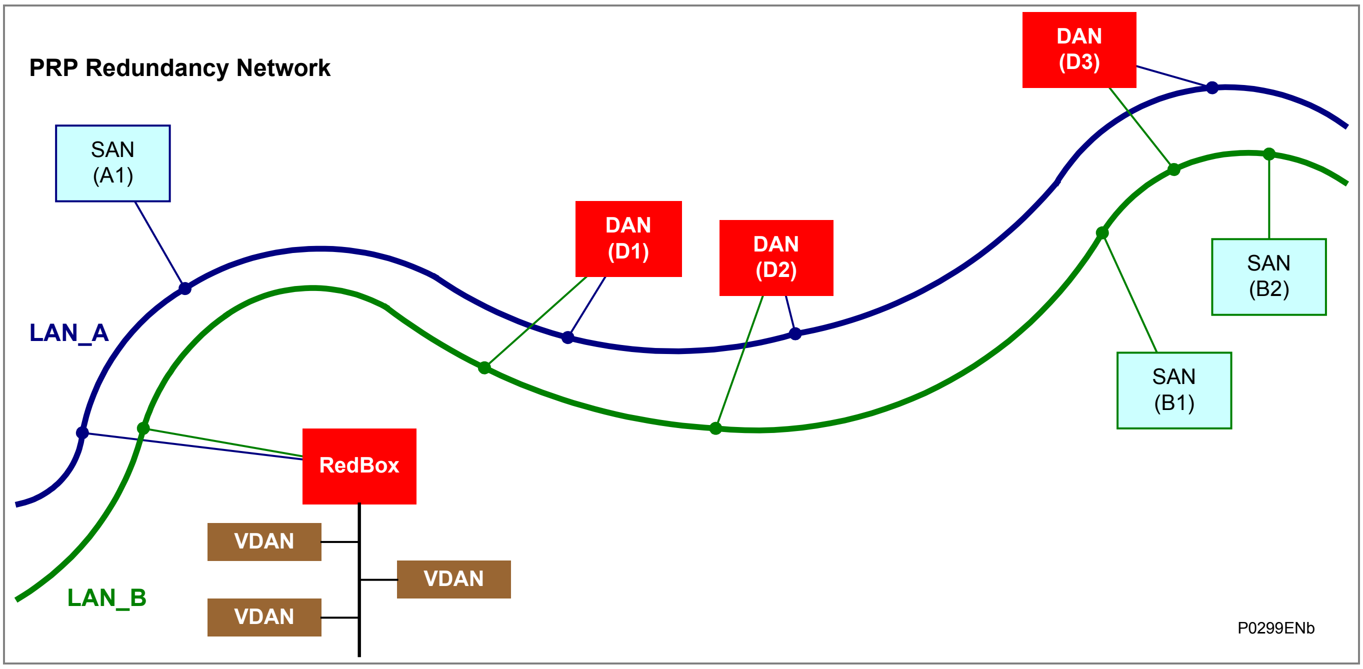


Figure 1 - PRP Redundancy Network

Figure 1 shows two similar Local Area Networks (LANs) which have various Nodes in common. The key features of these networks include:

- With the exception of a RedBox (see below), no direct cable connections can be made between the two LANs.
- Each of these LANs can have one or more Single Attached Nodes (SANs). These are normally non-critical devices that are attached only to a single network. SANs can talk to one another, but only if they are on the same LAN.
- Matched pairs of devices which are critical to the operation of the overall scheme are connected one to each network as Doubly Attached Nodes (DANs).
- To be sure that network messages (also known as frames) are transferred correctly to each DAN, each DAN must have the same Media Access Control (MAC) code and Internet Protocol (IP) address. This will also mean that TCP/IP traffic will automatically communicate with both of the paired devices, so it will be unaware of any two-layer redundancy or frame duplication issues.
- A Redundancy Box (RedBox) is used when a single interface node has to be connected to both networks. The RedBox can talk to all other nodes. So far as other nodes are concerned, the RedBox behaves like a DAN, so a SAN that is connected through a RedBox is also called a Virtual Doubly Attached Node (VDAN). The RedBox must have its own unique IP address.
- Transmission delays can be different between related Nodes of the two LANs.
- Each LAN (i.e. LAN_A and LAN_B) must be powered from a different power source and must be failure independent.

The two LANs can differ in terms of performance and topology. The redundant Ethernet interface can be made using an optical fiber connection with an LC or ST connector type or with RJ45 copper connector type. There is no need for an optical interface away from the relay.

1.5 PRP Network Structure

PRP uses two independent LANs. The topology of each of these LANs is arbitrary, and ring, star, bus and meshed topologies are possible.

The main advantage of PRP is loss-free data transmission with an active (transit) LAN. When the terminal device receives no packets from one of the LANs, the second (transit) LAN maintains the connection. As long as 1 (transit) LAN is available, repairs and maintenance on the other (transit) LAN have no impact on the data packet transmission.

The elementary devices of a PRP network are known as RedBox (Redundancy Box) and DANP (Double Attached Node implementing PRP).

Both devices have one connection each to the (transit) LANs.

The devices in the (transit) LAN are conventional switches that do not require any PRP support. The devices transmit PRP data packets transparently, without evaluating the RCT information.

Terminal devices that are connected directly to a device in the (transit) LAN are known as SAN (Single Attached Node). If there is an interruption, these terminal devices cannot be reached via the redundant line. To use the uninterruptible redundancy of the PRP network, you integrate your device into the PRP network via a RedBox.

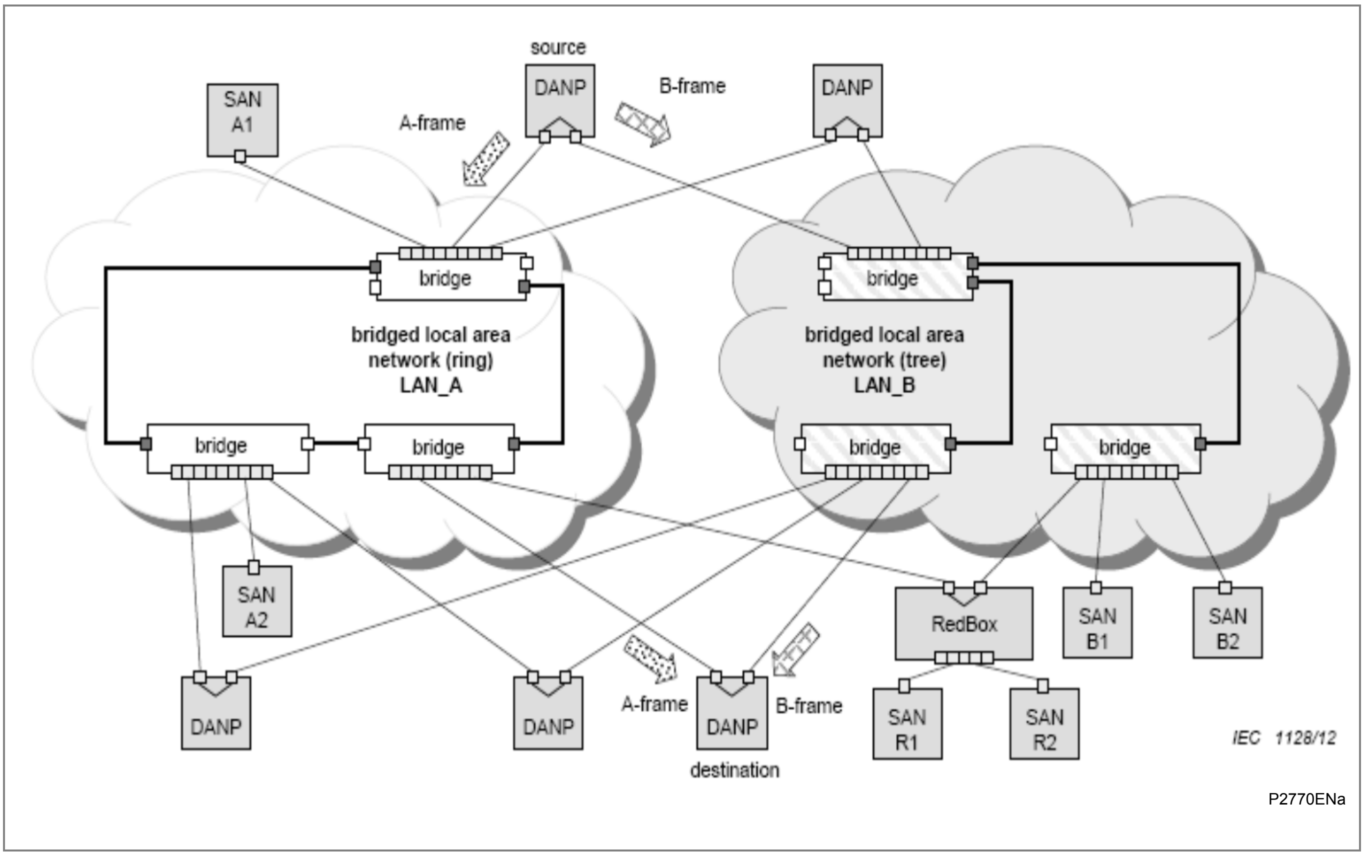


Figure 2 - PRP example of general redundant network

1.6 Structure of a DAN

A MiCOM P40 relay working in PRP Mode works as a DAN within the overall network topology. Each DAN has two ports that operate in parallel. They are attached to the upper layers of the communications stack through the Link Redundancy Entity (LRE) as in Figure 3:

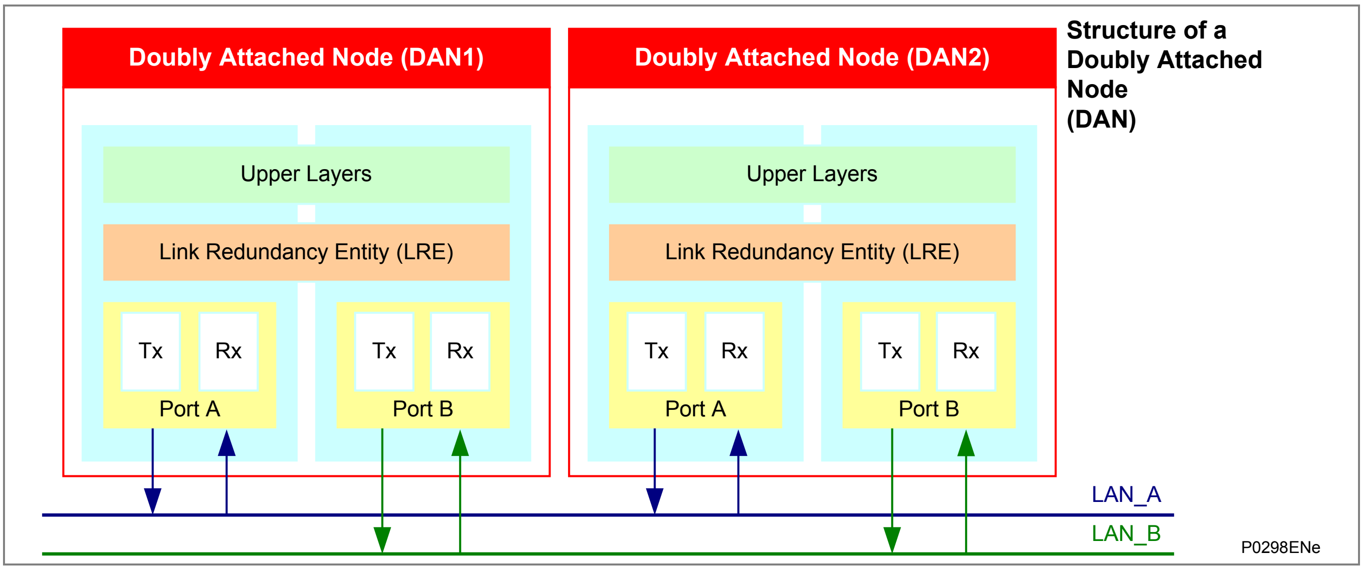


Figure 3 - Communication between two DANs (in PRP)

The LRE has two main tasks:

- handling message frames and
- management of redundancy

When an upper layer sends a frame to the LRE, the LRE replicates the frame and sends it through both its ports at nearly the same time. The two frames move through the two LANs with slightly different delays, ideally arriving at the destination node within a small time window.

When receiving frames, the LRE forwards the first frame it received to its upper layers and then discards the duplicate.

As both DAN nodes have the same MAC and IP addresses, this makes redundancy transparent to the upper layers. This allows the Address Resolution Protocol (ARP) to work in the same way as with a SAN. Accordingly, to the upper layers of a DAN, the LRE layer shows the same interface as the network adapter of a non-redundant adapter.

To manage redundancy, the LRE:

- Adds a 32-bit Redundancy Check Tag (RCT) to each frame it sends and
- Removes the RCT from each frame it receives

1.7 Communication between SANs and DANs

A SAN can be connected to any LAN and can communicate with any other SAN on the same LAN or any DAN. However, a SAN which connected to one LAN can not communicate directly to a SAN which is connected to the other LAN.

A DAN is connected to both LANs and can communicate with any RedBox or any other DANs or any SANs on either network. For communication purposes, a DAN "views" a SAN connected through a RedBox as a VDAN.

When a SAN generates a basic frame, it sends the frame only onto the LAN to which it is connected.

Originating at the SAN, a typical frame contains these parameters:

- dest_addr Destination Address
- src_addr Source Address
- type Type
- data
- fcs Frame Check Sequence (i.e. extra checksum characters added to allow error detection and correction)

The frame from the SAN is then received by the DAN; which sends the frame to its upper layers, which act accordingly.

When a DAN generates a frame, it needs to send the frame onto both of the LANs to which it is connected. When it does this, it extends the frame by adding the 48-bit Redundancy Control Trailer (RCT) into the frame.

The RCT consists of these parameters:

- 16-bit Sequence Number
- 4-bit LAN identifier, 1010 (0xA) for LAN_A and 1011 (0xB) for LAN_B
- 12-bit frame size
- PRP suffix

Note	*The Sequence number is a measure of the number of messages which have been sent since the last system reset. Each time the link layer sends a frame to a particular destination the sender increases the sequence number corresponding to that destination and sends the (nearly) identical frames over both LANs.*

Accordingly, originating at the DAN, a typical frame then contains these parameters:

- dest_addr Destination Address
- src_addr Source Address
- type Type
- lsdu Link Service Data Unit
- Padding if needed
- RCT data:
  - 16-bit sequence number:
    4-bit LAN identifier
    12-bit frame size
  - 16-bit PRP suffix (0X88 0XFB)
- fcs Frame Check Sequence

LSDU	*The Link Service Data Unit (LSDU) data allows PRP frames to be distinguished from none-PRP frames.*
Padding	*After the LSDU data, there may be some data padding. This is added to frames which would otherwise be too short for conventional network traffic (minimum frame size is 64 octets).*

Size	*The frame size will vary depending on the contents of the frame and how it has been tagged by the various SANs and DANs. In VLANs, frame tags may be added or removed during transit through a switch. To make the length field independent of tagging, only the LSDU and the RCT are considered in the size.*

Figure 4 shows the frame types with different types of data.

