MiCOM P746

Technical Manual

Numerical Busbar Protection

Platform Hardware Version: K
Platform Software Version: O1
Publication Reference: P746/EN M/F11

GRID

ALSTOM

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SAFETY SECTION

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STANDARD SAFETY STATEMENTS AND EXTERNAL LABEL INFORMATION FOR ALSTOM GRID EQUIPMENT

1.   INTRODUCTION

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

The technical data in this Safety Section is typical only, see the technical data section of the relevant equipment documentation for data specific to a particular equipment.

Before carrying out any work on the equipment the user should be familiar with the contents of this Safety Section and the ratings on the equipment's rating label.

Reference should be made to the external connection diagram before the equipment is installed, commissioned or serviced.

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

2.   HEALTH AND SAFETY

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

It is assumed that everyone who will be associated with the equipment will be familiar with the contents of this Safety Section, or the Safety Guide (SFTY/4L M).

When electrical equipment is in operation, dangerous voltages will be present in certain parts of the equipment. Failure to observe warning notices, incorrect use, or improper use may endanger personnel and equipment and also cause personal injury or physical damage.

Before working in the terminal strip area, the equipment must be isolated.

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).

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 Alstom Grid technical sales office and request the necessary information.

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3. SYMBOLS AND LABELS ON THE EQUIPMENT

For safety reasons the following symbols which may be used on the equipment or referred to in the equipment documentation, should be understood before it 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.

*NOTE: 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/4L M) for typical equipment labeling information.

4. INSTALLING, COMMISSIONING AND SERVICING

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) precautions 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.

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. Alstom Grid strongly recommends that these contacts are hardwired into the substation's automation system, for alarm purposes.

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

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

Protection Class I Equipment

- Before energizing the equipment it must be earthed using the protective conductor terminal, if provided, or the appropriate termination of the supply plug in the case of plug connected equipment.

- The protective conductor (earth) connection must not be removed since the protection against electric shock provided by the equipment would be lost.

- When the protective (earth) conductor terminal (PCT) is also used to terminate cable screens, etc., it is essential that the integrity of the protective (earth) conductor is checked after the addition or removal of such functional earth connections. For M4 stud PCTs the integrity of the protective (earth) connections should be ensured by use of a locknut or similar.

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

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

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

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.

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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 and/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.

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 MMLG, MMLB and MiCOM P990 types, hazardous voltages may be accessible when using these. *CT shorting links must be in place before the insertion or removal of MMLB 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 should not be viewed directly. 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. 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: 2005	This equipment requires a protective conductor (earth) connection to ensure user safety.

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6.3   Installation category

IEC 60255-27: 2005   Installation category III (Overvoltage Category III):

EN 60255-27: 2005   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 Altitude - Operation up to 2000m standards.

IEC 60255-27:2005

EN 60255-27: 2005

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INTRODUCTION

Date:	**2008**
Hardware Suffix:	**K**
Software Version:	**01**
Connection Diagrams:	**10P746xx (xx = 01 to 07)**

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FIGURES

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1. MiCOM DOCUMENTATION STRUCTURE

The manual provides a functional and technical description of the MiCOM protection relay and a comprehensive set of instructions for the relay's use and application.

The section contents are summarized below:

P746/EN IT   **Introduction**

A guide to the MiCOM range of relays and the documentation structure. General safety aspects of handling Electronic Equipment is discussed with particular reference to relay safety symbols. Also a general functional overview of the relay and brief application summary is given.

P746/EN TD   **Technical Data**

Technical data including setting ranges, accuracy limits, recommended operating conditions, ratings and performance data. Compliance with norms and international standards is quoted where appropriate.

P746/EN GS   **Getting Started**

A guide to the different user interfaces of the protection relay describing how to start using it. This section provides detailed information regarding the communication interfaces of the relay, including a detailed description of how to access the settings database stored within the relay.

P746/EN ST   **Settings**

List of all relay settings, including ranges, step sizes and defaults, together with a brief explanation of each setting.

P746/EN OP   **Operation**

A comprehensive and detailed functional description of all protection and non-protection functions.

P746/EN AP   **Application Notes**

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.

P746/EN PL   **Programmable Logic**

Overview of the programmable scheme logic and a description of each logical node. This section includes the factory default (PSL) and an explanation of typical applications.

P746/EN MR   **Measurements and Recording**

Detailed description of the relays recording and measurements functions including the configuration of the event and disturbance recorder and measurement functions.

P746/EN FD   **Firmware Design**

Overview of the operation of the relay's hardware and software. This section includes information on the self-checking features and diagnostics of the relay.

P746/EN CM   **Commissioning**

Instructions on how to commission the relay, comprising checks on the calibration and functionality of the relay.

P746/EN MT   **Maintenance**

A general maintenance policy for the relay is outlined.

P746/EN TS   **Troubleshooting**

Advice on how to recognize failure modes and the recommended course of action. Includes guidance on whom within Alstom Grid to contact for advice.

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P746/EN SC   SCADA Communications

This section 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.

P746/EN SG   Symbols and Glossary

List of common technical abbreviations found within the product documentation.

P746/EN IN   Installation

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. All external wiring connections to the relay are indicated.

P746/EN VH   Firmware and Service Manual Version History

History of all hardware and software releases for the product.

2. INTRODUCTION TO MiCOM

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

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 on any MiCOM product, visit our website:

www.alstom.com/grid/sas

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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 integral biased differential busbar, breaker failure, dead zone and overcurrent protection and is 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

- Three MiCOM P746 for up to 18 (single phase) CTs per relay

- As many times "three MiCOM P746 for up to 18 (single phase)" when possible.

Which, with the MiCOM S1 V2 or MiCOM S1 Studio software and the Remote HMI monitoring tool, allow full flexibility for all configurations up to 2 zones (or n times 2 zones).

3.1 Functional overview

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

The protection features are summarized below:

Protection Functions Overview			
ANSI	IEC 61850		P746
87BB / P	PhsPDIF	Phase segregated biased current differential high speed busbar protection	•
87CZ / P	CzPPDIF	Check Zone segregated biased phase current differential high speed busbar protection	•
50 / 51 / P	OcpPTOC	Phase overcurrent protection (2 stages)	•
50 / 51 / N	EfmPTOC	Earth overcurrent protection (2 stages)	•
50ST / P	DzpPhsPTOC	Dead zone phase protection (short zone between CTs and open CBs)	•
CTS		Current transformer supervision (single box mode only)	•
VTS		Voltage transformer supervision	•
50BF	RBRF	Breaker failure protection (LBB)	•
89	RBRF	Lockout	•
		ISL Isolator discrepancy alarm	•
	OptGGIO	Digital inputs	16 to 40*
	RlyGGIO	Output relays	16 to 32*
		Front communication port (RS232)	•
		Rear communication port (Kbus/EIA(RS)485)	•
		Rear communication port (Ethernet) *	Option
		Time synchronisation port (IRIG-B) *	Option
	FnkGGIO	Function keys	10
	LedGGIO	Programmable tri-colour LEDs	18

- *Refer to the data sheet for model selection*

The P746 supports the following relay management functions in addition to the functions illustrated above.

- 4 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

- Multi-level password protection

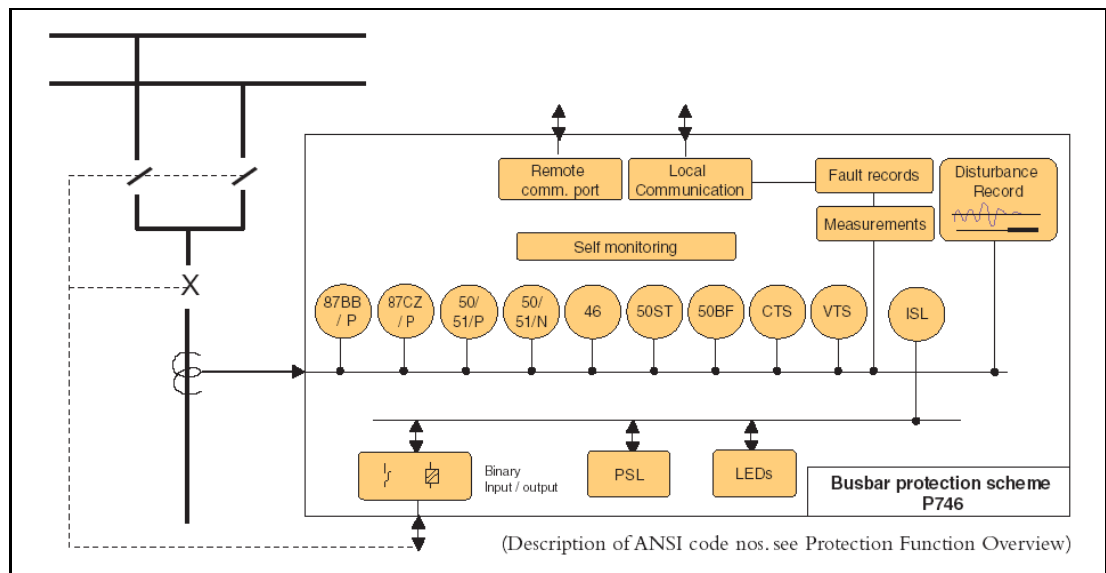- Power-up diagnostics and continuous self-monitoring of relay

Application overview

FIGURE 1: FUNCTIONAL DIAGRAM

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3.2 Ordering options

Information Required with Order

Relay Type (Busbar Protection Relay) **P746**										

Auxiliary Voltage Rating

24 – 48V dc only	1
48 – 125V dc (30 – 110V ac)	2
110 – 250V dc (100 – 240V ac)	3

In/Vn RatingBoards

CT1 - CT18 In=1/5A, Vn=100/120V (18CT/3VT)	1
CT1 - CT18 In=1/5A, Vn=380/480V (18CT/3VT)	2

Hardware options

Nothing	1
IRIG-B modulated only	2
Fibre Optic Converter only	3
IRIG-B modulated + Fibre Optic Converter	4
Ethernet (100Mbps) only	6
2nd Rear Comms port	7
2nd Rear comms port + IRIG-B (modulated)	8
Ethernet (100Mbps)+IRIG-B (modulated)	A
Ethernet (100Mbps) IRIG-B (demodulated)	B
IRIG-B demodulated only	C

Product Specific

16 optos + 16 Relays	A
16 optos + 8 Relays + 8 High Break Relays	B
16 optos + 32 Relays C	C
16 optos + 24 Relays + 4 High Break Relays D	D
24 optos + 24 Relays E	E
24 optos + 16 Relays + 8 High Break Relays F	F
24 optos + 8 Relays + 12 High Break Relays G	G
32 optos + 24 Relays H	H
32 optos + 16 Relays + 8 High Break Relays J	J
40 optos + 24 Relays K	K

Protocol Options

K-Bus/Courier	1
MODBUS	2
IEC60870-5-103	3
dnp3.0	4
IEC 61850-8.1 (NEEDS ETHERNET BOARD)	6

Mounting

Panel / flush Mounting	M
rack mounting	n

Language

Multilingual – English, French, German, Spanish	0
Multilingual – English, French, German, Russian	5
Multilingual – English, French, German, Chinese	C

Software Version

Unless specified the latest version will be delivered	* *

Settings File

Default	0
Customer Specific	A

Hardware Suffix

Original	K

TD

TECHNICAL DATA

Date: **2009**

Hardware Suffix: **K**

Software Version: **01**

Connection Diagrams: **10P746xx (xx = 01 to 07)**

Technical Data

Mechanical Specification

Design
Modular MiCOM Px40 platform relay, Size 16"
case (80TE)
Mounting is front of panel flush mounting.

Enclosure Protection

Per IEC 60529: 1989
IP 52 Protection (front panel) against dust and
dripping water,
IP 50 Protection for the rear and sides of the
case against dust,
IP 10 Product safety protection for the rear due
to live connections on the terminal block.

Weight

P746: 13.4 kg

Terminals

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

General Input/Output Terminals
For power supply, opto inputs, output contacts
and COM1& optional COM2 rear
communications.
Located on general purpose (grey) blocks:
Threaded M4 terminals, for ring lug
connection.

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.

Front Port Serial PC Interface
EIA RS232 DTE, 9 pin D-type female
connector.
Courier protocol for interface to MiCOM S1
software.
PEB rated Maximum cable length 15m.

Front Download/Monitor Port
EIA RS232, 25 pin D-type female connector.
For firmware downloads. PEB rated circuit.

Rear Communications Port
K-Bus/EIA(RS485) signal levels, two wire
Connections located on general purpose block,
M4 screw.
For screened twisted pair cable, multidrop,
1000m max. Courier protocol. SELV rated
circuit.
Ethernet (copper & fibre)

Optional Second Rear Communication
PortEIA(RS)232, 9 pin D-type female
connector,
socket SK4. Courier protocol: K-Bus, or
EIA(RS)485 or EIA(RS)232. Maximum cable
length: 15m.

**Optional Rear Ethernet Connection for
IEC 61850**
10 Base T / 100 Base TX Communications
Interface in accordance with IEEE802.3 and
IEC61850
Isolation: 1.5kV. Connector type: RJ45
Cable type: Screened Twisted Pair (STP)
Max. cable length: 100m

100 Base FX Interface
Interface in accordance with IEEE802.3 and
IEC61850
Wavelength: 1300nm
Fiber: multi-mode 50/125µm or 62.5/125µm
Connector style: BFOC 2.5 - (ST®)

**Optional Rear IRIG-B Interface modulated
or un-modulated**

BNC socket
SELV rated circuit.
50 ohms coaxial cable.

Ratings

AC Measuring Inputs
Nominal frequency:
∗ 50 and 60 Hz (settable)
Operating range:
∗ 45 to 65Hz
Phase rotation:
∗ ABC or ACB

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:
∗ <0.15VA 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 64 In (non-offset AC current).

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

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Power supply

Auxiliary Voltage (Vx)
Three ordering options:
(i)   Vx: 24 to 48 Vdc
(ii) Vx: 48 to 110 Vdc, and 40 to 100Vac (rms)
(iii) Vx: 110 to 250 Vdc, and 100 to 240Vac (rms).

Operating Range
(i)   19 to 65V   (dc only for this variant)
(ii) 37 to 150V   (dc), 32 to 110V (ac)
(iii) 87 to 300V   (dc), 80 to 265V (ac).
With a tolerable ac ripple of up to 12% for a dc supply, per IEC 60255-11: 1979.

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

Power-up Time
Time to power up < 8s.

Power Supply Interruption
Per IEC 60255-11: 1979
The relay will withstand a 20ms interruption in the DC auxiliary supply, without de-energizing.
Per IEC 61000-4-11: 1994
The relay will withstand a 20ms interruption in an AC auxiliary supply, without de-energizing.
Note: the use of a E124 extends these limits

Battery Backup
Front panel mounted Type ½ AA, 3.6V

Field Voltage Output
Regulated 48Vdc
Current limited at 112mA maximum output

Digital ("Opto") Inputs
Universal opto inputs with programmable voltage thresholds. May be energized from the 48V field voltage, or the external battery supply.
Rated nominal voltage:
∗   24 to 250Vdc
Operating range:
∗   19 to 265Vdc
Withstand:
∗   300Vdc.
Nominal pick-up and reset thresholds:
∗   Pick-up: approx. 70% of battery nominal set,
∗   Reset: approx. 66% of battery nominal set.
Recognition time:
∗   7ms

Output Contacts

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

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

Watchdog Contacts
Non-programmable contacts for relay healthy/relay fail indication:
Breaking capacity:
∗   DC: 30W resistive
∗   DC: 15W inductive (L/R = 40ms)
∗   AC: 375VA inductive (cos ϕ = 0.7)

IRIG-B 12X Interface (Modulated)
External clock synchronization per IRIG standard 200-98, format B12X.
Input impedance 6kΩ at 1000Hz
Modulation ratio:
∗   3:1 to 6:1
Input signal, peak-peak:
∗   200mV to 20V

IRIG-B 00X Interface (Un-modulated)
External clock synchronization per IRIG standard 200-98, format B00X.
Input signal TTL level
Input impedance at dc 10kΩ

Environmental Conditions

Ambient Temperature Range
Operating temperature range:
* −25°C to +55°C (or -13°F to +131°F).
Storage and transit:
* −40°C to +70°C (or -28°F to +158°F).

Ambient Humidity Range
Per IEC 60068-2-3: 1969:
* 56 days at 93% relative humidity and +40 °C
Per IEC 60068-2-30: 1980:
* Damp heat cyclic, six (12 + 12) hour cycles, 93% RH, +25 to +55 °C

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 H2S, NO2, Cl2 and SO2.

Type Tests

Insulation
Per IEC 60255-27: 2005,
* Insulation resistance > 100MΩ at 500Vdc
(Using only electronic/brushless insulation tester).

Creepage Distances and Clearances
Per IEC 60255-27: 2005
* Pollution degree 3,
* overvoltage category III,
* impulse test voltage 5 kV.

High Voltage (Dielectric) Withstand
(EIA RS232 ports excepted).
(i) Per IEC 60255-27: 2005, 2 kV rms, AC, 1 minute:
Between all case terminals connected together and the case earth.
Also, between all terminals of independent circuits.
* 1kV rms AC for 1 minute, across open watchdog contacts and across open contacts of changeover output relays.
(ii) Per ANSI/IEEE C37.90-1989 (reaffirmed 1994):
* 1.5 kV rms AC for 1 minute, across open contacts of changeover output relays.

Impulse Voltage Withstand Test
Per IEC 60255-27: 2005
Front time: 1.2 µs, Time to half-value: 50 µs, Peak value: 5 kV, 0.5J
Between all terminals, and all terminals and case earth.

Electromagnetic Compatibility (EMC)

1 MHz Burst High Frequency Disturbance Test
Per IEC 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 RS232 ports excepted).

100 kHz Damped oscillatory Test
Per EN 61000-4-18: 2007, Level 3,
Common-mode test voltage: 2.5 kV,
Differential test voltage: 1.0 kV,

Immunity to Electrostatic Discharge
Per IEC 60255-22-2: 1997, Class 4,
15kV discharge in air to user interface, display, and exposed metalwork.
Per IEC 60255-22-2: 1997, Class 3,
8kV discharge in air to all communication ports.
6kV point contact discharge to any part of the front of the product.

Electrical Fast Transient or Burst Requirements
Per IEC 60255-22-4: 2002 and EN 61000-4-4: 2004.
Test severity:
* Class III and IV:
Amplitude:
* 2 kV, burst frequency 5kHz (Class III),
Amplitude:
* 4 kV, burst frequency 2.5kHz (Class IV).
Applied directly to auxiliary supply, and applied to all other inputs. (EIA RS232 ports excepted).
Amplitude:
* 4 kV, burst frequency 5kHz (Class IV).
Applied directly to auxiliary supply.

Surge Withstand Capability
Per IEEE/ANSI C37.90.1: 2002:
4kV fast transient and 2.5kV oscillatory applied directly across each output contact, optically isolated input, and power supply circuit.

Surge Immunity Test
(EIA RS232 ports excepted).
Per IEC 61000-4-5: 2006 Level 4,
Time to half-value: 1.2 / 50 µs,
* Amplitude: 4kV between all groups and case earth,
* Amplitude: 2kV between terminals of each group.

TD

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Immunity to Radiated Electromagnetic Energy
Per IEC 60255-22-3: 2000, Class III:
Test field strength, frequency band 80 to 1000 MHz:
* 10 V/m,
* Test using AM: 1 kHz / 80%,
* Spot tests at 80, 160, 450, 900 MHz
Per IEEE/ANSI C37.90.2: 2004:
25MHz to 1000MHz, zero and 100% square wave modulated.
Field strength of 35V/m.

Radiated Immunity from Digital Communications
Per EN61000-4-3: 2002, 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%.

Radiated Immunity from Digital Radio Telephones
Per EN 61000-4-3: 2002
* 10 V/m, 900MHz and 1.89GHz.

Immunity to Conducted Disturbances Induced by Radio Frequency Fields
Per IEC 61000-4-6: 1996, Level 3,
Disturbing test voltage: 10 V

Power Frequency Magnetic Field Immunity
Per IEC 61000-4-8: 2001, Level 5,
* 100A/m applied continuously,
* 1000A/m applied for 3s.
Per IEC 61000-4-9: 2001, Level 5,
* 1000A/m applied in all planes.
Per IEC 61000-4-10: 2001, Level 5,
* 100A/m applied in all planes at 100kHz/1MHz with a burst duration of 2s.

Conducted Emissions
Per EN 55022: 1998:
* 0.15 – 0.5MHz, 79dBμV (quasi peak) 66dBμV (average)
* 0.5 – 30MHz, 73dBμV (quasi peak) 60dBμV (average).

Radiated Emissions
Per EN 55022: 1998:
* 30 - 230MHz, 40dBμV/m at 10m measurement distance
* 230 – 1GHz, 47dBμV/m at 10m measurement distance.

EU Directives

EMC Compliance
Per 2004/108/EC:
Compliance to the European Commission Directive on EMC is claimed via the Technical Construction File route. Product Specific Standards were used to establish conformity:
* EN50263: 2000

Product Safety
Per 2006/95/EC:
Compliance with European Commission Low Voltage Directive. Compliance is demonstrated by reference to generic safety standards:
* IEC 60255-27:2005

CE

R&TTE compliance
Radio and telecommunication terminal equipment (R&TTE) directive 99/5/EC.
Compliance demonstrated by compliance to both the EMC directives on low voltage directive down to 0V.
Applicable to rear communication ports.

Mechanical Robustness

Vibration Test
Per IEC 60255-21-1: 1996
Response Class 2
Endurance Class 2

Shock and Bump
Per IEC 60255-21-2: 1995
Shock response Class 2
Shock withstand Class 1
Bump Class 1

Seismic Test
Per IEC 60255-21-3: 1995
Class 2

Timing and Accuracy

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

Performance Data

Busbar Protection

Busbar fault Accuracy
Pick-up:
∗   Setting ± 5% or 20 mA, Whichever Is Greater (WIG)
Drop-off:
∗   >0.95 x Setting or 20 mA, WIG
Busbar trip with high speed contact:
∗   8 ms (min) & 12 ms (typical) at 3.5 x tripping threshold (50Hz)
∗   6 ms (min) & 10 ms (typical) at 4.5 x tripping threshold (60Hz)
Busbar trip with standard contact:
∗   13 ms (min) & 17 ms (typical) at 3.5 x tripping threshold (50Hz)
∗   11 ms (min) & 15 ms (typical) at 4.5 x tripping threshold (60Hz)

Circuitry fault Accuracy
Pick-up:
∗   Setting ± 5% or 20 mA, Whichever Is Greater (WIG)
Drop-off:
∗   >0.95 x Setting or 20 mA, WIG
DT operation:
∗   ±5 % or 50 ms WIG

Dead Zone Protection

Accuracy
Pick-up:
∗   Setting ± 5% or 20 mA Whichever Is Greater (WIG)
Drop-off:
∗   >0.95 x Setting or 20 mA WIG
Min. trip level:
∗   1.05 x Setting ± 5% or 20 mA WIG
DT operation:
∗   ±5 % or 50 ms WIG

Three phase overcurrent protection

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

Earth Fault Protection

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

Transient overreach and overshoot

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

Programmable scheme logic

Accuracy
Output, dwell and pulse conditioner timers:
∗   Setting ±2% or 50ms whichever is greater

TD

IRIG-B and Real Time Clock

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

Un-modulated IRIG-B:
Input signal TTL level
Input impedance at dc 10kΩ
External clock synchronization per IRIG standard 200-98, format B00X.

Performance Accuracy (for modulated and un-modulated versions)
Real time clock accuracy: < ±2 seconds/day

Measurements

Accuracy
Phase current:
* ±1.0% of reading
Phase local current:
* ±1.0% of reading
* or ±(f-fn)/fn %
Phase remote current
* ±1.0% of reading
* or ±(f-fn)/fn %
Phase differential current:
* ±5.0%
Bias current:
* ±5.0%
Frequency:
* ±1%

Disturbance records

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

Reference conditions
Ambient temperature:
* 20°C

Frequency Tracking Range
45 to 65Hz

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

IEC 61850 Ethernet data

10 Base T /100 Base TX Communications
Interface in accordance with IEEE802.3 and IEC61850
Isolation 1.5kV
Cable type: Screened twisted pair STP
Max length: 100m

100 Base FX Interface
Interface in accordance with IEEE802.3 and IEC61850
Wavelength: 1300nm
Fibre: multi-mode 50/125μm or 62.5/125μm
Connector style: ST

Transmitter Optical Characteristics
(TA = 0°C to 70°C, VCC = 4.75 V to 5.25 V)

Parameter	Sym	Min.	Typ.	Max	Unit
Output Optical Power BOL 62.5/125 μm, NA = 0.275 Fiber EOL	PO	-19 -20	-16.8	-14	dBm avg.
Output Optical Power BOL 50/125 μm, NA = 0.20 Fiber EOL	PO	-22.5 -23.5	-20.3	-14	dBm avg.
Optical Extinction Ratio				10 -10	% dB
Output Optical Power at Logic "0" State	PO ("0")			-45	dBm avg.

BOL – Beginning of life
EOL – End of life

Receive Optical Characteristics
(TA = 0°C to 70°C, VCC = 4.75 V to 5.25 V)

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

TD

Settings, Measurements and Records List

Global Settings (System Data):
Language:
* English/French/German/Spanish
Frequency:
* 50/60Hz

Voltage transformers
Phase VT Primary: 100V...100kV
Phase VT Secondary V: 80…140V

Current transformers
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)
Supervision of I_0 calculation:
* Kce: 0.01... 1.00
I_0 error alarm time delay:
* Tce: 0.0...10.0 s

Differential Protection
IRef:
* 100A…30kA (step 5A)

Disabled/Enabled
$I_D>2$:
* 10%…250% (step 1%)
k2:
* 20%...90% (step 1%)
tDiff:
* 0…10s (step 10ms)

Check zone
kCZ:
* 0%…90% (step 1%)

Circuitry fail
Disabled/Enabled
$I_D>1$:
* 5%…600% (step 1%)
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)

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)

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

Breaker failure protection
Caution: the following current set values are expressed in multiple of the local CT's nominal rated current inp (primary) or ins (secondary).

Breaker Failure
1ST phase O/C threshold (dead pole detection for 50BF):
* I<: 0.05...1.00 xIn
Confirmation I>:
* Disabled/Enabled
2nd phase O/C threshold:
* I>: 0.05...4.00 xIn
Confirmation I_N>:
* Disabled/Enabled
2nd residual O/C threshold:
* I_N>: 0.05...4.00 xIn

Timers for 50BF internal tripping
CB fail 1 timer:
* tBF1: 0.00 s...10.00 s
CB fail 2 timer:
* tBF2: 0.00 s...10.00 s

Timers for 50BF external tripping (orders from 21 or 87Tetc…)
CB fail 1 timer:
* TBF3: 0.00 s......10.00 s
CB fail 2 timer:
* TBF4: 0.00 s......10.00 s

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Overcurrent Protection

Phase Fault Protection (50/51)
3 phase Overcurrent function Status I>1:
* Disabled
* DT
* IEC S Inverse or IEC V Inverse or IEC E Inverse
* UK LT Inverse
* IEEE M Inverse or IEEE V Inverse or IEEE E Inverse
* US Inverse or US ST Inverse

Current Set if "function status" ≠0
* I>1: 0.10...32.00 xIn

Time delay if "function status"=1
* I>1: 0.00...100.00 xIn

TMS if 2≤ "function status" ≤5
* I>1: 0.025...1.200 xIn (step 0.025)

Time dial if "function status"≥6
* I>1: 0.5...15.0 xIn

Reset Char. if "function status"≥6
I>1:
* DT
* Inverse

tReset if 2≤"function status"≤5 OR if "Reset Char."=1 AND "function status"≥6
* I>1: 0.0...100.0 xIn

3 phase Overcurrent threshold function status I>2:
* Disabled
* Blocking 87BB
* High set I>2
* Both
* Current Set
   I>2: 0.10... 32.00

Time Delay if "function status"=1
* I>2: 0.00...100.00 s

Earth Fault Protection (50N/51N) (One Box Mode)
Residual Overcurrent Function Status I_N>1:

Disabled
* DT
* IDG
* RI
* IEC S Inverse or IEC V Inverse or IEC E Inverse
* UK LT Inverse, UK Rectifier
* IEEE M Inverse or IEEE V Inverse or IEEE E Inverse
* US Inverse or US ST Inverse

Current Set if "function status" ≠0
* I_N >1: 0.10...32.00 xIn

Time delay if "function status"=1
* I_N >1: 0.00...100.00 xIn

TMS if 2≤"function status"≤5
* I_N >1: 0.025...1.200 xIn (step 0.025)

Time dial if "function status"≥6
* I_N >1: 0.5...15.0 xIn

Reset Char. if "function status"≥6
I_N >1:
* DT
* Inverse

tReset if 2≤"function status"≤5 OR if "Reset Char."=1 AND "function status"≥6
* I_N >1: 0.0...100.0

Residual Overcurrent threshold function status I_N >2:
* Disabled
* Blocking 87BB
* High set I>2
* Both

Current Set
* I_N >2: 0.10 xIn...32.00 xIn

Time Delay if "function status"=1
* I_N >2: 0.00...100.00 s

Supervision

Voltage transformer supervision:
Status:
* Blocking & indication
* Manual & automatic mode

Time delay:
* 1s...10.00s (step 100ms)

Current transformer supervision:
Status:
* Blocking & indication

Time delay:
* 0…10.00s (step 100ms)

CTS I1 / CTS I2/I1>1 / CTS I2/I1 >2:
* 5%...100% (step 1%)

Date and Time
IRIG-B Sync:
* Disabled/Enabled

Battery Alarm:
* Disabled/Enabled

Configuration
Setting Group:

.	Select via Menu
.	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
Dead zone OC Prot:	Disabled/Enabled
Diff Busbar Prot:	Disabled/Enabled
Overcurrent Prot:	Disabled/Enabled
Earth Fault Prot:	Disabled/Enabled
CB Fail & I>:	Disabled/Enabled
Setting Values:	Primary/Secondary
LCD Contrast:	(Factory pre-set)

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
* Topology at the fault occurrence

Event Recorder
Records for the last 512 events

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 point within the relay (opto input, output contact, alarms, starts, trips, controls, logic…).
Sampling frequency:
∗ 1200Hz

Communications

RP1 Protocol:
∗ Courier
RP1 Address (courier)
∗ 6…34
Inactivity Timer: 1…30 minutes
∗ IEC870-5-103
RP1 Address: (Courier):
∗ 6…34
RP1 InactivTimer:
∗ 1…30mins
RP1 Port Config (Courier)::
∗ K Bus
∗ EIA485 (RS485)
RP1 Comms Mode (EIA485 (RS485)):
∗ IEC60870 FT1.2 Frame
∗ IEC60870 10-Bit FrameRP1 Baud Rate (EIA485 (RS485)): 9600/19200/38400 bits/s

Optional Additioal 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…30mins
RP2 Baud Rate:
∗ 9600 bits/s
∗ 19200 bits/s
∗ 38400 bits/s

Optional Ethernet Port

NIC Tunl Timeout:
∗ 1...30mins
NIC Link Report:
∗ Alarm/Event/None
NIC Link Timeout:
∗ 0.1...60s

COMMISSION TESTS

Monitor Bit 1 (up to 8):

Binary function link strings, selecting which DDB signals have their status visible in the Commissioning menu, for test purposes

Test Mode:
Enabled or Disabled
87BB and 50BF trip blocked per zone

Test Pattern:
Configuration of which output contacts are to be energized when the contact test is applied.
Static Test Mode:
∗ Disabled/Enabled
Opto input voltage range:
∗ 24-27V
∗ 30-34V
∗ 48-54V
∗ 110-125V
∗ 220-250V
Custom
Opto Input 1
(up to # = max. opto no. fitted)

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

Opto Input Labels

Opto Input 1 up to:
∗ 16 if mounted up to 32 Outputs
∗ 40 if mounted up to 24 Outputs

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

Outputs Labels

Relay 1 up to:
∗ 32 if mounted up to 16 Inputs
∗ 24 if mounted up to 40 Inputs
User defined text string to describe the function of the particular relay output contact.

IED CONFIGURATOR

Switch Conf.Bank:
∗ No Action/Switch Banks

IEC61850 GOOSE

GoEna:
∗ Disabled/Enabled
Test Mode:
∗ Disabled/Pass Through/Forced
VOP Test Pattern:
∗ 0x00000000... 0xFFFFFFFF
Ignore Test Flag:
∗ No/Yes

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GS

GETTING STARTED

Date:	**2008**
Hardware Suffix:	**K**
Software Version:	**01**
Connection Diagrams:	**10P746xx (xx = 01 to 07)**

CONTENTS

GS

FIGURES

GS

1. GETTING STARTED

⚠ **BEFORE CARRYING OUT ANY WORK ON THE EQUIPMENT, THE USER SHOULD BE FAMILIAR WITH THE CONTENTS OF THE SAFETY SECTION/SAFETY GUIDE SFTY/4LM/H11 OR LATER ISSUE, THE TECHNICAL DATA SECTION 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 Introduction to the relay

1.2.1 Front panel

The front panel of the relay is shown in Figure 1, with the hinged covers at the top and bottom of the relay shown open. Extra physical protection for the front panel can be provided by an optional transparent front cover. With the cover in place read only access to the user interface is possible. Removal of the cover does not compromise the environmental withstand capability of the product, but allows access to the relay settings. When full access to the relay keypad is required, for editing the settings, the transparent cover can be unclipped and removed when the top and bottom covers are open. If the lower cover is secured with a wire seal, this will need to be removed. 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. The cover can then be moved vertically down to release the two fixing lugs from their recesses in the front panel.
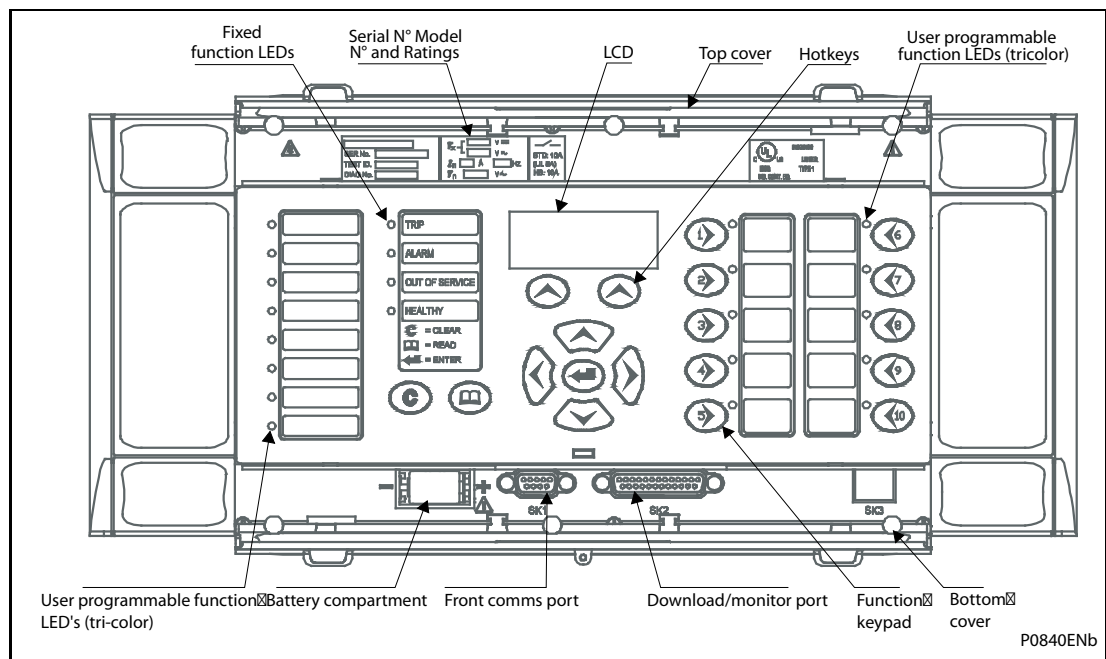

FIGURE 1: RELAY FRONT VIEW

The front panel of the relay includes the following, as indicated in Figure 1:

− 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 (Ⓒ), a read key (▣), 2 hot keys (◉) and 10 (① – ⑩) programmable function keys

GS

Function key functionality:

−   The relay front panel features control pushbutton switches with programmable LEDs that facilitate local control. Factory default settings associate specific relay functions with these 10 direct-action pushbuttons and LEDs e.g. reset indications. Using programmable scheme logic, the user can readily change the default direct-action pushbutton functions and LED indications to fit specific control and operational needs.

−   Hotkey functionality: When the functionality is disabled:

−   SCROLL

>   Starts scrolling through the various default displays.

−   STOP

>   Stops scrolling the default display.

>   When the functionality is disabled:

−   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

1.2.1.1   LED indications

Fixed Function

The 4 fixed function LEDs on the left-hand side of the front panel are used to indicate the following 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 to indicate that 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) indicates that the relay's protection is unavailable or a test mode is selected.

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 indicate 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.

Programmable LEDs

All the programmable LEDs are tri-colour and can be programmed to indicate RED, YELLOW or GREEN depending on the requirements. The 8 programmable LEDs on the left are suitable for programming alarm indications and the default indications and functions are indicated in the table below. The 10 programmable LEDs physically associated with the function keys, are used to indicate the status of the associated pushbutton's function and the default indications are shown below:

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

LED Number	LED Input Connection/Text	Latched	P746 LED Function Indication
1	LED1 Red		CB1 closed
	LED1 Yellow	Yes	CB1 Alarm
	LED1 Green		CB1 open
2	LED2 Red		CB2 closed
	LED2 Yellow	Yes	CB2 Alarm
	LED2 Green		CB2 open
3	LED3 Red		CB3 closed
	LED3 Yellow	Yes	CB3 alarm
	LED3 Green		CB3 open
4	LED4 Red		CB4 closed
	LED4 Yellow	Yes	CB4 Alarm
	LED4 Green		CB4 open
5	LED5 Red		CB5 closed
	LED5 Yellow	Yes	CB5 Alarm
	LED5 Green		CB5 open
6	LED6 Red		CB6 closed
	LED6 Yellow	No	CB6 Alarm
	LED6 Green		CB6 open
7	LED7 Red		50BF Trip zone 1
	LED7 Yellow	No	87BB & 50 BF trip zone 1
	LED7 Green		87BB Trip zone 1
8	LED8 Red		50BF Trip zone 2
	LED8 Yellow	No	87BB & 50 BF trip zone 2
	LED8 Green		87BB Trip zone 2
9	FnKey LED1 Red		Zone 1: blocked
	FnKey LED1 Yellow	No	Zone 1: alarm (zone blocked but not the CZ)
	FnKey LED1 Green		Zone 1: healthy
10	FnKey LED2 Red		Zone 1: 87BB&50BF blocked
	FnKey LED2 Yellow	yes	Not used
	FnKey LED2 Green		Zone 1: Test mode

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LED Number	LED Input Connection/Text	Latched	P746 LED Function Indication
11	FnKey LED3 Red	No	Fault on phase A
	FnKey LED3 Yellow		Not used
	FnKey LED3 Green		Not used
12	FnKey LED4 Red	No	Fault on phase B
	FnKey LED4 Yellow		Not used
	FnKey LED4 Green		Not used
13	FnKey LED5 Red	No	Fault on phase C
	FnKey LED5 Yellow		Not used
	FnKey LED5 Green		Not used
14	FnKey LED6 Red	No	Zone 2: blocked
	FnKey LED6 Yellow		Zone 2: alarm (zone blocked but not the CZ)
	FnKey LED6 Green		Zone 2: healthy
15	FnKey LED7 Red	Yes	Zone 2: 87BB&50BF blocked
	FnKey LED7 Yellow		Not used
	FnKey LED7 Green		Zone 2: Test mode
16	FnKey LED8 Red	No	Circuit fault
	FnKey LED8 Yellow		Not used
	FnKey LED8 Green		Not used
17	FnKey LED9 Red	No	Trip latched
	FnKey LED9 Yellow		Not used
	FnKey LED9 Green		Indications resetting
18	FnKey LED10 Red	No	Not used
	FnKey LED10 Yellow		External disturbance record
	FnKey LED10 Green		Disturbance record started

1.2.2   Relay rear panel

Examples of the rear panel of the relay are shown in Figure 2. All current 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.
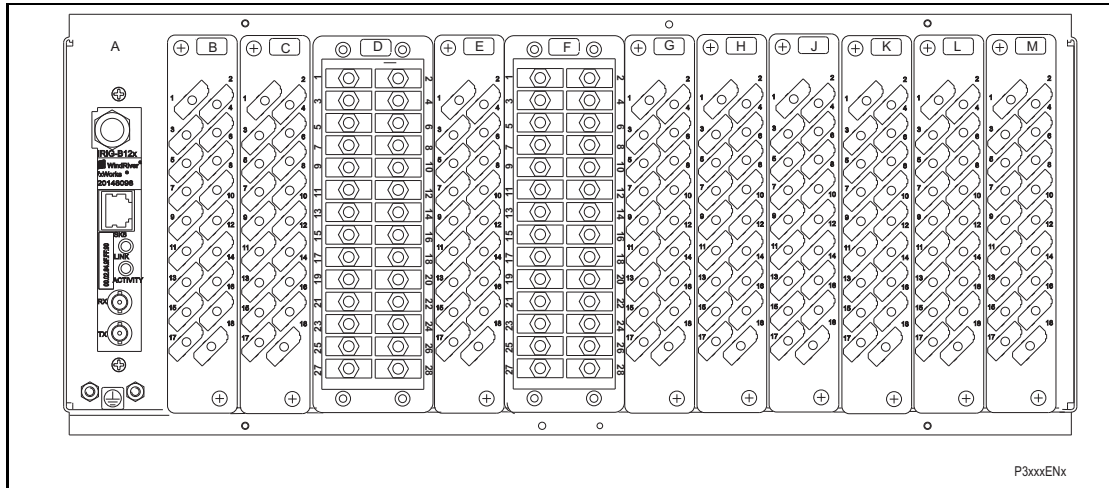
A – IRIG B / Ethernet / COMMS   G – Sigma Delta Opto Board
B – Opto \ high break   H – Relay \ Opto \ high break
C – Opto \ high break   J – Relay \ high break
D – Sigma Delta analogue input board   K – Relay \ high break
E – Sigma Delta Opto Board   L – Relay board
F – Sigma Delta analogue input board   M – Power supply board

FIGURE 2: P746 RELAY REAR VIEW 80TE

Refer to the wiring diagram in 'Installation Chapter' (P746/EN IN) for complete connection details.

1.3 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 following auxiliary voltage versions and these are specified in the table below:

Nominal Ranges	Operative dc Range	Operative ac Range
24 - 48V dc	19 to 65V	-
48 - 110V dc (30 - 100V ac rms) **	37 to 150V	24 to 110V
110 - 250V dc (100 - 240V ac rms) **	87 to 300V	80 to 265V

** rated for ac or dc operation

Please note that the label does not specify the logic input ratings. The P746 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 Firmware section for more information on logic input specifications. Please note that 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. Figure 2 and 3 indicates the location of the power supply terminals but please refer to the wiring diagrams in the Installation section for complete installation details ensuring that the correct polarities are observed in the case of dc supply.

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1.4   Introduction to the user interfaces and settings options

The relay has three user interfaces:

−   The front panel user interface via the LCD and keypad

−   The front port which supports Courier communication

−   The rear port which supports five protocols:

−   Courier

−   DNP3

−   IEC 60870-5-103

−   IEC 61850-8.1

−   MODBUS..

−   The optional Ethernet port which supports IEC 61850

The measurement information and relay settings that can be accessed from the four interfaces are summarized in Table 1.

	Keypad/ LCD	Courier	IEC870-5-103	IEC 61850
Display & modification of all settings	•	•		
Digital I/O signal status	•	•	•	•
Display/extraction of measurements	•	•	•	•
Display/extraction of fault records	•	•		•
Extraction of disturbance records		•	•	•
Programmable scheme logic settings		•		
Reset of fault & alarm records	•	•	•	
Clear event & fault records	•	•		
Time synchronization		•	•	•
Control commands	•	•	•	

Table 1

1.5 Menu structure

The relay's menu is arranged in a tabular structure. Each setting in the menu is referred to as a cell, and each cell in the menu may be accessed by reference to a row and column address. The settings are arranged so that each column contains related settings, for example all of the disturbance recorder settings are contained within the same column. As shown in Figure 4, 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 Content Map at the end of this section.
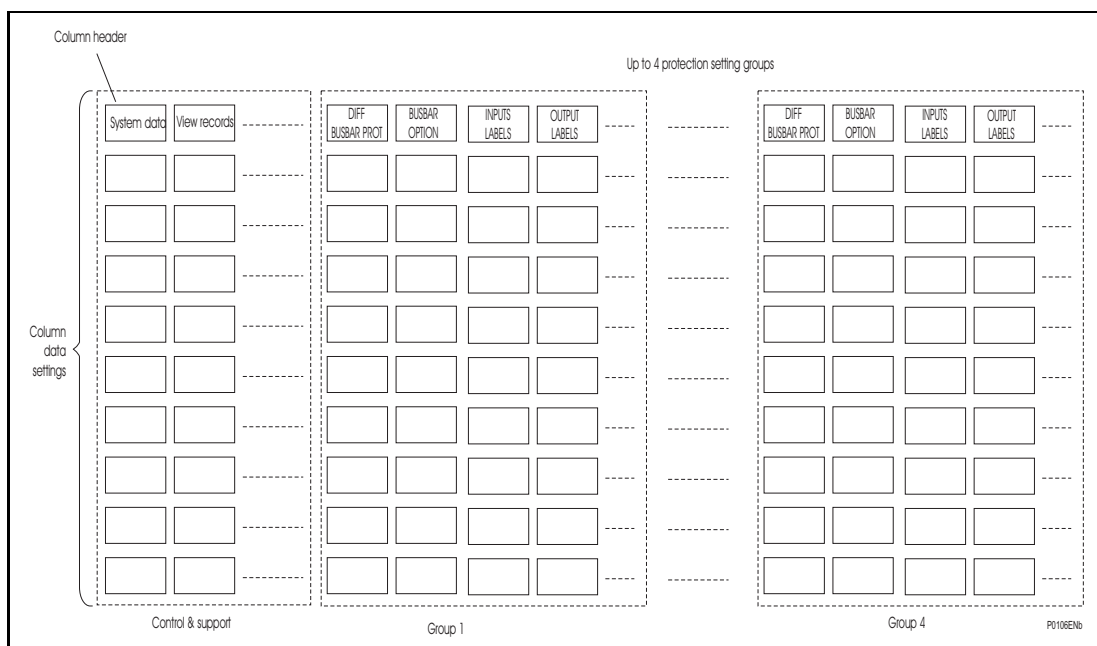
FIGURE 3: MENU STRUCTURE

All of the settings in the menu fall into one of three categories; protection settings, disturbance recorder settings, or control and support (C&S) settings. One of two different methods is used to change a setting depending on which category the setting falls into. Control and support 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.

1.5.1 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.

1.5.2 Disturbance recorder settings

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

1.5.3 Control and support settings

The control and support settings include:

- Relay configuration settings

- Open/close circuit breaker

- CT & VT ratio settings

- Reset LEDs

- Active protection setting group

- Password & language settings

- Communications settings

- Measurement settings

- Event & fault record settings

- User interface settings

- Commissioning settings

GS

1.6 Password protection

The menu structure contains three levels of access. The level of access that is enabled determines which of the relay's settings can be changed and is controlled by entry of two different passwords. The levels of access are summarized in Table 2.

Access level	Operations enabled
Level 0 No password required	Read access to all settings, alarms, event records and fault records
Level 1 Password 1 or 2 required	As level 0 plus: Control commands, e.g. Circuit breaker open/close (when available). Reset of fault and alarm conditions. Reset LEDs. Clearing of event and fault records.
Level 2 Password 2 required	As level 1 plus: All other settings

Table 2

Each of the two passwords is 4 characters of upper case text. The factory default for both passwords is AAAA. Each password is user-changeable once it has been correctly entered. Entry of the password is achieved either by a prompt when a setting change is attempted, or by moving to the 'Password' cell in the 'System data' column of the menu. The level of access is independently enabled for each interface, that is to say if level 2 access is enabled for the rear communication port, the front panel access will remain at level 0 unless the relevant password is entered at the front panel. The access level enabled by the password entry will time-out independently for each interface after a period of inactivity and revert to the default level. If the passwords are lost an emergency password can be supplied - contact Alstom Grid with the relay's serial number. The current level of access enabled for an interface can be determined by examining the 'Access level' cell in the 'System data' column, the access level for the front panel User Interface (UI), can also be found as one of the default display options.

The relay is supplied with a default access level of 2, such that no password is required to change any of the relay settings. It is also possible to set the default menu access level to either level 0 or level 1, preventing write access to the relay settings without the correct password. The default menu access level is set in the 'Password control' cell which is found in the 'System data' column of the menu (note that this setting can only be changed when level 2 access is enabled).

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1.7 Relay configuration

The relay is a multi-function device that supports numerous different protection, control and communication features. In order 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 four protection settings groups is selected as active through the 'Active settings' cell. A protection setting group can also be disabled in the configuration column, provided it is not the present active group. Similarly, a disabled setting group cannot be set as the active group.

1.8 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 be used to 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.
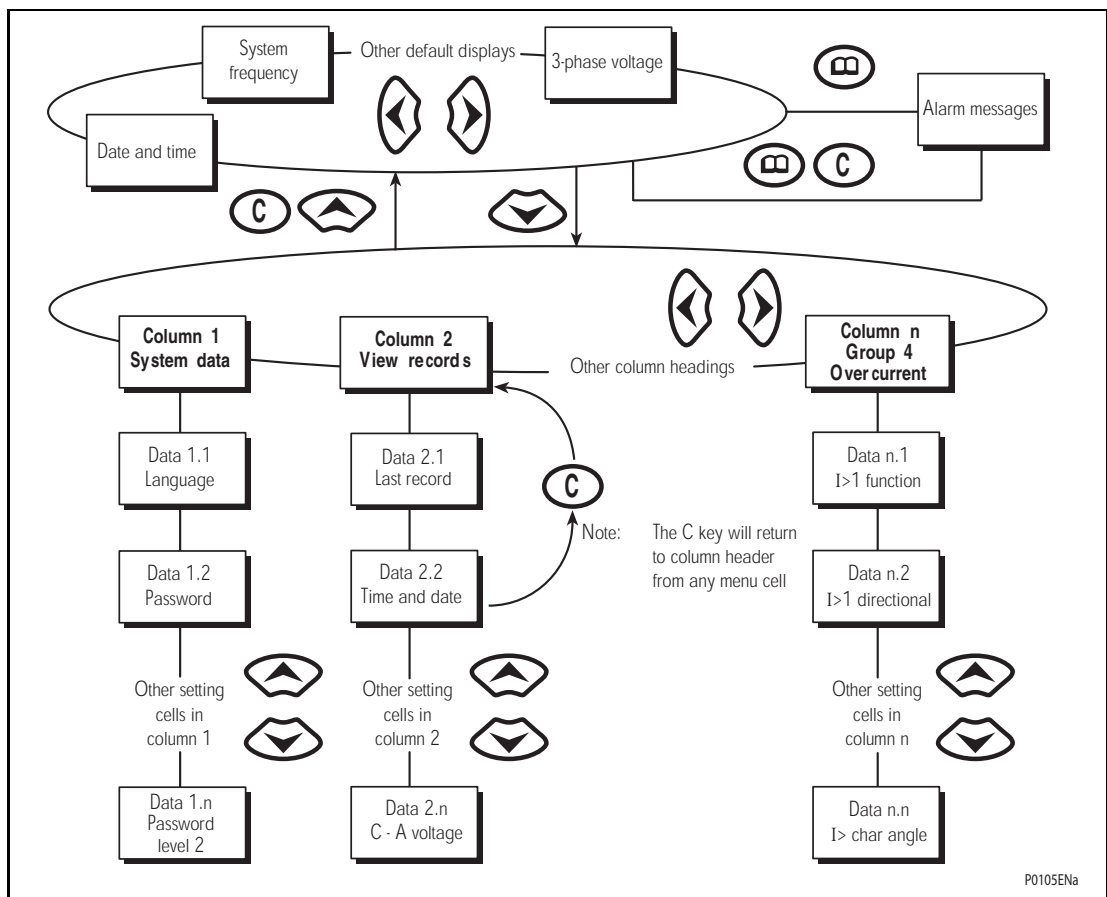

FIGURE 4: FRONT PANEL USER INTERFACE

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1.8.1   Default display and menu time-out

The front panel menu has a default display, the contents of which can be selected from the following options in the 'default display' cell of the 'Measure't. setup' column:

−   Date and time

−   Relay description (user defined)

−   Plant reference (user defined)

−   Check zone bias currents (A, B, C)

−   Check zone differential currents (A, B, C)

From the default display it is also possible to view the other default display options using the ◁ and ▷ keys. However, if there is no keypad activity for the 15 minute timeout period, the default display will revert to that selected by the setting and the LCD backlight will turn off. If this 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.

1.8.2   Menu navigation and setting browsing

The menu can be browsed using the four arrow keys, following the structure shown in Figure 5. Therefore, starting at the default display the ⬙ key will display the first column heading. To select the required column heading use the ◁ and ▷ keys. The setting data contained in the column can then be viewed by using the ⬙ and ⬙ keys. It is possible to return to the column header either by holding the [up arrow symbol] key down or by a single press of the clear key ©. It is only possible to move across columns at the column heading level. To return to the default display, press the ⬙ key or the clear key © from any of the column headings. It is not possible to go straight to the default display from within one of the column cells using the auto-repeat facility of the ⬙ key, as the auto-repeat will stop at the column heading. To move to the default display, the ⬙ key must be released and pressed again.

1.8.3   Hotkey menu navigation

The hotkey menu can be browsed using the two keys directly below the LCD. These are known as direct access keys. The direct access keys perform the function that is displayed directly above them on the LCD. Therefore, to access the hotkey menu from the default display the direct access key below the "HOTKEY" text must be pressed. Once in the hotkey menu the ⇐ and ⇒ keys can be used to scroll between the available options and the direct access keys can be used to control the function currently displayed. If neither the ⇐ or ⇒ keys are pressed with 20 seconds of entering a hotkey sub menu, the relay will revert to the default display. The clear key ©   will also act to return to the default menu from any page of the hotkey menu. The layout of a typical page of the hotkey menu is described below:

•   The top line shows the contents of the previous and next cells for easy menu navigation

•   The centre line shows the function

•   The bottom line shows the options assigned to the direct access keys

The functions available in the hotkey menu are listed below:

1.8.3.1   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 "Changing setting group" section in the Operation section (P746/EN OP).

1.8.3.2   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.

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For more information refer to the "Control Inputs" section in the Operation section (P746/EN OP).
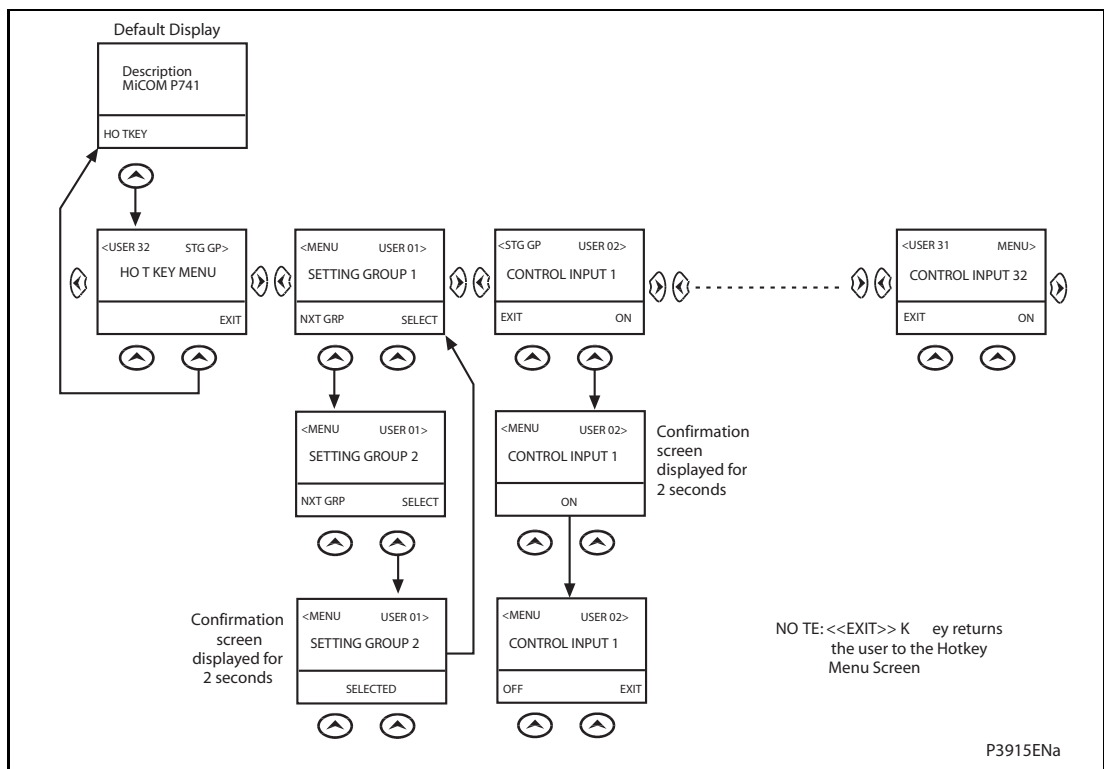
1.8.3.3   Hotkey menu navigation

FIGURE 5: HOTKEY MENU NAVIGATION

1.8.4   Password entry

When entry of a password is required the following prompt will appear:

```
Enter password
**** Level 1
```

Note: The password required to edit the setting is the prompt as shown
            above.

A flashing cursor will indicate which character field of the password may be changed. Press
the ⊗ and ⊗ keys to vary each character between A and Z. To move between the
character fields of the password, use the ⟨ and ⟩ keys. The password is confirmed by
pressing the enter key ⏎. The display will revert to 'Enter Password' if an incorrect
password is entered. At this point a message will be displayed indicating whether a correct
password has been entered and if so what level of access has been unlocked. If this level is
sufficient to edit the selected setting then the display will return to the setting page to allow
the edit to continue. If the correct level of password has not been entered then the password
prompt page will be returned to. To escape from this prompt press the clear key Ⓒ.
Alternatively, the password can be entered using the 'Password' cell of the 'System data'
column.

For the front panel user interface the password protected access will revert to the default
access level after a keypad inactivity time-out of 15 minutes. It is possible to manually reset
the password protection to the default level by moving to the 'Password' menu cell in the
'System data' column and pressing the clear key Ⓒ instead of entering a password.

1.8.5   Reading and clearing of alarm messages and fault records

The presence of one or more alarm messages will be indicated by the default display and by
the yellow alarm LED flashing. The alarm messages can either be self-resetting or latched,
in which case they must be cleared manually. To view the alarm messages press the read
key ▣. When all alarms have been viewed, but not cleared, the alarm LED will change from
flashing to constant illumination and the latest fault record will be displayed (if there is one).
To scroll through the pages of this use the ▣ key. When all pages of the fault record have
been viewed, the following prompt will appear:

```
Press clear to
reset alarms
```

To clear all alarm messages press Ⓒ; to return to the alarms/faults present display and
leave the alarms uncleared, press ▣. Depending on the password configuration settings, it
may be necessary to enter a password before the alarm messages can be cleared (see
section on password entry). When the alarms have been cleared the yellow alarm LED will
extinguish, as will the red trip LED if it was illuminated following a trip.

Alternatively it is possible to accelerate the procedure, once the alarm viewer has been
entered using the ▣ key, the Ⓒ key can be pressed, and this will move the display straight
to the fault record. Pressing Ⓒ again will move straight to the alarm reset prompt where
pressing Ⓒ once more will clear all alarms.

1.8.6   Setting changes

To change the value of a setting, first navigate the menu to display the relevant cell. To change the cell value press the enter key ⏎, which will bring up a flashing cursor on the LCD to indicate that the value can be changed. This will only happen if the appropriate password has been entered, otherwise the prompt to enter a password will appear. The setting value can then be changed by pressing the ⌄ or ⌃ keys. If the setting to be changed is a binary value or a text string, the required bit or character to be changed must first be selected using the ⟨ and ⟩ keys. When the desired new value has been reached it is confirmed as the new setting value by pressing ⏎. Alternatively, the new value will be discarded either if the clear button Ⓒ is pressed or if the menu time-out occurs.

For protection group settings and disturbance recorder settings, the changes must be confirmed before they are used by the relay. To do this, when all required changes have been entered, return to the column heading level and press the ⌄ key. Prior to returning to the default display the following prompt will be given:

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

Pressing ⏎ will result in the new settings being adopted, pressing Ⓒ will cause the relay to discard the newly entered values. It should be noted that, the setting values will also be discarded if the menu time out occurs before the setting changes have been confirmed. Control and support settings will be updated immediately after they are entered, without the 'Update settings?' prompt.

1.9   **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 Figure 7. This port supports the Courier communication protocol only. Courier is the communication language developed by Alstom Grid to allow communication with its range of protection relays. The front port is particularly designed for use with the relay settings programs MiCOM S1 or MiCOM S1 Studio (Windows 2000, Windows XP or Windows Vista based software package).
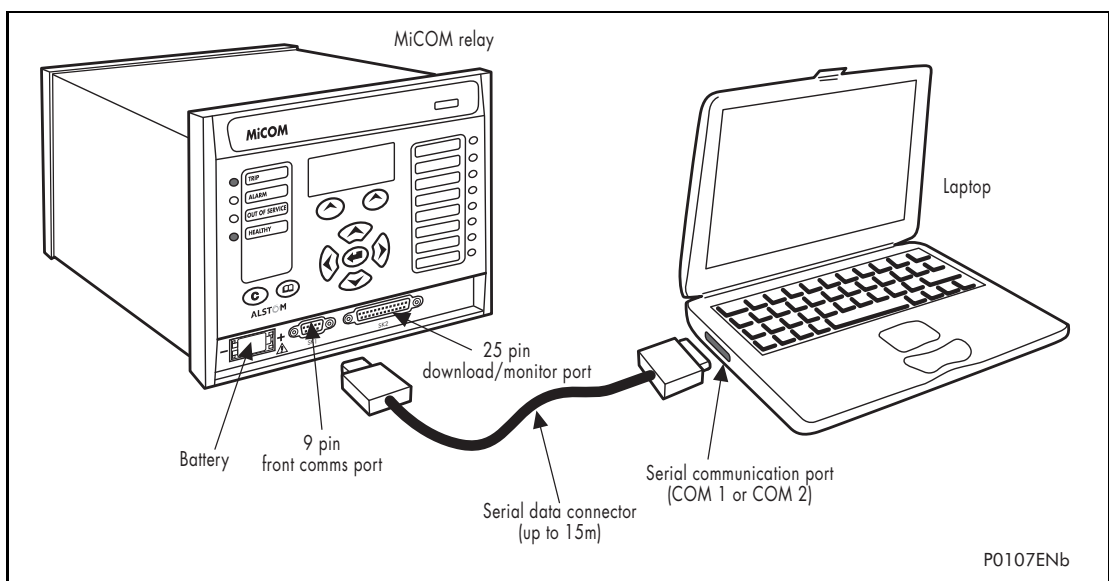
FIGURE 6: FRONT PORT CONNECTION

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

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

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):

	25 Way	9 Way	
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

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 Figure 7. 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 that 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.
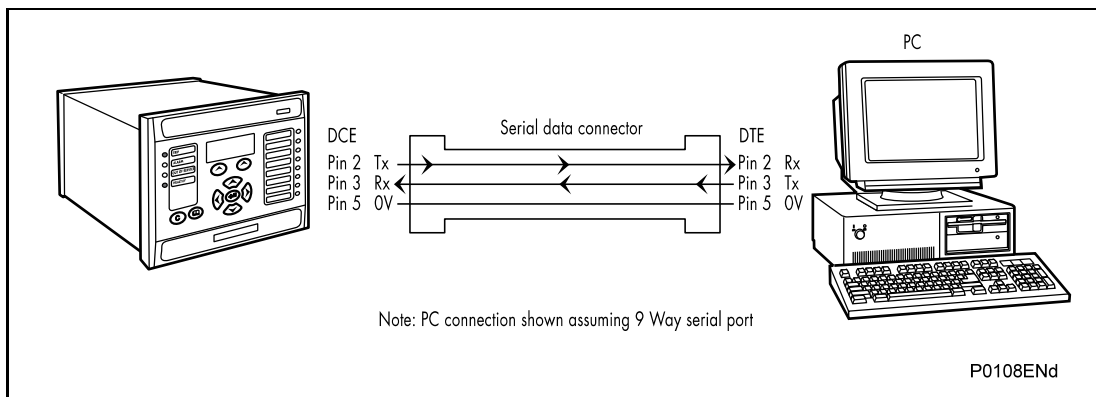
FIGURE 7: PC – RELAY SIGNAL CONNECTION

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

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

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

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1.9.1   Front courier port

The front EIA(RS)232 [1] 9 pin port supports the Courier protocol for one to one communication. It 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

It should be noted that although automatic extraction of event and disturbance records is not supported it is possible to manually access this data via the front port.

1.10   MiCOM S1 relay communications basics

The front port is particularly designed for use with the relay settings program MiCOM S1 or MiCOM S1 Studio. MiCOM S1 and MiCOM S1 Studio are 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.

MiCOM S1 provides full access to MiCOM Px40 relays and MiCOM Mx20 measurements units.

MiCOM S1 Studio provides full access to MiCOM Px40 relays and other protection devices.

1.10.1   PC requirements

The following minimum requirements must be met for the MiCOM S1 software to properly work on a PC.

- IBM computer or 100% compatible,

- WindowsTM 98 or NT 4.0 (Not WindowsTM 95)

- Pentium II 300 Mhz minimum,

- Screen VGA 256 colours minimum,

- Resolution 640 x 400 minimum (1024 x 768 recommended),

- 48Mb RAM minimum,

- 500Mb free on computer hard-disk.

MiCOM S1 Studio software necessitates the following requirements:

---

[1] This port is actually compliant to EIA(RS)574; the 9-pin version of EIA(RS)232, see www.tiaonline.org.

- Minimum:

    – Processor: 1 GHz,

    – Memory: 256 MB,

    – Operating system: Windows 2000,

    – Screen resolution: 800 x 600.

- Recommended:

    – Processor: 2 GHz,

    – Memory: 1 GB,

    – Operating system: Windows XP,

    – Screen resolution: 1024 x 768.

- Microsoft Vista:

    – Processor: 2 GHz,

    – Memory: 2 GB,

1.10.2   Connecting to the P746 relay using MiCOM S1 V2

Before starting, verify that the EIA(RS)232 serial cable is properly connected to the EIA(RS)232 port on the front panel of the relay. Please follow the instructions in section 1.9 to ensure a proper connection is made between the PC and the relay before attempting to communicate with the relay.

This section is intended as a quick start guide to using MiCOM S1 and assumes you have a copy of MiCOM S1 installed on your PC. Please refer to the MiCOM S1 User Manual for more detailed information.

1.10.3   Connecting to the P746 relay using MiCOM S1 Studio

1.10.3.1 Connection to the Relay

To start MiCOM S1, click the start icon:

In the "Programs" menu, select "MiCOM S1" then "MiCOM S1 Start-up".

WARNING: CLICKING ON "UNINSTALL MiCOM S1", WILL UNINSTALL MiCOM S1, AND ALL DATA AND RECORDS USED IN MiCOM S1.

You access the MiCOM S1 launcher screen.