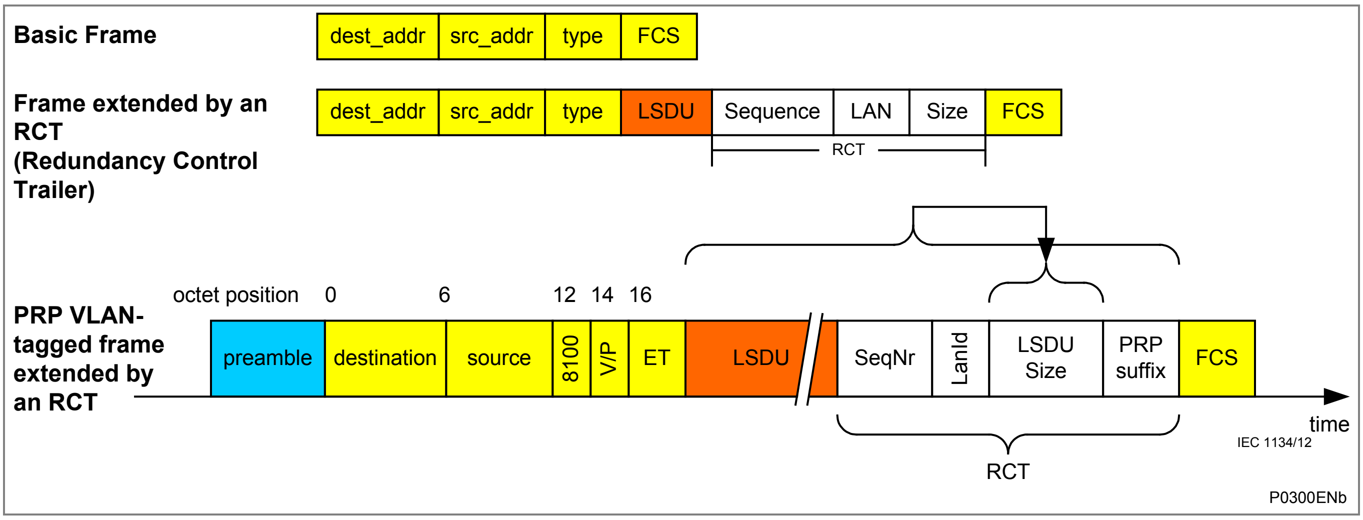


Figure 4 - Frames (basic, extended by an RCT and a VLAN tagged frame extended by RCT)

The key points about these differing frame structures is that:

- SANs do not implement any redundancy features, so they generate basic frames which SANs and DANs can understand.
- SANs can still understand the frames that come from DANs, as SANs ignore the RCT components in frames which come from DANs (a SAN cannot distinguish the RCT from the IEEE802.3 padding)
- If a DAN receives a frame which does not include the RCT component, it sends a single copy of the frame to its upper layers.
- If a DAN receives a frame which does include the RCT component, it does not send a duplicate copy of the frame to its upper layers.
- If a DANP cannot identify that the remote Node is a DAN, it inserts no RCT.

When using a Single Attached Nodes connected to the IED, a redbox is suggested to handle the case when the TPDU size for the client has been set above than 1024.

1.8 PRP Technical Data

- One VLAN tag supported.
- 128 publishers supported per receiver.
- Up to 100Mbit/s full duplex Ethernet.
- Dynamic frame memory allocation (page manager).
- Configurable duplicate detection.
- Wishbone interface for configuration and status registers.
- CPU port interface - Ethernet or Wishbone.
- Support for link-local protocols - CPU may send to specific ports only - CPU knows receive port.
- Configurable frame memory and queue length.
- Duplicate detection with configurable size and aging time.
- MAC address filtering (8 filter masks for interlink, 6 for CPU).
- Support for interfaces with or without Ethernet preamble.

Maximum Transmission Unit

According to the IEC 8802-3, the MTU (Ethernet maximum packet size) is:

- 1518 bytes without VLAN and without PRP
- 1522 bytes with VLAN and without PRP
- 1524 bytes without VLAN and with PRP
- 1528 bytes with VLAN and with PRP

Note: Check that the LAN switches setting for the MTU is at least 1528 bytes

2 PRP AND MICOM FUNCTIONS

2.1 MiCOM Products and PRP

The PRP functions being introduced as part of the overall MiCOM product range provide additional functionality, which is backwards compatible with existing Schneider Electric MiCOM equipment. This means that existing MiCOM relays/IEDS can be used on networks which use PRP functions, with no changes being made to those relays/IEDs.

The new MiCOM products that use the PRP, will interrogate other equipment to determine the equipment model number, and then use the model number to decide (at runtime), whether that particular item of equipment can support PRP or not.

MiCOM models which include the following Ethernet board assembly provide the possibility of PRP function support. This is denoted by Digit 7 where the Hardware option is N, P, Q or R, as shown in Table 1:

Hardware Option	Type	Model No format
"N" at Digit No 7	2 ST ports redundant Ethernet board (Modulated IRIG-B)	Px4xxxNx6Mxxx8K
"P" at Digit No 7	2 ST ports redundant Ethernet board (Un-modulated IRIG-B)	Px4xxxPx6Mxxx8K
"Q" at Digit No 7	2 LC + 1 RJ45 ports redundant Ethernet board (Modulated/ Un-modulated IRIG-B)	Px4xxxQx6Mxxx8M
"R" at Digit No 7	3 RJ45 ports redundant Ethernet board (Modulated/ Un-modulated IRIG-B)	Px4xxxRx6Mxxx8M

Table 1 - MiCOM model numbers for PRP options

The MiCOM relay/IED firmware has been modified to allow the PRP options to be accepted for the power-up tests in addition to the implementation of the supervision frame transmission.

2.2 MiCOM S1 Studio Software and the PRP Function

The addition of this function has no impact of the MiCOM S1 Studio support files so there is no need to upgrade any MiCOM S1 Studio software.

2.3 MiCOM Relay Configuration and the PRP Function

There is no need to change the configuration of any relay (as relays which include support for this function will be able to recognize other devices which support it).

2.4 Hardware Changes for PRP Protocol

This protocol is implemented using the existing redundant Ethernet and dual redundant Ethernet card as a starting point. The Frame management is achieved by re-programming the Field-Programmable Gate Array (FPGA).

The low-level management of the redundant frames is performed within the FPGA; this being defined as the Link Redundancy Entity (LRE). This will involve the addition of the Redundancy Check Tag (RCT) to a frame to be transmitted; this identifies the LAN and the sequence number of the message over the two networks. The FPGA is also responsible for the stripping of the RCT from received frames and discarding the duplicated messages such that only a single application frame is received by the Ethernet processor.

The LRE functionality of the supervision frame transmission is performed by the Ethernet processor card.

2.5 PRP Parameters

The Redundant Ethernet standard (IEC 62439-3:2012) defines several parameters for the PRP protocol; these being fixed at a default value within this release. The following values are set:

Parameter	Value	Description
Supervision Frame Multicast Address	01-15-4E-00-01-00	Target MAC Address for multicast supervision frame
Life Check Interval	2 seconds	Period between transmission of supervision frames
PRP Mode	Duplicate Discard	This is normal PRP mode, Duplicate address will not be supported.
Node Forget Time	60 s	This is the time after which a node entry is cleared.
Entry Forget Time	400 ms	Duration that the received message Sequence number will be held to discard a duplicate message.
Node Reboot Interval	500ms	Duration following reboot for which no PRP frames should be transmitted.

Table 2 - PRP parameter values (for PRP Protocol Version 1)

2.6 Product Implementation Features

Here is a list of the main Product Requirements for MiCOM products which support PRP:

- The MiCOM relay/IED provides two redundant Ethernet ports using PRP.
- The MiCOM relay/IED must be connected to the redundant Ethernet network as a Double Attached Node (DAN) using PRP (DAN using PRP is known as DANP)
- The redundant Ethernet interface can be made using an RJ45 or an optical fibre connection with an LC or ST connector type (Ethernet card dependent).
- The management of the PRP redundancy is transparent to the application data provided via the Ethernet interface.
- The PRP option is available with any of the existing protocol options via the Ethernet Interface (IEC61850 and/or DNPoE)
- Loss of one of the LAN connections to the device does not cause any loss or degradation to the Application data over the Ethernet interface.
- The MiCOM relay/IED supports the transmission of the PRP Supervision frame at a fixed time period (LifeCheckInterval) of 2s (+/- 100ms)
- Each supervision frame includes a sequence number as defined in the IEC 62439-3:2012 specification. This is incremented for each supervision message and the value starts from zero following a system restart.
- The MiCOM relay/IED does not process received supervision frames to provide supervision of the redundant network.
- The MiCOM relay/IED does not provide for the PRP management to be configured (via either the MiCOM relay/IED HMI or the Ethernet interface). Accordingly, the default values (as defined within this document) are used for all PRP parameters.
- The performance of the Ethernet Interface is not degraded by using the PRP interface.

2.6.1 Abbreviations and Acronyms

Abbreviations / Acronyms	Meaning
CRC	Cyclic Redundancy Check
DAN	Doubly Attached Nodes
DANP	Doubly Attached Node implementing PRP
FPGA	Field-Programmable Gate Array
HMI	Human Machine Interface
IED	Intelligent Electronic Devices
IP	Internet Protocol
LAN	Local Area Network
LRE	Link Redundancy Entity
MAC	Media Access Control
MRP	Media Redundancy Protocol
PRP	Parallel Redundancy Protocol
RCT	Redundancy Check Tag
RedBox	Redundancy Box
RSTP	Rapid Spanning Tree Protocol
SAN	Singly Attached Node
TCP	Transmission Control Protocol
VDAN	Virtual Doubly Attached Node

Notes:

HSR NOTES

CHAPTER 21

Date (month/year):	11/2016			
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.			
Hardware Suffix:	P141/P142/P143	L	P54x (P543/P544/P545/P546)	M
	P145	M	P642	L
	P241	L	P643/P645	M
	P242/P243	M	P741/P743	M
	P342	L	P742	L
	P343/P344/P345	M	P746	M
	P391	A	P74x (P741, P743)	K
	P445	L	P841A (one circuit breaker)	M
	P44x (P441/P442/P444)	K	P841B (two circuit breakers)	M
	P44x (P442/P444)	M	P849	M
	P44y (P443/P446)	M		
Software Version:	P14x (P141/P142/P143/P145)	B0/B2	P54x (P543/P544/P545/P546)	H4
	P24x (P241/P242/P243)	D0	P64x (P642/P643/P645)	B2
	P34x (P342/P343/P344/P345/P391)	B0	P746	B3/C3
	P445	J4	P74x (P741/P742/P743)	B0
	P44x (P442/P444)	E0/E1	P841A	G4
	P44y (P443/P446)	H4	P841B	H4
			P849	B0/B1
Connection Diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P445: 10P445xx (xx = 01 to 04) P44x(P442 & P444): 10P44101 (SH 1 & 2) 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)		P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 1 to 10) 10P643xx (xx = 1 to 6) 10P645xx (xx = 1 to 9) P74x (P741, P742 & P743): 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)	

CONTENTS

TABLES

FIGURES

Notes:

1 INTRODUCTION TO HSR

1.1 Introduction to High-availability Seamless Redundancy (HSR)

This section gives an introduction to the High-availability Seamless Redundancy (HSR); and how it is implemented on MiCOM-based products manufactured by Schneider Electric.

1.2 Protocols

Industrial real-time Ethernets typically need much better levels of availability and uninterrupted operation than normal office-type Ethernet solutions. For power networks, even a short loss of connectivity may result in a significant loss of functionality or impaired safety. To recover from a network failure, various redundancy schemes have been considered, including: Rapid Spanning Tree Protocol (RSTP), Media Redundancy Protocol (MRP), High-availability Seamless Redundancy (HSR). The key properties of these are as follows:

RSTP This uses mesh-based topologies or ring topology and computes a tree, based on path costs and priorities. In case of network failure, a typical reset time for RSTP-based system is normally a few seconds.

MRP This uses ring-based topologies. In case of network failure, the network is broken into two separate lines, which are reconnected by de-blocking the previously blocked part. The guaranteed reset time for MRP protocol-based systems is typically around 100ms.

HSR HSR basically uses ring topology, This Clause describes the application of the HSR principles (Clause 5) to implement a High-availability Seamless Redundancy (HSR), retaining the PRP property of zero recovery time, applicable to any topology, in particular rings and rings of rings. With respect to PRP, HSR allows to roughly halve the network infrastructure. With respect to rings based on IEEE 802.1D (RSTP), IEC 62439-2 (MRP), IEC 62439-6 (DRP) or IEC 62439-7 (RRP), the available network bandwidth for network traffic is somewhat reduced depending on the type of traffic. Nodes within the ring are restricted to be HSR-capable bridging nodes, thus avoiding the use of dedicated bridges. Singly Attached Nodes (SANs) such as laptops or printers cannot be attached directly to the ring, but need attachment through a RedBox (redundancy box).

Power networks need to be able to respond to problems very quickly (typically in less than 10ms), and HSR is an available protocol which is robust enough to achieve this. The HSR protocol used in the MiCOM relay/IED is defined in the IEC62439-3 (2012) standard and is configured using the existing redundant Ethernet card(s).

1.3 HSR Summary (IEC 62439-3 Clause 5)

A summary of the main HSR features is given below:

- HSR Ethernet redundancy method independent of any industrial Ethernet protocol and typically used in a ring topology
- Seamless switchover and recovery in case of failure, which supports real-time communication
- Supervises redundancy continuously for better management of network devices
- Suitable for hot swap, 24 hour/365 day operation in substations
- Allows laptops and workstations to be connected to the network with HSR Redbox
- Particularly suited for substation automation, high-speed drives and transportation

1.4 Example of an HSR Network

Essentially a HSR network is a ring topology. An example of a HSR network is shown in Figure 1:

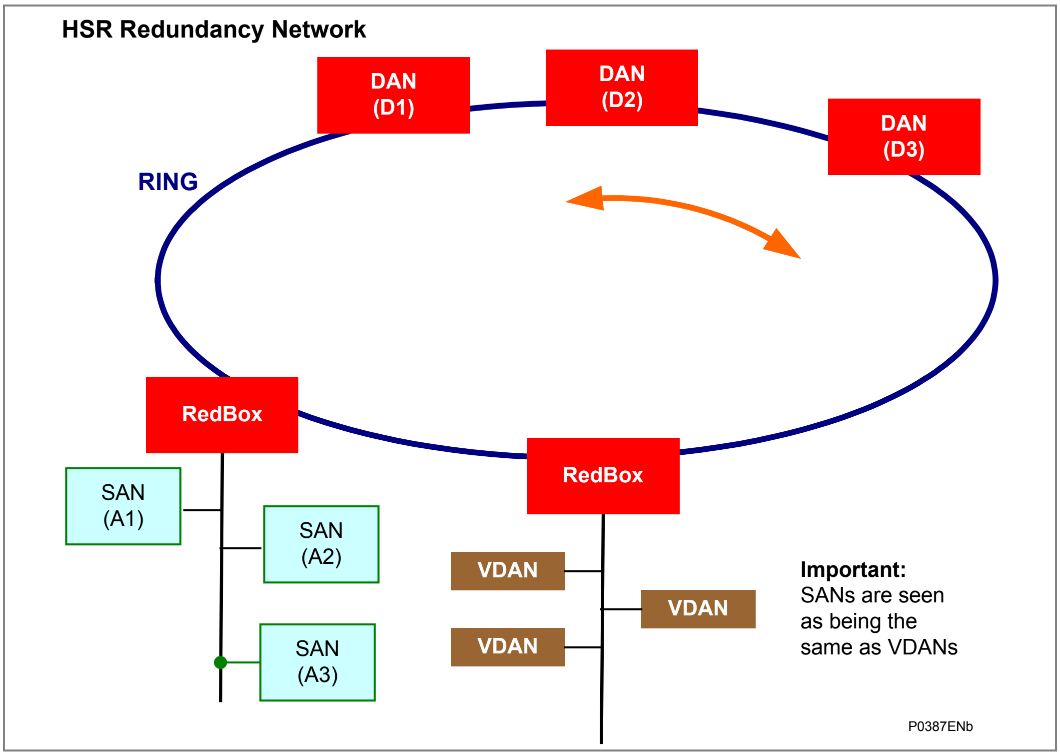


Figure 1 - HSR Redundancy Network

Figure 1 shows typical ring networks that have various Nodes in common.

The key features of the network include:

- Nodes within the ring are restricted to be HSR-capable bridging nodes, thus avoiding the use of dedicated bridges
- Singly Attached Nodes (SANs) such as laptops or printers cannot be attached directly to the ring, but need attachment through a RedBox (redundancy box)
- A simple HSR network consists of doubly attached bridging nodes, each having two ports, interconnected by full-duplex link
- A source DANH sends a frame passed from its upper layers, prefixes it by an HSR tag to identify frame duplicates and sends the frame over each port
- A destination DANH receives, in the fault-free state, two identical frames from each port within a certain interval, if it is a multicast frame, it instantaneously forwards it on the ring (see Note *), removes the HSR tag of the first frame before passing it to its upper layers and discards any duplicate.

*Note **	*In particular, the node will not forward a frame that it injected into the ring.*
*Note **	*A destination node of a unicast frame does not forward a frame for which it is the only destination, except for testing.*

1.5 Structure of a DAN

A MiCOM P40 relay working in HSR Mode works as a DAN within the overall network topology. Each DAN has two ports that operate in parallel. As in Figure 2, The two HSR ports A and B and the device port C are connected by the LRE, which includes a switching matrix allowing to forward frames from one port to the other. The switching matrix allows cut-through bridging. The Link Redundancy Entity (LRE) presents to the higher layers the same interface as a standard Ethernet transceiver would do.

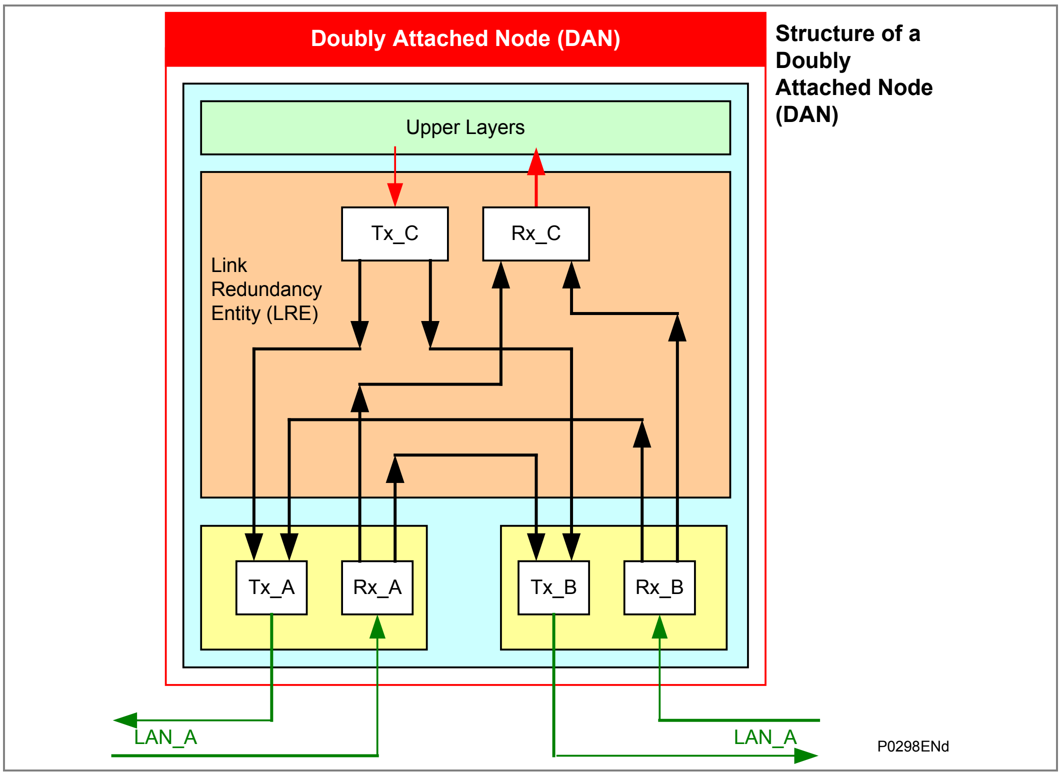


Figure 2 - DAN communication between two paths (in HSR)

DAN node is operable in HSR-tagged forwarding mode, the DAN inserts the HSR tag on behalf of its host and forwards the ring traffic, except for frames sent by the node itself. Duplicate frames and frames where the node is the unicast destination is not forwarded.

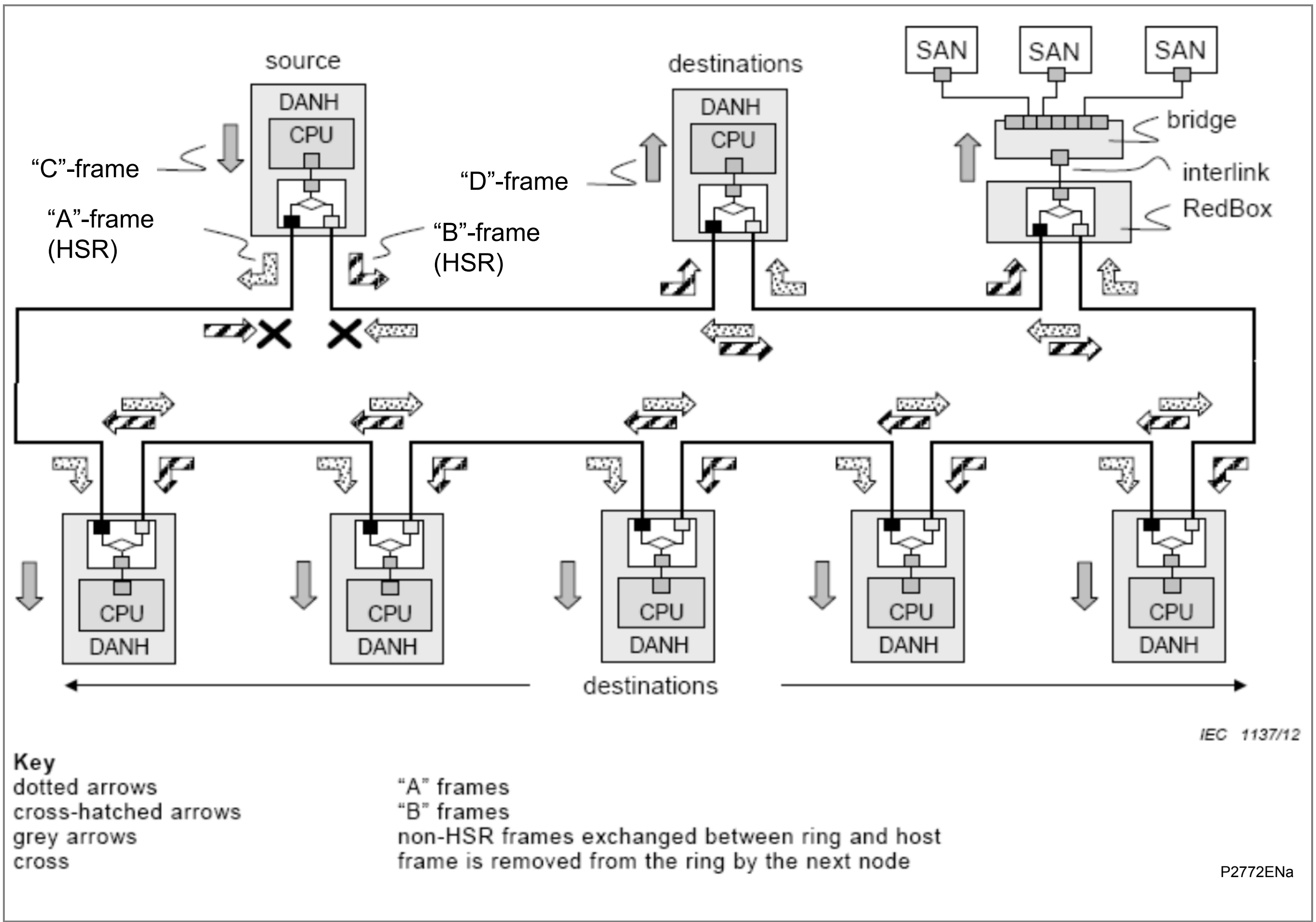


Figure 3 - HSR example of ring configuration for multicast traffic

1.6 Structure of a RedBox

The RedBox has a LRE that performs the duties of the HSR protocol, in particular:

- forwards the frames received from one HSR port to the other HSR port, unless the frame receives frames addressed to its own upper protocols
- prefixes the frames sent by its own upper layers with the corresponding HSR tag before sending two copies over its HSR ports

The switching logic is incorporated into the RedBox, so interlink becomes an internal connection.

A simple RedBox is present in every node, since the LRE makes a transition to a single non-HSR host. In addition, it is usual to have more than one host in a node, since a port for maintenance often exists.

A node does not send over a port a frame that is a duplicate of a frame previously sent over that port in that same direction.

For the purpose of Duplicate Discard, a frame is identified by:

- its source MAC address;
- its sequence number.

The Duplicate Discard method forgets an entry identified by <Source MAC Address><Sequence number> after a time EntryForgetTime.

1.7 Communication between SANs, DANs and RedBoxs

Singly Attached Nodes (SANs), for instance maintenance laptops or printers cannot be inserted directly into the ring since they have only one port and cannot interpret the HSR tag in the frames. SANs communicate with ring devices through a RedBox (Redundancy Box) that acts as a proxy for the SANs attached to it.

A source DANH sends a frame passed from its upper layers, and prefixes it by an HSR tag to identify frame duplicates and sends the frame over both ports.

A destination DANH receives, in the fault-free state, two identical frames from each port within a certain interval, if it is a multicast frame, it instantaneously forwards it on the ring, removes the HSR tag of the first frame before passing it to its upper layers and discards any duplicate.

A typical frame contains these parameters:

- dest_addr Destination Address
- src_addr Source Address
- type Type
- data
- fcs Frame Check Sequence (i.e. extra checksum characters added to allow error detection and correction)

HSR frames are identified uniquely by their HSR tag.

The HSR tag consists of these parameters:

- 16-bit Ethertype (HSR_EtherType = 0x892F)
- 4-bit path identifier (PathId), 0000 for both HSR nodes A and B, and 0010-1111 for one of 7 PRP networks (A/B).
- 12-bit frame size (LSDUsize)
- 16-bit Sequence Number (SeqNr)

Note	*The 4-bit PathId field prevents reinjection of frames coming from one PRP network to another PRP network.*

Accordingly, a typical HSR frame then contains these parameters:

- dest_addr Destination Address
- src_addr Source Address
- HSR tag data:
    - 16-bit Ethertype (HSR_EtherType = 0x892F)
    - 4-bit path identifier
    - 12-bit frame size
    - 16-bit sequence number:
- type Type
- payload Payload
- Padding if needed
- fcs Frame Check Sequence

Padding	*After the payload data, there may be some data padding. This is added to frames which would otherwise be too short for conventional network traffic (minimum frame size is 70 octets).*
Size	*The frame size will vary depending on the contents of the frame and how it has been tagged by the various SANs and DANs. In VLANs, frame tags may be added or removed during transit through a switch. To make the length field independent of tagging, only the original LPDU and the HSR tag are considered in the size.*

Figure 4 and Figure 5 shows the frame types with different types of data.

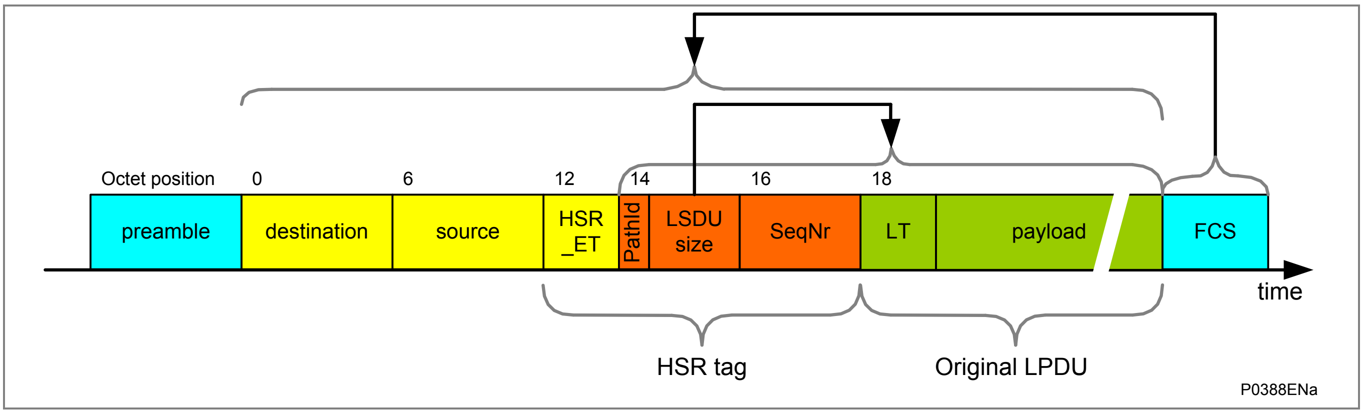


Figure 4 - HSR frame without a VLAN tag

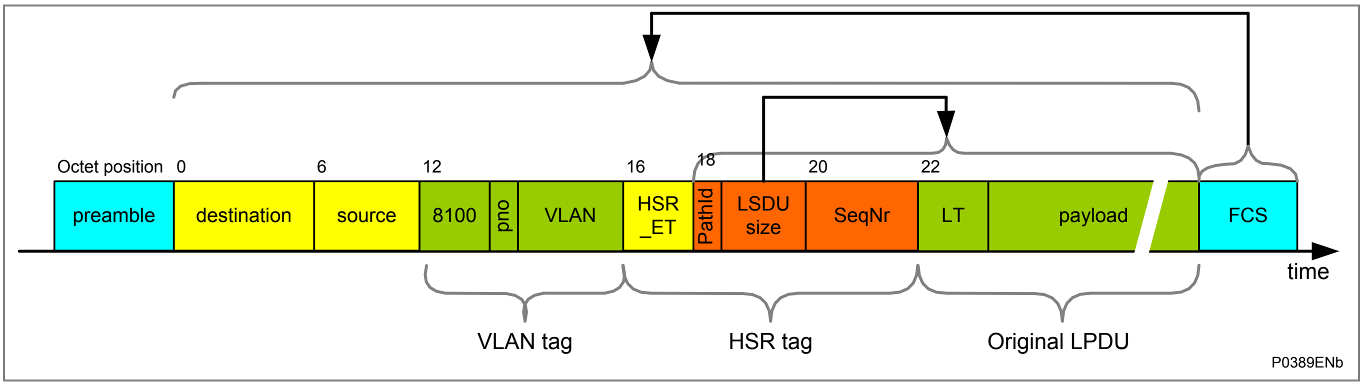


Figure 5 - HSR frame with VLAN tag

The key points about these differing frame structures are that:

- Unlike PRP, SANs cannot be attached directly to such a duplicated network unless they are able to interpret the HSR tag.
- In particular, the node will not forward a frame that it injected into the ring.
- A destination node of a unicast frame does not forward a frame for which it is the only destination, except for testing.
- DANH receiving from an HSR port, if this frame is not HSR-tagged and is a link local traffic, consume the frame and do not forward it.
- DANH receiving from an HSR port, if this frame is HSR-tagged and this node is not a destination, do not pass the frame to the link layer interface.
- A node accepts an HSR tagged frame also if the LanId does not correspond to the PortId and if the LSDUsize does not match the frame size.