The MiCOM S1 launcher is the software that gives access to the different application programs:

- MiCOM S1 for MiCOM Px40 IEDs

- MiCOM S1 disturbance application

To access these different programs, use the blue arrows,

Click on the desired type of access

IED front port access

S0015ENa
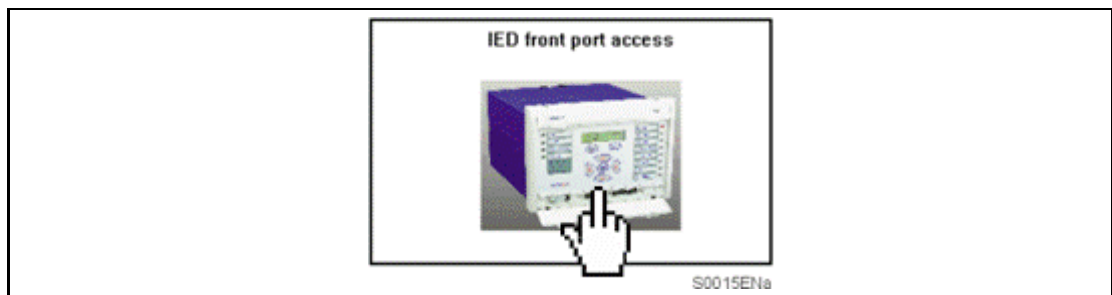
and click on the required MiCOM Px40 series

Px40/L Series
(Front port communication interface)

P0698ENa
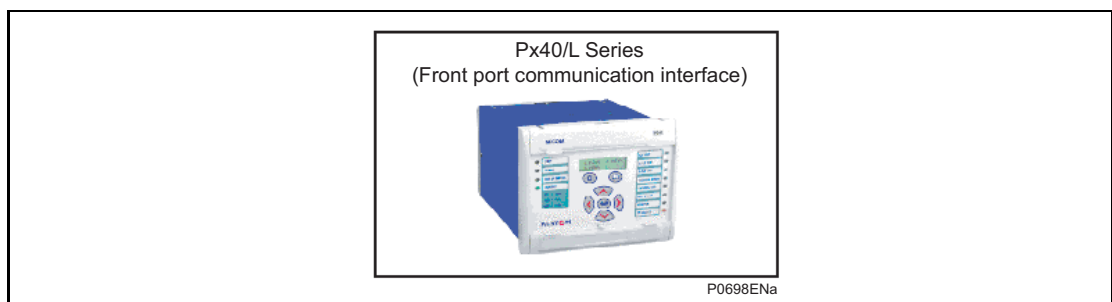
1.10.3.2 Open communication link with relay

To open the communications link from S1 to the P746 relay the following procedure must be followed:

First the communication setup must be adjusted if necessary. In the "Device" menu, select "Communications Setup…"
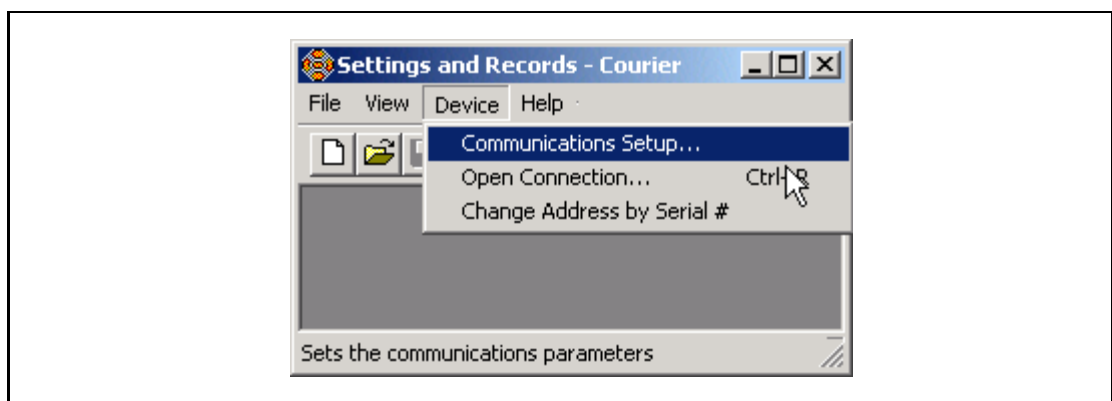
This brings up the following screen:

GS
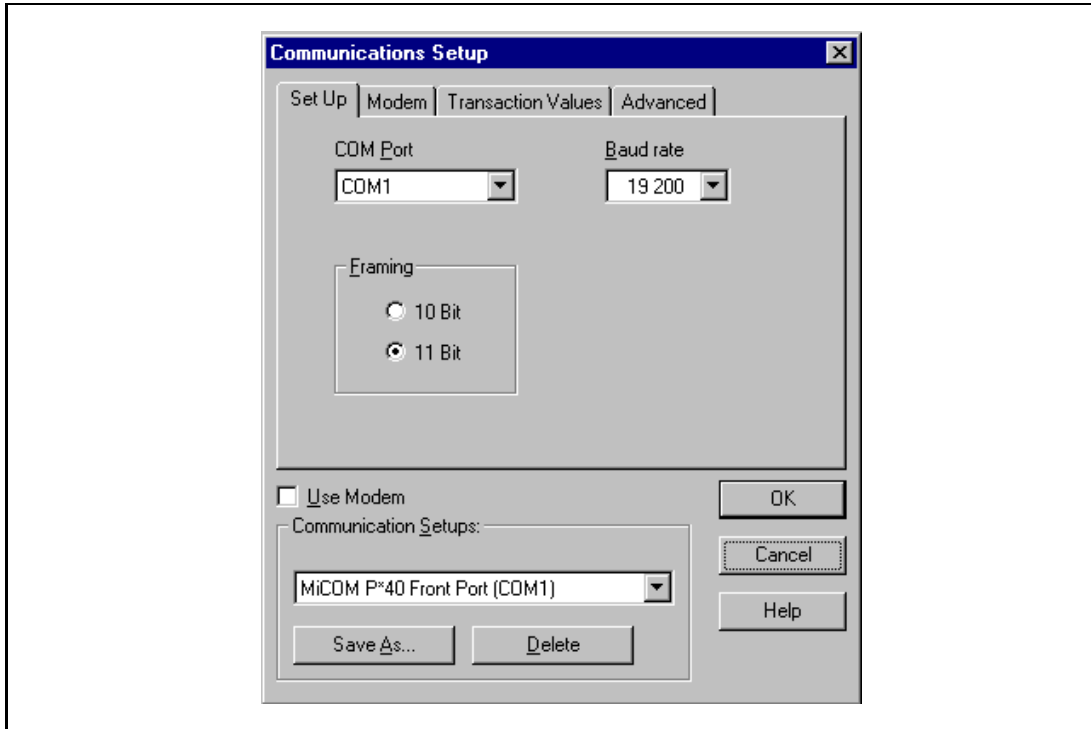
FIGURE 8: COMMUNICATION SET-UP SCREEN

WHEN THE COMMUNICATIONS SETUP IS CORRECT THE LINK WITH THE RELAY CAN BE INITIALIZED. IN THE "DEVICE" MENU, SELECT "OPEN CONNECTION…"
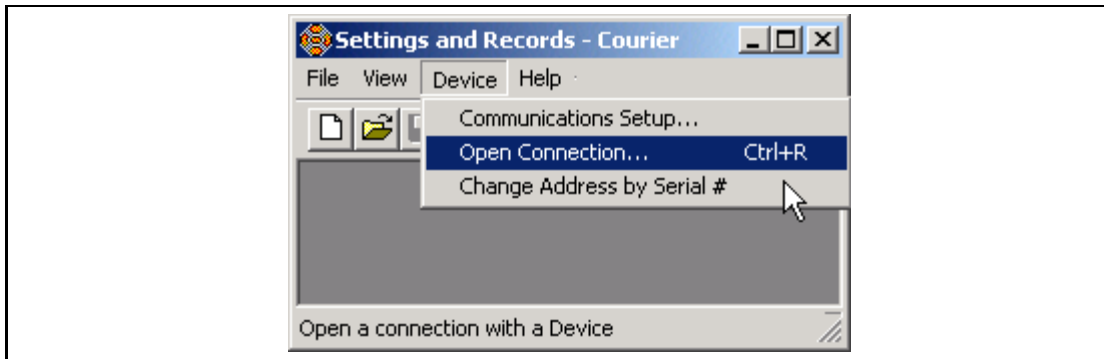
This brings up a prompt for the address of the relay to be interrogated:
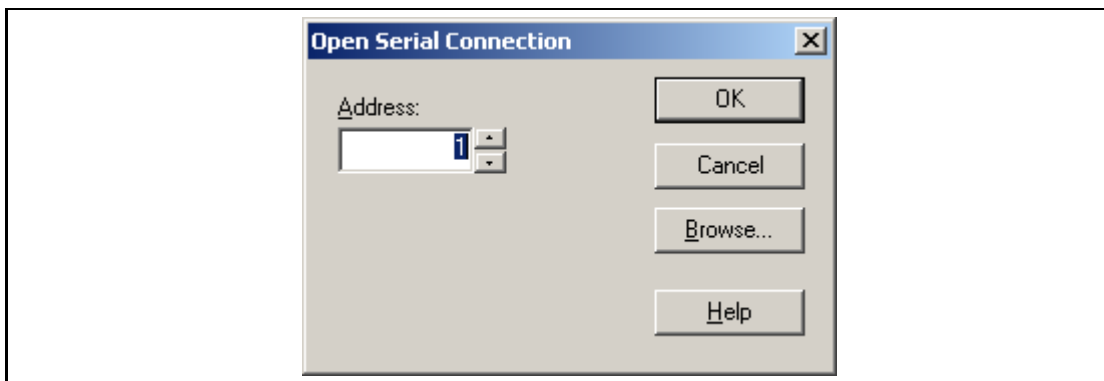
When this has been entered a prompt for the password appears.

When these have been entered satisfactorily the relay is then able to communicate with MiCOM S1. When a communication link has been established between the PC and a

MiCOM IED, both are said to be online. Data and information can be directly transferred from and to the IED using the menu available under the "DEVICE" menu.

For further instruction on how to extract, download and modify settings files, please refer to the MiCOM S1 User Manual.

1.10.3.3 Off-line use of MiCOM S1

As well as being used for the on-line editing of settings, MiCOM S1 can also be used as an off-line tool to prepare settings without access to the relay. In order to open a default setting file for modification, in the "File" menu, select "New" and then "Settings File…"
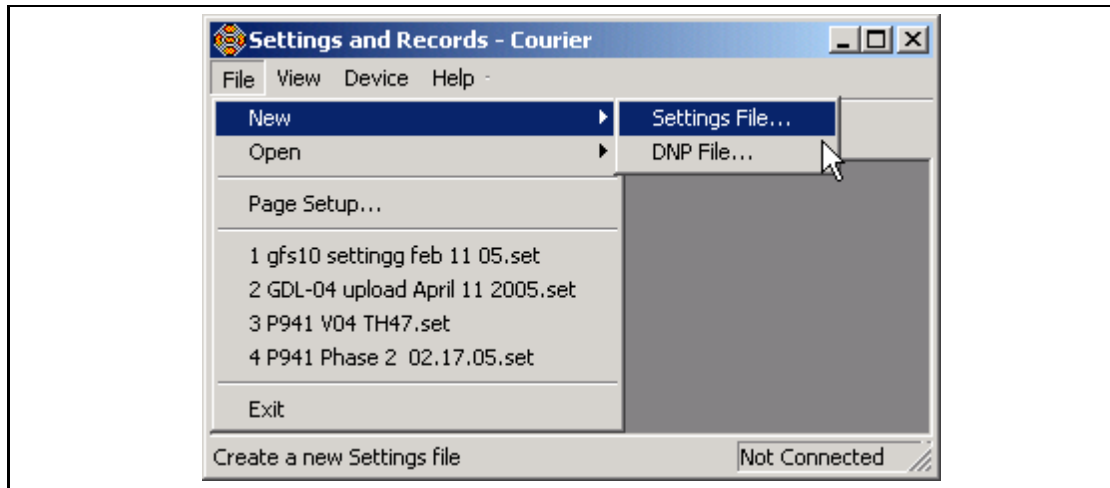
This brings up a prompt for the relay model type where you can select the correct relay for your application:
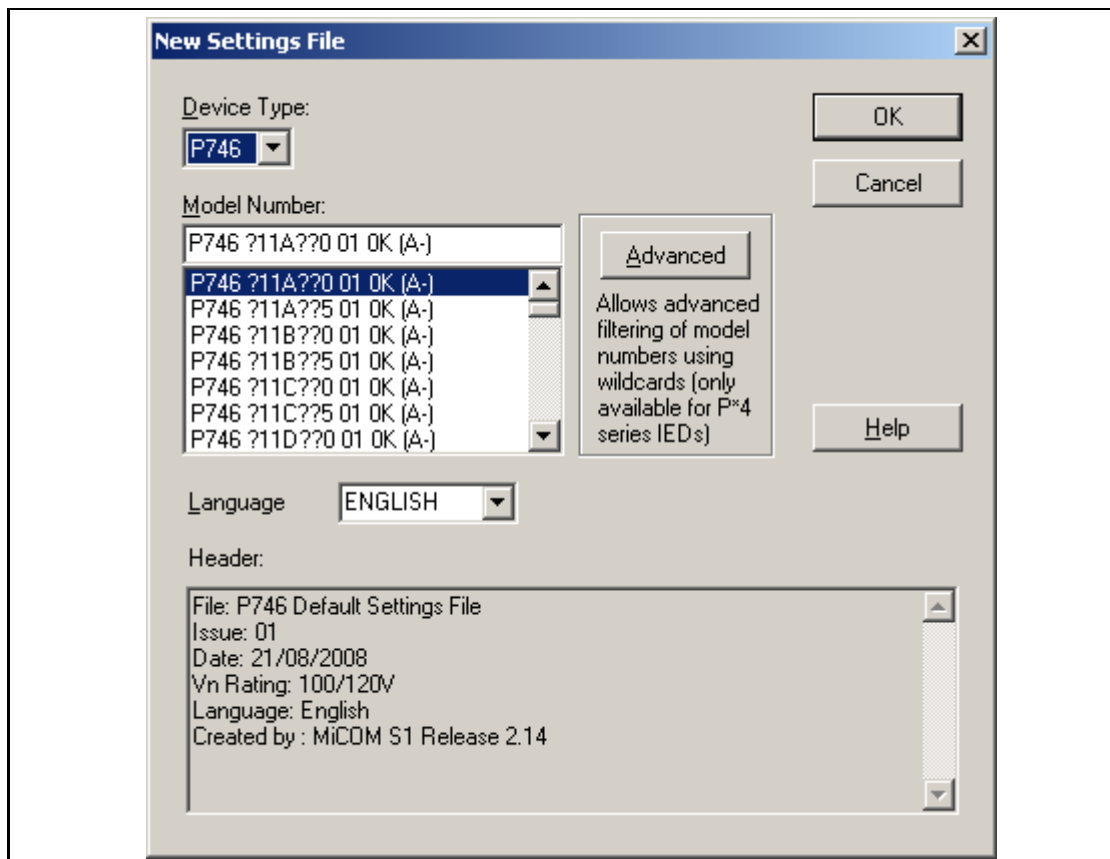
Clicking on OK will open the default file and you can start to edit settings. For further instruction on how to extract, download and modify settings files, please refer to the MiCOM S1 User Manual.

1.10.4   Connecting to the P746 relay using MiCOM S1 Studio

1.10.4.1 "Quick Connection" to the relay

To start MiCOM S1 Studio, click on the start icon:

In the "Programs" menu, select " Alstom Grid " then "MiCOM S1 Studio".

The MiCOM S1 Studio launcher screen is displayed:

−   Click on the "Quick Connect" button at the top left of the application:

−   Create a new system (see § 1.10.4.2) or open an existing one:
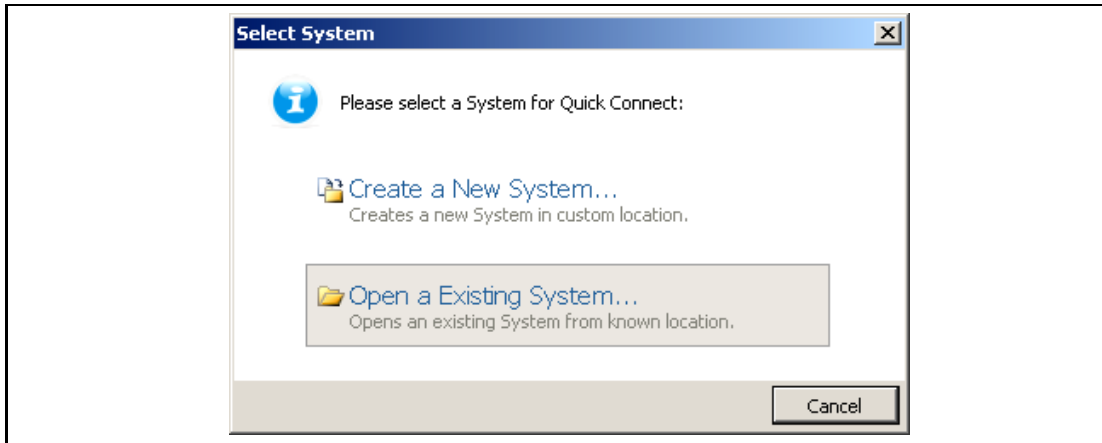
−   When a system is opened (or created), the following "device type" window is displayed.

−   Select "Px40 Series" from the presented options:
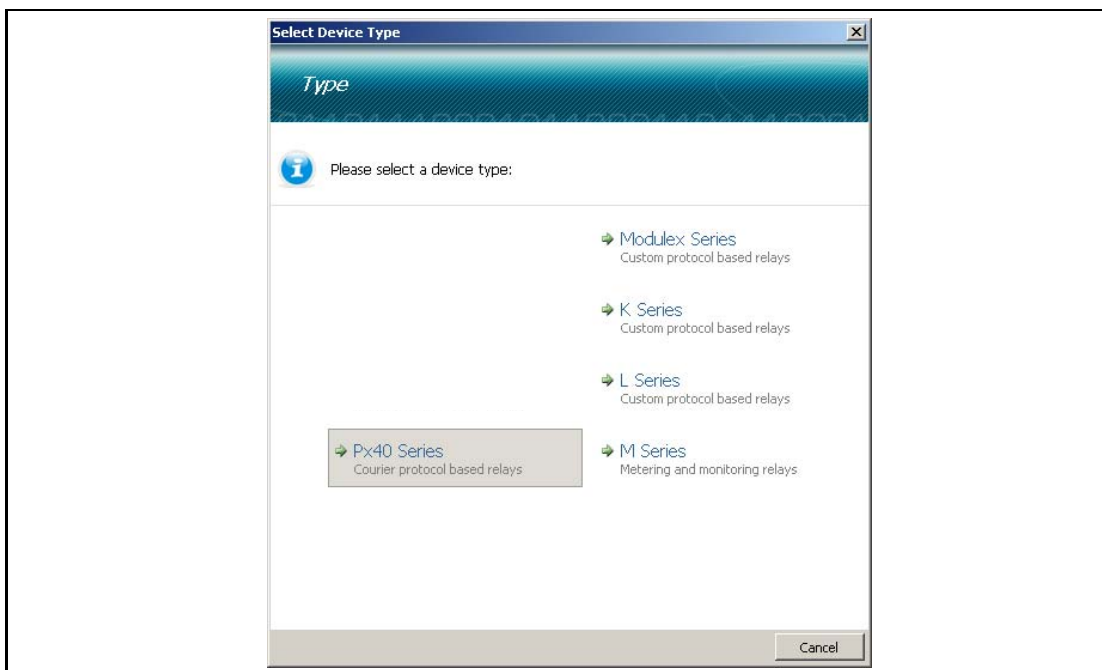
−   On a successful connection, a dialog will be displayed showing device type, model number and plant reference. Options for language, device name and comment are also available.

−   The device is displayed in the Studio Explorer panel.

1.10.4.2 Create a system

In MiCOM S1 Studio, a System provides a root node in the Studio Explorer from which all subsequent nodes are created.

Substations, bays, voltage levels and devices are added to the system. If a system is no longer needed, it can be deleted using the delete command.

The use of Quick Connect will automatically create a default system, if one does not already exist. Systems are not opened automatically, unless "Reopen last System at start-up" is selected in "Options / Preferences…" menu.

To create a new system:

−   By default, the window displays the message "create new or open existing system": click on "new" to create a new system.

−   If a system is loaded in the "Studio Explorer" window, right-click on the panel background and select New System or select the corresponding icon on Studio Explorer's toolbar.

GS
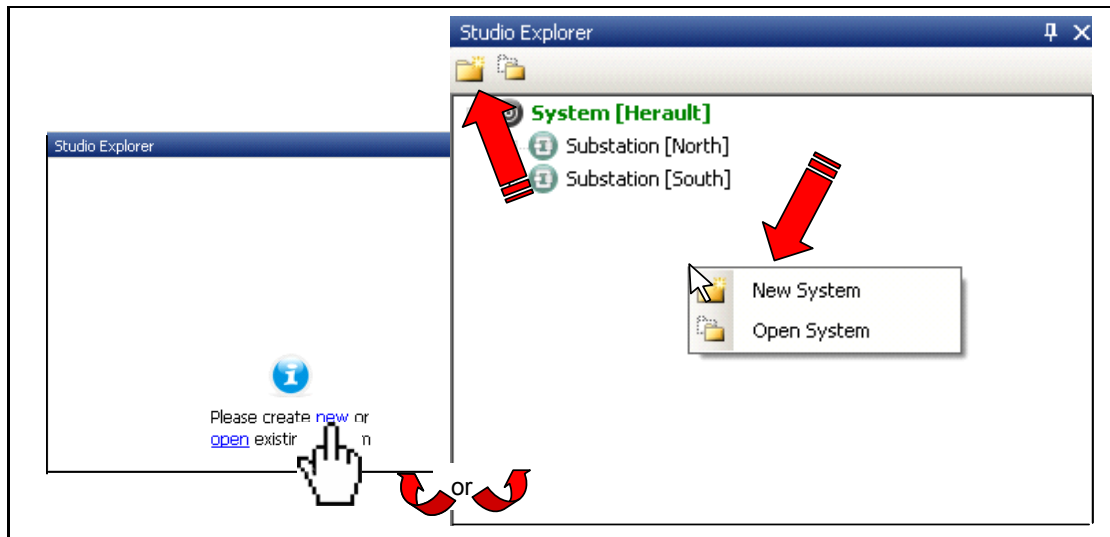
The following window is displayed: Enter the name of the system, and the path to save the system file.
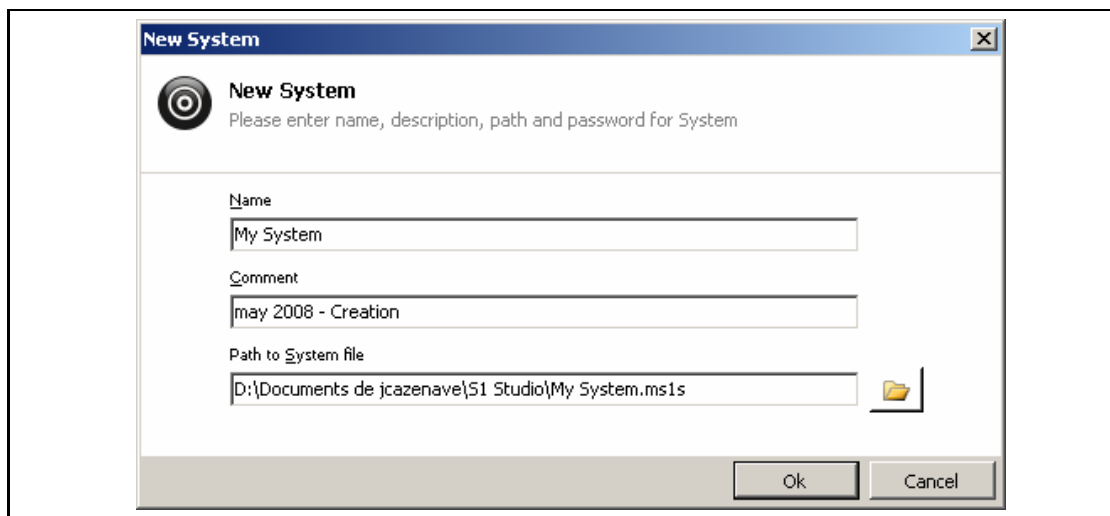
The new System is displayed in the Studio Explorer panel:

Note: In the Studio Explorer panel, if an item is selected, its properties are displayed in the "Properties" panel
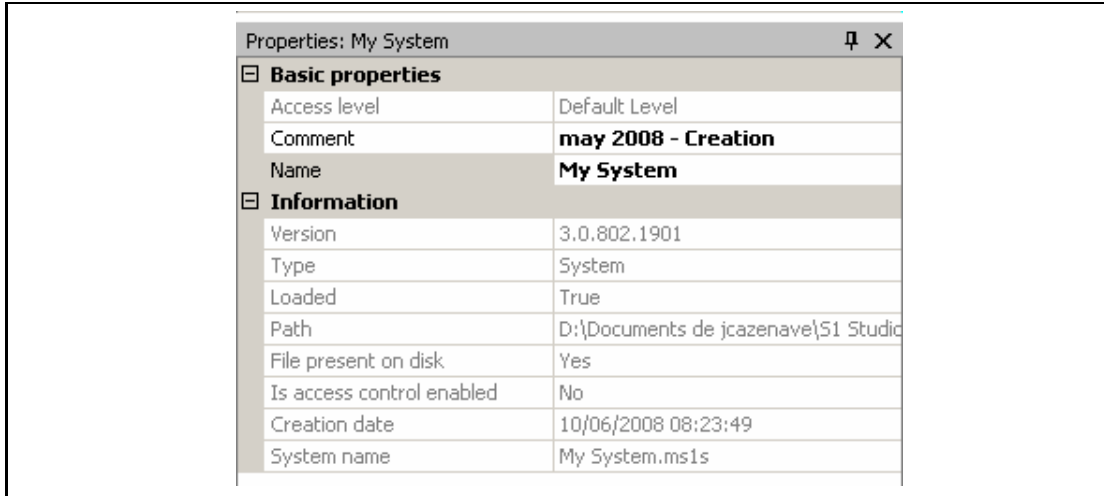
GS

1.10.4.3 Create a new substation

Select the system: the menu bar is updated with "new device", "new substation", "close", "delete", "paste", "properties" and "options" icons.

Click on "new substation" icon (or select the menu using right-click). The following window is displayed:
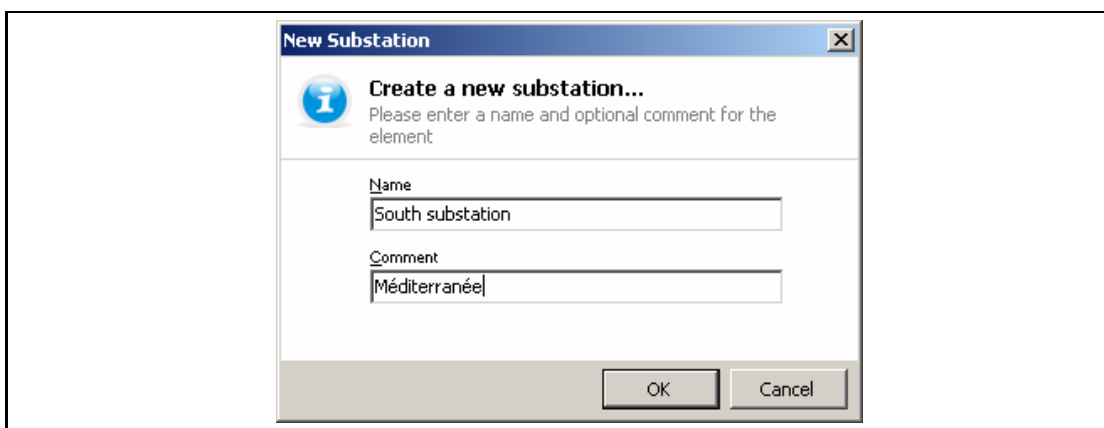
The new substation is displayed and the menu bar is updated when a substation is selected:
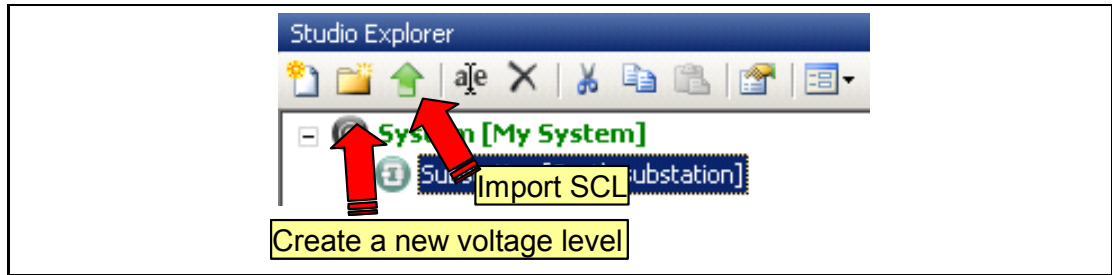
Click on "Import SCL" button to import a Substation Configuration File.

To create a substation configuration, click on "new voltage level" button.

1.10.4.4 Create a new voltage level

Select the substation and click on "new station level" button (or select the menu using right-click).

In the "Create a new voltage level", enter the voltage level of the station.

The "new voltage level" is displayed and the "new bay" icon is displayed.
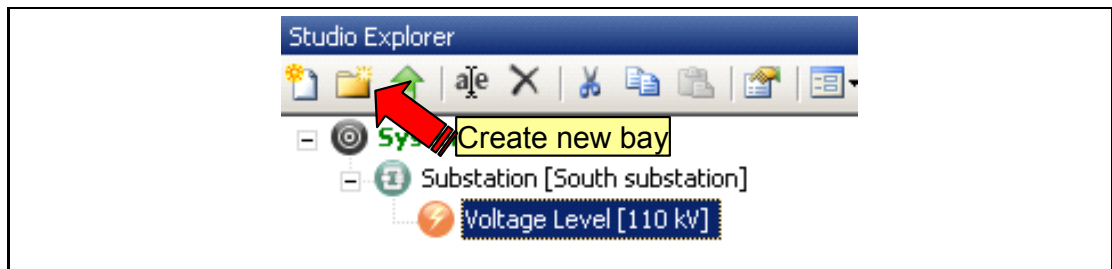
1.10.4.5 Create a new bay

Select the substation and click on "new bay" button (or select the menu using right-click).

In the "Create new bay…" window, enter the bay indication,

The new bay is displayed.
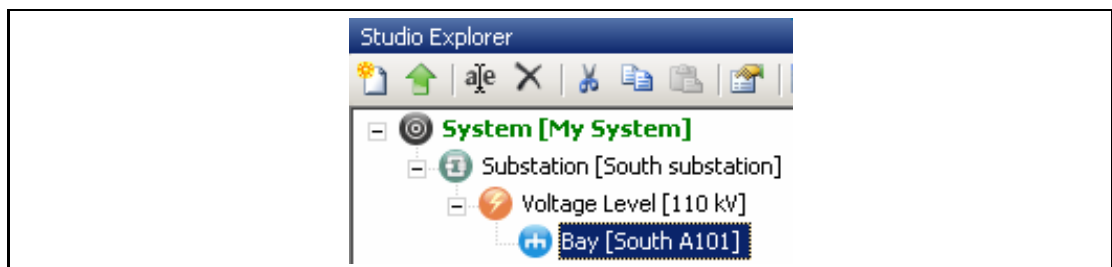
1.10.4.6 Create a new device

Click on "new device" button (or select the menu using right-click). The "Device Type" panel is displayed.

In the "Select device" panel, select the device type (1). The "Type" panel is displayed.

Select the P746 device (2) and click the "next" button (3). The "Model Number" panel is displayed.

Enter the model number (4) (this number is noted on the front label of the device) and click the "next" button (5) to display the "Model" panel.

GS

Select the model in the list (6) and click in the "Next" button (7). The "Device Name" panel is displayed.

Enter the name and description of the relay (8) and click on the "Next" button (9).

The new device is created and displayed.
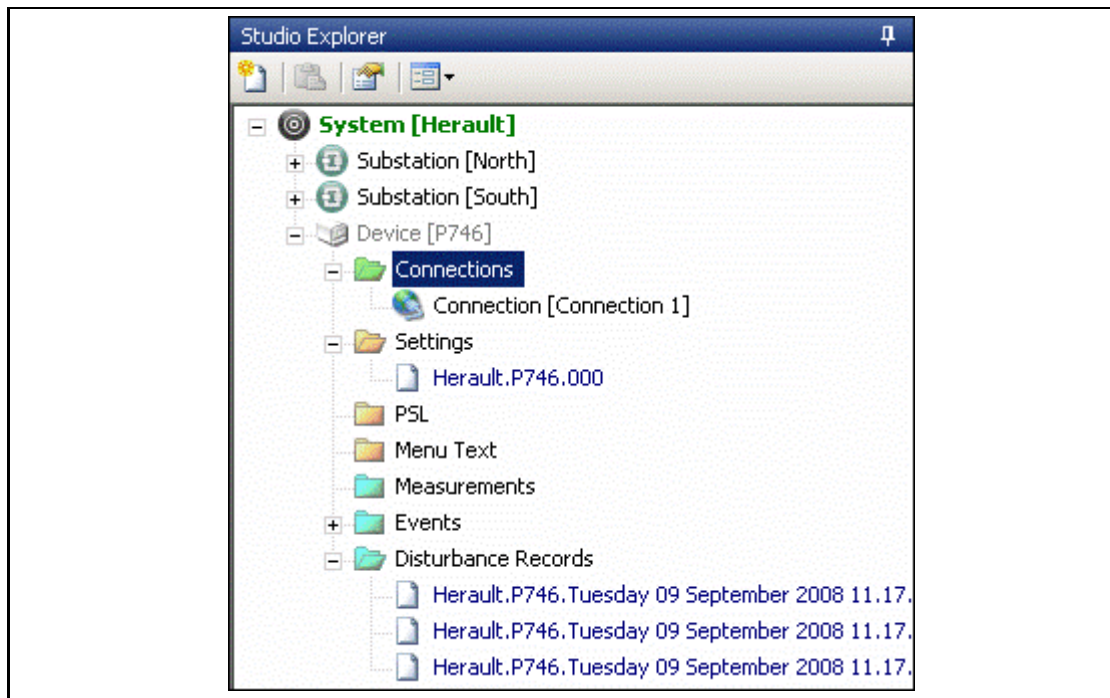
GS

1.10.4.7 Open Settings File

To open an existing file:

- If the file is saved or if the relay is not connected: open the Settings folder and open the Settings file,

- If the relay is connected, extract the settings from the relay: click on the "Extract Settings" command or right click on the Settings folder.
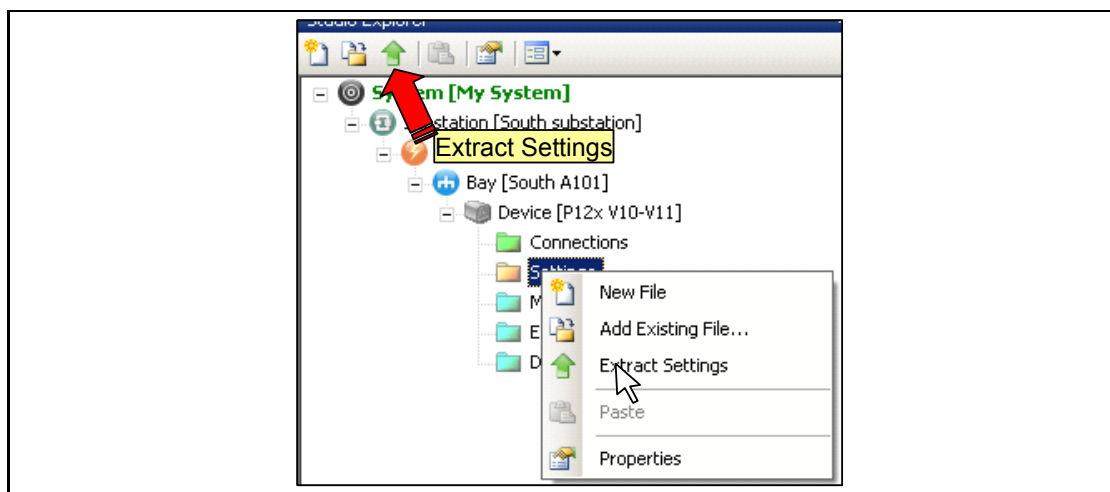
To open default settings:

- Click on "Open Default Settings File" Option in the File menu.