1.8 HSR Technical Data

- One VLAN tag supported
- Up to 128 devices supported
- Up to 100Mbit/s full duplex Ethernet
- Dynamic frame memory allocation (page manager)
- Configurable duplicate detection
- Wishbone interface for configuration and status registers
- CPU port interface - Wishbone
- Support for link-local protocols - CPU may send to specific ports only - CPU knows receive port
- Configurable frame memory and queue length
- Duplicate detection with configurable size and aging time

- MAC address filtering (8 filter masks for interlink port, 6 for CPU port)
- Support for interfaces with or without Ethernet preamble

Limitations:

Number of IEDs on a same ring at 100Mbit/s:

Each hop (IED or RedBox) not only carries its own messages but also all the other IED messages thus the bandwidth used is proportional to the number of IEDs.

The maximum number of hops is around 20 when the GOOSE messages are highly used or 40 if the number and importance of GOOSE messages is not high.

When Precision Time Protocol («IEEE1588/IEC 61588») is used:

As the GPS receiver inaccuracy is 200ns and as each hop (IED or RedBox) can add a 50ns inaccuracy, the maximum number of hops is 16 if 1µs accuracy is required (PMU application or Process Bus)

2 HSR AND MICOM FUNCTIONS

2.1 MiCOM Products and HSR

The HSR functions being introduced as part of the overall MiCOM product range provide additional functionality, which is backwards compatible with existing Schneider Electric MiCOM equipment. This means that existing MiCOM relays/IEDS can be used on networks, which use HSR functions, with no changes being made to those relays/IEDs.

The new MiCOM products that use the HSR, will interrogate other equipment to determine the equipment model number, and then use the model number to decide (at runtime), whether that particular item of equipment can support HSR or not.

MiCOM models which include the following Ethernet board assembly provide the possibility of HSR function support. This is denoted by Digit 7 where the Hardware option is Q or R, as shown below:

Hardware Option	Type	Model No format
"Q" at Digit No 7	2 LC + 1 RJ45 ports redundant Ethernet board (Modulated/ Un-modulated IRIG-B)	Px4xxxQx6Mxxx8M
"R" at Digit No 7	3 RJ45 ports redundant Ethernet board (Modulated/ Un-modulated IRIG-B)	Px4xxxRx6Mxxx8M

Table 1 - Hardware option numbers with HSR functions

The MiCOM relay/IED firmware has been modified to allow the HSR options to be accepted for the power-up tests in addition to the implementation of the supervision frame transmission.

2.2 MiCOM S1 Studio Software and the HSR Function

The addition of this function has no impact of the MiCOM S1 Studio support files so there is no need to upgrade any MiCOM S1 Studio software.

2.3 MiCOM Relay Configuration and the HSR Function

There is no need to change the configuration of any relay (as relays which include support for this function will be able to recognize other devices which support it).

2.4 Hardware Changes for HSR Protocol

This protocol is implemented using the redundant Ethernet card as a starting point. The Frame management is achieved by programming the Field-Programmable Gate Array (FPGA).
The low-level management of the redundant frames is performed within the FPGA; this being defined as the Link Redundancy Entity (LRE). This will add the HSR tag to a frame to be transmitted. The FPGA is also responsible for the stripping of the HSR tag from received frames and discarding the duplicated messages so that only a single application frame is received by the Ethernet processor.
The LRE functionality of the supervision frame transmission is performed by the NIOS II.

The new version of the redundant Ethernet card is based on the 2072069A01 and 2072071A01 (both have modulated and un-modulated IRIG-B).

2.5 HSR Parameters

The Redundant Ethernet standard (IEC 62439-3:2012/FDIS) defines several parameters for the HSR protocol; these being fixed at a default value within this release. The following values are set:

Parameter	Value	Description
Supervision Frame Multicast Address	01-15-4E-00-01-00	Target MAC Address for multicast supervision frame
Life Check Interval	2 seconds	Period between transmission of supervision frames
HSR Mode	Duplicate Discard	This is normal HSR mode, Duplicate address will not be supported.
Node Forget Time	60 s	This is the time after which a node entry is cleared.
Entry Forget Time	400 ms	Duration that the received message Sequence number will be held to discard a duplicate message.
Node Reboot Interval	500ms	Duration following reboot for which no HSR frames should be transmitted.
MulticastFilterSize	16	Number of multicast addresses to be filtered

Table 2 - HSR parameter values

2.6 Product Implementation Features

Here is a list of the main Product Requirements for MiCOM products that support HSR:

- The MiCOM relay/IED provides two redundant Ethernet ports using HSR.
- The MiCOM relay/IED must be connected to the redundant Ethernet network as a Double Attached Node (DAN) using HSR (DAN using HSR is known as DANH)
- The redundant Ethernet interface can be made using an RJ45 or an optical fibre connection with an LC connector type.
- The management of the HSR redundancy is transparent to the application data provided via the Ethernet interface.
- The HSR option is available with any of the existing protocol options via the Ethernet Interface (IEC61850 and/or DNPoE)
- Loss of one of the Node connections to the device does not cause any loss or degradation to the Application data over the Ethernet interface.
- The MiCOM relay/IED supports the transmission of the HSR Supervision frame at a fixed time period (LifeCheckInterval) of 2s (+/- 100ms)
- Each supervision frame includes a sequence number as defined in the IEC 62439-3:2012/FDIS specification. This will be incremented for each supervision message and the value will start from zero following a system restart.
- The MiCOM relay/IED support SNMP.
- The MiCOM relay/IED does not provide for the HSR management to be configured (via either the MiCOM relay/IED HMI or the Ethernet interface). Accordingly, the default values (as defined within this document) are used for all HSR parameters.
- The performance of the Ethernet Interface is not degraded by using the HSR interface.

2.6.1 Abbreviations and Acronyms

Abbreviations / Acronyms	Meaning
CRC	Cyclic Redundancy Check
DAN	Doubly Attached Nodes
DANH	Doubly Attached Node implementing HSR
FPGA	Field-Programmable Gate Array
HMI	Human Machine Interface
HSR	High-availability Seamless Redundancy
IED	Intelligent Electronic Devices
IP	Internet Protocol
LAN	Local Area Network
LRE	Link Redundancy Entity
MAC	Media Access Control
MRP	Media Redundancy Protocol
PRP	Parallel Redundancy Protocol
HSR	High-availability Seamless Redundancy
RedBox	Redundancy Box
RSTP	Rapid Spanning Tree Protocol
SAN	Singly Attached Node
TCP	Transmission Control Protocol
VDAN	Virtual Doubly Attached Node (effectively seen as a DAN)

Notes:

P746 REMOTE HMI

CHAPTER 22

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Hardware Suffix:	M
Software Version:	B4 (P746_1) / C4 (P746_2)
Connection Diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

Notes:

1 INTRODUCTION

1.1 About the MiCOM P746 Remote HMI Software

The MiCOM P746 Remote HMI is an application that is used to define/create the busbar topology and display the MiCOM P746 measurement data. You can create topology schemes by editing pre-existing topology schemes or by creating new ones. You can save topology schemes on a PC or a memory device and you can create paper printouts of the topology schemes too. You create topology schemes by adding Busbars, Feeder Groups and Tie Groups into the topology scheme design frame and linking them together or associating them with one another. Further details of the possible options are shown in the P746 Remote HMI Symbols Library.

1.2 Installing the P746 Remote HMI Software

This software is by default installed during the installation of Easergy Studio. If it has not been, launch the install of Easergy Studio and click on “Modify” then select “MiCOM P746 Remote HMI”

You can download Easergy Studio from our web site:

www.schneider-electric.com

1.3 Starting the P746 Remote HMI Software

To start the software, either double-click the P746 Remote HMI icon on the desktop or click the following menu options from the Start menu, *Programs > Schneider Electric > MiCOM P746 Remote HMI > MiCOM P746 Remote HMI*

Full details of how to use the MiCOM P746 Remote HMI software are provided in the on-line help. Alternatively, open the Easergy Studio tool and find the *MiCOM P746 Remote HMI Tool* option in the Tool menu.

1.4 Accessing the P746 Remote HMI Software Help

To access the on-line help for the MiCOM P746 Remote HMI software, either press the *F1* key on the keyboard, or select the *Help + User Guide* menu options

The on-line help provides complete information about the MiCOM P746 Remote HMI. The help is installed automatically with the MiCOM P746 Remote HMI software. Both the software and the on-line help are provided in several different languages.

The on-line help provides you with technical information about the MiCOM P746 Remote HMI system. It contains a summary of the system, descriptions of the commands within it and detailed instructions about how to use them.

Notes:

VERSION HISTORY

CHAPTER 23

Date:	12/2017
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix. MiCOM P746
Hardware Suffix:	M
Software Version:	B4 (P746_1) / C4 (P746_2)
Connection Diagrams:	10P746xx (xx = 00 to 21)

CONTENTS

Notes:

1 VERSION HISTORY

This table shows the Software Version together with the Hardware Suffix the particular software runs on. The changes introduced by each Software Version are shown with each change on one row.

The Easergy Studio software is updated periodically. These updates provide support for new features (such as allowing you to manage new MiCOM products, as well as using new software releases and hardware suffixes). The updates may also include fixes. **Accordingly, we strongly advise customers to use the latest Schneider Electric version of Easergy Studio.** This table shows the earliest version of the software which lets you use that feature. Unless otherwise stated in the Studio software, the latest version lets you to use all the features of previous versions.
If you need more information regarding bug fixes, please contact your **Schneider Electric** local support.

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
01		K	Feb 2008	Original Issue: First release to production.	V2.14	P746/EN xx/A11
01	C	K	Nov 2008	Improvement of the CBF undercurrent detection reset.	V2.14	P746/EN xx/B11
01	D	K	Feb 2009	Addition of high break relay boards.	V2.14	P746/EN xx/C11
01	E	K	May 2009	Improvement of internal fault tripping.	V2.14	P746/EN xx/E11
02	A	K	May 2010	Ratio of virtual CT as reference for secondary currents calculation fixed to 2000/1. New phase comparison setting. New option with 32I/32O board.	V2.14	P746/EN xx/F21
03	A	K	Jan 2011	Secure communications (cyber security). New Redundant Ethernet board option (Dual Homing Protocol and Self Healing Ring).	V3.1	P746/EN xx/G31
A0	A	K	Jan 2013	**Hardware:** New Power Supply Unit (PSU), opto-isolated input, output relay boards & Sigma input modules. New Redundant Ethernet board option (Parallel Redundant Protocol (PRP)). **Software Corrections:** French and German translations. Relay enhancement for high-speed CT operation. Addition of Trigger time extraction (CS103), 'Prot'n Disable' alarm reset, Disturbance extraction (IEC61850). Enhancement of Z1/Z2 / dead zone topology, CBF + zone logic + CBF reset adjustments, CB trip in Test Zone, Local time, GMT time adjustment, Multi-group Z1/Z2 bus settings, 87BB, 87BB + 50BF Zx blocked fault in "Test Mode", Header of *.set file. Iref cell in read only mode (remote control).	Easergy Studio	P746/EN xx/H42
B0	A	M	May 2014	**Hardware:** Update hardware design suffix to M. The 24-48 Vdc power supply range has been changed to cover 24-32 Vdc only (new cortec option 9). Three new Ethernet boards released (new cortec option Q, R and S) with Parallel Redundant Protocol (PRP), High-availability Seamless Redundancy (HSR) and Dual Ethernet communications (Dual IP). **Software:** Parallel Redundant Protocol (PRP), High-availability Seamless Redundancy (HSR) and Dual Ethernet communications (Dual IP) by configuration. IEC 61850 Ed.2 and Ed.1 by configuration. GOOSE number and GOOSE performance enhancement. Disturbance Record Enhancement. Time Synchronization via LTIM/LTMS. Monitor DDB for port physical link status. Minor bug fixes.	Easergy Studio	P746/EN AD/I52

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document -ation
Major	**Minor**					
B1	A	M	Feb 2015	Support up to 4 zones scheme. Disturbance enhancement to support Diff/ Bias current. Protocol IEC61850 Edition 1 and Edition 2 and IEC60870-5-103 via rear RS485 supported. Protocol IEC61850 Edition 1 and Edition 2 and DNP3 via rear RS485 supported. Minor bug fixes.	Easergy Studio	P746/EN M/J62
B2	A	M	Oct 2015	**Protocol IEC61850 Edition 1 / 2 and DNPoE and DNP3 Serial supported.** Minor bug fixes.	Easergy Studio	P746/EN M/K62
B3	A	M	Oct 2016	New protocol option IEC61850 Ed1/2 and DNPoE and DNP serial Cyber Security. This release integrated the Cyber Security RBAC and provided the option for the user if they want/don't want to use the Cyber Security which depends on the protocol options. CLS0 - Simple password management - No Security Administration Tool (SAT) required. CLS1 - Advanced user account right management, security logs/events and secure administration capability - Security Administration Tool (SAT) required. Check Zone check for Dead Zone OC added. Dead Zone OC always trips local and remote CB. Courier Tunneling via Secured Communication. Fault Record via DNP3.0 and IEC61850. 32 User Alarms. Virtual I/O Naming. Restore Record Clear Functions. New DDB: Logic 0, IRIG-B Valid and Simul. GOOSE Bug Fixes.	Easergy Studio v7.0.0	P746/EN M/L72
B4	A	M	Dec 2017	DNPOE unsolicited messages feature. The setting value consistency (Primary /Secondary) in all ports. Change the setting step of CB fail timers in CBF module. Bug Fixes.	Easergy Studio V8.0.0 or later	P746/EN M/M82
C1	A	M	Feb 2015	**Hardware:** New sampling module available (21CT supported). **Software:** Support up to 4 zones scheme. Disturbance enhancement to support Diff/ Bias current. Protocol IEC61850 Edition 1 and Edition 2 and IEC60870-5-103 via rear RS485 supported. Protocol IEC61850 Edition 1 and Edition 2 and DNP3 via rear RS485 supported. Minor bug fixes.	Easergy Studio	P746/EN M/J62
C2	A	M	Oct 2015	Protocol IEC61850 Edition 1 / 2 and DNPoE and DNP3 Serial supported. Minor bug fixes.	Easergy Studio	P746/EN M/K62

Software Version		Hard-ware Suffix	Original Date of Issue	Description of Changes	S1 Compat-ibility	Technical Document-ation
Major	Minor					
C3	A	M	Oct 2016	New protocol option IEC61850 Ed1/2 and DNPoE and DNP serial Cyber Security. This release integrated the Cyber Security RBAC and provided the option for the user if they want/don't want to use the Cyber Security which depends on the protocol options. CLS0 - Simple password management - No Security Administration Tool (SAT) required. CLS1 - Advanced user account right management, security logs/events and secure administration capability - Security Administration Tool (SAT) required. Check Zone check for Dead Zone OC added. Dead Zone OC always trips local and remote CB. Courier Tunneling via Secured Communication. Fault Record via DNP3.0 and IEC61850. 32 User Alarms. Virtual I/O Naming. Restore Record Clear Functions. New DDB: Logic 0, IRIG-B Valid and Simul. GOOSE Bug Fixes.	Easergy Studio v7.0.0	P746/EN M/L72
C4	A	M	Dec 2017	DNPOE unsolicited messages feature. The setting value consistency (Primary /Secondary) in all ports. Change the setting step of CB fail timers in CBF module. Bug Fixes.	Easergy Studio V8.0.0 or later	P746/EN M/M82

This table shows the Software Version together with the Hardware Suffix the particular software runs on. The changes introduced by each Software Version are shown with each change on one row.

The Easergy Studio software is updated periodically. These updates provide support for new features (such as allowing you to manage new MiCOM products, as well as using new software releases and hardware suffixes). The updates may also include fixes. **Accordingly, we strongly advise customers to use the latest Schneider Electric version of Easergy Studio.** This table shows the earliest version of the software which lets you use that feature. Unless otherwise stated in the Studio software, the latest version lets you to use all the features of previous versions.
If you need more information regarding bug fixes, please contact your **Schneider Electric** local support.

Table 1 - Software and hardware version changes

2 SETTING FILE AND RELAY SOFTWARE VERSION

Setting File Software Version	Relay Software Version												
	01	**02**	**03**	**A0**	**B0**	**B1**	**B2**	**B3**	**B4**	**C1**	**C2**	**C3**	**C4**
01	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
02	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
03	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
A0	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
B0	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
B1	✗	✗	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗
B2	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗
B3	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗
B4	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗
C1	✗	✗	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗
C2	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗
C3	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗
C4	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓

Table 2 - Setting File and Relay Software Version

3 PSL FILE AND RELAY SOFTWARE VERSION

PSL File Software Version	Relay Software Version												
	01	02	03	A0	B0	B1	B2	B3	B4	C1	C2	C3	C4
01	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×
02	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×
03	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×
A0	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×
B0	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×
B1	×	×	×	×	×	✓	×	×	×	✓	×	×	×
B2	×	×	×	×	×	×	✓	×	×	×	✓	×	×
B3	×	×	×	×	×	×	×	✓	×	×	×	×	×
B4	×	×	×	×	×	×	×	×	✓	×	×	×	×
C1	×	×	×	×	×	✓	×	×	×	✓	×	×	×
C2	×	×	×	×	×	×	✓	×	×	×	✓	×	×
C3	×	×	×	×	×	×	×	×	×	×	×	✓	×
C4	×	×	×	×	×	×	×	×	×	×	×	×	✓

Table 3 - PSL File and Relay Software Version

4 MENU TEXT FILE AND RELAY SOFTWARE VERSION

Menu Text File Software Version	Relay Software Version												
	01	02	03	A0	B0	B1	B2	B3	B4	C1	C2	C3	C4
01	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×
02	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×
03	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×
A0	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×
B0	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×
B1	×	×	×	×	×	✓	×	×	×	✓	×	×	×
B2	×	×	×	×	×	×	✓	×	×	×	✓	×	×
B3	×	×	×	×	×	×	×	✓	×	×	×	×	×
B4	×	×	×	×	×	×	×	×	✓	×	×	×	×
C1	×	×	×	×	×	✓	×	×	×	✓	×	×	×
C2	×	×	×	×	×	×	✓	×	×	×	✓	×	×
C3	×	×	×	×	×	×	×	×	×	×	×	✓	×
C4	×	×	×	×	×	×	×	×	×	×	×	×	✓

Table 4 - Menu Text File and Relay Software Version

SYMBOLS AND GLOSSARY

CHAPTER SG

Date	09/2016	
Products covered by this chapter:	This chapter covers the specific versions of the MiCOM products listed below. This includes ***only*** the following combinations of Software Version and Hardware Suffix.	
Hardware Suffix	All MiCOM Px4x products	
Software Version	All MiCOM Px4x products	
Connection Diagrams:	P14x (P141, P142, P143 & P145): 10P141xx (xx = 01 to 02) 10P142xx (xx = 01 to 05) 10P143xx (xx = 01 to 11) 10P145xx (xx = 01 to 11) P24x (P241, P242 & P243): 10P241xx (xx = 01 to 02) 10P242xx (xx = 01) 10P243xx (xx = 01) P34x (P342, P343, P344, P345 & P391): 10P342xx (xx = 01 to 17) 10P343xx (xx = 01 to 19) 10P344xx (xx = 01 to 12) 10P345xx (xx = 01 to 07) 10P391xx (xx = 01 to 02) P445: 10P445xx (xx = 01 to 04) P44x (P441, P442 & P444): 10P44101 (SH 1 & 2) 10P44201 (SH 1 & 2) 10P44202 (SH 1) 10P44203 (SH 1 & 2) 10P44401 (SH 1) 10P44402 (SH 1) 10P44403 (SH 1 & 2) 10P44404 (SH 1) 10P44405 (SH 1) 10P44407 (SH 1 & 2) P44y (P443 & P446): 10P44303 (SH 01 and 03) 10P44304 (SH 01 and 03) 10P44305 (SH 01 and 03) 10P44306 (SH 01 and 03) 10P44600 10P44601 (SH 1 to 2) 10P44602 (SH 1 to 2) 10P44603 (SH 1 to 2)	P54x (P543, P544, P545 & P546): 10P54302 (SH 1 to 2) 10P54303 (SH 1 to 2) 10P54400 10P54404 (SH 1 to 2) 10P54405 (SH 1 to 2) 10P54502 (SH 1 to 2) 10P54503 (SH 1 to 2) 10P54600 10P54604 (SH 1 to 2) 10P54605 (SH 1 to 2) 10P54606 (SH 1 to 2) P547: 10P54702xx (xx = 01 to 02) 10P54703xx (xx = 01 to 02) 10P54704xx (xx = 01 to 02) 10P54705xx (xx = 01 to 02) P64x (P642, P643 & P645): 10P642xx (xx = 1 to 10) 10P643xx (xx = 1 to 6) 10P645xx (xx = 1 to 9) P74x (P741, P742 & P743): 10P740xx (xx = 01 to 07) P746: 10P746xx (xx = 00 to 21) P841: 10P84100 10P84101 (SH 1 to 2) 10P84102 (SH 1 to 2) 10P84103 (SH 1 to 2) 10P84104 (SH 1 to 2) 10P84105 (SH 1 to 2) P849: 10P849xx (xx = 01 to 06)

CONTENTS

TABLES

FIGURES

Notes:

1 ACRONYMS AND ABBREVIATIONS

Term	Description
<	Less than: Used to indicate an “under” threshold, such as undercurrent (current dropout).
>	Greater than: Used to indicate an “over” threshold, such as overcurrent (current overload)
A	Ampere
AA	Application Association
AC / ac	Alternating Current
ACSI	Abstract Communication Service Interface
ACSR	Aluminum Conductor Steel Reinforced
ALF	Accuracy Limit Factor
AM	Amplitude Modulation
ANSI	American National Standards Institute
AR	Auto-Reclose
ARIP	Auto-Reclose In Progress
ASCII	American Standard Code for Information Interchange
ATEX	ATEX is the Potentially Explosive Atmospheres directive 94/9/EC
AUX / Aux	Auxiliary
AV	Anti virus
AWG	American Wire Gauge
BAR	Block Auto-Reclose signal
BCD	Binary Coded Decimal
BCR	Binary Counter Reading
BDEW	Bundesverband der Energie- und Wasserwirtschaft | Startseite (i.e. German Association of Energy and Water Industries)
BMP	BitMaP – a file format for a computer graphic
BN>	Neutral over susceptance in the context of the protection element: Reactive component of admittance calculation from neutral current and residual voltage.
BOP	Blocking Overreach Protection - a blocking aided-channel scheme.
BPDU	Bridge Protocol Data Unit
BRCB	Buffered Report Control Block
BRP	Beacon Redundancy Protocol
BU	Backup: Typically a back-up in the context of the protection element
Business Service Layer	This layer coordinates the application, processes commands, make logical decision and calculation according to the business rules
CA	Certification Authority
CAT	Computer Administration Tool , for replacing CMT
C/O	A ChangeOver contact having normally-closed and normally-open connections: Often called a “form C” contact.
CB	Circuit Breaker
CB Aux.	Circuit Breaker auxiliary contacts: Indication of the breaker open/closed status.
CBF	Circuit Breaker Failure in the context of protection element. Could be labelled 50BF in ANSI terminology.
CDC	Common Data Class
CET	Sepam Configuration tool
CF	Control Function
Ch	Channel: usually a communications or signaling channel

Term	Description
Check Synch	Check Synchronizing function
CID	Configured IED Description
CIFS	Common Internet File System. Microsoft protocol use to share resources on a network.
CIP	Critical Infrastructure Protection
CIP Standards	Critical Infrastructure Protection standards. NERC CIP standards have been given the force of law by the Federal Energy Regulatory Commission (FERC)
CLIO	Current Loop Input Output: 0-1 mA/0-10 mA/0-20 mA/4-20 mA transducer inputs and outputs CLI = current loop input - 0-1 mA/0-10 mA/0-20 mA/4-20 mA transducer input CLO = current loop output - 0-1 mA/0-10 mA/0-20 mA/4-20 mA transducer output
CLK / Clk	Clock
Cls	Close - generally used in the context of close functions in circuit breaker control.
CMC	Certificates Management over CMS. An IETF RFC for distribution and registration of public keys and certificates
CMP	Certificates Management Protocol. An IETF RFC for distribution and registration of public keys and certificates (RFC 4210)
CMV	Complex Measured Value
CNV	Current No Volts
COMFEDE	Common Format for Event Data Exchange
CPNI	Centre for the Protection of National Infrastructure
CRC	Cyclic Redundancy Check
CRL	Certificates Revocation List. A list of revoked certificates. Theoretically still valid, but forbidden by the Security Administrator or the Security Server
CRP	Cross-network Redundancy Protocol
CRV	Curve (file format for curve information)
CRx	Channel Receive: Typically used to indicate a teleprotection signal received.
Crypto Device	A small device embedding cryptographic capabilities and storage memory. It could be a smartcard, USB stick, serial dongle, etc.
CS	Cyber Security or Check Synchronism.
CSMS	Cyber Security Management System
CSV	Comma Separated Values (a file format for database information)
CT	Current Transformer
CTRL	Control - as used for the Control Inputs function
CTS	Current Transformer Supervision: To detect CT input failure.
CTx	Channel Transmit: Typically used to indicate a teleprotection signal send.
CUL	Canadian Underwriters Laboratory
CVT	Capacitor-coupled Voltage Transformer - equivalent to terminology CCVT.
CZ	Abbreviation of “Check Zone”: Zone taking into account only the feeders.
DA	Data Attribute
DAN	Double or Doubly Attached Node
DANH	Double or Doubly Attached Node with HSR protocol
DANP	Double or Doubly Attached Node implementing PRP
Data Layer	Consists of the domain-related objects and their relationships that are manipulated by the user during the interaction with the software
DAU	Data Acquisition Unit
DC	Data Concentrator

Term	Description
DC / dc	Direct Current
DCC	An Omicron compatible format
DCE	Data Communication Equipment
DCS	Distributed Control System
DDB	Digital Data Bus within the programmable scheme logic: A logic point that has a zero or 1 status. DDB signals are mapped in logic to customize the relay's operation.
DDR	Dynamic Disturbance Recorder
DEF	Directional Earth Fault (protection): A directionalized ground fault aided protection scheme. Could be labeled 67N in ANSI terminology.
df/dt	Rate of Change of Frequency (equivalent to ROCOF). Could be labeled 81R in ANSI terminology.
df/dt>1	First stage of df/dt in the context of protection element
DFT	Discrete Fourier Transform
DG	Distributed Generation
DHCP	Dynamic Host Configuration Protocol
DHM	Dual Homing Manager
DHP	Dual Homing Protocol
DHS	Dual Homing Star. Ethernet protocol allowing bumpless redundancy. Used with Redundant Ethernet board with dual homing protocol
Diff	Differential in the context of protection elements . Could be labeled 87 in ANSI terminology.
DIN	Deutsches Institut für Normung (German standards body)
Dist	Distance in the context of protection elements . Could be labeled 21 in ANSI terminology.
DITA	Darwinian Information Typing Architecture
DLDB	Dead-Line Dead-Bus: In system synchronism check, indication that both the line and bus are de-energized.
DLLB	Dead-Line Live-Bus: In system synchronism check, indication that the line is de-energised whilst the bus is energized.
DLR	Dynamic Line Rating
DLY / Dly	Time Delay
DMT	Definite Minimum Time
DNP	Distributed Network Protocol
DO	Data Object
DPWS	Device Profile for Web Services
DR	Disturbance Record
DREB	Dual Redundant Ethernet Board
DSP	Digital Signal Processor
DST	Daylight Saving Time
DT	Definite Time: in the context of protection elements: An element which always responds with the same constant time delay on operation. Or Abbreviation of "Dead Time" in the context of auto-reclose:
DTD	Document Type Definition
DTOC	Definite Time Overcurrent in the context of protection element
DTS	Date and Time Stamp
DVC	Direct Variable Cost
DZ	Dead Zone. Area between a CT and an open breaker or an open isolator.
EF or E/F	Earth Fault (directly equivalent to Ground Fault)
EIA	Electronic Industries Alliance

Term	Description
ELR	Environmental Lapse Rate
EMC	ElectroMagnetic Compatibility
ENA	Energy Networks Association
ER	Engineering Recommendation
ESD	ElectroStatic Discharge
ESP	Electronic Security Perimeter
ESS	Embedded Security Server
ETS	Element To Secure. An ETS is an entity that represents a tool, utility or application function block that can be protected within the tool suite. It gathers a list of corresponding permissions with their set of values. This list is pre-defined and cannot be edited by any business user. A same ETS can be associated to many roles with different set of authorizations.
FAA	Ageing Acceleration Factor: Used by Loss of Life (LOL) element
FCS	Frame Check Sequence
FFail	A field failure (loss of excitation) element: Could be labeled 40 in ANSI terminology.
FFT	Fast Fourier Transform
FIR	Finite Impulse Response
FLC	Full load current: The nominal rated current for the circuit.
FLT / Flt	Fault - typically used to indicate faulted phase selection.
Fn or FN	Function
FPGA	Field Programmable Gate Array
FPS	Frames Per Second
FTP	File Transfer Protocol or Foil Twisted Pair
FTPS	FTP over TLS protocol. The classic file transfer protocol (FTP) secured using TLS tunneling.
FWD, Fwd or Fwd.	Indicates an element responding to a flow in the “Forward” direction
Gen Diff	A generator differential element: Could be labeled 87G in ANSI terminology.
Gen-Xformer Diff	A generator-transformer differential element: Could be labeled 87GT in ANSI terminology.
GI	General Interrogation
GIF	Graphic Interchange Format – a file format for a computer graphic
GN>	Neutral over conductance in the context of protection element: Real component of admittance calculation from neutral current and residual voltage.
GND / Gnd	Ground: used in distance settings to identify settings that relate to ground (earth) faults.
GoCB	GOOSE Control Block
GOOSE	Generic Object Oriented Substation Event
GPS	Global Positioning System
GRP / Grp	Group. Typically an alternative setting group.
GSE	General Substation Event
GSSE	Generic Substation Status Event
GUESS	Generator Unintentional Energization at StandStill.
GUI	Graphical User Interface
HIPS	Host Intrusion Prevention System based on “white list” of accepted executables.
HMI	Human Machine Interface
HSR	High Availability Seamless Redundancy
HTML	Hypertext Markup Language