- Select the device type then the communication protocol.

- Select the device type and click on the "Next" button:

GS
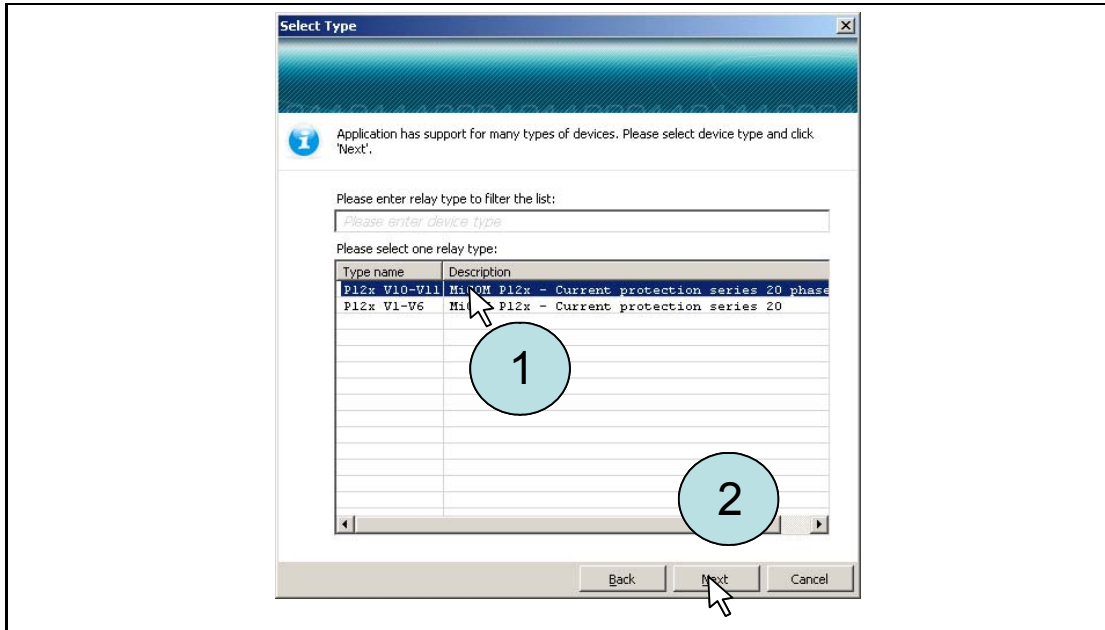
−   Select the Model and click on the "Finish" button. The default settings are displayed.
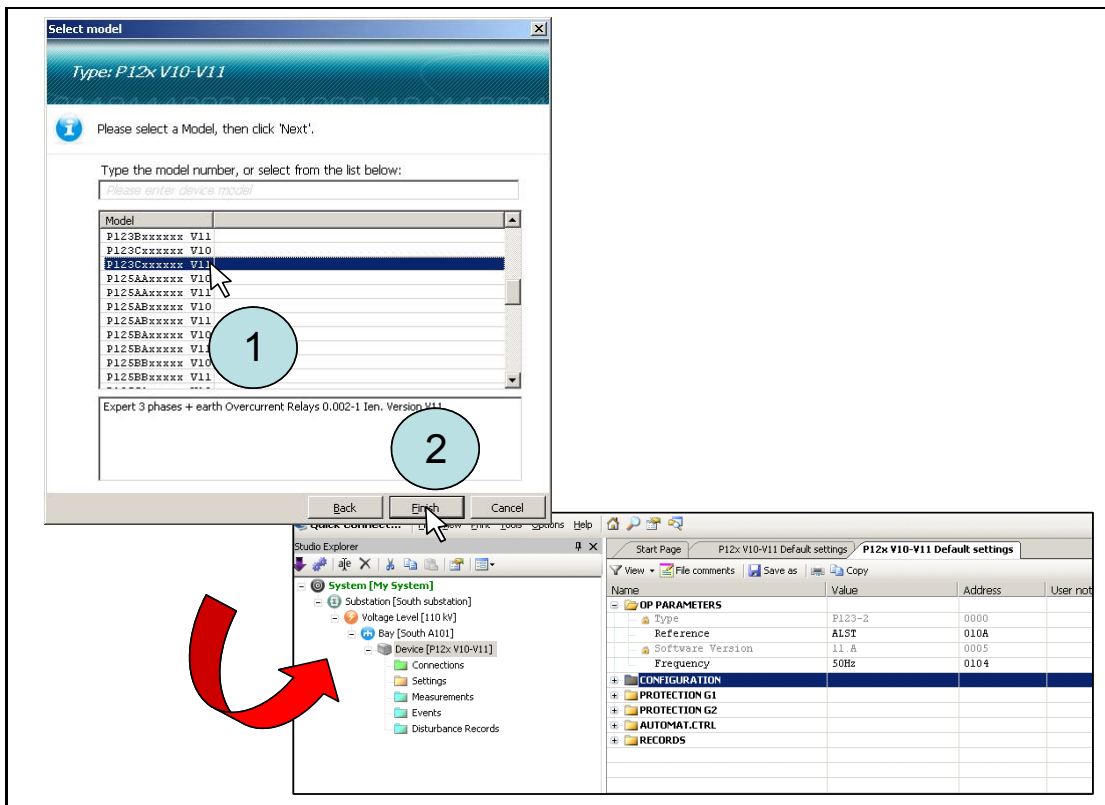
Appendix – P746 Relay Menu Map (Default)

Note: This menu map is annotated with the factory default settings.

SYSTEM DATA
- Language — English
- Password — ****
- Sys Fn Links — 0
- Description — MiCOM P746
- Plant Reference — MiCOM
- Model Number
- Serial Number
- Frequency — 50
- Comms Level — 2
- Relay Address — 255
- Plant Status — 000000
- Control Status — 0000000000000000
- Active Group — 1
- Software Ref. 1 — Ref. Number
- Software Ref. 2 — Ref. Number
- Plant Status — 1,0101E+ 14
- Opto I/P Status — 0000000000111011
- Opto I/P Status2 — 00000000
- Rly O/P Status — 0000000000000000
- Alarm Status 1 — 0000000000000000
- Alarm Status 2 — 0000000000000000
- Alarm Status 3 — 0000000000000000
- Access Level — 2
- Password Control — 2
- Password Level 1 — ****
- Password Level 2 — ****

VIEW RECORDS
- Select Event* — [0…511] — 0
- Select Fault* — [0…4] — 0
- Reset Indication — No
- *: If existing

MEASUREMENTS 1
One box conf.
- IA-1 Magnitude — 0.000 A
- IA-1 Phase Angle — 0.000 °
- IB-1 Magnitude — 0.000 A
- IB-1 Phase Angle — 0.000 °
- IC-1 Magnitude — 0.000 A
- IC-1 Phase Angle — 0.000 °
- Continue as above up to IA-6…IC-6
- I0-T1 Magnitude — 0.000 A
- I1-T1 Magnitude — 0.000 A
- I2-T1 Magnitude — 0.000 A
- IN-T1 Deriv Mag. — 0.000 A
- IN-T1 deriv Ang — 0.000 °
- Continue as above up to I0-T6…IN-T6
- VAN Magnitude — 0.000 V
- VAN Phase Angle — 0.000 °
- VBN Magnitude — 0.000 V
- VBN Phase Angle — 0.000 °
- VCN Magnitude — 0.000 V
- VCN Phase Angle — 0.000 °
- V1 Magnitude — 0.000 V
- V2 Magnitude — 0.000 V
- V0 Magnitude — 0.000 V
- VN Derived Mag — 0.000 V
- VN Derived Ang — 0.000 °
- VAB Magnitude — 0.000 V
- VAB Phase Angle — 0.000 °

Three box conf.
- IX-1 Magnitude — 0.000 A
- IX-1 Phase Angle — 0.000 °
- Continue as above up to IX-18
- IX-18 Magnitude — 0.000 A
- IX-18 Phase Angle — 0.000 °
- Where X = A, B or C

- VBC Magnitude — 0.000 V
- VBC Phase Angle — 0.000 °
- VCA Magnitude — 0.000 V
- VCA Phase Angle — 0.000 °
- VAN RMS — 0.000 V
- VBN RMS — 0.000 V
- VCN RMS — 0.000 V
- Frequency — 50.00 °

MEASUREMENTS 2
- IA Z1 diff — 0.000 A
- IB Z1 diff — 0.000 A
- IC Z1 diff — 0.000 A
- IA Z1 bias — 0.000 A
- IB Z1 bias — 0.000 A
- IC Z1 bias — 0.000 A
- IA Z2 diff — 0.000 A
- IB Z2 diff — 0.000 A
- IC Z2 diff — 0.000 A
- IA Z2 bias — 0.000 A
- IB Z2 bias — 0.000 A
- IC Z2 bias — 0.000 A
- IA CZ Diff — 0.000 A
- IB CZ Diff — 0.000 A
- IC CZ Diff — 0.000 A
- IA CZ Bias — 0.000 A
- IB CZ Bias — 0.000 A
- IC CZ Bias — 0.000 A

DATE AND TIME
- Date — 05 Jan 2006
- Time — 12:00:00
- IRIG-B Sync — Disabled
- Battery Status — Healthy
- Battery Alarm — Enabled
- SNTP Status — Disabled
- LocalTime Enable — Fixed
- LocalTime Offset — 0.000 mins
- DST Enable — Enable
- DST Offset — 60.00 mins
- DST Start — Last
- DST Start Day — Sunday
- DST Start Month — March
- DST Start Mins — 60.00 mins
- DST End — Last
- DST End Day — Sunday
- DST End Month — October
- DST End Mins — 60.00 mins

GS

GS

CONFIGURATION	CT AND VT RATIOS	RECORD CONTROL (When Visible)		
Restore Defaults No Operation	Main VT Primary 110,0 V	Clear Events No	DDB 479 - 448 111111111111111	DDB 1279 - 1248 111111111111111
Setting Group Select via Menu	Main VT Sec'y 110,0 V	Clear Faults No	DDB 511 - 480 111111111111111	1311 - 1280 543 - 512 111111111111111
Active Settings Group 1	Ref Current 1000 A	Clear Maint No	DDB 543 - 512 111111111111111	DDB 1343 - 1312 111111111111111
Save Changes No Operation	Tx CT *	Alarm Event Enabled	DDB 575 - 544 111111111111111	DDB 1375 - 1344 111111111111111
Copy From Group 1	Polarity Standard	Relay O/P Event Enabled	DDB 607 - 576 111111111111111	DDB 1407 - 1376 111111111111111
Copy To No Operation	Primary 1.000 kA	Opto Input Event Enabled	DDB 639 - 608 111111111111111	DDB 1439 - 1408 111111111111111
Setting Group 1 Enabled	Secondary 1000 A	General Event Enabled	DDB 671 - 640 111111111111111	DDB 1471 - 1440 111111111111111
Setting Group 2 Disabled	* x = 1 to 6 (1 box) x = 1 to 18 (3 box)	Fault Rec Event Enabled	DDB 703 - 672 111111111111111	DDB 1503 - 1472 111111111111111
Setting Group 3 Disabled		Maint Rec Event Enabled	DDB 735 - 704 111111111111111	DDB 1535 - 1504 111111111111111
Setting Group 4 Disabled		Protection Event Enabled	DDB 767 - 736 111111111111111	DDB 1567 - 1536 111111111111111
OP Mode One Box Mode		Clear Dist Recs No	DDB 799 - 768 111111111111111	DDB 1599 - 1568 111111111111111
Diff Protection Enabled		DDB 31 - 0 111111111111111	DDB 831 - 800 111111111111111	DDB 1631 - 1600 111111111111111
Dead Zone OC Disabled		DDB 63 - 32 111111111111111	DDB 863 - 832 111111111111111	DDB 1663 - 1632 111111111111111
Overcurrent Enabled		DDB 95 - 64 111111111111111	DDB 895 - 864 111111111111111	DDB 1695 - 1664 111111111111111
Earth fault Enabled		DDB 127 - 96 111111111111111	DDB 927 - 896 111111111111111	DDB 1727 - 1696 111111111111111
CB fail Disabled		DDB 159 - 128 111111111111111	DDB 959 - 928 111111111111111	DDB 1759 - 1728 111111111111111
Supervision Disabled		DDB 191 - 160 111111111111111	DDB 991 - 960 111111111111111	DDB 1791 - 1760 111111111111111
Input Labels Visible		DDB 223 - 192 111111111111111	DDB 1022 - 992 111111111111111	DDB 1823 - 1792 111111111111111
Output Labels Visible	Setting Values Primary	DDB 255 - 224 111111111111111	DDB 1055 - 1024 111111111111111	DDB 1855 - 1824 111111111111111
CT & VT Ratios Visible	Control Inputs Visible	DDB 287 - 256 111111111111111	DDB 1087 - 1056 111111111111111	DDB 1887 - 1856 111111111111111
Record Control Visible	Control I/P Config Visible	DDB 319 - 288 111111111111111	DDB 1119 - 1088 111111111111111	DDB 1919 - 1888 111111111111111
Disturb Recorder Visible	Control I/P Labels Visible	DDB 351 - 320 111111111111111	DDB 1151 - 1120 111111111111111	DDB 1951 - 1920 111111111111111
Measure't Setup Visible	Direct Access Enabled	DDB 383 - 352 111111111111111	DDB 1183 - 1152 111111111111111	DDB 1983 - 1952 111111111111111
Comms Setting Visible	Function Key Visible	DDB 415 - 384 111111111111111	DDB 1215 - 1184 111111111111111	DDB 2015 - 1984 111111111111111
Commission Tests Visible	LCD Contrast 11	DDB 447 - 416 111111111111111	DDB 1247 - 1216 111111111111111	DDB 2047 - 2016 111111111111111

GS

DISTURB RECORDER (When Visible)			MEASURET SETUP (When Visible)	COMMUNICATIONS (If set visible)

DISTURB RECORDER (When Visible)

Duration
1.500   ms

Trigger Position
33,30   %

Trigger Mode
Single

Analog Channel 1
VAN

Analog Channel 2
VBN

Analog Channel 3
VCN

Analog Channel 4
IA-T1 / IX-T1

Analog Channel 5
IB-T1 / IX-T2

Analog Channel 6
IC-T1 / IX-T3

Analog Channel 7
IA-T2 / IX-T4

Analog Channel 8
IB-T2 / IX-T5

Analog Channel 9
IC-T2 / IX-T6

Analog Channel 10
IA-T3 / IX-T7

Analog Channel 11
IB-T3 / IX-T8

Analog Channel 12
IC-T3 / IX-T9

Analog Channel 13
IA-T4 / IX-T10

Analog Channel 14
IB-T4 / IX-T11

Analog Channel 15
IC-T4 / IX-T12

Analog Channel 16
IA-T5 / IX-T13

Analog Channel 17
IB-T5 / IX-T14

Analog Channel 18
IC-T5 / IX-T15

Analog Channel 19
IA-T6 / IX-T16

Analog Channel 20
IB-T6 / IX-T17

Analog Channel 21
IC-T6 / IX-T18

Digital input 1
Output R1

Input 1 Trigger
No Trigger

Digital Input 2
Output R2

Input 2 Trigger
No Trigger

Digital Input 3
Output R3

Input 3 Trigger
No Trigger

Digital Input 4
Output R4

Input 4 Trigger
No Trigger

Digital Input 5
Output R5

Input 5 Trigger
No Trigger

Digital Input 6
Output R6

Input 6 Trigger
No Trigger

Digital Input 7
Output R7

Input 7 Trigger
No Trigger

Digital Input 8
Output R8

Input 8 Trigger
No Trigger

Digital Input 9
Any Trip

Input 9 Trigger
Trigger L/H

Digital Input 10
Output R10

Input 10 Trigger
Trigger L/H

Digital Input 11
Diff Fault Z1

Input 11 Trigger
Trigger L/H

Digital Input 12
Diff Fault Z2

Input 12 Trigger
Trigger L/H

Digital Input 13
Diff Fault CZ

Input 13 Trigger
Trigger L/H

Digital Input 14
Idiff Start Z1

Input 14 Trigger
Trigger L/H

Digital Input 15
Idiff Start Z2

Input 15 Trigger
Trigger L/H

Digital Input 16
Idiff CZ Start

Input 16 Trigger
Trigger L/H

Digital Input 17
PhComp Blk Z1

Input 17 Trigger
No Trigger

Digital Input 18
PhComp Blk Z2

Input 18 Trigger
No Trigger

Digital Input 19
Unused

Input 19 Trigger
No trigger

Digital Input 20
Idiff Trip Z1

Input 20 Trigger
No Trigger

Digital Input 21
Idiff Trip Z2

Input 21 Trigger
No Trigger

Digital Input 22
CCtFail Blk Z1

Input 22 Trigger
No Trigger

Digital Input 23
CCtFail Blk Z2

Input 23 Trigger
No Trigger

Digital Input 24
CCtFail Blk CZ

Input 24 Trigger
No Trigger

Digital Input 25
Diff Z1 Blked

Input 25 Trigger
No Trigger

Digital Input 26
Diff Z2 Blked

Input 26 Trigger
No Trigger

Digital Input 27
Diff CZ Blked

Input 27 Trigger
No Trigger

Digital Input 28
Fault A

Input 28 Trigger
No Trigger

Digital Input 29
Fault B

Input 29 Trigger
No Trigger

Digital Input 30
Fault C

Input 30 Trigger
No Trigger

Digital Input 31
Fault N

Input 31 Trigger
No Trigger

Digital Input 32
Function key 10

Input 32 Trigger
Trigger L/H

MEASURET SETUP (When Visible)

Default Display
Description

Local Values
Primary

Remote Values
Primary

Measurement Ref
VA

Measurement Mode
0

COMMUNICATIONS (If set visible)

RP1 Protocol
Courier

RP1 Address
6

RP1 InactivTimer
15 mins

RP1 Card Status
K Bus OK

RP1 Port Config
K Bus

If RS485:

RP1 Comms Mode
IEC60870 FT1.2

RP1 Baud Rate
19200

If Ethernet:

NIC Protocol
IEC61850

NIC Mac Address
00.02.86.92.01.4

NIC Tunl Timeout
5.000 mins

NIC Link Report
Alarm

NIC Link Timeout
60.00 s

If Second rear port:

Loopback Mode
No Action

Reload Mode
No Action

RP2 Protocol
Courier

RP2 Card Status
0

RP2 Port Config
EIA232 (RS232)

RP2 Comms Mode
IEC60870 FT1.2

RP2 Address
255

RP2 InactivTimer
15

RP2 Baud Rate
19200 bits/s

Msg Reject Count
0

Report Link Test
Alarm

Link Time Out
60.0 s

GS

COMMISSION TESTS (When Visible)

Opto I/P Status 0000000000000000

Opto I/P Status 2 00000000

Rly O/P Status 0000000000000000

Test Port Status 00000000

Monitor Bit 1   64

Monitor Bit 2   65

Monitor Bit 3   66

Monitor Bit 4   67

Monitor Bit 5   68

Monitor Bit 6   69

Monitor Bit 7   70

Monitor Bit 8   71

Test Mode Disabled

if "Contacts Blocked"

Test Pattern 0000000000000000

Contact Test No Operation

If "Test Mode" or disabled

Test LEDs No Operation

Red LED Status 0000010001000000

Green LED Status 0000010001000000

Test Zone none

DDB 31 - 0 0000000000000000

DDB 63 - 32 0000000000000000

DDB 95 - 64 0000000000000000

DDB 127 - 96 0000000000000000

DDB 159 - 128 0000000000000000

DDB 191 - 160 0000000000000000

DDB 223 - 192 0000000000000000

DDB 255 - 224 0000000000000000

DDB 287 - 256 0000000000000000

DDB 319 - 288 0000000000000000

DDB 351 - 320 0000000000000000

DDB 383 - 352 0000000000000000

DDB 415 - 384 0000000000000000

DDB 447 - 416 0000000000000000

DDB 479 - 448 0000000000000000

DDB 511 - 480 0000000000000000

DDB 543 - 512 0000000000000000

DDB 575 - 544 0000000000000000

DDB 607 - 576 0000000000000000

DDB 639 - 608 0000000000000000

DDB 671 - 640 0000000000000000

DDB 703 - 672 0000000000000000

DDB 735 - 704 0000000000000000

DDB 767 - 736 0000000000000000

DDB 799 - 768 0000000000000000

DDB 831 - 800 0000000000000000

DDB 863 - 832 0000000000000000

DDB 895 - 864 0000000000000000

DDB 927 - 896 0000000000000000

DDB 959 - 928 0000000000000000

DDB 991 - 960 0000000000000000

DDB 1022 - 992 0000000000000000

DDB 1055 - 1024 0000000000000000

DDB 1087 - 1056 0000000000000000

DDB 1119 - 1088 0000000000000000

DDB 1151 - 1120 0000000000000000

DDB 1183 - 1152 0000000000000000

DDB 1215 - 1184 0000000000000000

DDB 1247 - 1216 0000000000000000

DDB 1279 - 1248 0000000000000000

DDB 1311 - 1280 0000000000000000

DDB 1343 - 1312 0000000000000000

DDB 1375 - 1344 0000000000000000

DDB 1407 - 1376 0000000000000000

DDB 1439 - 1408 0000000000000000

DDB 1471 - 1440 0000000000000000

DDB 1503 - 1472 0000000000000000

DDB 1535 - 1504 0000000000000000

DDB 1567 - 1536 0000000000000000

DDB 1599 - 1568 0000000000000000

DDB 1631 - 1600 0000000000000000

DDB 1663 - 1632 0000000000000000

OPTO CONFIG

Global Nominal V 48/54V

Opto Filter Ctrl 1111111111111111

Opto Filter Ctr2 11111111

Characteristics Standard 60%-80%

DDB 1695 - 1664 0000000000000000

DDB 1727 - 1696 0000000000000000

DDB 1759 - 1728 0000000000000000

DDB 1791 - 1760 0000000000000000

DDB 1823 - 1792 0000000000000000

DDB 1855 - 1824 0000000000000000

DDB 1887 - 1856 0000000000000000

DDB 1919 - 1888 0000000000000000

DDB 1951 - 1920 0000000000000000

DDB 1983 - 1952 0000000000000000

DDB 2015 - 1984 0000000000000000

DDB 2047 - 2016 0000000000000000

CONTROL INPUTS (When Visible)

Ctrl I/P Status 0000000000000000

Control Input 1 No Operation

* Continue as above up to Control input 32

Control Input 32 No Operation

GS

CTRL I/P CONFIG (When Visible)		FUNCTION KEYS (When Visible)	CTRL I/P LABELS
Hotkey Enabled 1111111111111111		Fn Key Status 0000000000	Control Input 1 Control Input 1
Control Input 1 Latched	Control Input 12 Latched	Fn Key 1 Unlocked	Control Input 2 Control Input 2
Ctrl Command 1 Set/Reset	Ctrl Command 12 Set/Reset	Fn Key 1 Mode Normal	
Control Input 2 Latched	Control Input 13 Latched	Fn Key 1 Label Function Key 1	* Continue as above up to Control input 32
Ctrl Command 2 Set/Reset	Ctrl Command 13 Set/Reset	Fn Key 2 Unlocked	
Control Input 3 Latched	Control Input 14 Latched	Fn Key 2 Mode Toggled	Control Input 32 Control Input 32
Ctrl Command 3 Set/Reset	Ctrl Command 14 Set/Reset	Fn Key 2 Label Function Key 2	

Columns of boxes (CTRL I/P CONFIG):

Control Input 4 — Latched
Ctrl Command 4 — Set/Reset
Control Input 5 — Latched
Ctrl Command 5 — Set/Reset
Control Input 6 — Latched
Ctrl Command 6 — Set/Reset
Control Input 7 — Latched
Ctrl Command 7 — Set/Reset
Control Input 8 — Latched
Ctrl Command 8 — Set/Reset
Control Input 9 — Latched
Ctrl Command 9 — Set/Reset
Control Input 10 — Latched
Ctrl Command 10 — Set/Reset
Control Input 11 — Latched
Ctrl Command 11 — Set/Reset

Control Input 15 — Latched
Ctrl Command 15 — Set/Reset
Control Input 16 — Latched
Ctrl Command 16 — Set/Reset
Control Input 17 — Latched
Ctrl Command 17 — Set/Reset
Control Input 18 — Latched
Ctrl Command 18 — Set/Reset
Control Input 19 — Latched
Ctrl Command 19 — Set/Reset
Control Input 20 — Latched
Ctrl Command 20 — Set/Reset
Control Input 21 — Latched
Ctrl Command 21 — Set/Reset
Control Input 22 — Latched
Ctrl Command 22 — Set/Reset

Control Input 23 — Latched
Ctrl Command 23 — Set/Reset
Control Input 24 — Latched
Ctrl Command 24 — Set/Reset
Control Input 25 — Latched
Ctrl Command 25 — Set/Reset
Control Input 26 — Latched
Ctrl Command 26 — Set/Reset
Control Input 27 — Latched
Ctrl Command 27 — Set/Reset
Control Input 28 — Latched
Ctrl Command 28 — Set/Reset
Control Input 29 — Latched
Ctrl Command 29 — Set/Reset
Control Input 30 — Latched
Ctrl Command 30 — Set/Reset
Control Input 31 — Latched
Ctrl Command 31 — Set/Reset
Control Input 32 — Latched
Ctrl Command 32 — Set/Reset

Columns of boxes (FUNCTION KEYS):

Fn Key 3 — Unlocked
Fn Key 3 Mode — Normal
Fn Key 3 Label — Function Key 3
Fn Key 4 — Unlocked
Fn Key 4 Mode — Normal
Fn Key 4 Label — Function Key 4
Fn Key 5 — Unlocked
Fn Key 5 Mode — Normal
Fn Key 5 Label — Function Key 5
Fn Key 6 — Unlocked
Fn Key 6 Mode — Normal
Fn Key 6 Label — Function Key 6
Fn Key 7 — Unlocked
Fn Key 7 Mode — Toggled
Fn Key 7 Label — Function Key 7
Fn Key 8 — Unlocked

Columns of boxes (continued):

Fn Key 8 Mode — Normal
Fn Key 8 Label — Function Key 8
Fn Key 9 — Unlocked
Fn Key 9 Mode — Disabled
Fn Key 9 Label — Function Key 9
Fn Key 10 — Unlocked
Fn Key 10 Mode — Normal
Fn Key 10 Label — Function Key 10

GS

SYSTEM CONFIG GROUP 1	DIFF PROTECTION GROUP 1	DEAD ZONE OC GROUP 1	OVERCURRENT GROUP 1	EARTH FAULT GROUP 1

SYSTEM CONFIG GROUP 1

- OP MODE — One Box Mode
- *1 box* → Phase Sequence — Standard ABC
- *3 box* → Protected phase — phase A
- Feeder Numbers — 6
- Z1 Terminals — 000011
- Z2 Terminals — 001100
- Xfer Terminals — 010000
- ChZONE Terminal — 011111
- Bus Coupling by — Breaker
- Z1 Bus CT — CT6
- Z1 Bus CT Pol — Inverted
- Z2 Bus CT — CT6
- Z2 Bus CT Pol — Standard

DIFF PROTECTION GROUP 1

- Busbar Diff — Enabled
- *if enabled* → ID> 2 Current — 1200 A
- Phase Slope k2 — 60.00 %
- tDIFF — 0.000s
- CheckZone Status — Enabled
- *if enabled* → IDCZ> 2 Current — 1200 A
- Phase Slope kCZ — 30.00%
- Circuitry fail — Disabled
- *If enabled* → ID> 1 Current — 100.0A
- Phase Slope k1 — 10.00%
- ID> 1 Alarm timer — 5.000 s
- CZ CCTFAIL MODE — AlarmSR&No Block
- Zx CCTFAIL MODE — Self-Reset
- cctFail Blk Mode — Blocking/ Phase
- CCTFAIL tReset — 5.000s
- Voltage check
- Voltage check — Disabled
- *if enabled* → VT Connected to — Zone 1
- Voltage Mode — Phase-Phase
- V< Status — Disabled
- *if enabled* → V< Set — 80.00 V
- V< PickUpTimer — 0.000 s
- V1< Status — Disabled

if enabled column:
- V1< Set — 50.00 V
- V1< PickUpTimer — 0.000 s
- V2> Status — Disabled
- *if enabled* → V2> Set — 10.00 V
- V2> PickUpTimer — 0.000 s
- VN> Status — Disabled
- *if enabled* → VN> Set — 50.00 V
- VN> PickUpTimer — 0.000 s

DEAD ZONE OC GROUP 1

- DEAD ZONE OC
- I> Status — Disabled
- *if enabled* → I> Current Set — 120.0 %
- I> Time Delay — 50.00 ms

OVERCURRENT GROUP 1

- Terminal 1 to 6
- I> 1 Function — IEC S Inverse
- *if US ST Inverse, US Inverse, IEEE E Inverse, IEEE V Inverse, IEEEE M Inverse*
  - I> 1 Current Set — 1.000 kA
  - I> 1 Time Dial — 1.000
  - I> 1 Reset Char — DT
  - I> 1 tReset — 0.000 s
- *if RI*
  - I> 1 Current Set — 1.000 kA
  - I> 1 k(RI) — 1.000
  - I> 1 tReset — 0.000 s
- *if UK Rectifier, UK LT Inverse, IEC E Inverse, IEC V inverse, IEC S Inverse*
  - I> 1 Current Set — 1.000 kA
  - I> 1 TMS — 1.000
  - I> 1 tReset — 0.000 s
- *if DT*
  - I> 1 Current Set — 1.000 kA
  - I> 1 Time Delay — 1.000 s
  - I> 1 tReset — 0.000 s
- *if Disabled*
  - I> 2 Function — Disabled
  - *if DT*
    - I> 2 Current Set — 1.000 kA
    - I> 2 Time Delay — 0.000 s

EARTH FAULT GROUP 1

- 1-box
- Terminal 1 to 6
- IN> 1 Function — IEC S Inverse
- *if US ST Inverse, US Inverse, IEEE E Inverse, IEEE V Inverse, IEEEE M Inverse*
  - IN> 1 Current — 1.000 kA
  - IN> 1 Time Dial — 1.000
  - IN> 1 Reset Char — DT
  - IN> 1 tReset — 0.000 s
- *if IDG*
  - IN> 1 Current — 200.0 A
  - IN> 1 IDG IS — 1.500
  - IN> 1 IDG Time — 1.200 s
- *if UK Rectifier, UK LT Inverse, IEC E Inverse, IEC V inverse, IEC S Inverse*
  - IN> 1 Current — 1.000 kA
  - IN> 1 TMS — 1.000
  - IN> 1 tReset — 0.000 s
- *if DT*
  - IN> 1 Current — 200.0 A
  - IN> 1 Time Delay — 1.000 s
  - IN> 1 tReset — 0.000 s
- *if RI*
  - IN> 1 Current Set — 1.000 kA
  - IN> 1 k(RI) — 1.000
  - IN> 1 tReset — 0.000 s
- *if Disabled*
  - IN> 2 Function — Disabled
  - *if DT*
    - IN> 2 Current — 200.0 A
    - IN> 2 Time Delay — 0.000 s

```
┌──────────────┐      ┌──────────────┐      ┌──────────────┐      ┌──────────────┐  Idem Group 2,3 & 4  ┌──────────────┐
│ CB Fail & I< │      │ SUPERVISION  │      │ INPUT LABELS │      │ OUPUT LABELS │ ───────────────────► │  PSL DATA    │
│   GROUP 1    │      │   GROUP 1    │      │   GROUP 1    │      │   GROUP 1    │                      │              │
└──────┬───────┘      └──────┬───────┘      └──────┬───────┘      └──────┬───────┘                      └──────┬───────┘
       ▼                     ▼                     ▼                     ▼                                     ▼
┌──────────────┐      ┌──────────────┐      ┌──────────────┐      ┌──────────────┐                      ┌──────────────┐
│ BREAKER FAIL │      │ VT SUPERVISION│     │ Opto Input 1 │      │ Relay 1      │                      │ Grp 1 PSL Ref│
│              │      │              │      │ Input L1     │      │ OutputR1     │                      │ Reference    │
└──────┬───────┘      └──────┬───────┘      └──────┬───────┘      └──────┬───────┘                      └──────┬───────┘
       ▼                If "Indic-                 ▼                     ▼                                     ▼
┌──────────────┐        ation"           ┌──────────────┐      ┌──────────────┐                      ┌──────────────┐
│ CBF Control by│     ┌──────────────┐    │ Opto Input 2 │      │ Relay 2      │                      │ JJ Month AAAA│
│ I<           │     │ VTS Status   │     │ Input L2     │      │ Output R2    │                      │ HH:MM:SS:mmm │
└──────┬───────┘     │ Blocking     │     └──────┬───────┘      └──────┬───────┘                      └──────┬───────┘
       ▼             └──────┬───────┘            ▼                     ▼                                     ▼
┌──────────────┐            ▼             ┌──────────────┐      ┌──────────────┐                      ┌──────────────┐
│ I<  Current Set│   ┌──────────────┐     │ Opto Input 3 │      │ Relay 3      │                      │ Grp 1 PSL ID │
│    5.000 %    │    │ VTS Reset Mode│    │ Input L3     │      │ Output R3    │                      │    0xB83E9B5E│
└──────┬───────┘     │ Manual       │     └──────┬───────┘      └──────┬───────┘                      └──────┬───────┘
   if "52a"          └──────┬───────┘            ▼                     ▼                                     ▼
       ▼                    ▼             ┌──────────────┐      ┌──────────────┐                      ┌──────────────┐
┌──────────────┐     ┌──────────────┐     │ * Continue as above up│ * Continue as above up│            │ Grp 2 PSL Ref│
│ CB Fail 1 Timer│   │ VTS Time Delay│    │ to opto Input 32│   │ to Relay 24  │                      │ Reference    │
│    50.00 ms   │    │    5.000 s   │     │              │      │              │                      └──────┬───────┘
└──────┬───────┘     └──────┬───────┘     └──────┬───────┘      └──────┬───────┘                             ▼
       ▼                    ▼                    ▼                     ▼                               same for
┌──────────────┐     ┌──────────────┐     ┌──────────────┐      ┌──────────────┐                      Groupe 3 & 4
│ CB Fail 2 Timer│   │ CT SUPERVISION│    │ Opto Input 32│      │ Relay 24     │
│    200.00 ms  │    │              │      │ Input L32    │      │ Output R24   │
└──────┬───────┘     └──────┬───────┘     └──────────────┘      └──────────────┘
       ▼                    ▼
┌──────────────┐     ┌──────────────┐
│ CB Fail 3 Timer│   │ Diff CTS     │
│    50.00 ms   │    │ Enabled      │
└──────┬───────┘     └──────┬───────┘
       ▼                if enabled
┌──────────────┐     ┌──────────────┐
│ CB Fail 4 Timer│   │ CTS Status   │
│    200.00 ms  │    │ Blocking     │
└──────┬───────┘     └──────┬───────┘
       ▼                if "block-
┌──────────────┐         ing"
│ I>  Status   │     ┌──────────────┐
│ Disabled     │     │ CTS Time Delay│
└──────┬───────┘     │    2.000 s   │
   if Enabled        └──────┬───────┘
       ▼                    ▼
┌──────────────┐     ┌──────────────┐
│ I>  Current Set│   │ CTS I1       │
│   120.0 %    │     │    10.00 %   │
└──────────────┘     └──────┬───────┘
                            ▼
                     ┌──────────────┐
                     │ CTS I2/I1> 1 │
                     │    5.000 s   │
                     └──────┬───────┘
                            ▼
                     ┌──────────────┐
                     │ CTS I2/I1> 2 │
                     │    40.00 %   │
                     └──────────────┘
```

GS

GS

ST

SETTINGS

Date: **2008**

Hardware Suffix: **K**

Software Version: **01**

Connection Diagrams: **10P746xx (xx = 01 to 07)**

CONTENTS

ST

ST

1. SETTINGS

The P746 must be configured to the system and 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 (see section P746/EN GS for the detailed relay menu maps). The relay is supplied with a factory-set configuration of default settings.