Term	Description
I	Current
I/O	Input/Output
I/P	Input
IANA	Internet Assigned Numbers Authority
ICAO	International Civil Aviation Organization
ICD	IED Capability Description
ID	Identifier or Identification. Often a label used to track a software version installed.
IDMT	Inverse Definite Minimum Time. A characteristic whose trip time depends on the measured input (e.g. current) according to an inverse-time curve.
IEC	International Electro-technical Commission
IED	Intelligent Electronic Device - a term used to describe microprocessor-based controllers of power system equipment. Common types of IEDs include protective relaying devices, load tap changer controllers, circuit breaker controllers, capacitor bank switches, recloser controllers, voltage regulators, etc.
IEEE	Institute of Electrical and Electronics Engineers
IET	IED Engineering ToolSuite. Similar to SET but dedicated to IED. Or IED Engineering Tool.
IETF	Internet Engineering Task Force
IID	Instantiated/Individual IED Description
IIR	Infinite Impulse Response
Inh	An Inhibit signal
Inst	An element with Instantaneous operation: i.e. having no deliberate time delay.
IP	Internet Protocol
IRIG	InterRange Instrumentation Group
ISA	International Standard Atmosphere or Instrumentation Systems and Automation Society
ISO	International Standards Organization
JPEG	Joint Photographic Experts Group – a file format for a computer graphic
L	Live
LAN	Local Area Network
LCB	Log Control Block
LCD	Liquid Crystal Display: The relay front-panel text display.
LD	Level Detector: An element responding to a current or voltage below its set threshold. Or Logical Device
LDAP	Lightweight Directory Access Protocol
LDOV	Level Detector for OverVoltage
LDUV	Level Detector for UnderVoltage
LED	Light Emitting Diode
LLDB	Live-Line Dead-Bus : In system synchronism check, indication that the line is energized whilst the bus is de-energized.
Ln	Natural logarithm
LN	Logical Node
LOGS	All the operations related to the security (connection, configuration…) are automatically caught in events that are logged in order to provide a good visibility of the previous actions to the security administrators.
LoL	A Loss of Load scheme, providing a fast distance trip without needing a signaling channel.
LPDU	Link Protocol Data Unit
LPHD	Logical Physical Device
LRE	Link Redundancy Entity

Term	Description
MAC	Media Access Control or Mandatory Access Control
MC	MultiCast
MCB	Miniature Circuit Breaker
MIB	Management Information Base
MICS	Model Implementation Conformance Statement
MMF	Magneto-Motive Force
MMS	Manufacturing Message Specification (IEC 61850)
MRP	Media Redundancy Protocol
MU	Merging Unit (function)
MV	Measured Value
N	Neutral
N/A	Not Applicable
N/C	A Normally Closed or “break” contact: Often called a “form B” contact.
N/O	A Normally Open or “make” contact: Often called a “form A” contact.
NERC	North American Reliability Corporation
NERO	NERC Electric Reliability Organization (ERO) certified by the Federal Energy Regulatory Commission to establish and enforce reliability standards for the bulk-power system.
NIC	Network Interface Card: i.e. the Ethernet card of the IED
NIST	National Institute of Standards and Technology
NPS	Negative Phase Sequence
NTP	The Network Time Protocol (NTP) is a protocol for synchronizing the clocks of computer systems.
NVD	Neutral Voltage Displacement: Equivalent to residual overvoltage protection.
NXT	Abbreviation of “Next”: In connection with hotkey menu navigation.
o	A small circle on the input or output of a logic gate: Indicates a NOT (invert) function.
O/C	Overcurrent
O/P	Output
OCB	Oil Circuit Breaker
OCSP	Online Certificate Status Protocol. An IETF RFC for online verification of certificates by servers (RFC 2560).
OID	Object IDentifier
OOS	Out-Of-Step
Opto	An Optically coupled logic input. Alternative terminology: binary input.
OSI	Open Systems Interconnection
PAP	Policy Administration Point. Software entity that manage the security Policy
PCB	Printed Circuit Board
PCT	Protective Conductor Terminal (Ground)
PDC	Phasor Data Concentrator
PDP	Policy Decision Point. Software entity that evaluates the applicable policy and takes an authorization decision
PEP	Policy Enforcement Point. Software entity that performs access control and enforces authorization decision.
Ph	Phase - used in distance settings to identify settings that relate to phase-phase faults.
PICS	Protocol Implementation Conformance Statement
PIP	Policy Information Point. Software entity acting as an information source for the PDP.
PKI	Public Key infrastructure

Term	Description
PMU	Phasor Measurement Unit
PNG	Portable Network Graphics – a file format for a computer graphic
Pol	Polarize - typically the polarizing voltage used in making directional decisions.
POR	A Permissive OverReaching transfer trip scheme (alternative terminology: POTT).
POTT	A Permissive Overreaching Transfer Trip scheme (alternative terminology: POR).
PRP	Parallel Redundancy Protocol
PSB	Power Swing Blocking, to detect power swing/out of step functions, could be labeled 78 in ANSI terminology.
PSL	Programmable Scheme Logic: The part of the relay’s logic configuration that can be modified by the user, using the graphical editor within MiCOM S1 Studio software.
PSlip	A Pole slip (out-of-step - OOS) element: could be labeled 78 in ANSI terminology.
PSP	Physical Security Perimeter
PSTN	Public Switched Telephone Network (RTC in French)
PT	Power Transformer
PTP	Precision Time Protocol
PUR	A Permissive UnderReaching transfer trip scheme (alternative terminology: PUTT).
PURR	A Permissive Underreaching Transfer Trip scheme (alternative terminology: PUR).
Q	Quantity defined as per unit value
Qx	Isolator number x
R	Resistance
RA	Registration Authority
R&TTE	Radio and Telecommunications Terminal Equipment
RBAC	Role Based Access Control. Authentication and authorization mechanism based on roles granted to a user. Roles are made of rights, themselves being actions that can be applied on objects. Each user’s action is authorized or not based on his roles
RBN	Lead burden for the neutral path.
RBPh	Lead burden for the phasepath.
RCA	Relay Characteristic Angle - The center of the directional characteristic.
RCB	Report Control Block
RCT	Redundancy Control Trailer or Redundancy Check Tag
REB	Redundant Ethernet Board
RedBox	Redundancy Box
REF	Restricted Earth Fault
Rev.	Indicates an element responding to a flow in the “reverse” direction
RMS / rms	Root mean square. The equivalent a.c. current: Taking into account the fundamental, plus the equivalent heating effect of any harmonics.
RoCoF	Rate of Change of Frequency
RP	Rear Port: The communication ports on the rear of the IED
RS232	A common serial communications standard defined by the EIA
RS485	A common serial communications standard defined by the EIA (multi-drop)
RST or Rst	Reset generally used in the context of reset functions in circuit breaker control.
RSTP	Rapid Spanning Tree Protocol.
RTCS	Real Time Certificate Status. Facility. An IETF draft for online certificates validation.
RTD	Resistance Temperature Device
RTU	Remote Terminal Unit

Term	Description
RX	Receive: Typically used to indicate a communication transmit line/pin.
SAM	Security Administration Module. Device in charge of security management on an IP-over-Ethernet network.
SAMU	Stand Alone Merging Unit (device)
SAN	Singly or Single Attached Node
SAS	Substation Automation Solutions / System
SAT	Security Administration Tool TSF based application used to define and create security configuration
SAU	Security Administration Utility
SBS	Straight Binary Second
SC	Synch-Check or system Synchronism Check.
SCADA	Supervisory Control and Data Acquisition
SCD	Substation Configuration Description
SCEP	Simple Certificate Enrollment Protocol. An IETF draft for distribution and registration of public keys and certificates
SCL	Substation Configuration Language. In IEC 61850, the definition of the configuration files.
SCSM	Specific Communication Service Mappings: In IEC 61850, the SCSMs define the actual information exchange mechanisms currently used (e.g. MMS).
SCU	Substation Control Unit
SCVP	Server-based Certificate Validation Protocol. An IETF RFC for online certificates validation.
SDEF	Sensitive Differential Earth Fault in the context of protection element. Could be labeled 87N in ANSI terminology.
SEF	Sensitive Earth Fault in the context of protection element
Sen	Sensitive
SET	System Engineering Tools. New Tools in place of SCE and SMT, to deal with complete life cycle for Systems (design, realization, testing, commissioning, maintenance).
SFTP	A Secured File Transfer Protocol based on SSH.
SGCB	Setting Group Control Block
SHM	Self-Healing Manager
SHP	Self Healing Protocol
SHR	Self Healing Ring: Ethernet protocol allowing bumpless redundancy. Used with Redundant Ethernet board with self-healing protocol.
SIR	Source Impedance Ratio
SLA	Service Level Agreement
SMB	Server Message Block. Microsoft protocol for network resources sharing. Called CIFS on NT
SMT	Substation Management Tool (previously used on PACIS project)
SMTP	Simple Mail Transfer Protocol (SMTP) is an Internet standard for electronic mail (e-mail) transmission across Internet Protocol (IP) networks.
SMV	Sampled Measured Values
SNMP	Simple Network Management Protocol (SNMP) is an "Internet-standard protocol for managing devices on IP networks
SNTP	Simple Network Time Protocol
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SOC	Second of Century
SOTF	Switch on to Fault
SP	Single pole.
SPAR	Single pole auto-reclose.

Term	Description
SPC	Single Point Controllable
SPDT	Single Pole Dead Time. The dead time used in single pole auto-reclose cycles.
SPS	Single Point Status
SQRT	Square Root
SSD	Solid State Device
SSH	Secured Shell. A secured encrypted network protocol for remote administration of computers
SSL	Secured Socket Layer or Source Impedance Ratio or See TLS (TLS is based on SSLv3).
SSO	Single Sign On
STP	Shielded Twisted Pair or Spanning Tree Protocol
SUI	Substation User Interface
SV	Sampled Values
SVC	Static Var Compensator
SVM	Sampled Value Model
TAF	Turbine Abnormal Frequency
TAT	Transfer Administration Tool
TBD	To Be Defined
TCP	Transmission Control Protocol
TCS	Trip Circuit Supervision
TD	Time Dial. The time dial multiplier setting: Applied to inverse-time curves (ANSI/IEEE).
TE	Unit for case measurements: One inch = 5TE units
THD	Total Harmonic Distortion
TICS	Technical Issues Conformance Statement
TIFF	Tagged Image File Format – a file format for a computer graphic
TLS	Transport Layer Security network protocol successor to SSL. Or Transport Layer Security. Creates encrypted tunnel for TCP connections. Can guarantee authentication when used in a PKI.
TMS	Time Multiplier Setting: Applied to inverse-time curves (IEC)
TOC	Trip On Close (“line check”) (protection). Offers SOTF and TOR functionality.
TOR	Trip On Reclose (protection). Modified protection on autoreclosure of the circuit breaker.
TP	Two-Part
TSF	Tool Suite Foundation. Common framework for SET and IET. Mainly 3 parts Core, Workbench (for standardized HMI), Utilities (applicative components like trace viewer, installer)
TUC	Timed UnderCurrent
TVE	Total Vector Error
Tx	Transmit
UA	User Account. A user account is a logical representation of a person with some configurable parameters. It includes information about the user identity and gives him a login to be recognized within the tool suite. A user account is principally interesting when it is associated to some roles that will grant him authorizations.
UDP	User Datagram Protocol
UL	Underwriters Laboratory
UPCT	User Programmable Curve Tool
UTC	Universal Time Coordinated
V	Voltage

Term	Description
VA	Phase A voltage: Sometimes L1, or red phase
VB	Phase B voltage: Sometimes L2, or yellow phase
VC	Phase C voltage: Sometimes L3, or blue phase
VCO	Voltage Controlled Overcurrent element
VDAN	Virtual Double or Doubly Attached Node
VDEP OC>	A voltage dependent overcurrent element: could be a voltage controlled or voltage restrained overcurrent element and could be labeled 51V in ANSI terminology.
VDR	Voltage Dependent Resistor
VDS	Virtual Device Solution
V/Hz	An overfluxing element, flux is proportional to voltage/frequency: could be labeled 24 in ANSI terminology.
Vk	IEC knee point voltage of a current transformer.
VPN	Virtual Private Network (a secure private connection established on a public network or other unsecured environment).
VT	Voltage Transformer
VTS	Voltage Transformer Supervision: To detect VT failure.
WAN	Wide Area Network
XACML	eXtensible Access Control Markup Language. An OASIS standard defining an XML access control policy implementation.
Xformer	Transformer
XKMS	XML Keys Management Specifications. A 3C standard, XML based, for distribution and registration of public keys and certificates
XML	Extensible Markup Language
XSD	XML Schema Definition

Table 1 - Acronyms and abbreviations

2 COMPANY PROPRIETARY TERMS

Term	Description
Courier	Schneider Electric’s proprietary SCADA communications protocol
Easergy	Schneider Electric’s brand of protection relays and related software products
Metrosil	Brand of non-linear resistor produced by M&I Materials Ltd.
MiCOM	Schneider Electric’s brand of protection relays

Table 2 - Company-proprietary terms

3 ANSI TERMS

ANSI no.	Description
3PAR	Three pole auto-reclose.
3PDT	Three pole dead time. The dead time used in three pole auto-reclose cycles.
52a	A circuit breaker closed auxiliary contact: The contact is in the same state as the breaker primary contacts
52b	A circuit breaker open auxiliary contact: The contact is in the opposite state to the breaker primary contacts
64R	Rotor earth fault protection
64S	100% stator earth (ground) fault protection using a low frequency injection method.
89a	An Isolator closed auxiliary contact: The contact is in the same state as the breaker primary contacts.
89b	An Isolator open auxiliary contact: The contact is in the opposite state to the breaker primary contacts.

Table 3 - ANSI abbreviations

ANSI no.	Function	Description
Current Protection Functions		
50/51	Phase overcurrent	Three-phase protection against overloads and phase-to-phase short-circuits.
50N/51N	Earth fault	Earth fault protection based on measured or calculated residual current values: • 50N/51N: residual current calculated or measured by 3 phase current sensors
50G/51G	Sensitive earth fault	Sensitive earth fault protection based on measured residual current values: • 50G/51G: residual current measured directly by a specific sensor such as a core balance CT
50BF	Breaker failure	If a breaker fails to be triggered by a tripping order, as detected by the non-extinction of the fault current, this backup protection sends a tripping order to the upstream or adjacent breakers.
46	Negative sequence / unbalance	Protection against phase unbalance, detected by the measurement of negative sequence current: • sensitive protection to detect 2-phase faults at the ends of long lines • protection of equipment against temperature build-up, caused by an unbalanced power supply, phase inversion or loss of phase, and against phase current unbalance
46BC	Broken conductor protection	Protection against phase imbalance, detected by measurement of I2/I1.
49RMS	Thermal overload	Protection against thermal damage caused by overloads on machines (transformers, motors or generators). The thermal capacity used is calculated according to a mathematical model which takes into account: • current RMS values • ambient temperature • negative sequence current, a cause of motor rotor temperature rise
Re-Closer		
79	Recloser	Automation device used to limit down time after tripping due to transient or semipermanent faults on overhead lines. The recloser orders automatic reclosing of the breaking device after the time delay required to restore the insulation has elapsed. Recloser operation is easy to adapt for different operating modes by parameter setting.
Directional Current Protection		
67N/67NC type 1 and 67	Directional phase overcurrent	Phase-to-phase short-circuit protection, with selective tripping according to fault current direction. It comprises a phase overcurrent function associated with direction detection, and picks up if the phase overcurrent function in the chosen direction (line or busbar) is activated for at least one of the three phases.