1.1 Relay settings configuration

The relay is a multi-function device that supports numerous different protection, control and communication features. In order 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 four protection settings groups is selected as active through the 'Active settings' cell. A protection setting group can also be disabled in the configuration column, provided it is not the present active group. Similarly, a disabled setting group cannot be set as the active group.

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.

The aim of the configuration column is to allow general configuration from a single point in the menu. Items that are disabled or made invisible do not appear in the main relay menu.

ST

Menu Text	Default Setting	Available Settings
CONFIGURATION		
Restore Defaults	No Operation	No Operation All Settings Setting Group 1 Setting Group 2 Setting Group 3 Setting Group 4
Setting to restore a setting group to factory default settings.		
Setting Group	Select via Menu	Select via Menu Select via PSL
Allows setting group changes to be initiated via Opto Input or via Menu.		
Active Settings	Group 1	Group 1, Group 2, Group 3, Group 4
Selects the active setting group.		
Save Changes	No Operation	No Operation, Save, Abort
Saves all relay settings.		
Copy from	Group 1	Group 1, 2, 3 or 4
Allows displayed settings to be copied from a selected setting group.		
Copy to	No Operation	No Operation Group 1, 2, 3 or 4
Allows displayed settings to be copied to a selected setting group (ready to paste).		

Menu Text	Default Setting	Available Settings
Setting Group 1	Enabled	Enabled or Disabled
If the setting group is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this setting (paste).		
Setting Group 2 (as above)	Disabled	Enabled or Disabled
Setting Group 3 (as above)	Disabled	Enabled or Disabled
Setting Group 4 (as above)	Disabled	Enabled or Disabled
OP Mode	One BOX Mode	One BOX Mode or Three BOX Mode
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	Enabled	Enabled or Disabled
To enable (activate) or disable (turn off) the Differential Protection function.		
Dead Zone OC	Disabled	Enabled or Disabled
To enable (activate) or disable (turn off) the dead zone overcurrent function.		
Overcurrent	Enabled	Enabled or Disabled
To enable (activate) or disable (turn off) the overcurrent function.		
Earth fault	Enabled	Enabled or Disabled
To enable (activate) or disable (turn off) the earth fault overcurrent function.		
CB fail	Disabled	Enabled or Disabled
To enable (activate) or disable (turn off) the Circuit Breaker (CB) failure function.		
Supervision	Disabled	Enabled or Disabled
To enable (activate) or disable (turn off) the supervision function.		
Input Labels	Visible	Invisible or Visible
Sets the Input Labels menu visible further on in the relay settings menu.		
Output Labels	Visible	Invisible or Visible
Sets the Output Labels menu visible further on in the relay settings menu.		
CT & VT ratios	Visible	Invisible or Visible
Sets the current transformer and voltage transformer ratios and directions visible further in the menu.		
Recorder Control	Visible	Invisible or Visible
Sets the Record Control menu visible further on in the relay settings menu.		
Disturb. Recorder	Visible	Invisible or Visible
Sets the Disturbance Recorder menu visible further on in the relay settings menu.		
Measure't. Set-up	Visible	Invisible or Visible
Sets the Measurement Setup menu visible further on in the relay settings menu.		
Comms. Settings	Invisible	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.		

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Menu Text	Default Setting	Available Settings
Commission Tests	Visible	Invisible or Visible
Sets the Commissioning Tests menu visible further on in the relay settings menu.		
Setting Values	Primary	Primary or Secondary
This affects all protection settings that are dependent upon CT and VT ratios.		
Control Inputs	Visible	Invisible or Visible
Activates the Control Input status and operation menu further on in the relay setting menu.		
Ctrl I/P Config.	Visible	Invisible or Visible
Sets the Control Input Configuration menu visible further on in the relay setting menu.		
Ctrl I/P Labels	Visible	Invisible or Visible
Sets the Control Input Labels menu visible further on in the relay setting menu.		
Direct Access	Enabled	Enabled/Disabled/Hotkey only/CB Cntrl. only
Defines what CB control direct access is allowed. Enabled implies control via menu, hotkeys etc.		
Function Key	Visible	Invisible or Visible
Sets the Function Key menu visible further on in the relay setting menu.		
LCD Contrast	11	0…31
Sets the LCD contrast.		

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1.1.1 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 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.

1.2 Protection settings

The 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.

1.2.1   System Configuration

ST

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
SYSTEM CONFIG				
OP Mode: One Box Mode / Three Box Mode				
Displays one box mode or three box mode relay configuration (ront panel only).				
OP Mode = One Box Mode				
Phase Sequence	Standard ABC	Standard ABC / Reverse ACB		
Sets the phase sequence (standard or reverse, only available for one box mode)				
Feeder Numbers	6	0	6	1
Sets the number of feeders connected to the relay (up to 6)				
Z1 terminals	000000	0 or 1		
Sets the configuration of the terminals fixed to zone 1 from terminal 6 (1st digit) to terminal 1 (last digit). The terminal is activated when its corresponding digit is set to 1.				
Z2 terminals	000000	0 or 1		
Sets the configuration of the terminals fixed to zone 2 from terminal 6 (1st digit) to terminal 1 (last digit). The terminal is activated when its corresponding digit is set to 1.				
Xfer Terminals	011111	0 or 1		
Sets the configuration of the terminals that can be switched between the two zones.				
ChZONE terminal	011111	0 or 1		
Sets the configuration of the terminals that are needed for Check Zone				
Bus Coupling by	Breaker	Breaker / none / Isolator		
Sets the configuration of the bus coupling. It indicates whether bus is coupled by breaker, isolator or not (none).				
Z1 Bus CT	CT6	No CT / CT1 to CT6		
Sets the busbar current transformer belonging to zone 1.				
Z1 Bus CT Pol	Inverted	Inverted / standard		
Sets the direction of the busbar current transformer in zone 1.				
Z2 Bus CT	CT6	No CT / CT1 to CT6		
Sets the busbar current transformer belonging to zone 2.				
Z2 Bus CT Pol	Standard	Inverted / standard		
Sets the direction of the busbar current transformer in zone 2.				

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
OP Mode = Three Box Mode				
Protected phase	Phase A	Phase A / Phase B / Phase C		
Sets the connected phase to be protected (only available for three box mode).				
Feed Numbers	6	0	18	1
Sets the number of feeders connected to the relay (up to 18)				
Z1 terminals	0000000000000000	0 / 1		
Sets the configuration of the terminals fixed to zone 1 from terminal 18 (1st digit) to terminal 1 (last digit). The terminal is activated when its corresponding digit is set to 1.				
Z2 terminals	0000000000000000	0 / 1		
Sets the configuration of the terminals fixed to zone 2 from terminal 18 (1st digit) to terminal 1 (last digit). The terminal is activated when its corresponding digit is set to 1.				
Xfer Terminals	0000000000000000	0 / 1		
Sets the configuration of the terminals that can be switched between the two zones.				
ChZONE terminal	0000000000000000	0 / 1		
Sets the configuration of the terminals that are needed for Check Zone				
Bus Coupling by	Breaker	Breaker / none / Isolator		
Sets the configuration of the bus coupling. It indicates whether bus is coupled by breaker, isolator or none.				
Z1 Bus CT	No CT	No CT / CT1 to CT18		
Sets the busbar current transformer belonging to zone 1.				
Z1 Bus CT Pol	Standard	Inverted / standard		
Sets the direction of the busbar current transformer in zone 1.				
Z2 Bus CT	No CT	No CT / CT1 to CT18		
Sets the busbar current transformer belonging to zone 2.				
Z2 Bus CT Pol	Standard	Inverted / standard		
Sets the direction of the busbar current transformer in zone 2.				

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1.2.2   Differential protection configuration

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	Default Setting	Setting Range		Step Size
		Min.	Max.	
DIFF PROTECTION				
Busbar Diff	Enabled	Disabled / Enabled		
To enable (activate) or disable (turn off) the busbar differential protection. If the function is activated, the following options are accessible.				
ID>2 Current	1.200 kA	100.0 A	2.500 kA	10.0 A
Setting that determines the minimum differential operating current for all the discriminating zone biased differential elements				
Phase Slope k2	60.00 %	20.00 %	90.00 %	1 %
Slope angle setting for all the zones biased differential element.				

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
tDIFF	0.000 s	0.000 s	10.00 s	10.00 ms
Sets the time delay up to 10 seconds				
CheckZone Status	Enabled	Disabled / Enabled		
To enable (activate) or disable (turn off)				
IDCZ>2 Current	1.200 kA	100.0 A	6.000 kA	10.0 A
Setting that determines the minimum differential operating current for the Check Zone biased differential element				
Phase Slope kCZ	30.00 %	0.000 %	90.00 %	1.00 %
Slope angle setting for the check zone biased differential element.				
Circuitry fail	Enabled	Disabled / Enabled		
To enable (activate) or disable (turn off) the circuitry fail protection. If the function is activated, the following options are accessible.				
ID>1 Current	100.0 A	50.00 A	6.000 kA	10.00 A
Setting for the phase circuitry fault monitoring characteristic for the minimum pickup				
Phase Slope k1	10.00 %	0.000 %	50.00 %	1.000 %
Slope angle setting for the phase circuitry fault monitoring characteristic.				
ID>1 Alarm timer	5.000 s	0.000 s	600.0 s	10.00 ms
Setting for the operating time delay of the phase circuitry fault monitoring				
CZ CCTFAIL MODE	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.				

ST

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Zx CCTFAIL MODE	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.				
cctFailBlkMode	Blocking/Phase	Blocking/Phase 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.				
CCTFAIL tReset	5.000 s	0.000 s	600.0 s	100.0 ms
Setting for the reset time delay of the circuitry fail reset option.				
Voltage check	Disabled	Disabled / Enabled		
To enable (activate) or disable (turn off) voltage check.				
VT Connected to	Zone 1	Zone 1 / Zone 2		
If "voltage check" is enabled, used to indicate the voltage check zone.				
Voltage Mode	Phase-Phase	Phase-Phase / Phase-Neutral		
Sets the voltage mode				
V< Status	Disabled	Disabled / Enabled		
To enable (activate) or disable (turn off) the undervoltage check.				
V< Set	80.00 V	10.00 V	120.0 V	1.00 V
If "V< Status" is enabled, pickup setting for undervoltage element.				
V< PickUpTimer	0.000 s	0.000 s	10.00 s	2.000 ms
If "V< Status" is enabled, sets the minimum pickup for undervoltage timer.				
V1< Status	Disabled	Disabled / Enabled		
To enable (activate) or disable (turn off) the first stage of undervoltage element.				
V1< Set	50.00 V	10.00 V	120.0 V	1.00 V
If "V1< Status" is enabled, pickup setting for first stage of undervoltage element.				

ST

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
V1< PickUpTimer	0.000 s	0.000 s	10.00 s	2.000 ms
If "V1< Status" is enabled, sets the minimum pickup for first stage of undervoltage timer.				
V2> Status	Disabled	Disabled / Enabled		
To enable (activate) or disable (turn off) second stage of overvoltage. When activated, V2> configuration is visible				
V2> Set	10.00 V	1.000 V	110.0 V	1.000 V
If "V2> Status" is enabled, pickup setting for second stage of overvoltage element.				
V2> PickUpTimer	0.000 s	0.000 s	10.00 s	2.000 ms
If "V2> Status" is enabled, sets the minimum pickup for first stage of overvoltage timer.				
VN> Status	Disabled	Disabled / Enabled		
To enable (activate) or disable (turn off) the residual voltage check.				
VN> Set	10.00 V	1.000 V	80.00 V	1.000 V
If "VN> Status" is enabled, pickup setting for residual voltage element..				
VN> PickUpTimer	0.000 s	0.000 s	10.00 s	2.000 ms
If "VN> Status" is enabled, sets the minimum pickup for residual voltage timer.				

ST

1.2.3   Dead Zone Overcurrent configuration

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
DEAD ZONE OC				
I> Status				
I> Status	Disabled	Disabled / Enabled		
To enable (activate) or disable (turn off) the overcurrent check.				
I> Current Set	120.0 %	10.00 %	400.0 %	1 %
Pick-up setting for overcurrent element.				
I> Time Delay	50.00 ms	0.000 s	100.0 s	10.00 ms
Sets the time-delay for the overcurrent element.				

1.2.4   Non directional Phase overcurrent protection

The overcurrent protection included in the P746 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 definite time characteristics only.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
OVERCURRENT				
TERMINAL 1 to 6 (one box) / TERMINAL 1 to 18 (three box)				
I>1 Function	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	1.000 kA	80.00 A	4.000 kA	10 A
Pick-up setting for first stage overcurrent element				
I>1 Time Dial	1.000	0.010	100.0	0.010
Setting for the time multiplier setting to adjust the operating time of the IEEE/US IDMT curves.				
I>1 Reset Char	DT	DT / Inverse		
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
I>1 tReset	0.000 s	0.000 s	100.0 s	10.00 ms
Setting that determines the reset/release time for definite time reset characteristic.				
I>1 k(RI)	1.000	0.100	10.00	0.050
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 TMS	1.000	0.025	1.200	0.025
Setting for the time multiplier setting to adjust the operating time of the IEC IDMT characteristic				
I>1 Time Delay	1.000 s	0.000 s	100.0 s	10.00 ms
Setting for the time-delay for the definite time setting if selected for first stage element				
I>2 Function	Disabled	Disabled / DT		
Setting for the second stage overcurrent element.				
I>2 Current	1.000 kA	80.00 A.	32.00 kA	10 A
Pick-up setting for second stage overcurrent element.				
I>2 Time delay	1.000 s	0.000 s	100.0 s	10.00 s
Setting for the operating time-delay for second stage overcurrent element.				

ST

1.2.5   Earth fault (only available for one box mode)

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
EARTH FAULT				
TERMINAL 1 to 6 (one box)				
IN>1 Function	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	200.0 A	80.00 A	4.000 kA	10 A
Pick-up setting for the first stage earth fault element				
IN>1 Time Dial	1.000	0.010	100.0	0.010
Setting for the time multiplier setting to adjust the operating time of the IEEE/US IDMT curves.				
IN>1 Reset Char	DT	DT / Inverse		
Setting to determine the type of reset/release characteristic of the IEEE/US curves.				
IN>1 tReset	0.000 s	0.000 s	100.0 s	10.00 ms
Setting that determines the reset/release time for definite time reset characteristic.				
IN>1 IDG Is	1.500	1.000	4.000	0.100
Setting to determine the IDG characteristics				
IN>1 TMS	1.000	0.025	1.200	0.025
Setting for the time multiplier setting to adjust the operating time of the IEC IDMT characteristic				
IN>1 IDG Time	1.200 s	1.000 s	2.000 s	10 ms
Setting thet determines the IDG time.				
IN>1 k (RI)	1.000	0.100	10.00	0.050
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 Time Delay	1.000 s	0.000 s	200.0 s	10.00 ms
Setting for the time-delay for the definite time setting if selected for first stage element				
IN>2 Function	Disabled	Disabled / DT		
Setting to enable or disable the second stage overcurrent element.				
IN>2 Current	200.0 A	80.00 A.	32.00 kA	10 A
Pick-up setting for second stage overcurrent element.				
IN>2 Time delay	1.000 s	0.000 s	100.0 s	10.00 s
Setting for the operating time-delay for second stage overcurrent element.				

ST

1.2.6   Circuit Breaker Fail and undercurrent fonction

This function consists of two-stage circuit breaker fail functions that can be initiated by:

- Internal protection element initiation.

- External protection element initiation.

For current-based protection, the reset condition is based on undercurrent operation 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 Failure condition.

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

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
CB FAIL & I<				
BREAKER FAIL				
CBF Control by	I< and 52a	52a / I< / I< and 52a		
Setting which determines the elements that will reset the circuit breaker fail time protection function. Both means that 52a and current criteria have to indicate open to reset the CB fail.				
I< Current Set	5.000 %	5.000 %	400.0 %	1.000 %
If "CBF Control by" "I<" or "I> and 52a": setting that determines the circuit breaker fail timer reset current for overcurrent based protection circuit breaker fail initiation				
CB Fail 1 Timer	50.00 ms	0.000 s	10.00 s	10.00 ms
Setting for the circuit breaker fail timer stage 1 for which the initiating condition must be valid.				
CB Fail 2 Timer	200.0 ms	40.00 ms	10.00 s	10.00 ms
Setting to enable or disable the second stage of the circuit breaker function.				
CB Fail 3 Timer	50.00 ms	0.000 s	10.00 s	10.00 ms
Setting to enable or disable the third stage of the circuit breaker function.				
CB Fail 4 Timer	200.0 ms	40.00 ms	10.00 s	10.00 ms
Setting to enable or disable the fourth stage of the circuit breaker function.				
I> Status	Disabled	Disabled / Enabled		
To enable (activate) or disable (turn off) the overcurrent check				
I> Current Set	120.0 %	5.000 %	400.0 %	1.000 %
If "I> Status" is enabled, pick-up setting for overcurrent element				

1.2.7   Supervision

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
SUPERVISION				
VT SUPERVISION				
VTS Status	Blocking	Blocking / indication		
This menu enables or disables Voltage Transformer Supervision (VTS).				

ST

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
VTS Reset Mode	Manual	Manual / Auto		
This setting enables the automatic or manual mode of the voltage transformer supervision.				
VTS Time Delay	5.000 s	1.000 s	10.00 s	100.0 ms
This setting determines the operating time-delay of the element upon detection of a voltage transformer supervision condition.				
CT SUPERVISION				
Diff CTS	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	Blocking	Blocking / Indication		
This menu enables or disables Current Transformer Supervision (CTS): when "Indication" is selected, CTS is enabled, the following menus are accessible and settable.				
CTS Time Delay	2.000 s	0.000 s	10.00 s	100.0 ms
This setting determines the operating time-delay of the element upon detection of a current transformer supervision condition.				
CTS I1	10.00 %	5.000 %	100.0 %	1.000 %
Setting for positive sequence current that is not to be exceeded in order to determine CTS condition				
CTS I2/I1>1	5.000 %	5.000 %	100.0 %	1.000 %
Setting for low set ratio that is not to be exceeded in order to determine CTS condition				
CTS I2/I1>2	40.00 %	5.000 %	100.0 %	1.000 %
Setting for the high set ratio to be exceeded at exactly one end in order to determine CTS condition				

ST

1.3 Control and support settings

The control and support settings are part of the main menu and are used to configure the relays global configuration. It includes submenu settings as below and is discussed in more detail below:

- 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

1.3.1 System data

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

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Language	English			
The default language used by the device. Selectable as English, French, German, Russian, Spanish.				
Password	****			
Device default password.				
Sys. Fn. Links	0			1
Setting to allow the fixed function trip LED to be self resetting.				
Description	MiCOM P746			
16 character relay description. Can be edited.				
Plant Reference	MiCOM			
Associated plant description and can be edited.				
Model Number	P746??????????K			
Relay model number. This display cannot be altered.				
Serial Number	6 digits + 1 letter			
Relay model number. This display cannot be altered.				
Frequency	50 Hz			10Hz
Relay set frequency. Settable between 50 and 60Hz				
Comms Level	2			
Displays the conformance of the relay to the Courier Level 2 comms.				
Relay Address	255	0	255	1
Fixed front and first rear port relay address.				
Plant Status	00000000000000			
Displays the circuit breaker plant status for up to 6 circuit breakers (one box mode) or up to 18 circuit breakers (three box modes).				
Control Status	0000000000000000			
Not used.				
Active Group	1			
Displays the active settings group.				
Software Ref. 1				
Displays the relay software version including protocol and relay model.				
Opto I/P Status	00000000000000000000000000000000			
Duplicate. Displays the status of opto inputs (L1 to L32).				
Opto I/P Status2	00000000			
Duplicate. Displays the status of opto inputs (L33 to L40).				
Plant Status	01010101010101			
Displays the circuit breaker plant status for up to 6 circuit breakers (from CB1 to CB6 and Bus CB coupler).				

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Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Rly O/P Status	00000000			
Duplicate. Displays the status of output relays.				
Alarm Status 1	00000000000000000000000000000000			
32 bits field give status of first 32 alarms.				
Alarm Status 2	00000000			
Next 32 alarm status defined.				
Alarm Status 3	00000000			
Next 16 alarm status defined. Assigned specifically for platform alarms.				
Access Level	2			
Displays the current access level. Level 0 - No password required - Read access to all settings, alarms, event records and fault records Level 1 - Password 1 or 2 required - As level 0 plus: Control commands, e.g. circuit breaker open/close Reset of fault and alarm conditions, Reset LEDs Clearing of event and fault records Level 2 - Password 2 required - As level 1 plus: All other settings				
Password Control	2			
Sets the menu access level for the relay. This setting can only be changed when level 2 access is enabled.				
Password Level 1	****			
Allows user to change password level 1.				
Password Level 2	****			
Allows user to change password level 2.				

1.3.2   Date and time

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

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Date/Time	Data			
Displays the relay's current date and time.				
IRIG-B Sync	Disabled	Disabled or Enabled		
Enable IRIG-B time synchronization (with Irig-B option).				
IRIG-B Status	Data	Card not fitted/Card failed/ Signal healthy/No signal		
Displays the status of IRIG-B (with Irig-B option).				
Battery Status	Data			
Displays whether the battery is healthy or not.				
Battery Alarm	Enabled	Disabled or Enabled		
Setting that determines whether an unhealthy relay battery condition is alarmed or not.				

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
SNTP Status	Data	Disabled, Trying Server 1, Trying Server 2, Server 1 OK, Server 2 OK, No response, No valid clock		
For Ethernet option only:				
Displays information about the SNTP time synchronization status				
LocalTime Enable	Disabled	Disabled/Fixed/Flexible		
Setting to turn on/off local time adjustments.				
Disabled - No local time zone will be maintained. Time synchronisation 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 synchronisation 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	0	-720	720	15
Setting to specify an offset of -12 to +12 hrs in 15 minute intervals for local time zone. This adjustment is applied to the time based on the master clock which is UTC/GMT				
DST Enable	Disabled	Disabled or Enabled		
Setting to turn on/off daylight saving time adjustment to local time.				
DST Offset	60mins	30	60	30min
Setting to specify daylight saving offset which will be used for the time adjustment to local time.				
DST Start	Last	First, Second, Third, Fourth, Last		
Setting to specify the week of the month in which daylight saving time adjustment starts				
DST Start Day	Sunday	Monday, Tuesday, Wednesday, Thursday, Friday, Saturday		
Setting to specify the day of the week in which daylight saving time adjustment starts				
DST Start Month	March	January, February, March, April, May, June, July, August, September, October, November, December		
Setting to specify the month in which daylight saving time adjustment starts				
DST Start Mins	60min	0	1425	15min
Setting to specify the time of day in which daylight saving time adjustment starts. This is set relative to 00:00 hrs on the selected day when time adjustment is to start.				
DST End	Last	First, Second, Third, Fourth, Last		
Setting to specify the week of the month in which daylight saving time adjustment ends.				
DST End Day	Sunday	Monday, Tuesday, Wednesday, Thursday, Friday, Saturday		
Setting to specify the day of the week in which daylight saving time adjustment ends				

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Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
DST End Month	October	January, February, March, April, May, June, July, August, September, October, November, December		
Setting to specify the month in which daylight saving time adjustment ends				
DST End Mins	60	0	1425	15min
Setting to specify the time of day in which daylight saving time adjustment ends. This is set relative to 00:00 hrs on the selected day when time adjustment is to end.				
RP1 Time Zone	Local	UTC or Local		
Setting for the rear port 1 interface to specify if time synchronisation received will be local or universal time coordinated				
RP2 Time Zone	Local	UTC or Local		
Setting for the rear port 2 interface to specify if time synchronisation received will be local or universal time coordinated				
Tunnel Time Zone	Local	UTC or Local		
With Ethernet option only: Setting to specify if time synchronisation received will be local or universal time co-ordinate when 'tunnelling' courier protocol over Ethernet.				

ST

1.3.3   CT and VT Ratios

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
CT AND VT RATIOS				
Main VT Primary	110.0 V	100.0 V	1.000 MV	1.000 V
Sets the phase Voltage Transformer input primary voltage rating.				
Main VT's Sec'y	110.0 V	80.00 V	140.0 V	1.000 V
Sets the phase Voltage Transformer input secondary voltage rating.				
Ref Current	1000 A	100.0 A	30.000 kA	5 A
Sets the ratio of virtual CT as reference for secondary currents calculation.				
T1 CT to T6 CT (one box) / T1 CT to T18 CT (three box)				
Polarity	Standard	Standard / Inverted		
Standard or reverse phase sequence can be selected. This menu sets this phase sequence.				
Primary	1.000 kA	1.000 A	30.00 kA	1 A
Sets the phase Current Transformer input primary current rating.				
Secondary	1.000 kA	1.000 A	5.000 A	1 A
Sets the phase Current Transformer input secondary current rating.				

1.3.4 Record control

It is possible to disable the reporting of events from all interfaces that supports 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	Default Setting	Available Settings
RECORD CONTROL		
Clear Events	No	No or 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	No	No or Yes
Selecting "Yes" will cause the existing fault records to be erased from the relay.		
Clear Maint	No	No or Yes
Selecting "Yes" will cause the existing maintenance records to be erased from the relay.		
Alarm Event	Enabled	Enabled or Disabled
Disabling this setting means that all the occurrences that produce an alarm will result in no event being generated.		
Relay O/P Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any change in logic input state.		
Opto Input Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any change in logic input state.		
General Event	Enabled	Enabled or Disabled
Disabling this setting means that no General Events will be generated		
Fault Rec Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any fault that produces a fault record		
Maint. Rec Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any occurrence that produces a maintenance record.		
Protection Event	Enabled	Enabled or Disabled
Disabling this setting means that any operation of protection elements will not be logged as an event.		
Clear Dist Recs	No	No or 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.		
DDB 31 - 0	11111111111111111111111111111111	
Displays the status of DDB signals 0 – 31.		
DDB 2047 - 2016	11111111111111111111111111111111	
Displays the status of DDB signals 2047 – 2016.		

ST

1.3.5   Measurements

Menu Text	Default Settings	Available settings
MEASUREMENT SETUP		
Default Display	Description	Description / Phase Voltage / Date and Time / Plant reference / Frequency / Access Level
This setting can be used to select the default display from a range of options, note that it is also possible to view the other default displays whilst at the default level using the ◊ and ◊ keys. However once the 15 min timeout elapses the default display will revert to that selected by this setting.		
Local Values	Primary	Primary/Secondary
This setting controls whether measured values via the front panel user interface and the front courier port are displayed as primary or secondary quantities.		
Remote Values	Primary	Primary/Secondary
This setting controls whether measured values via the rear communication port are displayed as primary or secondary quantities.		
Measurement ref	VA	IA1 / IB1 / IC1 / VA / VB / VC / IA2 / IB2 / IC2 / IA3 / IB3 / IC3 / IA4 / IB4 / IC4 / IA5 / IB5 / IC5 / IA6 / IB6 / IC6
This menu sets the reference of the measure (phase reference and angle)		
Measurement Mode	0	0 / 1 / 2 / 3
Used to set the mode of measurement, according to the following diagram:		

1.3.6   Communications

The communications settings apply to the rear communications port. Further details are given in the SCADA communications section (P746/EN SC).

These settings are available in the menu 'Communications' column and are displayed.

1.3.6.1   Communications settings

1.3.6.1.1 Courier protocol

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
COMMUNICATIONS				
RP1 Protocol	Courier			
Indicates the communications protocol that will be used on the rear communications port.				
RP1 Address	255	0	255	1
This cell sets the unique address for the relay such that only one relay is accessed by master station software.				
RP1 InactivTimer	15.00 mins.	1 mins.	30 mins.	1 min.
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 Card Status	K Bus OK			
This cell indicates the status of the communication card.				
RP1 Port Config.	KBus	KBus or EIA(RS)485		
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	IEC60870 FT1.2 Frame	IEC60870 FT1.2 Frame or 10-Bit No Parity		
The choice is either IEC60870 FT1.2 for normal operation with 11-bit modems, or 10-bit no parity.				
RP1 Baud Rate	19200 bits/s	9600 bits/s, 19200 bits/s or 38400 bits/s		
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.				

ST

1.3.6.1.2 Rear port 2 connection settings

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

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
COMMUNICATIONS				
RP2 Protocol	Courier			
Indicates the communications protocol that will be used on the rear communications port.				
RP2 Port Config.	RS232	EIA(RS)232, EIA(RS)485 or KBus		
This cell defines whether an electrical EIA(RS)232, EIA(RS)485 or KBus is being used for communication.				
RP2 Comms. Mode	IEC60870 FT1.2 Frame	IEC60870 FT1.2 Frame or 10-Bit No Parity		
The choice is either IEC60870 FT1.2 for normal operation with 11-bit modems, or 10-bit no parity.				

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
RP2 Address	255	0	255	1
This cell sets the unique address for the relay such that only one relay is accessed by master station software.				
RP2 Inactivity Timer	15 mins.	1 mins.	30 mins.	1 min.
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	19200 bits/s	9600 bits/s, 19200 bits/s or 38400 bits/s		
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.				

ST

1.3.6.1.3 Ethernet port

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
NIC Protocol	IEC 61850			
Indicates that IEC 61850 will be used on the rear Ethernet port.				
NIC MAC Address	*Ethernet MAC Address*			
Indicates the MAC address of the rear Ethernet port.				
NIC Tunl Timeout	5 mins	1 min	30 mins	1 min
Duration of time waited before an inactive tunnel to MiCOM S1 is reset.				
NIC Link Report	Alarm	Alarm, Event, None		
Configures how a failed/unfitted network link (copper or fiber) is reported:				
Alarm - an alarm is raised for a failed link				
Event - an event is logged for a failed link				
None - nothing reported for a failed link				
NIC Link Timeout	60s	0.1s	60s	0.1s
Duration of time waited, after failed network link is detected, before communication by the alternative media interface is attempted.				

ST

1.3.7   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.

Menu Text	Default Setting	Available Settings
COMMISSION TESTS		
Opto I/P Status	00000000000000000000000000000000	
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		
Opto I/P Status2	00000000	
Status of the next relay's opto-isolated inputs (L33 to L40)		
Rly O/P Status	00000000000000000000000000000000	
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	00000000	
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	Relay Label 01	0 to 1022 See PSL section for details of digital data bus signals
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	Relay Label 08	0 to 1022
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	Disabled	Disabled / Contacts blocked / Test Mode
The Test Mode menu cell is used to allow secondary injection testing to be performed on a Peripheral Unit relay without operation of the connected zone. 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 'Contact blocked', which takes the relay 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 'Out of Service' is given. The 87BB and 50BF protections are in service as long as the cells '87BB Monitoring' and '87BB & 50BF disabl' are equal to 0. Once testing is complete the cell must be set back to 'Disabled' to restore the relay back to service.		
Test Pattern	0000000000000000	0 = Not Operated 1 = Operated
This cell is used to select the output relay contacts that will be tested when the 'Contact Test' cell is set to 'Apply Test'.		

Menu Text	Default Setting	Available Settings
Contact Test	No Operation	No Operation, Apply Test, 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.

Menu Text	Default Setting	Available Settings
Test LEDs	No Operation	No Operation 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	000001000100000000	

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	000001000100000000	

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.

DDB 31 - 0	00000000000000000000000000000000	

Displays the status of DDB signals 0 – 31.

DDB 2047 - 2016	00000000000000000000000000000000	

Displays the status of DDB signals 2047 – 2016.

ST

1.3.8   Opto configuration

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
OPTO CONFIG.				
Global Nominal V	48/54V	24/27V, 30/34V, 48/54V, 110/125V, 220/250V, 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.

Opto Filter Ctrl	11111111111111111111111111111111			

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	11111111			

Controls the next relay's opto-isolated inputs (L33 to L40).

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

Controls the changement of state of opto isolated inputs, according to the nominal voltage value.

1.3.9   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.

Menu Text	Default Setting	Setting Range	Step Size
CTRL I/P CONFIG.			
Hotkey Enabled	1111111111111111111111111111111		
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	Latched	Latched, Pulsed	
Configures the control inputs as either 'latched' or 'pulsed'. A latched control input will remain in the set state until a reset command is given, either by the menu or the serial communications. A pulsed control input, however, will remain energized for 10ms after the set command is given and will then reset automatically (i.e. no reset command required) .			
Ctrl command 1	Set/Reset	Set/Reset, ON/OFF, Enabled/Disabled, IN/OUT	
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 1 to 32	Latched	Latched, Pulsed	
Configures the control inputs as either 'No Operation', 'Set' or 'reset'.			
Ctrl command 2 to 32	Set/Reset	Set/Reset, ON/OFF, Enabled/Disabled, IN/OUT	
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.			

ST

1.3.10   Function keys

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
FUNCTION KEYS				
Fn. Key Status	0000000000			
Displays the status of each function key.				
Fn. Key 1 Status	Unlocked	Disabled, Locked, Unlock		
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	Normal	Toggled, Normal		
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	Function Key 1			
Allows the text of the function key to be changed to something more suitable for the application.				

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Fn. Key 2 to 10 Status	Unlocked	Disabled, Locked, Unlock		
Setting to activate function key. The 'Lock' setting allows a function key output that is set to toggle mode to be locked in its current active position.				
Fn. Key 2 to 10 Mode	Toggled	Toggled, Normal		
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 2 to 10 Label	Function Key 2 to 10			
Allows the text of the function key to be changed to something more suitable for the application.				

1.3.11 Control input labels

Menu Text	Default Setting	Setting Range	Step Size
CTRL I/P LABELS			
Control Input 1	Control Input 1	16 Character Text	
Setting 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 programmable scheme logic.			
Control Input 2 to 32	Control Input 2 to 32	16 Character Text	
Setting 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 programmable scheme logic.			

1.4 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.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
DISTURB. RECORDER				
Duration	600 s	100.0 ms	10.5 s	10.00 ms
This sets the overall recording time.				
Trigger Position	33.3%	0.0%	100.0%	0.10 %
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	Single	Single / Extended		
When set to single mode, if a further trigger occurs whilst a recording is taking place, the recorder will ignore the trigger.				

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
"ANALOG CHANNEL" submenus				
Analog. Channel 1	VAN	Any analog channel		
The Phase A calculated voltage is assigned to this channel.				
Analog. Channel 2	VBN	As above		
The Phase B calculated voltage is assigned to this channel.				
Analog. Channel 3	VCN	As above		
The Phase C calculated voltage is assigned to this channel.				
Analog. Channel 4	IA-T1/Ix-T1	As above		
The terminal 1 phase A calculated current is assigned to this channel.				
Analog. Channel 5	IB-T1/Ix-T1	As above		
The Terminal 1 Phase B calculated current is assigned to this channel.				
Analog. Channel 6	IC-T1/Ix-T2	As above		
The Terminal 1 Phase C calculated current is assigned to this channel.				
Analog. Channel 7	IA-T2 /Ix-T3	As above		
The Terminal 2 Phase A calculated current is assigned to this channel.				
Analog. Channel 8	IB-T2/Ix-T4	As above		
The Terminal 2 Phase B calculated current is assigned to this channel..				
Analog. Channel 9	IC-T2/Ix-T5	As above		
The Terminal 2 Phase C calculated current is assigned to this channel.				
Analog. Channel 10	IA-T3/Ix-T6	As above		
The Terminal 3 Phase A calculated current is assigned to this channel.				
Analog. Channel 11	IB-T3/Ix-T7	As above		
The Terminal 3 Phase B calculated current is assigned to this channel.				
Analog. Channel 12	IC-T3/Ix-T8	As above		
The Terminal 3 Phase C calculated current is assigned to this channel.				
Analog. Channel 13	IA-T4/Ix-T9	As above		
The Terminal 4 Phase A calculated current is assigned to this channel.				
Analog. Channel 14	IB-T4/Ix-T10	As above		
The Terminal 4 Phase B calculated current is assigned to this channel.				
Analog. Channel 15	IC-T4/Ix-T11	As above		
The Terminal 4 Phase C calculated current is assigned to this channel.				
Analog. Channel 16	IA-T5/Ix-T12	As above		
The Terminal 5 Phase A calculated current is assigned to this channel.				
Analog. Channel 17	IB-T5/Ix-T13	As above		
The Terminal 5 Phase B calculated current is assigned to this channel.				
Analog. Channel 18	IC-T5/Ix-T14	As above		
The Terminal 5 Phase C calculated current is assigned to this channel.				
Analog. Channel 19	IA-T6/Ix-T15	As above		
The Terminal 6 Phase A calculated current is assigned to this channel.				

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Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Analog. Channel 20	IB-T6/Ix-T16	As above		
The Terminal 6 Phase B calculated current is assigned to this channel.				
Analog. Channel 21	IC-T6/Ix-T17	As above		
The Terminal 6 Phase C calculated current is assigned to this channel.				
"DIGITAL INPUT" and "INPUT TRIGGER" submenus				
Digital Input 1	Output R1	Any O/P Contacts or Any Opto Inputs or Internal Digital Signals		
The relay 1 output digital channel is assigned to this channel. The digital channel will trigger the disturbance recorder when the corresponding assigned fault will occur. In this case, the digital recorder will trigger when the output R1will change. Following lines indicate default signals for the 32 channels.				
Input 1 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
This digital channel will not trigger the Disturbance recorder. When "Trigger L/H" is selected, the channel will trigger the disturbance recorder when changing from '0' (low Level) to '1' (High level). If "Trigger H/L" is selected, it will trigger when changing from '1' (high level) to '0' (low level). Following lines give default settings up to channel 32.				
Digital Input 2	Output R2	As above		
The relay 2 output digital channel is assigned to this channel.				
Input 2 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 3	Output R3	As above		
Relay 3 output digital channel.				
Input 3 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 4	Output R4	As above		
Relay 4 output digital channel.				
Input 4 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 5	Output R5	As above		
Relay 5 output digital channel.				
Input 5 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 6	Output R6	As above		
Relay 6 output digital channel.				
Input 6 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 7	Output R7	As above		
Relay 7 output digital channel.				
Input 7 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 8	Output R8	As above		
Relay 8 output digital channel.				
Input 8 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 9	Any Trip	As above		
Any trip				

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Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Input 9 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 10	Ouput R10	As above		
Relay 10 output digital channel.				
Input 10 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 11	Diff Fault Z1	As above		
Busbar Differential Fault in Zone 1				
Input 11 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 12	Diff Fault Z2	As above		
Busbar Differential Fault in Zone 2				
Input 12 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 13	Diff Fault CZ	As above		
Busbar Differential Fault in Check Zone				
Input 13 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 14	Idiff Start Z1	As above		
Differential current in main zone 1.				
Input 14 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 15	Idiff Start Z2	As above		
Differential current in main zone 2.				
Input 15 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 16	Idiff CZ Start	As above		
Differential current in Check Zone.				
Input 16 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 17	PhComp Blk Z1.	As above		
Phase comparision Block in zone 1.				
Input 17 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 18	PhComp Blk Z2.	As above		
Phase comparision Block in zone 2.				
Input 18 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 19	Unused	As above		
Unused.				
Input 19 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 20	Idiff Trip Z1	As above		
Differential busbar trip or gate of Z1 Diff phase in zone 1				
Input 20 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 21	Idiff Trip Z2	As above		
Differential busbar trip or gate of Z1 Diff phase in zone 2				
Input 21 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 22	CCtFail Blk Z1	As above		
Circuity Fault in zone 1				

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ST

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Input 22 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 23	CctFail Blk Z2	As above		
Circuity Fault in zone 2.				
Input 23 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 24	CctFail Blk CZ	As above		
Circuity Fault in check zone				
Input 24 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 25	Diff Z1 Blked	As above	10.5 s	0.01 s
Zone 1 Busbar Diff in Block Status				
Input 25 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 26	Diff Z2 Blked	As above	100.0%	0.1%
Zone 2 Busbar Diff in Block Status				
Input 26 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 27	Diff CZ Blked	As above		
Check Zone Busbar Diff in Block Status				
Input 27 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 28	Fault A	As above		
Phase A fault.				
Input 28 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 29	Fault B	As above		
Phase B fault				
Input 29 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 30	Fault C	As above		
Phase C fault				
Input 30 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 31	Fault N	As above		
Earth fault				
Input 31 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 32	Function key 10	As above		
Function Key 10 activated (in 'Normal' mode it is high on keypress and in 'Toggle' mode remains high/low on single keypress)				
Input 32 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		

OP

OPERATION

Date:	**2009**
Hardware Suffix:	**K**
Software Version:	**01**
Connection Diagrams:	**10P746xx (xx = 01 to 07)**

CONTENTS

OP

FIGURES

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1. OPERATION OF INDIVIDUAL PROTECTION FUNCTIONS

The following sections detail the individual protection functions.

Note however that 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 P746 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.

The figure includes the following equations:

$$I_i = |\Sigma \vec{I}_{in}|$$

$$I_o = |\Sigma \vec{I}_{on}|$$

$$I_{bias} = I_i + I_o$$

$$I_{diff} = I_i - I_o$$

Substation Simplified Scheme

Import $\Sigma \vec{I}_i$ Export $\Sigma \vec{I}_o$

P3766ENa
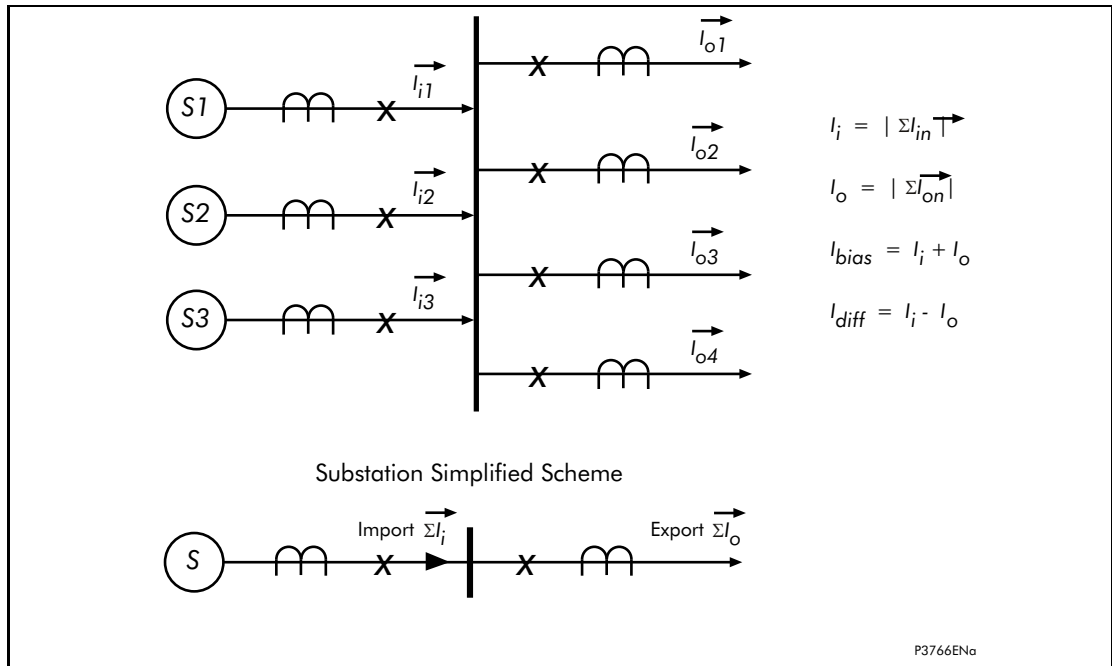
FIGURE 1: DIFFERENTIAL BUSBAR PROTECTION PRINCIPLE

1.1.2 Application of Kirchoffs law

Several methods of summation can be used for a differential protection scheme:

- Vector sum

- Instantaneous sum

The algorithms applied in MiCOM P746 use the vector sum method (on Fourier).

Differential currents may also be generated under external fault conditions due to CT error. To provide stability for through fault conditions the relay adopts a biasing technique, which effectively raises the setting of the relay in proportion to the through fault current thereby preventing relay maloperation.

The bias current is the scalar sum of the currents in the protected zone and for the check zone. Each of these calculations is done on a per phase basis for each node and then summated.

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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, (Figure 2) 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

$$i_{diff}(t) = \left| \Sigma\, i \right|$$

Bias or Restraining current

$$i_{bias}(t) = \Sigma \left| i \right|$$

Slope of the bias characteristic

$$kx$$

Tripping permitted by bias element for:

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

The main differential current element of MiCOM P746 will only be able to operate if the differential current reaches a threshold $I_Dx>2$. 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

Figure 2 shows the characteristics of the P746 scheme phase differential element.
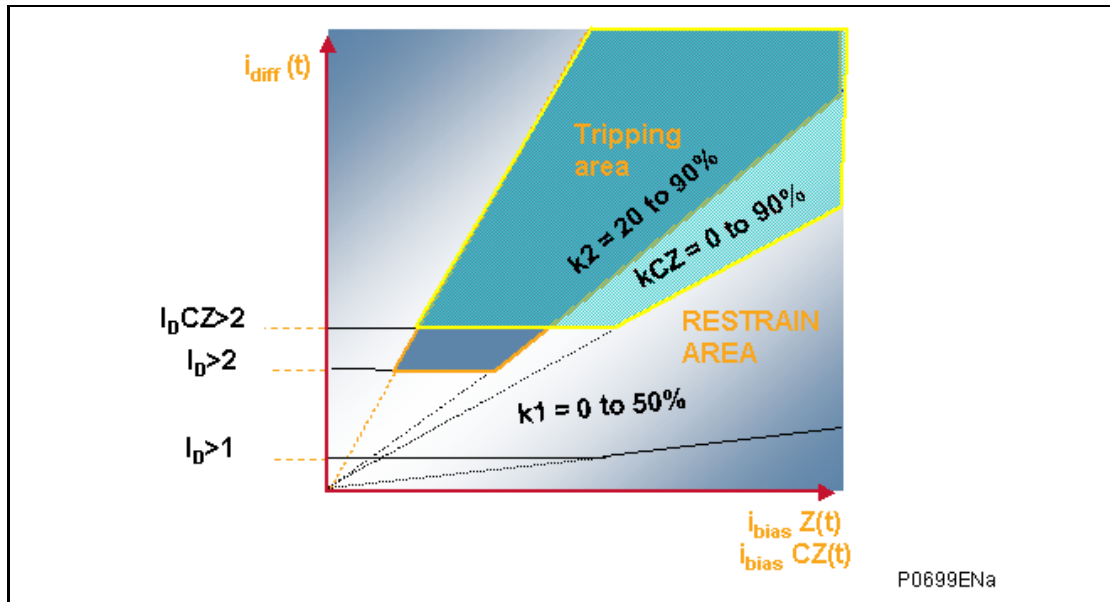
FIGURE 2: P746 SCHEME CHARACTERISTIC

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 ($k2 \times I_{bias}$) (k2 is the percentage bias setting ("slope") for the zone)

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

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 determined as an internal fault and initiate an unwanted trip of the busbar.

In order to avoid a risk of tripping under these circumstances, MiCOM P746 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 phase by phase snapshot of the 3 phase current angles is taken for each 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)

- The release criterion is that, phase by phase, all angles shall be within any 90° area*

- If only one current is taken into account it's an internal fault

*: Because of the CT requirements, the calculated phase of a saturated current can only vary from -90° to +90°.

Example:

1 bar, 1 incomer (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 getting in through CT1 and 100A are going 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 getting in through CT1 and 250A are going 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 getting in through CT1 and 600A are going 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 getting in through CT1 and 500A are going 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 P746 scheme 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 two currents with equal amplitude but of opposite sign in adjacent zones.

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

- Area above the $I_D CZ>2$ threshold check zone differential current threshold setting and the set slope of the bias characteristic ($kCZ \times I_{bias}$) (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 the sum of all the current nodes entering and leaving the substation (feeders).

Scheme differential current = sum of all differential current feeder nodes:

$i_{diff}(t)$ **CZ** $= \left| \Sigma \, i_{diff} \right|$

The Check Zone will operate as the Zone element.

1.2.4   Tripping Criteria

A trip signal for a zone will be issued:

1.   If the fault is detected in the zone AND

2.   confirmed by the check zone AND

3.   confirmed by the phase comparison.

For a fault to be detected, 4 trip criterions and 4 (optional) must be met; these criterions are:

For the Zone:

- If 2 consecutive calculations are above (ID>2) and k x Ibias

- Confirmation of the phase comparison algorithm

- Optional Voltage criteria (U< or V1< or V2> or 3V0>)

For the Check Zone:

- If 2 consecutive calculations are above (IDCZ>2) and kCZ x 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 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). Instead 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 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 and earth fault element which is only active when a dead zone is identified in the local topology.

OP

1.3.2   Circuit Breaker Fail (CBF)

The detailed logic of the circuit breaker failure element follows.

The P746 hardware corresponds to up to 6 circuit breaker 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.

1.3.2.1   Circuit Breaker Fail Reset Criteria

1.3.2.1.1 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.

1.3.2.1.2 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 P746, this method of detection is used and has the threshold I<.
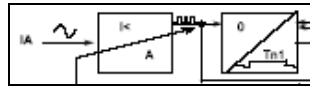
See figure 4, part for phase A.

> Note: The same algorithm is used for the other phases.

This 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 current has been ruptured, 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 chapters 1.3.2.1.3 and 1.3.2.1.4).

> 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).

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 neutral to confirm that the CB failure algorithm has started to count down.

OP

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 pl(t) signal. The latching duration is variable in order to take all cases into account:

- Just after the initiation of the CB fail signal, the waveform can include a DC component, and the time between two successive zero crossings can thus reach one 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).
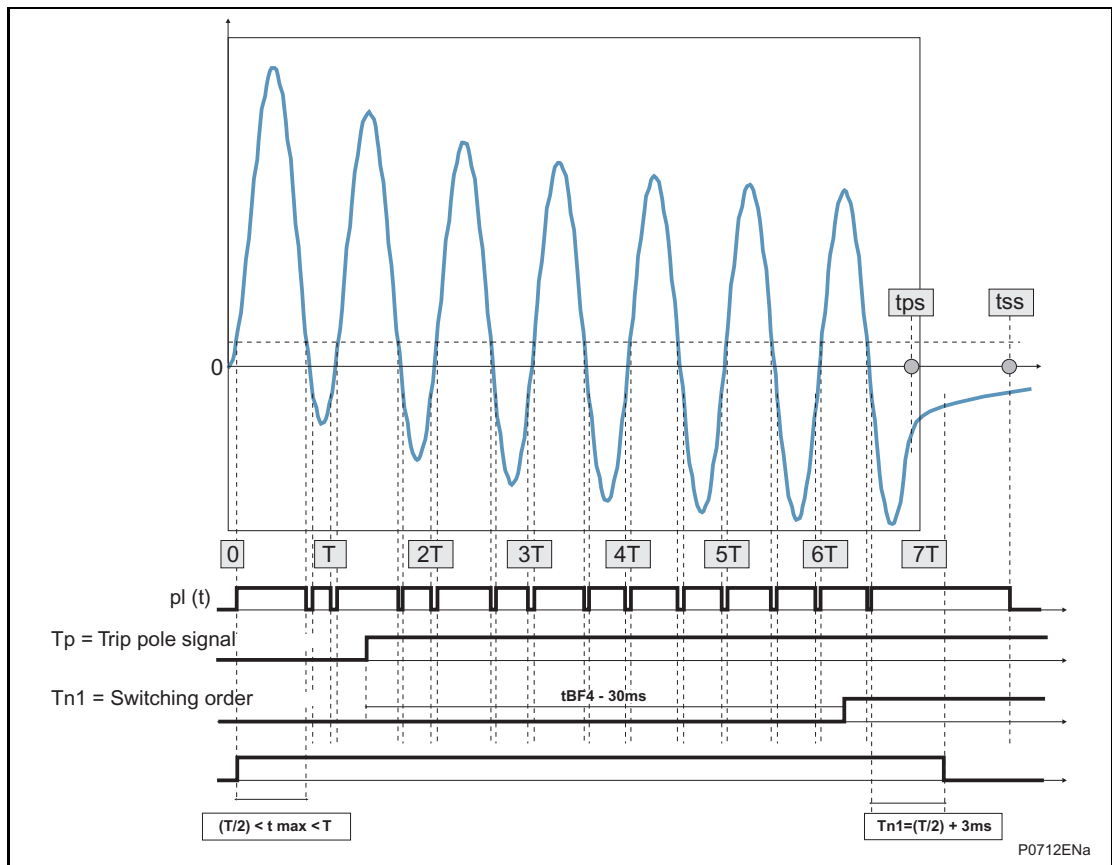
FIGURE 3: CB ELEMENT LOGIC

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 70 percent of the I< fundamental RMS 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 current ringdown 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 commuted 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.

1.3.2.1.3 Logic reset Criterion

OP

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 P746 protection system, this detection method is used with the '52a' threshold.

1.3.2.1.4 Logic AND Current reset Criterion

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 P746 protection system, this detection method is used with the 'I< AND 52a' (setting) threshold.

1.3.2.1.5 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.

Since the Overcurrent element may also be used in blocking schemes to provide back-up protection, it is possible to reset the Overcurrent start signals after the breaker fail time delay has elapsed. This ensures that the upstream back-up protection can be maintained by removal of the blocking signal. This would also ensure that the possible risk of re-trip on re-closure of the circuit breaker is minimised.

CB Trip 3 ph:

- Triphase Circuit Breaker Trip (Init 50BF TBF1 / TBF2), Logical OR of 87BB, 50BF, Manual Trip Zone X

Note: **The CB fail alarm is raised as soon as tBF1 or tBF2 or tBF3 or tBF4 has been reached (Logical OR of the signals 4, 5, 6, 7 in the following figure).**
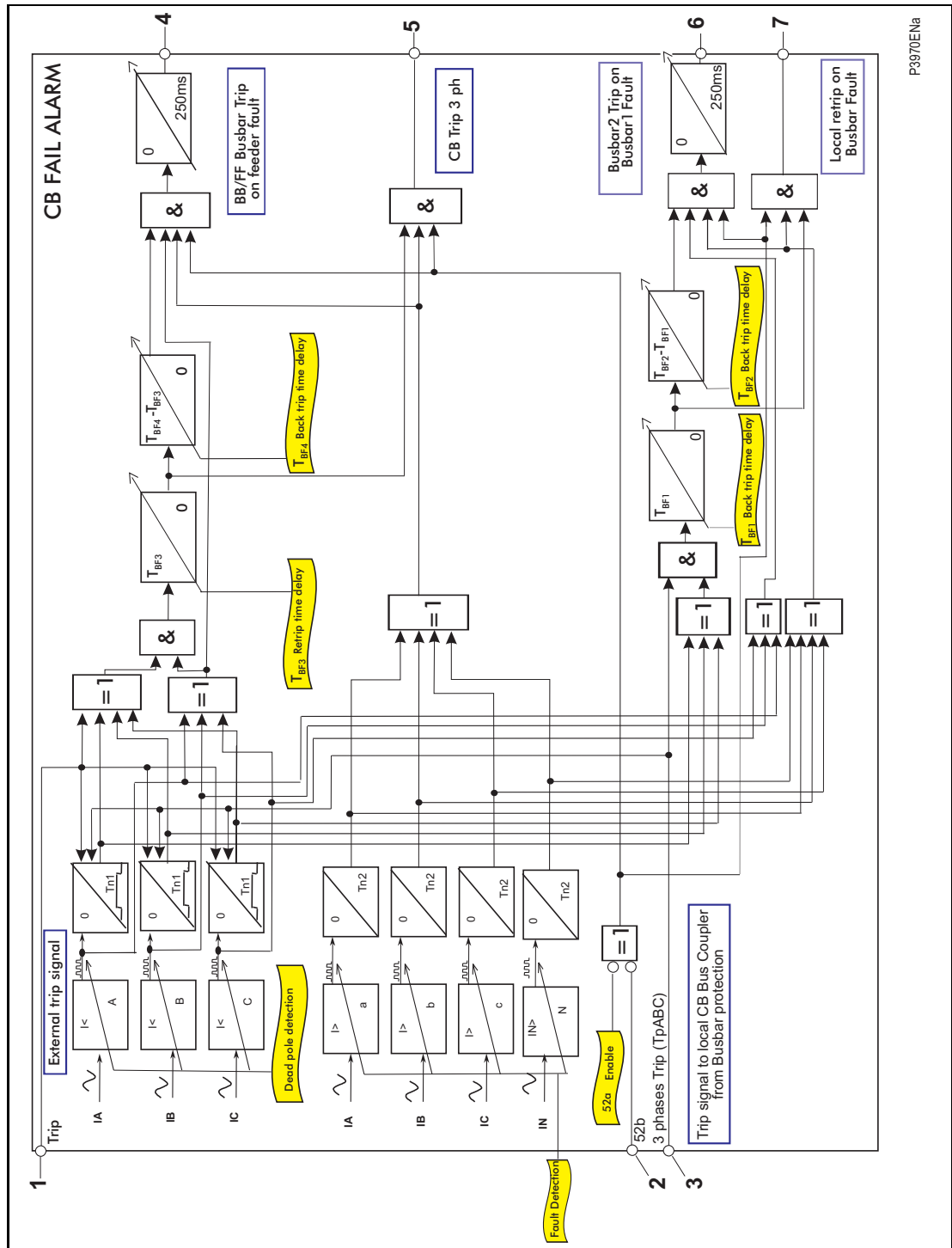
FIGURE 4: CB FAIL LOGIC

OP

1.3.2.1.6 Internally Initiated CBF i.e.

Tripping from the Differential Element 87BB

When a tripping order is generated by the busbar protection (87BB or 50BF) 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.

Optional: 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.

The tripping order from the busbar protection is referenced as Tp_{ABC}, it is always three-phase 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.

1.3.2.1.6.1 Description of the Logic for Internally Initiated CBF
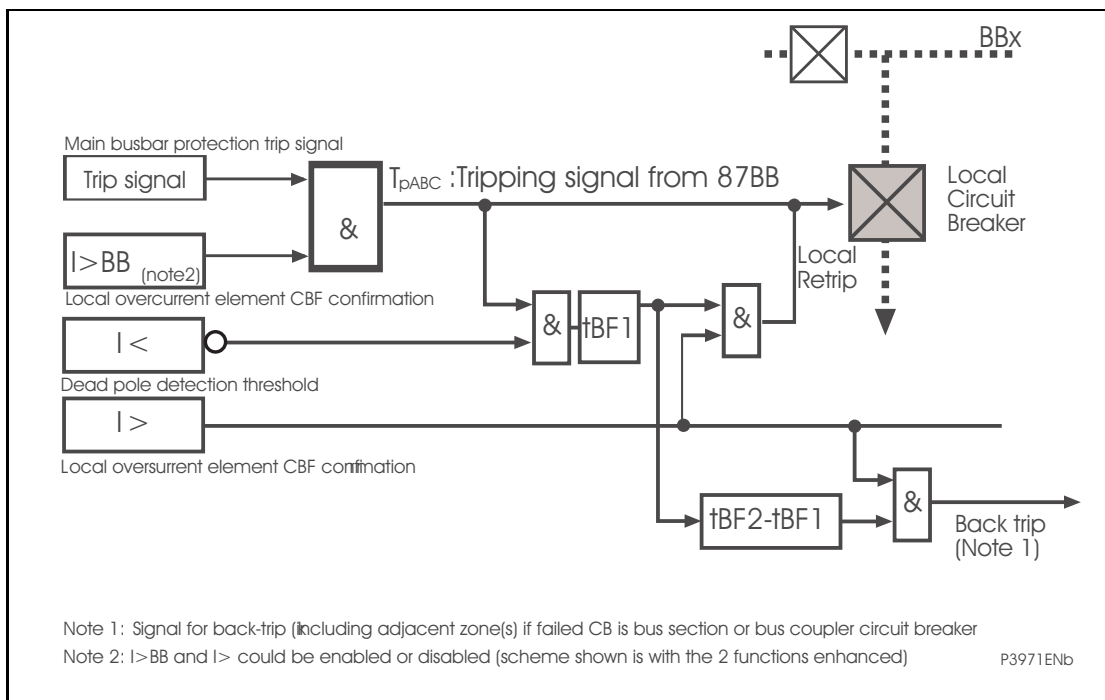
FIGURE 5: CB FAIL ELEMENT LOGIC – INTERNALLY INITIATED

1.3.2.1.6.2 Initial Trip

A trip signal is issued and then confirmed. If the (optional) threshold for the local Overcurrent protection setting for busbar protection (I>BB) is exceeded then the local circuit breaker trip coil is energised and subsequently the local circuit breaker is tripped.

1.3.2.1.6.3 Re-Trip after time tBF1

The dead pole detection threshold (I<) and external protection initiation (I>) trigger the first breaker failure timer (tBF1). This signal in turn is passed through an AND gate with the signal from the local Overcurrent protection for busbar protection (I>BB) (if a circuit breaker failure condition has evolved this will still be present) and a re-trip command is issued. Re-trip output contacts should be assigned using the PSL editor (including in default PSL settings).

1.3.2.1.6.4 Back-Trip after time tBF2

A signal from the first circuit breaker timer triggers the second breaker failure timer (tBF2). This in turn is passed through an AND gate with the signal from the local overcurrent protection for busbar protection (I>BB), if a circuit breaker failure condition has persisted this will still be present, and a general bus-zone back-trip signal 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 on the current state of the system. It is therefore of paramount importance that should an internally initiated scheme be implemented, the circuit breaker tripping order, must be thoroughly defined within the scheme topology to guarantee correct scheme operation.

1.3.2.1.7 Externally Initiated 50BF
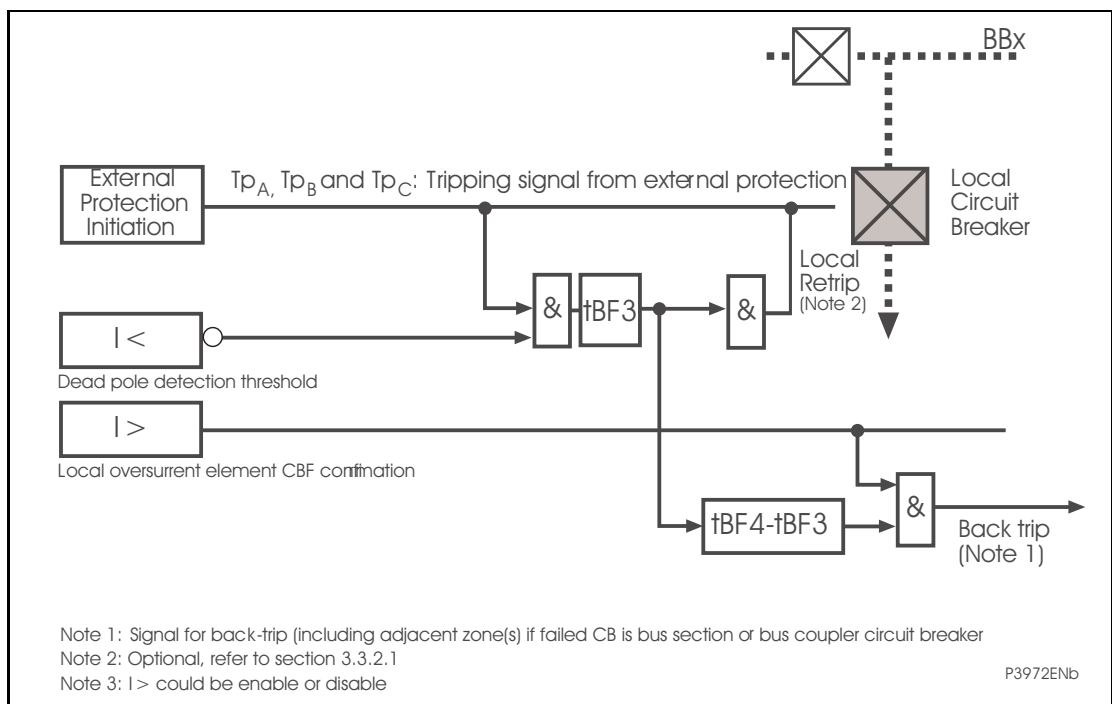
FIGURE 6: CB FAIL ELEMENT LOGIC – EXTERNALLY INITIATED

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. In the diagrams these signals are labelled Tp_A, Tp_B, Tp_C (Tripping pole A, B or C).

The logic is similar to that for internally initiated CB fail protection but utilises tBf3 for re-trip and tBF4 for back-trip functions.

1.3.2.1.8 Local re-trip after time tBf3

This re-trip command can be applied via either the main or back up trip coil. It is possible to choose between the 3 following modes:

- Local re-trip activated/deactivated via PSL. The relay used for this function can use the same fixed logic for the busbar protection or other independent relays.

- A re-trip can be applied after a time tBF3. This is typically set at 50ms when a single phase trip and re-trip is used. This prevents loss of phase selectivity by allowing the main protection trip to execute via the main CB trip coil before re-trip command is executed by the back-up CB trip coil.

- Single or three phase re-trip is possible. If the feeder protection executes single-phase tripping, the three-phase re-trip must be carried out in time tBF3 and this must be adjusted to have a value higher than the normal operation time of the circuit breaker. Typical setting under this condition is 150ms.

1.3.2.1.8.1 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.

Information is then relayed for routing, and the associated circuit breakers, in the adjacent zone(s) for a general three-phase back-trip.

1.3.2.1.9 CB Fail alarm

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

1.3.2.1.10 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. CB fail).

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.

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1.4   Three Phase Overcurrent Protection

1.4.1.1   Inverse Time (IDMT) Characteristic

IDMT characteristics are selectable from a choice of four IEC/UK and five IEEE/US curves as shown in the table below.

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
              I_S = 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
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	0.02394	0.02	0.01694

1.4.1.2   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.