ANSI no.	Function	Description
67N/67NC	Directional earth fault	Earth fault protection, with selective tripping according to fault current direction. Three types of operation: • Type 1: the protection function uses the projection of the I0 vector • Type 2: the protection function uses the I0 vector magnitude with half-plane tripping zone • Type 3: the protection function uses the I0 vector magnitude with angular sector tripping zone
67N/67NC type 1	Directional current protection	Directional earth fault protection for impedant, isolated or compensated neutral systems, based on the projection of measured residual current.
67N/67NC type 2	Directional current protection	Directional overcurrent protection for impedance and solidly earthed systems, based on measured or calculated residual current. It comprises an earth fault function associated with direction detection, and picks up if the earth fault function in the chosen direction (line or busbar) is activated.
67N/67NC type 3	Directional current protection	Directional overcurrent protection for distribution networks in which the neutral earthing system varies according to the operating mode, based on measured residual current. It comprises an earth fault function associated with direction detection (angular sector tripping zone defined by 2 adjustable angles), and picks up if the earth fault function in the chosen direction (line or busbar) is activated.
Directional Power Protection Functions		

32P	Directional active overpower	Two-way protection based on calculated active power, for the following applications:
		• active overpower protection to detect overloads and allow load shedding
		• reverse active power protection:
		  • against generators running like motors when the generators consume active power
		  • against motors running like generators when the motors supply active power

32Q/40	Directional reactive overpower	Two-way protection based on calculated reactive power to detect field loss on synchronous machines: • reactive overpower protection for motors which consume more reactive power with field loss • reverse reactive overpower protection for generators which consume reactive power with field loss.
Machine Protection Functions		
37	Phase undercurrent	Protection of pumps against the consequences of a loss of priming by the detection of motor no-load operation. It is sensitive to a minimum of current in phase 1, remains stable during breaker tripping and may be inhibited by a logic input.

48/51LR/14	Locked rotor / excessive starting time	Protection of motors against overheating caused by:
		• excessive motor starting time due to overloads (e.g. conveyor) or insufficient supply voltage.
		The reacceleration of a motor that is not shut down, indicated by a logic input, may be considered as starting.
		• locked rotor due to motor load (e.g. crusher):
		  • in normal operation, after a normal start
		  • directly upon starting, before the detection of excessive starting time, with detection of locked rotor by a zero speed detector connected to a logic input, or by the underspeed function.

66	Starts per hour	Protection against motor overheating caused by:
		• too frequent starts: motor energizing is inhibited when the maximum allowable number of starts is reached, after counting of:
		  • starts per hour (or adjustable period)
		  • consecutive motor hot or cold starts (reacceleration of a motor that is not shut down, indicated by a logic input, may be counted as a start)
		• starts too close together in time: motor re-energizing after a shutdown is only allowed after an adjustable waiting time.

ANSI no.	Function	Description
50V/51V	Voltage-restrained overcurrent	Phase-to-phase short-circuit protection, for generators. The current tripping set point is voltage-adjusted in order to be sensitive to faults close to the generator which cause voltage drops and lowers the short-circuit current.
26/63	Thermostat/Buchholz	Protection of transformers against temperature rise and internal faults via logic inputs linked to devices integrated in the transformer.
38/49T	Temperature monitoring	Protection that detects abnormal temperature build-up by measuring the temperature inside equipment fitted with sensors: • transformer: protection of primary and secondary windings • motor and generator: protection of stator windings and bearings.
Voltage Protection Functions		
27D	Positive sequence undervoltage	Protection of motors against faulty operation due to insufficient or unbalanced network voltage, and detection of reverse rotation direction.
27R	Remanent undervoltage	Protection used to check that remanent voltage sustained by rotating machines has been cleared before allowing the busbar supplying the machines to be re-energized, to avoid electrical and mechanical transients.
27	Undervoltage	Protection of motors against voltage sags or detection of abnormally low network voltage to trigger automatic load shedding or source transfer. Works with phase-to-phase voltage.
59	Overvoltage	Detection of abnormally high network voltage or checking for sufficient voltage to enable source transfer. Works with phase-to-phase or phase-to-neutral voltage, each voltage being monitored separately.
59N	Neutral voltage displacement	Detection of insulation faults by measuring residual voltage in isolated neutral systems.
47	Negative sequence overvoltage	Protection against phase unbalance resulting from phase inversion, unbalanced supply or distant fault, detected by the measurement of negative sequence voltage.
Frequency Protection Functions		
81O	Overfrequency	Detection of abnormally high frequency compared to the rated frequency, to monitor power supply quality. Other organizations may use 81H instead of 81O.
81U	Underfrequency	Detection of abnormally low frequency compared to the rated frequency, to monitor power supply quality. The protection may be used for overall tripping or load shedding. Protection stability is ensured in the event of the loss of the main source and presence of remanent voltage by a restraint in the event of a continuous decrease of the frequency, which is activated by parameter setting. Other organizations may use 81L instead of 81U.
81R	Rate of change of frequency	Protection function used for fast disconnection of a generator or load shedding control. Based on the calculation of the frequency variation, it is insensitive to transient voltage disturbances and therefore more stable than a phase-shift protection function. **Disconnection** In installations with autonomous production means connected to a utility, the “rate of change of frequency” protection function is used to detect loss of the main system in view of opening the incoming circuit breaker to: • protect the generators from a reconnection without checking synchronization • avoid supplying loads outside the installation. **Load shedding** The “rate of change of frequency” protection function is used for load shedding in combination with the underfrequency protection to: • either accelerate shedding in the event of a large overload • or inhibit shedding following a sudden drop in frequency due to a problem that should not be solved by shedding.
Dynamic Line Rating (DLR) Protection Functions		

ANSI no.	Function	Description
49DLR	Dynamic line rating (DLR)	Protection of overhead lines based on calculation of rating or ampacity to dynamically take into account the effect of prevailing weather conditions as monitored by external sensors for: • Ambient Temperature • Wind Velocity • Wind Direction • Solar Radiation

Table 4 - ANSI descriptions

4 CONCATENATED TERMS

Term
Undercurrent
Overcurrent
Overfrequency
Underfrequency
Undervoltage
Overvoltage

Table 5 - Concatenated terms

5 UNITS FOR DIGITAL COMMUNICATIONS

Unit	Description
b	bit
B	Byte
kb	Kilobit(s)
kbps	Kilobits per second
kB	Kilobyte(s)
Mb	Megabit(s)
Mbps	Megabits per second
MB	Megabyte(s)
Gb	Gigabit(s)
Gbps	Gigabits per second
GB	Gigabyte(s)
Tb	Terabit(s)
Tbps	Terabits per second
TB	Terabyte(s)

Table 6 - Units for digital communications

6 AMERICAN VS BRITISH ENGLISH TERMINOLOGY

British English	American English
…ae…	…e…
…ence	…ense
…ise	…ize
…oe…	…e…
…ogue	…og
…our	…or
…ourite	…orite
…que	…ck
…re	…er
…yse	…yze
Aluminium	Aluminum
Centre	Center
Earth	Ground
Fibre	Fiber
Ground	Earth
Speciality	Specialty

Table 7 - American vs British English terminology

7 LOGIC SYMBOLS AND TERMS

Symbol	Description	Units
&	Logical “AND”: Used in logic diagrams to show an AND-gate function.	
Σ	“Sigma”: Used to indicate a summation, such as cumulative current interrupted.	
τ	“Tau”: Used to indicate a time constant, often associated with thermal characteristics.	
ω	System angular frequency	rad
<	Less than: Used to indicate an “under” threshold, such as undercurrent (current dropout).	
>	Greater than: Used to indicate an “over” threshold, such as overcurrent (current overload)	
o	A small circle on the input or output of a logic gate: Indicates a NOT (invert) function.	
1	Logical “OR”: Used in logic diagrams to show an OR-gate function.	
ABC	Clockwise phase rotation.	
ACB	Anti-Clockwise phase rotation.	
C	Capacitance	A
df/dt	Rate of Change of Frequency protection	Hz/s
df/dt>1	First stage of df/dt protection	Hz/s
F<	Underfrequency protection: Could be labeled 81-U in ANSI terminology.	Hz
F>	Overfrequency protection: Could be labeled 81-O in ANSI terminology.	Hz
F<1	First stage of under frequency protection: Could be labeled 81-U in ANSI terminology.	Hz
F>1	First stage of over frequency protection: Could be labeled 81-O in ANSI terminology.	Hz
f_{max}	Maximum required operating frequency	Hz
f_{min}	Minimum required operating frequency	Hz
f_n	Nominal operating frequency	Hz
I	Current	A
I^	Current raised to a power: Such as when breaker statistics monitor the square of ruptured current squared (∧ power = 2).	An
I’f	Maximum internal secondary fault current (may also be expressed as a multiple of In)	A
I<	An undercurrent element: Responds to current dropout.	A
I>>	Current setting of short circuit element	In
I>	A phase overcurrent protection: Could be labeled 50/51 in ANSI terminology.	A
I>1	First stage of phase overcurrent protection: Could be labeled 51-1 in ANSI terminology.	A
I>2	Second stage of phase overcurrent protection: Could be labeled 51-2 in ANSI terminology.	A
I>3	Third stage of phase overcurrent protection: Could be labeled 51-3 in ANSI terminology.	A
I>4	Fourth stage of phase overcurrent protection: Could be labeled 51-4 in ANSI terminology.	A
I>BB	Minimum pick-up phase threshold for the local trip order confirmation.	A
I>DZ	Minimum pick-up phase threshold for the Dead Zone protection.	A
I_0	Earth fault current setting Zero sequence current: Equals one third of the measured neutral/residual current.	A
I_1	Positive sequence current.	A
I_2	Negative sequence current.	A
I2>	Negative sequence overcurrent protection (NPS element).	A
I2pol	Negative sequence polarizing current.	A
I2therm>	A negative sequence thermal element: Could be labeled 46T in ANSI terminology.	
IA	Phase A current: Might be phase L1, red phase.. or other, in customer terminology.	A
IB	Phase B current: Might be phase L2, yellow phase.. or other, in customer terminology.	A
IbiasPh> Cur.	SDEF blocking bias current threshold.	

Symbol	Description	Units
IC	Phase C current: Might be phase L3, blue phase.. or other, in customer terminology.	A
ID>1	Minimum pick-up phase circuitry fault threshold.	
ID>2	Minimum pick-up differential phase element for all the zones.	
IDCZ>2	Minimum pick-up differential phase element for the Check Zone.	
Idiff	Current setting of biased differential element	A
IDN>1	Minimum pick-up neutral circuitry fault threshold.	
IDN>2	Minimum pick-up differential neutral element for all the zones.	
IDNCZ>2	Minimum pick-up differential neutral element for the Check Zone.	
IDZ	Minimum pick-up differential neutral element for the Check Zone.	
If	Maximum secondary through-fault current	A
If max	Maximum secondary fault current (same for all feeders)	A
If max int	Maximum secondary contribution from a feeder to an internal fault	A
If Z1	Maximum secondary phase fault current at Zone 1 reach point	A
Ife	Maximum secondary through fault earth current	A
IfeZ1	Maximum secondary earth fault current at Zone 1 reach point	A
Ifn	Maximum prospective secondary earth fault current or 31 x I> setting (whichever is lowest)	A
Ifp	Maximum prospective secondary phase fault current or 31 x I> setting (whichever is lowest)	A
I_m	Mutual current	A
IM64	InterMiCOM64.	
IMx	InterMiCOM64 bit (x=1 to 16)	
I_n	Current transformer nominal secondary current. The rated nominal current of the relay: Software selectable as 1 amp or 5 amp to match the line CT input.	A
IN	Neutral current, or residual current: This results from an internal summation of the three measured phase currents.	A
IN>	A neutral (residual) overcurrent element: Detects earth/ground faults.	A
IN>1	First stage of ground overcurrent protection: Could be labeled 51N-1 in ANSI terminology.	A
IN>2	Second stage of ground overcurrent protection: Could be labeled 51N-2 in ANSI terminology.	A
IN>BB	Minimum pick-up neutral threshold for the local trip order confirmation.	
IN>DZ	Minimum pick-up neutral threshold for the Dead Zone protection.	
Inst	An element with “instantaneous” operation: i.e. having no deliberate time delay.	
I/O	Inputs and Outputs - used in connection with the number of optocoupled inputs and output contacts within the relay.	
I/P	Input	
Iref	Reference current of P63x calculated from the reference power and nominal voltage	A
IREF>	A Restricted Earth Fault overcurrent element: Detects earth (ground) faults. Could be labeled 64 in ANSI terminology.	A
IRm2	Second knee-point bias current threshold setting of P63x biased differential element	A
Is	Value of stabilizing current	A
IS1	Differential current pick-up setting of biased differential element	A
IS2	Bias current threshold setting of biased differential element	A
I_{SEF}>	Sensitive Earth Fault overcurrent element.	A
Isn	Rated secondary current (I secondary nominal)	A
Isp	Stage 2 and 3 setting	A
Ist	Motor start up current referred to CT secondary side	A
K	Dimensioning factor	

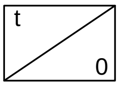
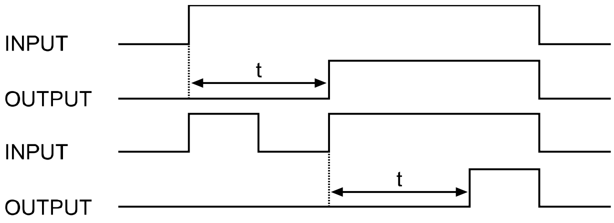
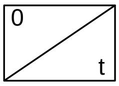
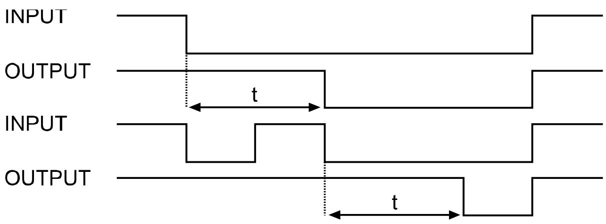
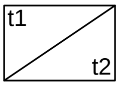
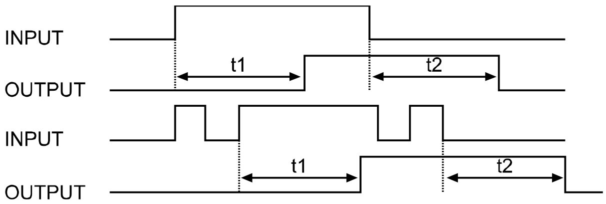
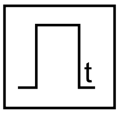
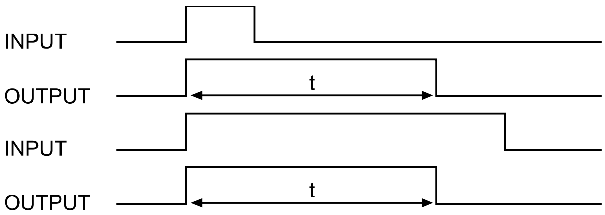
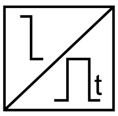
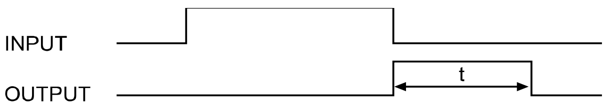
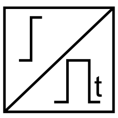
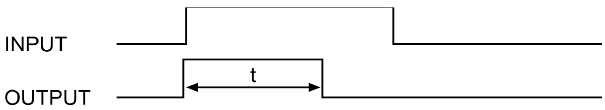
Symbol	Description	Units
K_1	Lower bias slope setting of biased differential element	%
K_2	Higher bias slope setting of biased differential element	%
KCZ	Slope of the differential phase element for the Check Zone.	
K_e	Dimensioning factor for earth fault	
km	Distance in kilometers	
K_{max}	Maximum dimensioning factor	
KNCZ	Slope of the differential neutral element for the Check Zone.	
K_{rpa}	Dimensioning factor for reach point accuracy	
K_s	Dimensioning factor dependent upon through fault current	
K_{ssc}	Short circuit current coefficient or ALF	
K_t	Dimensioning factor dependent upon operating time	
kZm	The mutual compensation factor (mutual compensation of distance elements and fault locator for parallel line coupling effects).	
kZN	The residual compensation factor: Ensuring correct reach for ground distance elements.	
L	Inductance	A
m1	Lower bias slope setting of P63x biased differential element	None
m2	Higher bias slope setting of P63x biased differential element	None
mi	Distance in miles.	
N	Indication of “Neutral” involvement in a fault: i.e. a ground (earth) fault.	
-P>	A reverse power (W) element: could be labeled 32R in ANSI terminology.	
P>	An overpower (W) element: could be labeled 32O in ANSI terminology.	
P<	A low forward power (W) element: could be labeled 32L in ANSI terminology.	
P1	Used in IEC terminology to identify the primary CT terminal polarity: Replace by a dot when using ANSI standards.	
P2	Used in IEC terminology to identify the primary CT terminal polarity: The non-dot terminal.	
P_n	Rotating plant rated single phase power	W
PN>	Wattmetric earth fault protection: Calculated using residual voltage and current quantities.	
Q<	A reactive under power (VAr) element	
R	Resistance (Ω)	Ω
R< or 64S R<	A 100% stator earth (ground) fault via low frequency injection under resistance element: could be labeled 64S in ANSI terminology.	
R Gnd.	A distance zone resistive reach setting: Used for ground (earth) faults.	
R Ph	A distance zone resistive reach setting used for Phase-Phase faults.	
Rct	Secondary winding resistance	Ω
RCT	Current transformer secondary resistance	Ω
Rl	Resistance of single lead from relay to current transformer	Ω
Rr	Resistance of any other protective relays sharing the current transformer	Ω
Rrn	Resistance of relay neutral current input	Ω
Rrp	Resistance of relay phase current input	Ω
Rs	Value of stabilizing resistor	Ω
Rx	Receive: typically used to indicate a communication receive line/pin.	
S<	An apparent under power (VA) element	
S1	Used in IEC terminology to identify the secondary CT terminal polarity: Replace by a dot when using ANSI standards.	