OP

All inverse reset curves conform to the following formula:

$$t_{Reset} = \left(\frac{TD}{7} \right) \times \left(\frac{tr}{1 - (I/Is)^{\alpha}} \right)$$

Where: t_{Reset} = Reset time
             tr   = Constant
             I   = Measured current
             I_S = Current threshold setting
             α = Cconstant
             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

Inverse Reset Characteristics

1.5 Earth Fault Protection

1.5.1 EF time delay characteristics

The earth-fault measuring elements for EF and SEF are followed by an independently selectable time delay. These time delays are identical to those of the Phase Overcurrent time delay. The reset time delay is the same as the Phase overcurrent reset time.

1.5.2 External Fault Detection by High-Set Overcurrent or Earth Fault Element

An ultra high-speed detection is carried out and can generate a blocking signal from the moment of the first sample at 0.42 ms.

In this scenario de-saturation may not occur until after the scheme has eliminated the saturation condition for the external fault.

This function can be activated independently for phase faults (I>2) and for Earth Faults (I_N>2).

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 the following 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 Input 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 the following two conditions would apply:

- Auxiliary contacts / wiring defective

- Circuit Breaker (CB) is defective

If any of the above conditions exist, an alarm will be issued after a 200ms time delay. A normally open / normally closed output contact can be assigned to this function via the programmable scheme logic (PSL). The time delay is set to avoid unwanted operation during normal switching duties.

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

- None

- Both 52A and 52B   (triphase - 2 optos)

- Both 52A and 52B   (per phase - 6 optos)

OP

No CB status available directly affects any function within the relay that requires this signal, for example topology for buscoupler, etc.

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	State Unknown	Alarm raised if the condition persists for longer than 150ms
Open	Open	State Unknown	Alarm raised if the condition persists for longer than 150ms

In the bus sections and bus couplers, the position used in the topology algorithm is open when the 'CB State Detected' is 'Breaker Open'. In all others cases, the position closed will be used to calculate the topology. CB auxiliary contacts and CB closed command are definitely required for all bus-sections and bus-couplers.

They are not definitely required for feeders, but if the information is supplied to the scheme, better operation is possible:

• Dead Zone fault, the CB position is required (send remote trip order to the other end of the line).

• CB supervision.

In that case the best is to provide the Manual CB closing order.

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.

In the PSL:

If 52a is per pole, 52b should be per pole;

If 52a is 3phase, 52b should be 3phase too.

It is recommended to use early make late break contacts for the coupler breaker.

If they do not exist, the CB Close command shall be used to force closed the breaker during the closing process; this choice is made in the PSL.

P0715ENa
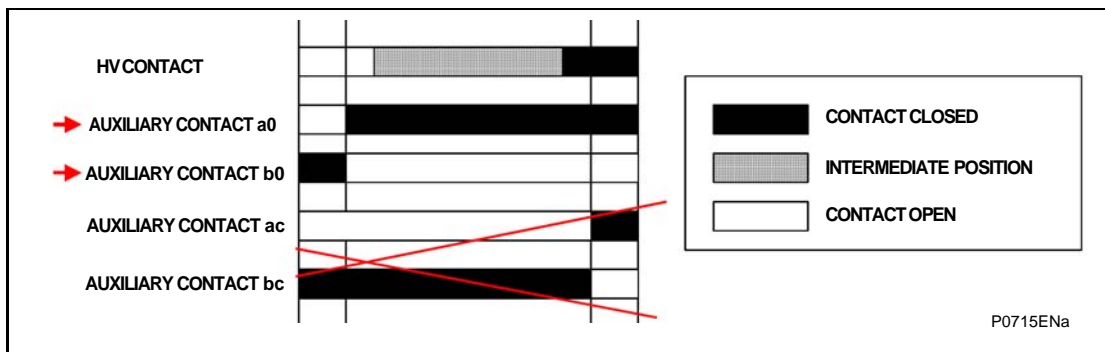
3. OPERATION OF NON PROTECTION FUNCTIONS

3.1 Programmable scheme logic

3.1.1 Level settings

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

3.1.2 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

3.2 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.

3.3 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.

3.4 Function keys

The P746 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 Settings section, P746/EN ST). 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.

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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. Please also 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.

3.5   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.

3.6   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	

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 800 – 831, 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	

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.

OP

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.

OP

AP

APPLICATION NOTES

Date:	**2009**
Hardware Suffix:	**K**
Software Version:	**01**
Connection Diagrams:	**10P746xx (xx = 01 to 07)**

CONTENTS

AP

AP

1. INTRODUCTION

Before carrying out any work on the equipment, the user should be familiar with the contents of the Safety Section/Safety Guide SFTY/4LM/H11 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 on 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.

AP

2.   APPLICATION OF INDIVIDUAL PROTECTION FUNCTIONS

The following sections detail protection functions in addition to where and how they may be applied. Each section provides some worked examples on how the settings are applied to the relay.
Up to 6 sets of CTs, the P746 scheme is made with a single relay.

Up to 18 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):

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: For the busbar protection reference **2 values** have to be entered:

1.   Phase reference CT Primary current (from 1 to 30000 A).

2.   Phase reference CT secondary current (1 or 5 A).

2.1.2   VT Ratios

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

1.   Phase VT Primary voltage (from 100 to 100 kV) given by the manufacturer.

2.   Phase VT secondary voltage (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)
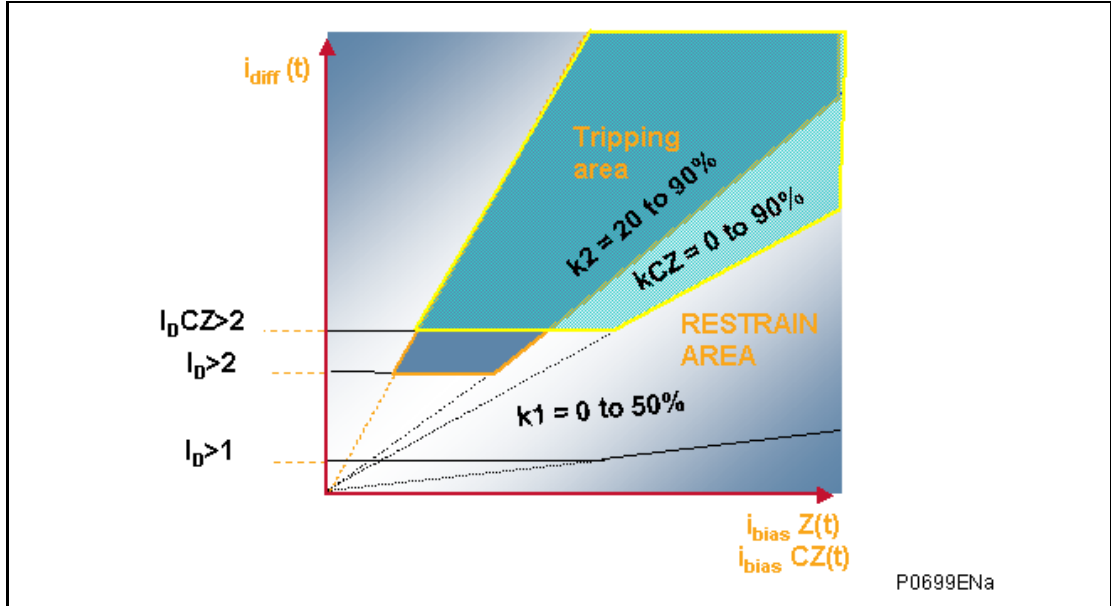
An Excel spreadsheet tool called "Idiff_Ibias" is available on request to assure a reliable setting choice:

AP
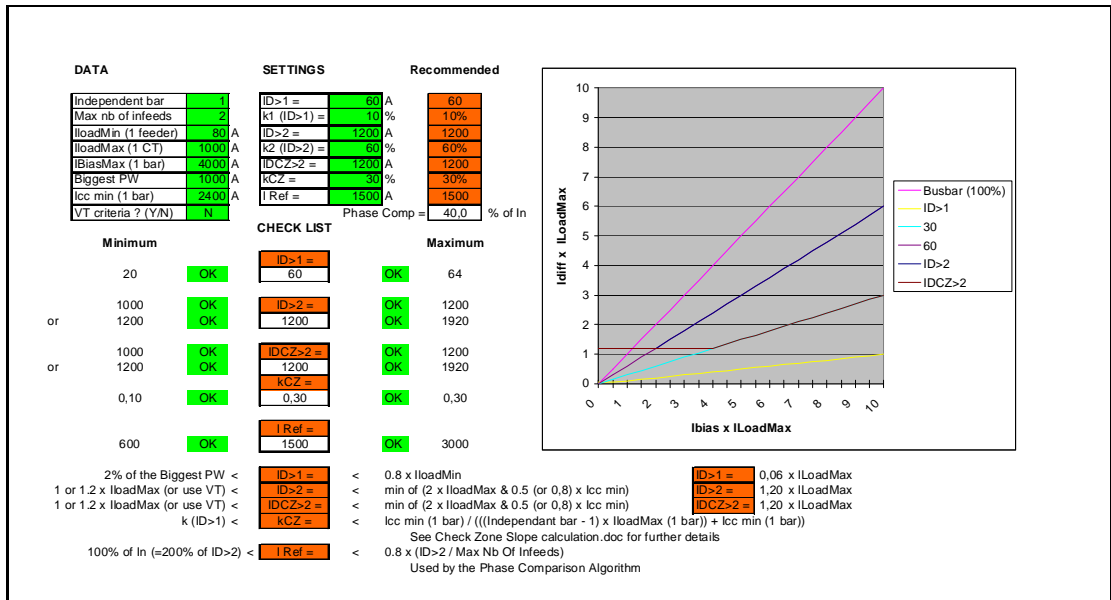
2.2.1.1.1 Sub-station features

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)

2.2.1.1.2 "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 7 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.

2.2.1.1.3 Differential Busbar Protection

1. ID>1 (from 5 A to 500 A (primary value)) as high as possible

2. Slope k1 (ID>1) (from 0% to 50%), recommendation is 10%

3. ID>2 (from 50 A to 50000 A (primary value)) as low as possible*, while ensuring the single CT failure will not cause tripping under maximum load conditions with no VT.

4. Slope k2 (ID>2) (from 20% to 90%), recommendation is generally 60%

5. IDCZ>2 (from 50 A to 50000 A (primary value)) as low as possible*

6. Slope kCZ (IDCZ>2) (from 0% to 90%), recommendation is generally 30%

7. ID>1 Alarm Timer (from 0 to 100 s) shall be greater than the longest protection time (such as line, overcurrent, etc.)

8. I Ref as recommended by the tool, recommendation depends on the number of infeeds

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 10Pxx 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: voltage criteria can be used for single busbar only in one box mode.

- and less than 80% of the minimum fault current to operate sub-cycle for the minimum fault (and 50% when possible to be sure to always operate in 13ms)

4. Slope k2 (ID>2)

a. Recommendation is 60%

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

      b.   Recommendation is 50% for China

In china, the requirement is to be able to detect a resistive fault equal to 50% of the bias current.

5.   IDCZ>2 same as ID>2

6.   Slope kCZ (IDCZ>2)

      a.   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) and depends on the number of bars:

- n bars (Independent bars)

- A minimum internal short-circuit value (Icc min (1 bar))

- A maximum load for a bar (IloadMax (1 bar)).

P3945ENa
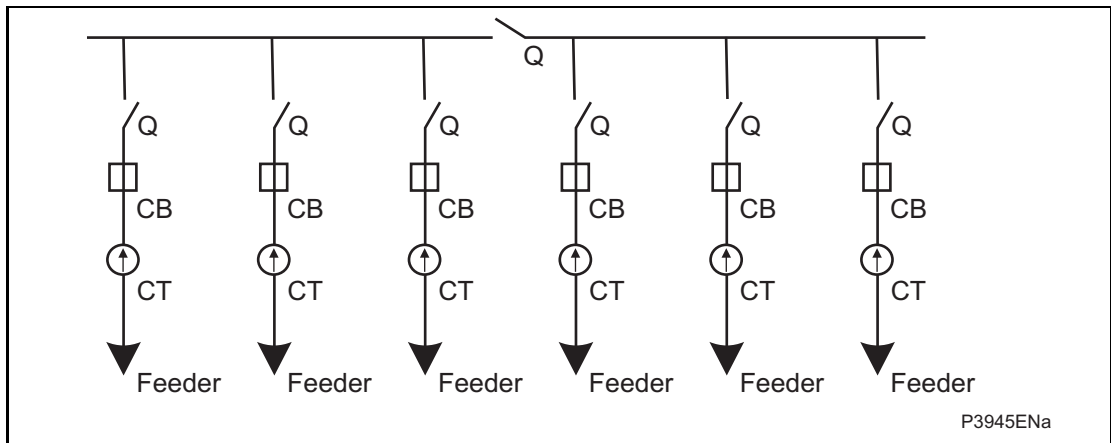
The worst case is:

- 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.

P3946ENa
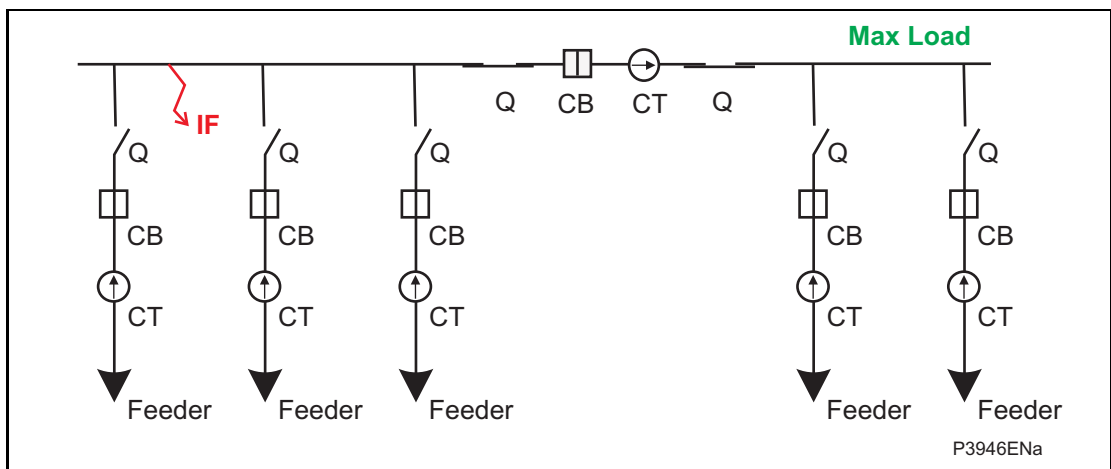
During the internal fault:

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

- the differential current is: Icc min (1 bar)

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

$$\frac{\text{Icc min (1 bar)}}{((\text{Independent bars - 1)} \times \text{IloadMax (1 bar))} + \text{Icc min (1 bar)}}$$

If for example:

There are 3 buses and Icc min = IloadMax, the slope must be below 33%

For a one and half breaker scheme there are:

- 2 bars (Independent bars)

- A minimum internal short-circuit value (Icc min (1 bar))

- A maximum load for a bar (IloadMax (1 bar)).

P0872ENa
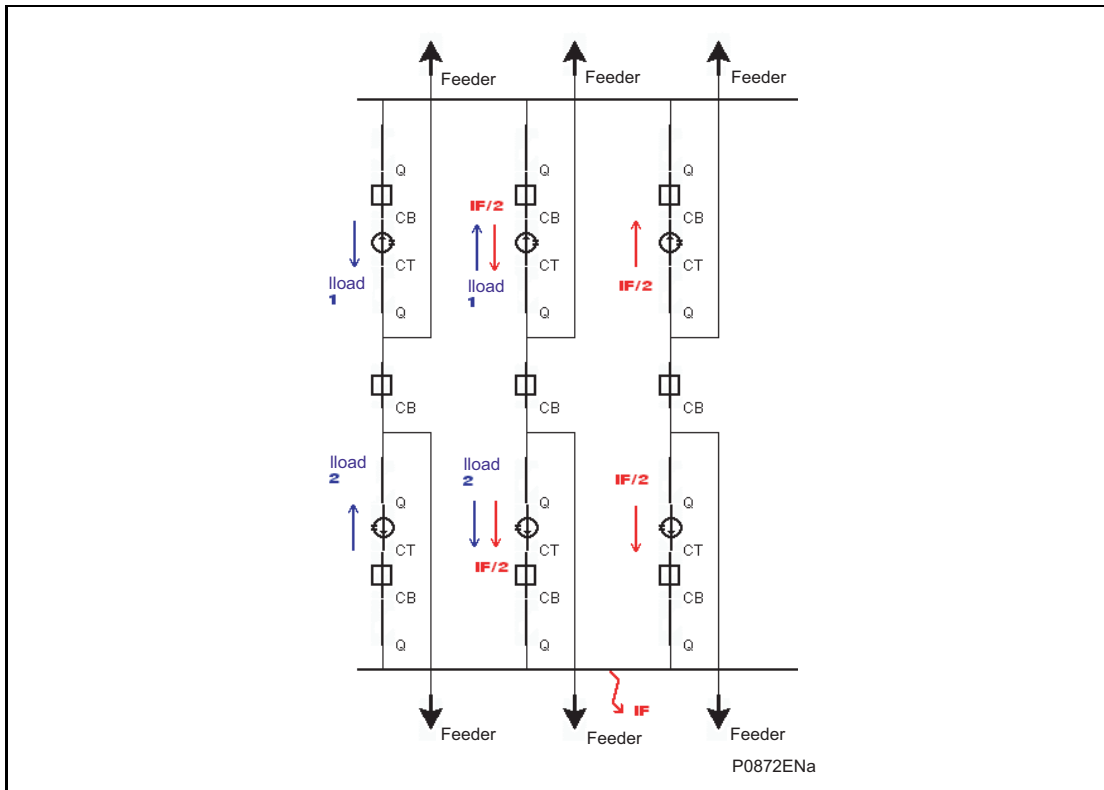
The worst case is:

- when the busbar is split in 2 and goes as well 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: Icc min (1 bar) + 4 x IloadMax (1 bar)

- the CZ differential current is: Icc min (1 bar)

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

$$\frac{\text{Icc min (1 bar)}}{(4 \times \text{IloadMax (1 bar))} + \text{Icc min (1 bar)}}$$

If for example:

Icc min = IloadMax, the slope must be below 20%

b. Recommendation is 25% for China

In china, the requirement is to be able to trip for a resistive fault that is counted twice by the Check Zone (for example one and half circuit breaker substation).

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. I Ref:

I Ref is used to define the minimum current to be included in the phase comparison algorithm; it is recommended to be 80% of (ID>2 / Max Nb Of Infeeds / 2) (the divided by 2 is hardcoded and compensate a x by 2)

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.

P3945ENa
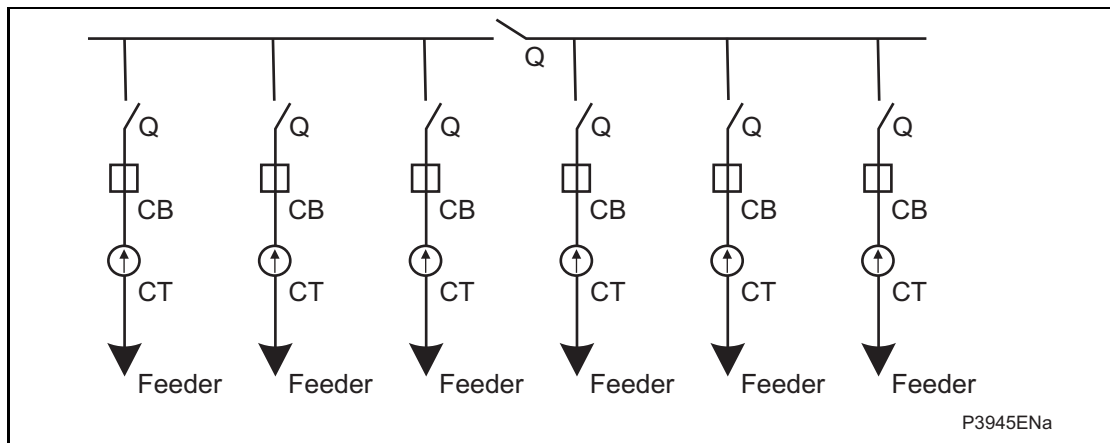
The worst scenario is when the CT is fully saturated and the differential algorithm picks up on the ID>2 threshold. The phase comparison must block the trip by detecting the incoming currents:

Number of Infeeds	Incoming current (min) as a percentage of the Outgoing current (min)
1.	100%
2.	50%
3.	33.3%
4.	25%
5.	20%
6.	16.6%
7.	Etc…

These percentages are directly proportional to the number of infeeds.

2.2.1.2   87BB Settings (Compensated Earthed Network Schemes)

2.2.1.2.1 Sub-station features

Only 5 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

2.2.1.2.2 Differential Busbar Protection

10 values have to be chosen:

1.   ID>1 (from 5 A to 500 A (primary value)), recommendation equal to 1,2 x (Ph-N Max.)

2.   Slope k1 (ID>1) (from 0% to 50%), recommendation is 10%.

3.   ID>1 Alarm Timer (from 0 to 100 s) shall be greater than the longest Busbar protection time

4.   Slope k2 (from 20% to 90%) but recommendation 65%.

5.   ID>2 (from 50 A to 50000 A (primary value)), recommendation is:

6.   Lower than 0,8 x (Ph-Ph min) and Higher than 1,2 x Iload Max and if possible equal to 6 x (ID>1).

7.   Slope kCZ (from 0% to 90%) but recommendation 30%.

8.   IDCZ>2 (from 50 A to 50000 A (primary value)), recommendation is:

9.   Lower than 0,8 x (Ph-Ph min) and Higher than 1,2 x Iload Max and if possible equal to 6 x (ID>1).

10.   I Ref as recommended, recommendation is around or below 50%

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 10Pxx current transformers

3.   ID>1 Alarm Timer to not operate for an external fault shall be greater than the longest protection time (such as line, overcurrent, etc…)

4.   Slope k2 (ID>2) recommendation is 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 x (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).

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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.

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 if the CB status positions are used (any value otherwise)

IMPORTANT NOTE:

When 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).

AP

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.

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:
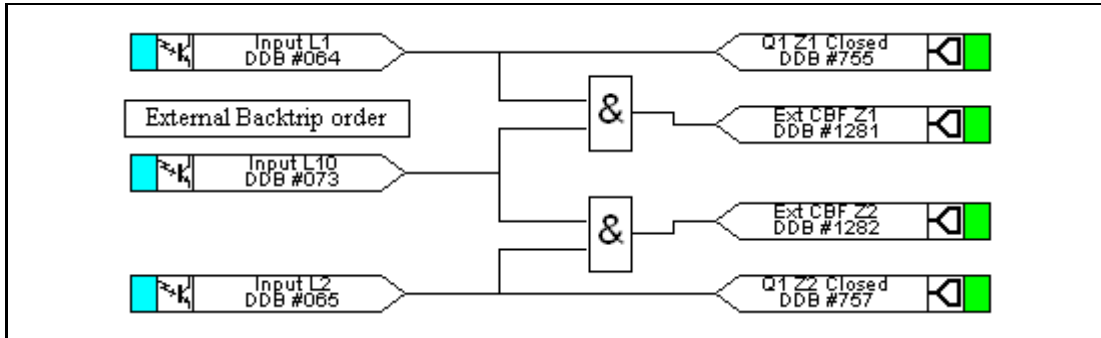
FIGURE 1: EXTERNAL BACKTRIP ORDER

AP

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 sent by the P746 to the P746 that undertakes scheme calculations.

In the P746, a settable common virtual current transformer of is used to convert to secondary values and more important is used as a setting for the phase comparison algorithm.

3.1.1.1 Setting guidelines

From 1 to 30000 by default 1000/1.

See the busbar protection setting guideline.

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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
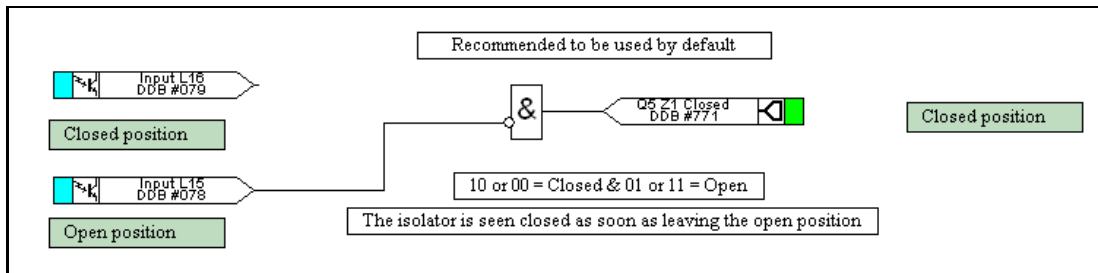
In that case, in the P746 topology, the position will be forced as closed as soon as the isolator will leave the open position.

4.1.2   Use of the two positions information
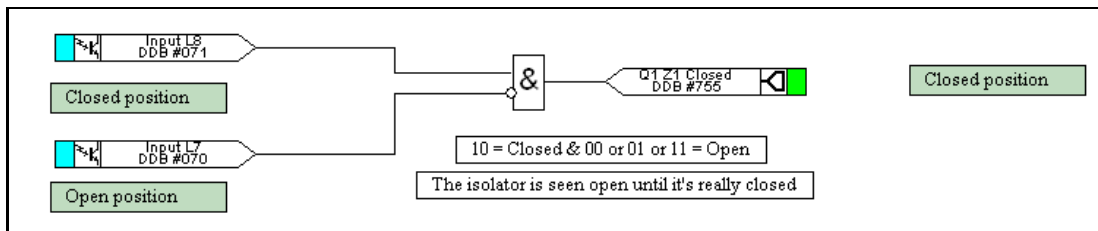
In that case, in the P746 topology, the position will be forced as open as soon as the isolator will leave the closed position.

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
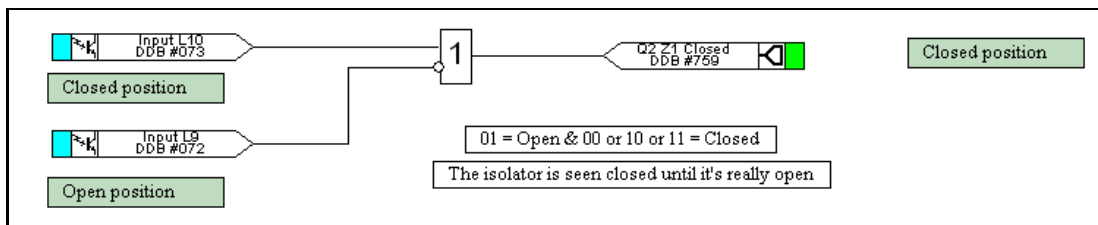
In that case, in the P746 topology, the position will be forced as closed as soon as the isolator will leave the open position.

4.1.4   Use of the two positions information
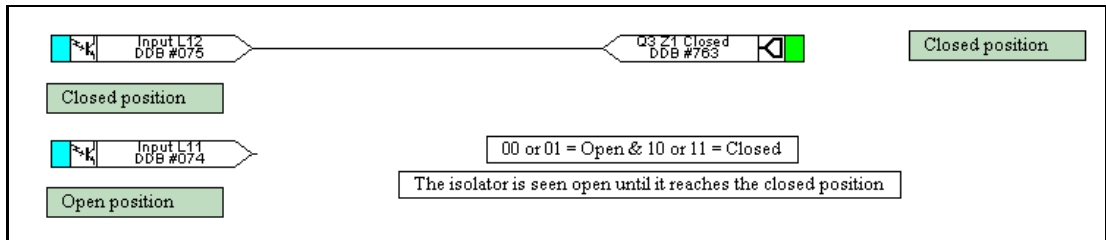
In that case, in the P746 topology, the position will be seen closed only when the isolator will arrive at the closed position.
This is not recommended as the P746 may trip in 2 steps instead of 1 in case of a fault appearing during the closing period of the isolator.

4.1.5   Use of the two positions information
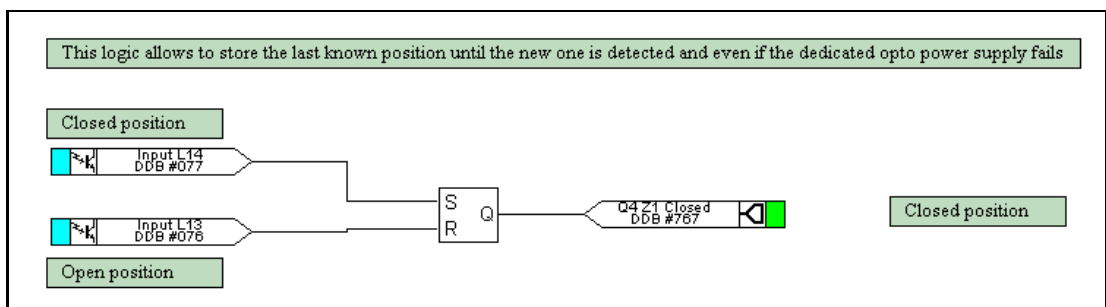
In that case, in the P746 topology, the position will be seen closed only when the isolator will arrive at the closed position and seen open only when the isolator will arrive at the open position.

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:
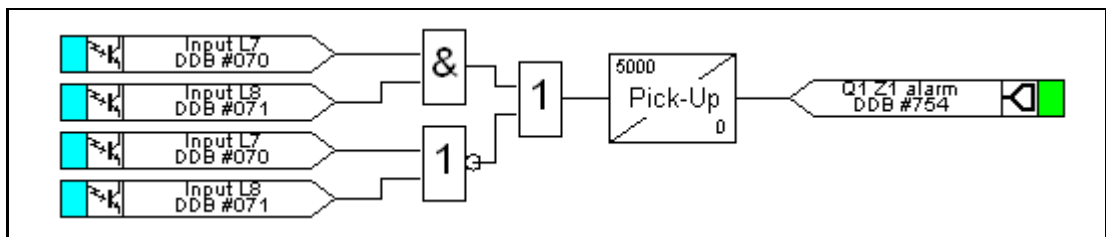
4.2   Circuit breaker state monitoring

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.

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4.3   Trip relays and Trip Circuit Supervision

Any relays contact can be used for tripping signals from busbar protection, overcurrent protection and breaker failure.

The trip circuit, in most protective schemes, extends beyond the relay 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 schemes with various features can be produced with the P746. Although there are no dedicated settings for TCS, in 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. If necessary, the user alarm can be re-named using the menu text editor to indicate that there is a fault with the trip circuit.

4.3.1   TCS scheme 1

4.3.1.1   Scheme description
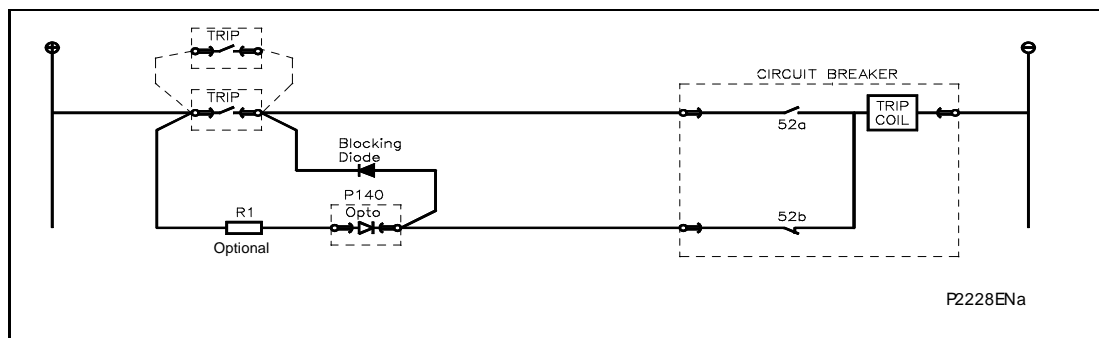
FIGURE 2: TCS SCHEME 1

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. Therefore, no supervision of the trip path is provided while 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 1**: SCHEME 1** OPTIONAL R1 **OPTO INPUT** RESISTOR VALUES

4.3.2 Scheme 1 PSL

Figure 2 shows the scheme logic diagram for the TCS scheme 1. Any of the available opto inputs can be used to indicate 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 and user alarms are reset.

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

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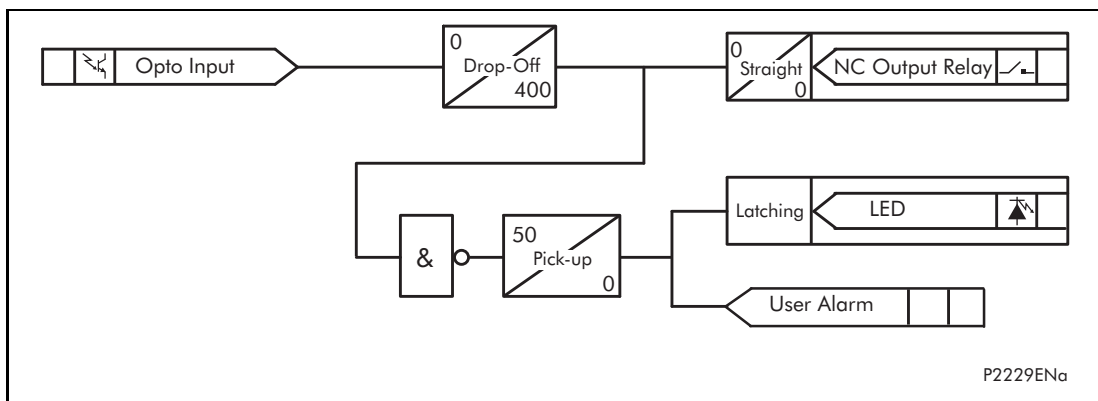
FIGURE 3: PSL FOR TCS SCHEMES 1 AND 3

4.3.3   TCS scheme 2

4.3.3.1   Scheme description
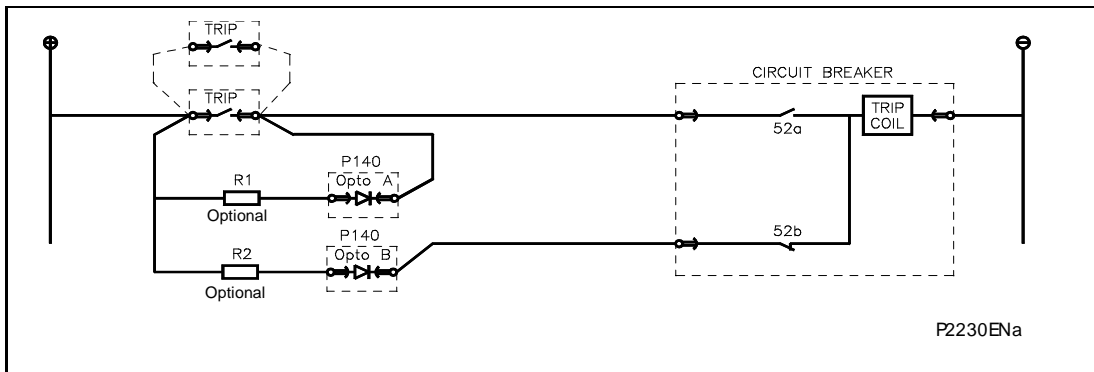
FIGURE 4: TCS SCHEME 2

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. Provided the "Circuit Breaker Status" is set to "52a
and 52b" (CB CONTROL column) the relay will correctly monitor the status of the breaker.
This scheme is also fully compatible with latched contacts as the supervision current will be
maintained through the 52b contact when the trip contact is closed.