Symbol	Description	Units
S2	Used in IEC terminology to identify the secondary CT terminal polarity: The non-dot terminal. Also used to signify negative sequence apparent power, S2 = V2 x I2.	
S2>	A negative sequence apparent power element, S2 = V2 x I2.	
t	A time delay.	
t'	Duration of first current flow during auto-reclose cycle	s
T1	Primary system time constant	s
TF	Through Fault monitoring	
tfr	Auto-reclose dead time	s
Thermal I>	A stator thermal overload element: could be labeled 49 in ANSI terminology.	
Thru/TF	Through Fault monitoring	
tIdiff	Current differential operating time	s
Ts	Secondary system time constant	s
Tx	Transmit: typically used to indicate a communication transmit line/pin.	
V	Voltage.	V
V<	An undervoltage element: could be labeled 27 in ANSI terminology	V
V<1	First stage of undervoltage protection: Could be labeled 27-1 in ANSI terminology.	V
V<2	Second stage of undervoltage protection: Could be labeled 27-2 in ANSI terminology.	V
V>	An overvoltage element: could be labeled 59 in ANSI terminology	V
V>1	First stage of overvoltage protection: Could be labeled 59-1 in ANSI terminology.	V
V>2	Second stage of overvoltage protection: Could be labeled 59-2 in ANSI terminology.	V
V0	Zero sequence voltage: Equals one third of the measured neutral/residual voltage.	V
V1	Positive sequence voltage.	V
V2	Negative sequence voltage.	V
V2>	A Negative Phase Sequence (NPS) overvoltage element: could be labeled 47 in ANSI terminology.	
$V2_{pol}$	Negative sequence polarizing voltage.	V
V_A	Phase A voltage: Might be phase L1, red phase.. or other, in customer terminology.	V
V_B	Phase B voltage: Might be phase L2, yellow phase.. or other, in customer terminology.	V
V_C	Phase C voltage: Might be phase L3, blue phase.. or other, in customer terminology.	V
Vf	Theoretical maximum voltage produced if CT saturation did not occur	V
Vin	Input voltage e.g. to an opto-input	V
V_k	Required CT knee-point voltage. IEC knee point voltage of a current transformer.	V
VN	Neutral voltage displacement, or residual voltage.	V
VN>	A residual (neutral) overvoltage element: could be labeled 59N in ANSI terminology.	V
V_n	Nominal voltage	V
Vn	The rated nominal voltage of the relay: To match the line VT input.	V
VN>1	First stage of residual (neutral) overvoltage protection.	V
VN>2	Second stage of residual (neutral) overvoltage protection.	V
VN3H>	A 100% stator earth (ground) fault 3rd harmonic residual (neutral) overvoltage element: could be labeled 59TN in ANSI terminology.	
VN3H<	A 100% stator earth (ground) fault 3rd harmonic residual (neutral) undervoltage element: could be labeled 27TN in ANSI terminology.	
Vres.	Neutral voltage displacement, or residual voltage.	V
Vs	Value of stabilizing voltage	V
V_x	An auxiliary supply voltage: Typically the substation battery voltage used to power the relay.	V

Symbol	Description	Units
WI	Weak Infeed logic used in teleprotection schemes.	
X	Reactance	None
X/R	Primary system reactance/resistance ratio	None
Xe/Re	Primary system reactance/resistance ratio for earth loop	None
Xt	Transformer reactance (per unit)	p.u.
Y	Admittance	p.u.
YN>	Neutral overadmittance protection element: Non-directional neutral admittance protection calculated from neutral current and residual voltage.	
Z	Impedance	p.u.
Z<	An under impedance element: could be labeled 21 in ANSI terminology.	
Z0	Zero sequence impedance.	
Z1	Positive sequence impedance.	
Z1	Zone 1 distance protection.	
Z1X	Reach-stepped Zone 1X, for zone extension schemes used with auto-reclosure.	
Z2	Negative sequence impedance.	
Z2	Zone 2 distance protection.	
ZP	Programmable distance zone that can be set forward or reverse looking.	
Zs	Used to signify the source impedance behind the relay location.	
Φal	Accuracy limit flux	Wb
Ψr	Remanent flux	Wb
Ψs	Saturation flux	Wb

Table 8 - Logic Symbols and Terms

8 LOGIC TIMERS

Logic symbols	Explanation	Time chart
	Delay on pick-up timer, t	
	Delay on drop-off timer, t	
	Delay on pick-up/drop-off timer	
	Pulse timer	
	Pulse pick-up falling edge	
	Pulse pick-up raising edge	

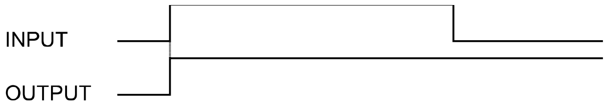
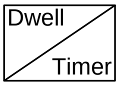
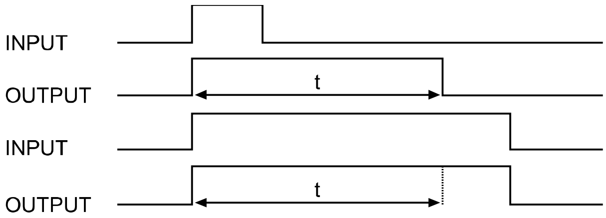
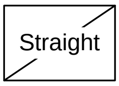
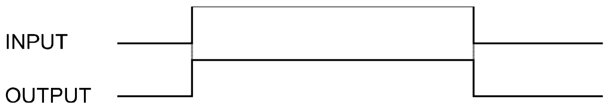
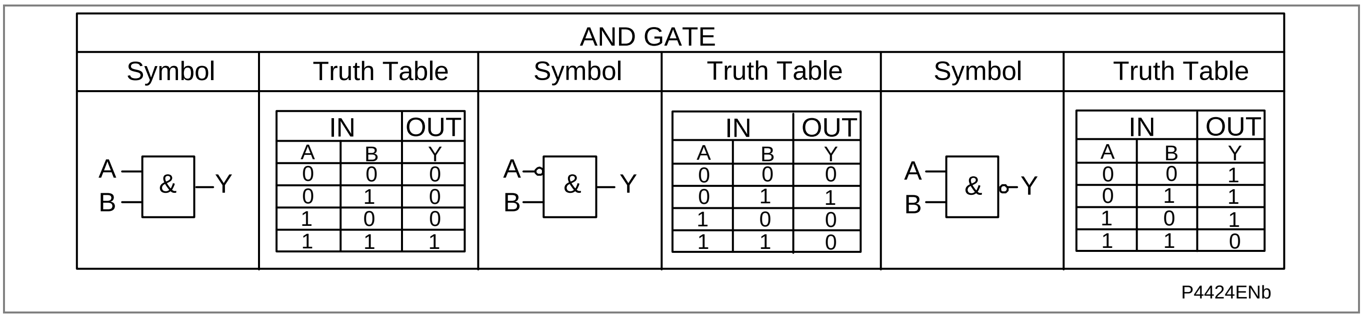
Logic symbols	Explanation	Time chart
	Latch	
	Dwell timer	
	Straight (non latching): Hold value until input reset signal	

Table 9 - Logic Timers

9 LOGIC GATES

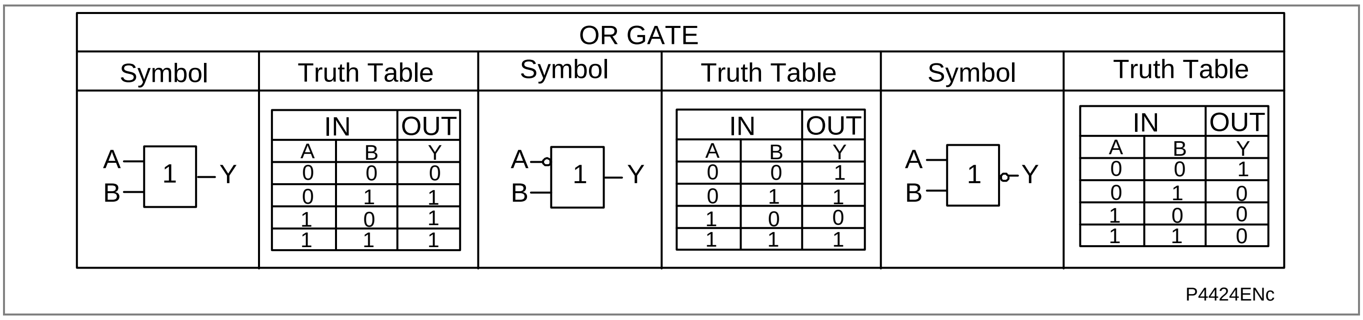


IN		OUT
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	0
1	1	0

IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

Figure 1 - Logic Gates - AND Gate

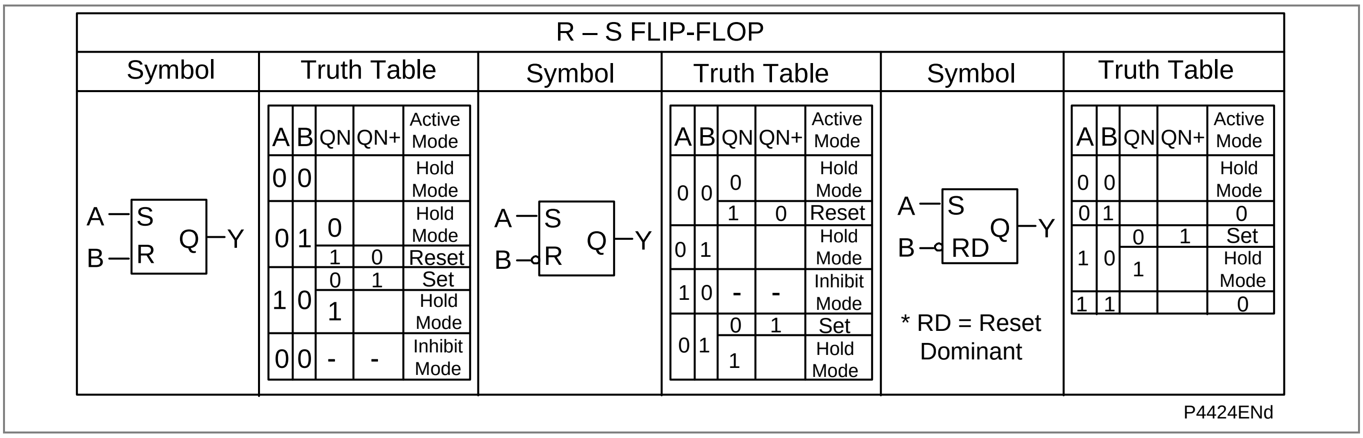


IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	0
1	1	1

IN		OUT
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

Figure 2 - Logic Gates - OR Gate

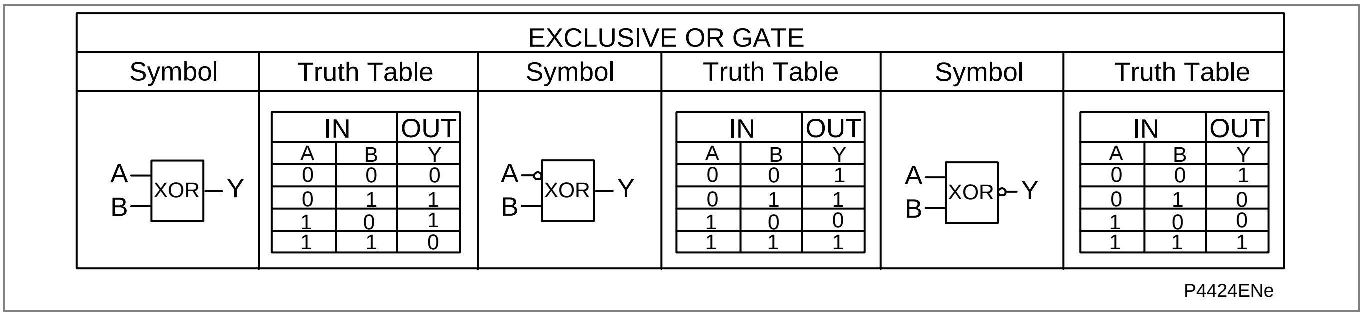


A	B	QN	QN+	Active Mode
0	0			Hold Mode
0	1	0		Hold Mode
		1	0	Reset
1	0	0	1	Set
		1		Hold Mode
0	0	-	-	Inhibit Mode

A	B	QN	QN+	Active Mode
0	0	0		Hold Mode
		1	0	Reset
0	1			Hold Mode
1	0	-	-	Inhibit Mode
0	1	0	1	Set
		1		Hold Mode

A	B	QN	QN+	Active Mode
0	0			Hold Mode
0	1			0
1	0	0	1	Set
		1		Hold Mode
1	1			0

Figure 3 - Logic Gates - R-S Flip-Flop Gate



IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

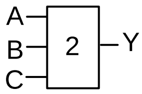
IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	0
1	1	1

IN		OUT
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

Figure 4 - Logic Gates - Exclusive OR Gate

PROGRAMMABLE GATE

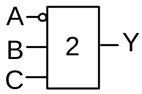
Symbol



Truth Table

IN			OUT
A	B	C	Y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

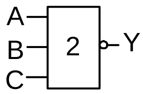
Symbol



Truth Table

IN			OUT
A	B	C	Y
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

Symbol



Truth Table

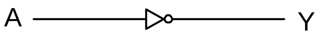
IN			OUT
A	B	C	Y
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

P4424ENf

Figure 5 - Logic Gates - Programmable Gate

NOT GATE

Symbol



Inverter (NOT)

Truth Table

IN	OUT
A	Y
0	1
1	0

P4424ENg

Figure 6 - Logic Gates - NOT Gate

Notes:

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Publisher: Schneider Electric

Publication: Easergy MiCOM P746/EN M/M82 Numerical Busbar Protection Relay Software Version: B4 (P746_1)/C4 (P746_2) Hardware Suffix: M

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