When the breaker is closed, supervision current passes through opto input A and the trip
coil. When the breaker is open current flows through opto input B and the trip coil. As with
scheme 1, no supervision of the trip path is provided while the breaker is open. Any fault in
the trip path will only be detected on CB closing, after a 400ms 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 (Figure 4) 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.
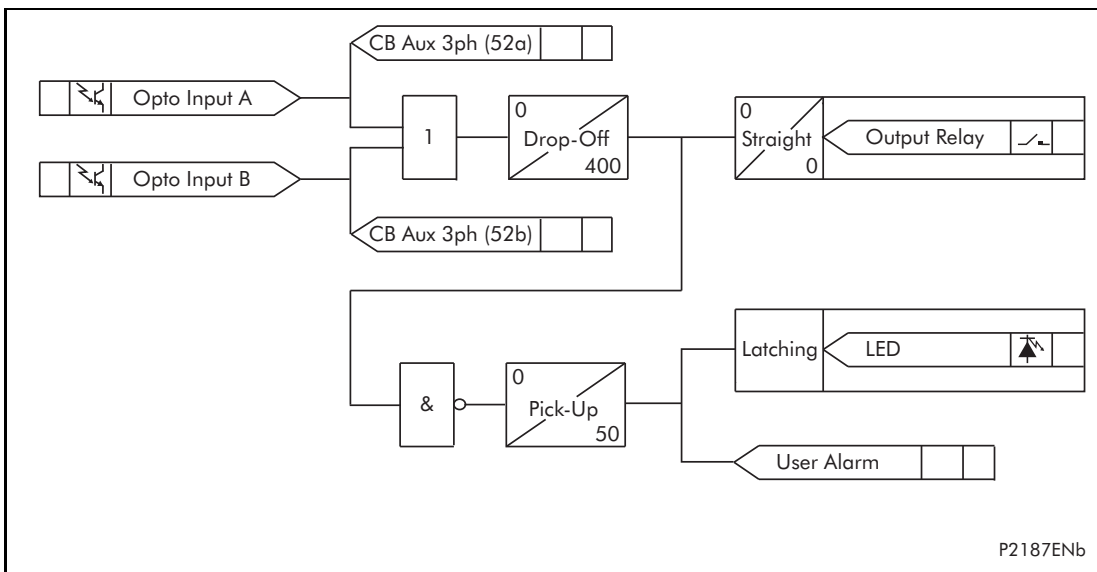
FIGURE 5: PSL FOR TCS SCHEME 2

4.3.5   TCS scheme 3

4.3.5.1   Scheme description
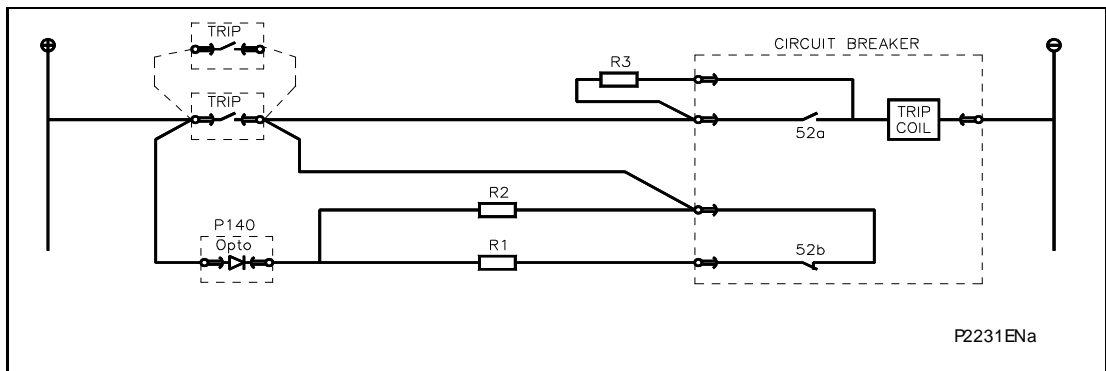
FIGURE 6: TCS SCHEME 3

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, therefore 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 2: 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 (see Figure 2).

5.   ISOLATION AND REDUCED FUNCTION MODE

The scheme permits maintenance on the busbar and, or busbar protection while 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 follow.

87BB Blocked & 50BF disabled:

It's a per zone selection.

In this mode, both the busbar and circuit breaker fail 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 output relays to the breakers connected to that selected zone and dead 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

AP

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. Therefore 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 utilized in the P746 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 the connection n°1 is on the right and increasing to the left up to 6 for one box mode and up to 18 for three boxes mode.

Z1 Terminals   000011 to be set to 1 if the terminal connection can only be to Zone 1

Z2 Terminals   000100 to be set to 1 if the terminal connection can only be to Zone 2

Xfer Terminals   001000 to be set to 1 if the terminal connection can be to Zone 1 or Zone 2

ChZONE Terminal   001111 to be set to 1 if the terminal connection is part of the Check Zone

AP

If there is no bus coupling or it is an isolator all the following settings shall be none.

For Bus coupling by Breaker with 1 CT

Z1 Bus CT   CT6 is the number of the CT used

Z1 Bus CT Pol   Inverted is the direction of the CT

Z2 Bus CT   CT6 is the number of the CT used

Z2 Bus CT Pol   Standard is the direction of the CT

For Bus coupling by Breaker with 2 CTs

Z1 Bus CT   CT5 is the number of the CT used

Z1 Bus CT Pol   Standard is the direction of the CT

Z2 Bus CT   CT6 is the number of the CT used

Z2 Bus CT Pol   Standard is the direction of the CT

Note: As the zone between the 2 CTs must belong to both zones, it is important to set the left CT to the right zone and vice versa.

6.2   Topology Monitoring Tool

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.
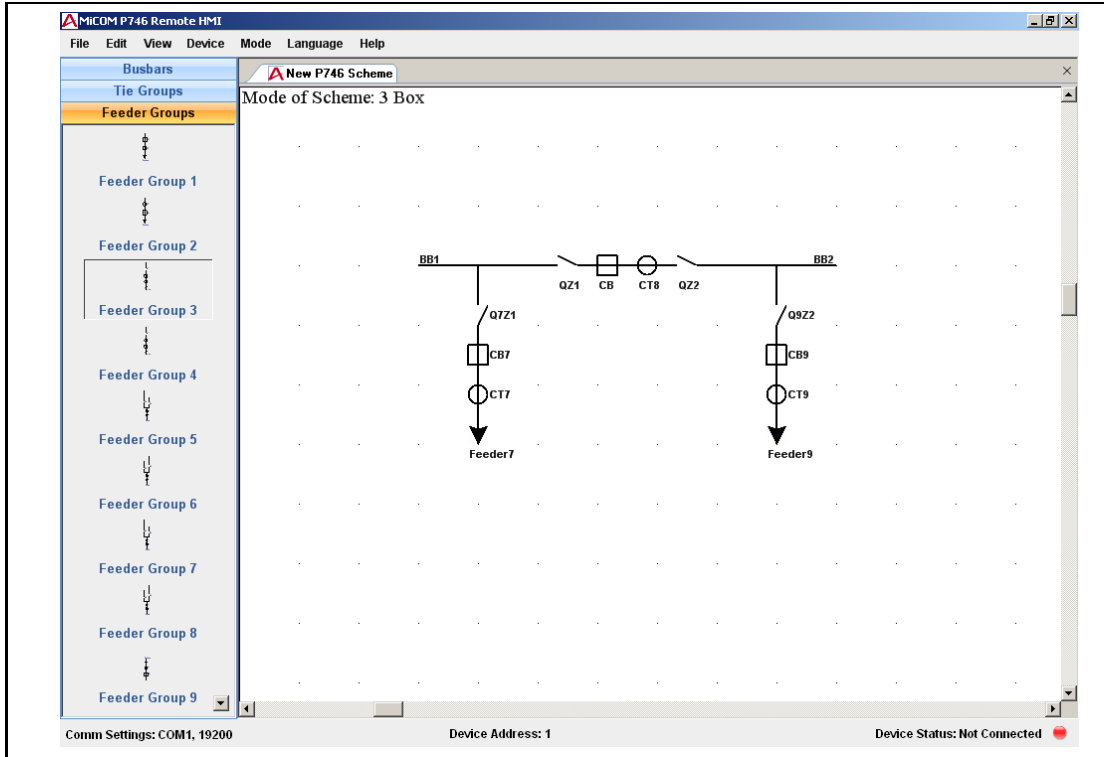
FIGURE 7: P746 SCHEME EDITOR
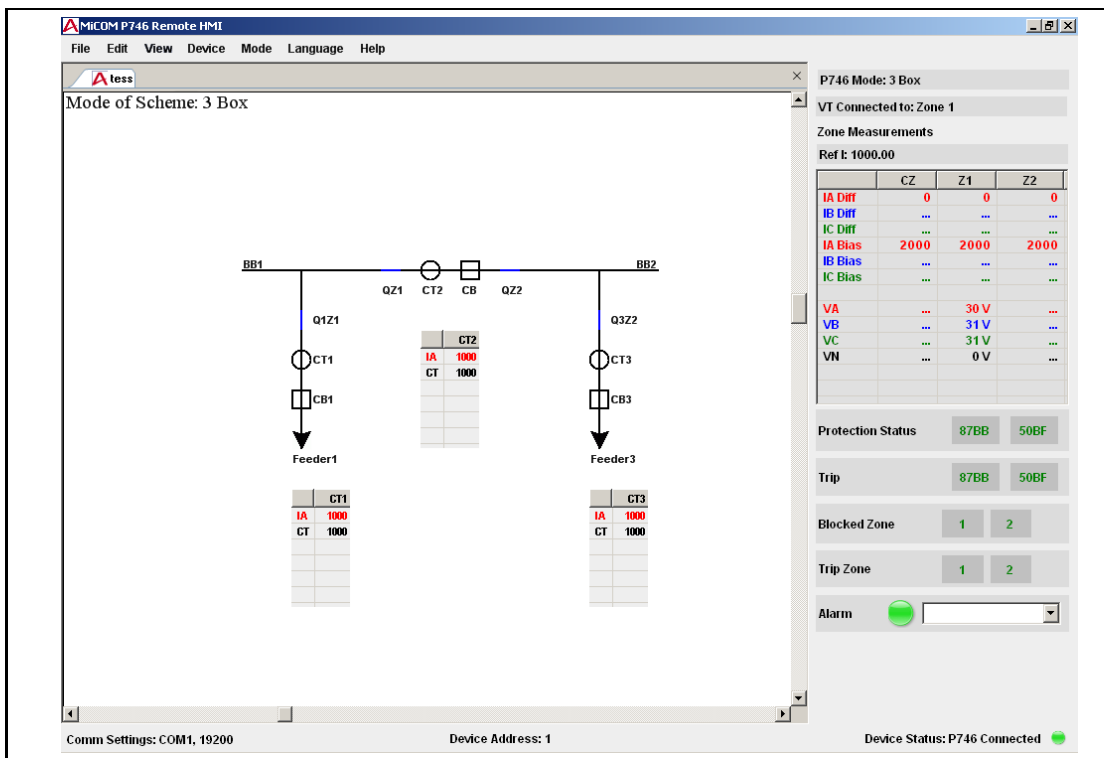
FIGURE 8: P746 SYNOPTIC

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 Single bar or double bus with bus sectionaliser
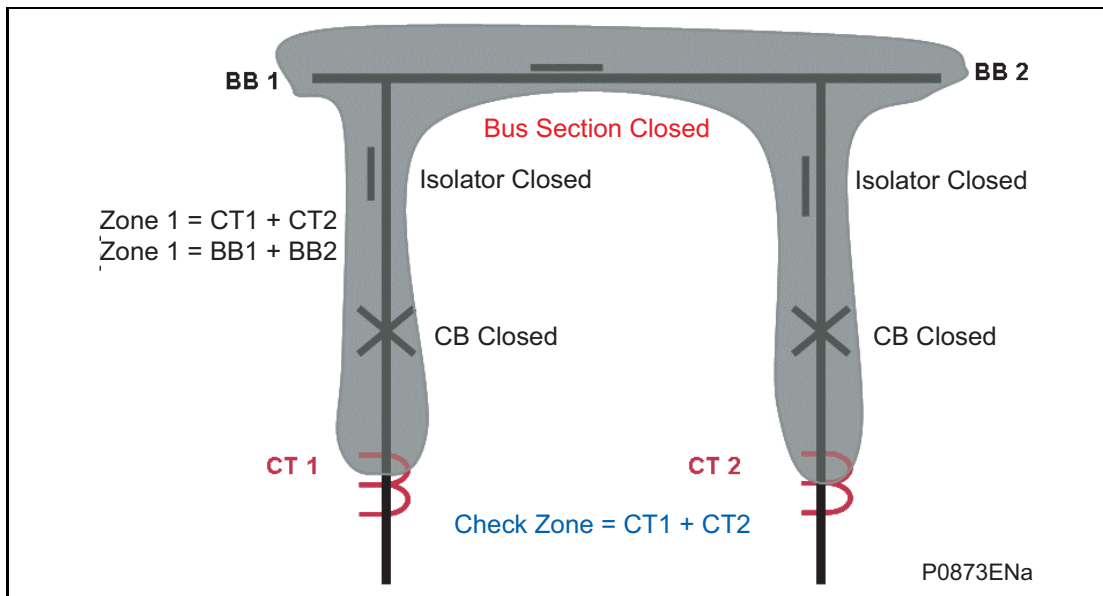
FIGURE 9: BUS SECTION CLOSED

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
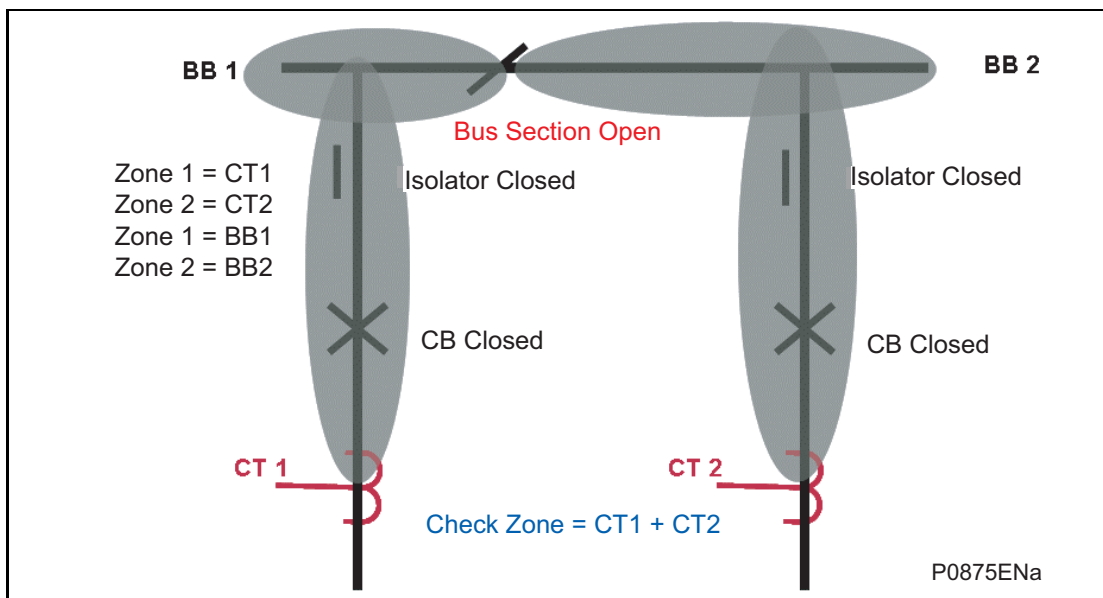
FIGURE 10: BUS SECTION OPEN

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   Double bus with one CT bus coupler
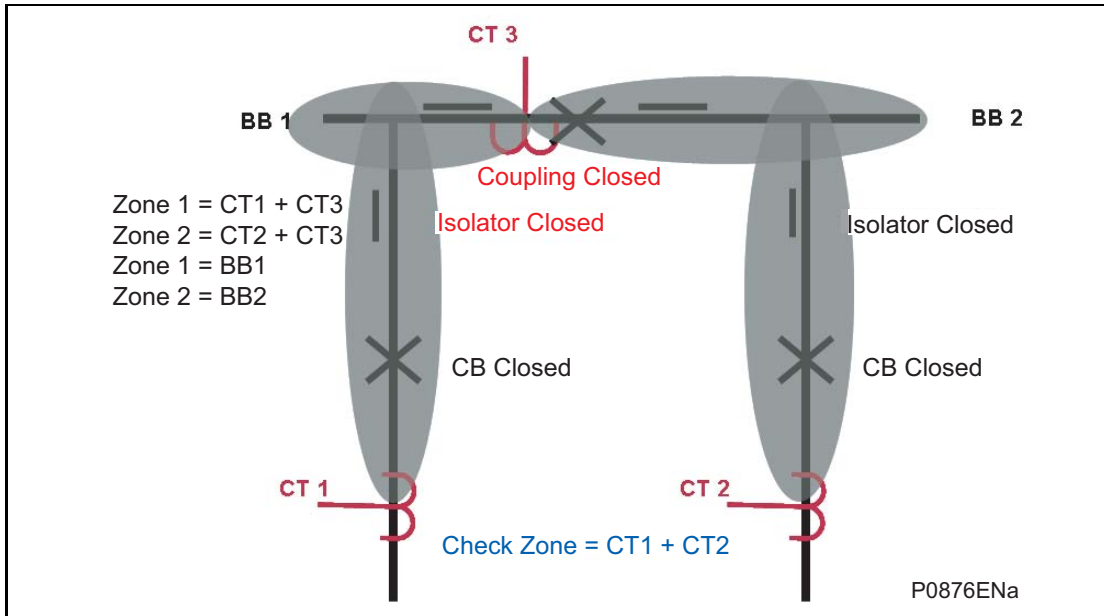
FIGURE 11: BUS COUPLER CLOSED

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.
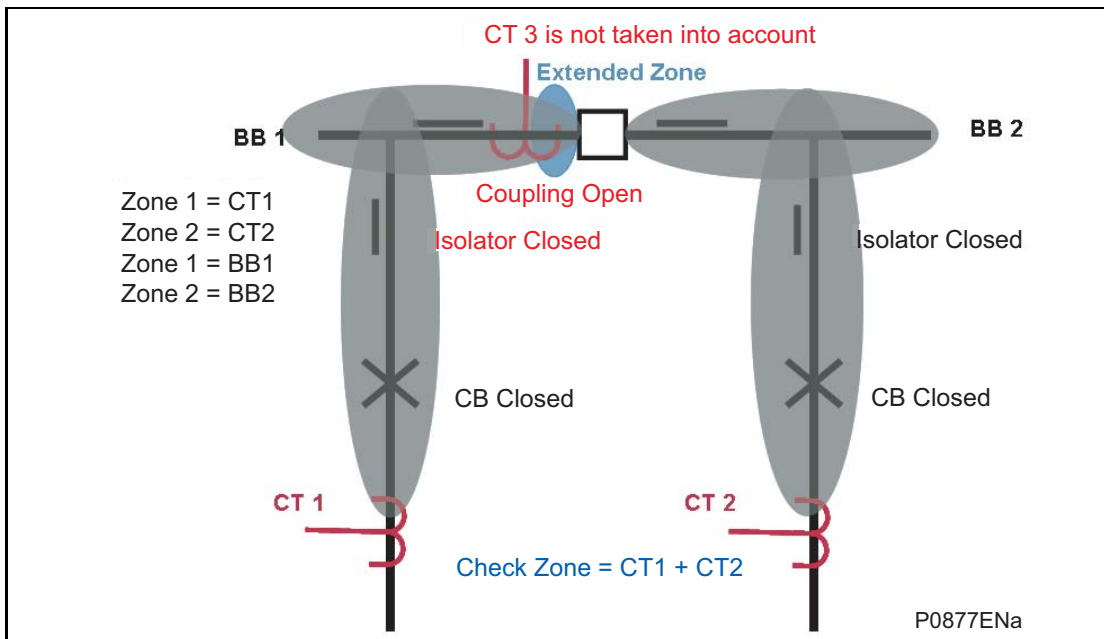
FIGURE 12: BUS COUPLER OPEN

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 Double bus with two CT bus coupler
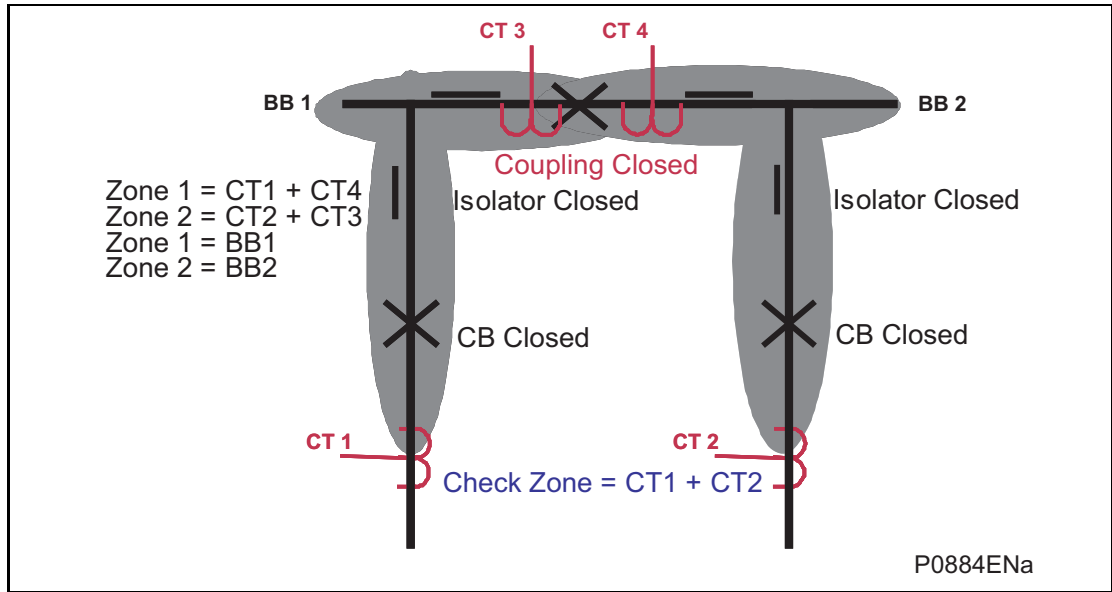
FIGURE 13: BUS COUPLER CLOSED

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.
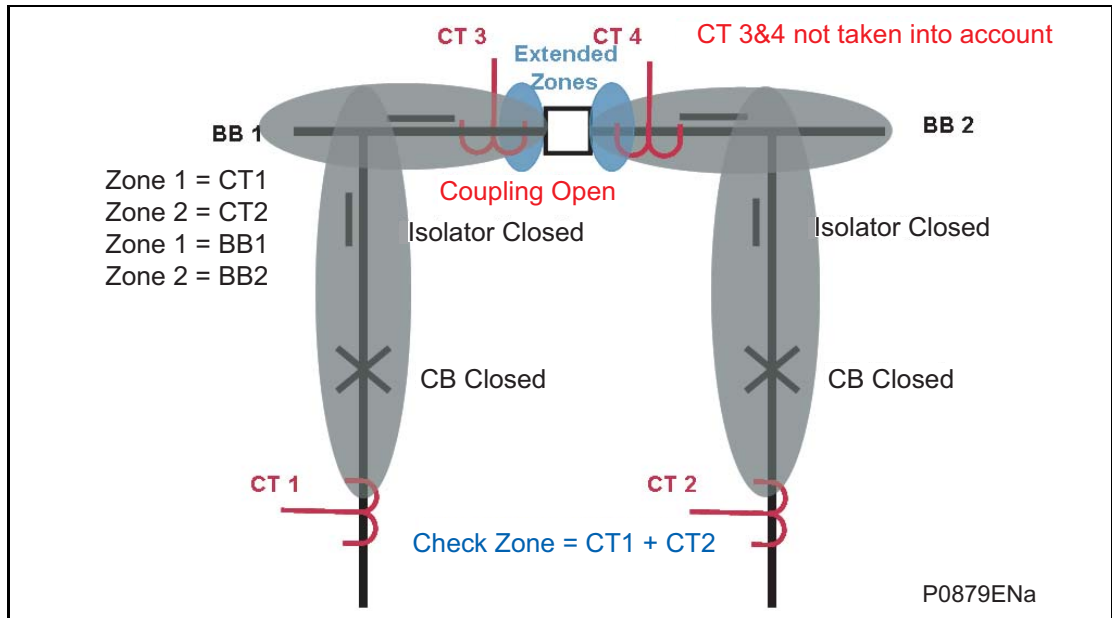
FIGURE 14: BUS COUPLER OPEN

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.
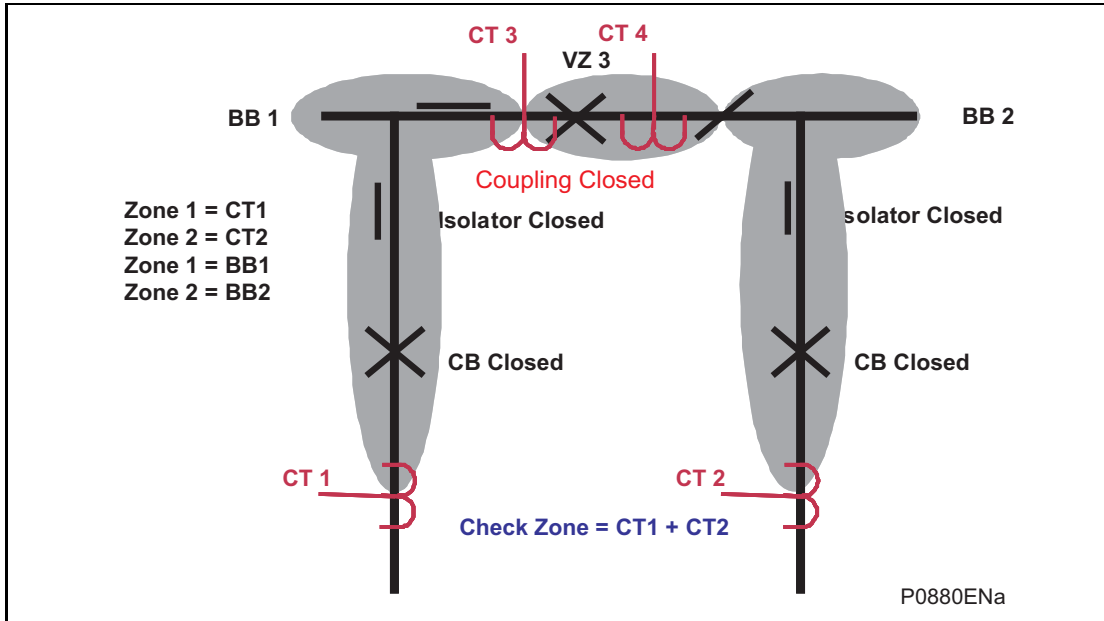
FIGURE 15: BUS COUPLER CLOSED AND ONE ISOLATOR OPEN

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.

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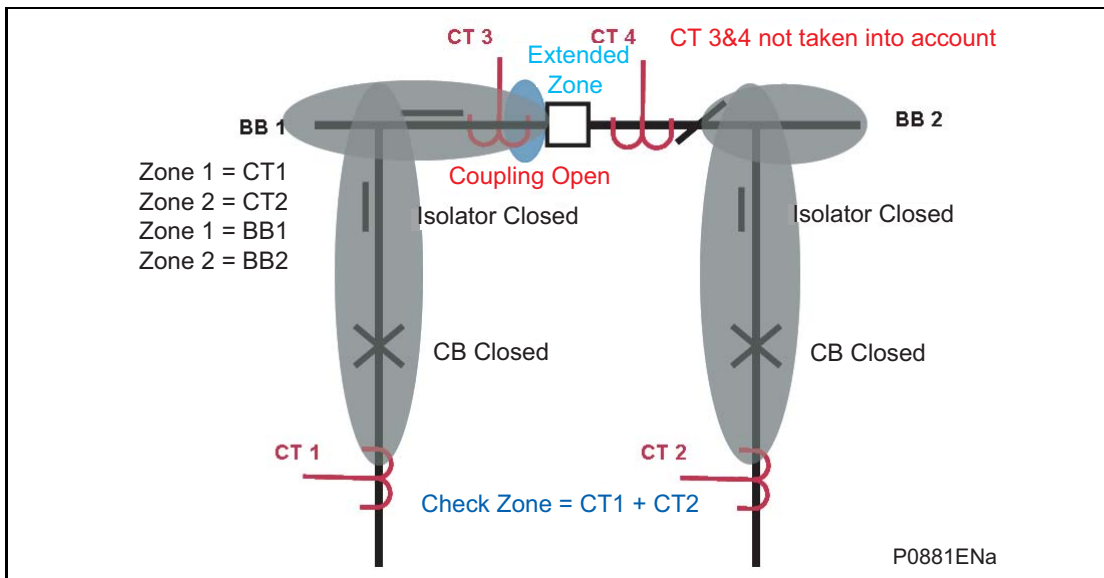
FIGURE 16: BUS COUPLER AND ONE ISOLATOR OPEN

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
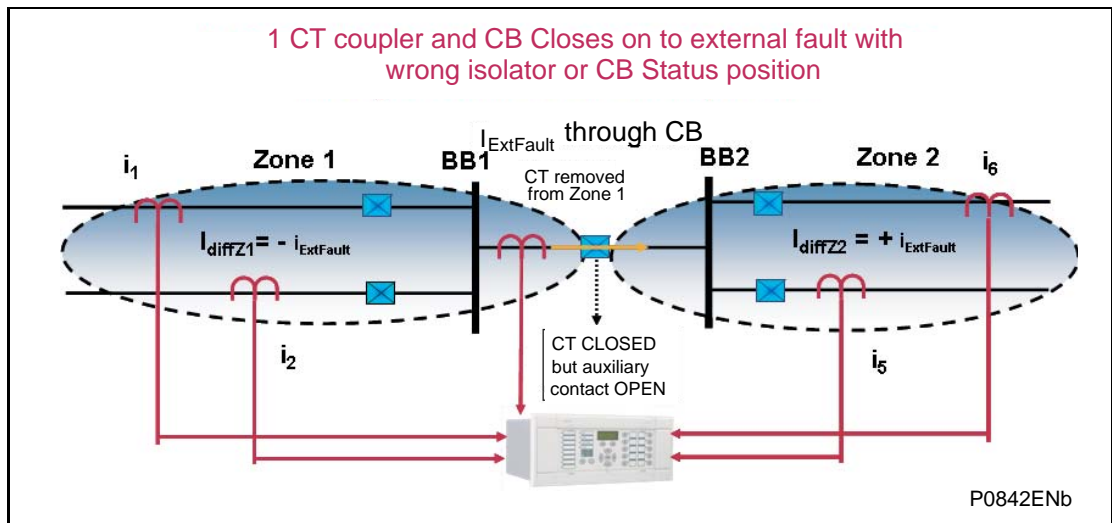
FIGURE 17: CT'S ON ONE SIDE OF BUS COUPLER,
CB CLOSES BEFORE STATUS ACQUISITION

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 $I_{diff} = I_1 + I_2 = i_{diff}Z1 = -i_{fault} > (I_D > 2$ 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 $I_{diff} = I_1 + I_2 + I_5 + I_6 = (-i_{fault}) + (+i_{fault}) = 0$

Again the system retains its stability for discrepancies in plant status (even for switch onto fault).

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6.3.5   CTs on both sides of bus coupler, CB closes before status acquisition.
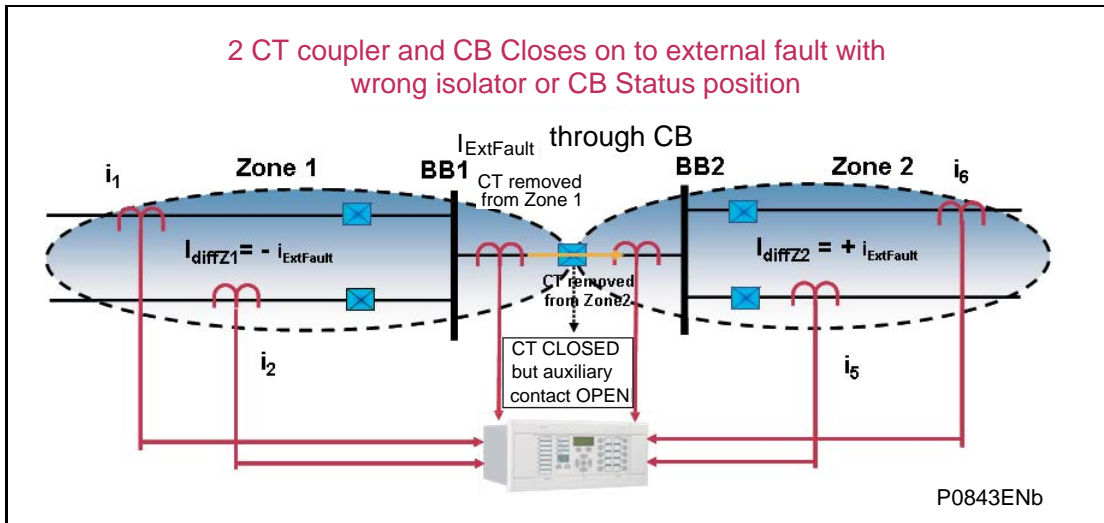
FIGURE 18: CT'S ON BOTH SIDES OF BUS COUPLER,
CB CLOSES BEFORE STATUS ACQUISITION

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 $I_{diff} = I_1 + I_2 + I_5 + I_6 = (-i_{fault}) + (+i_{fault}) = 0$

Therefore, 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).
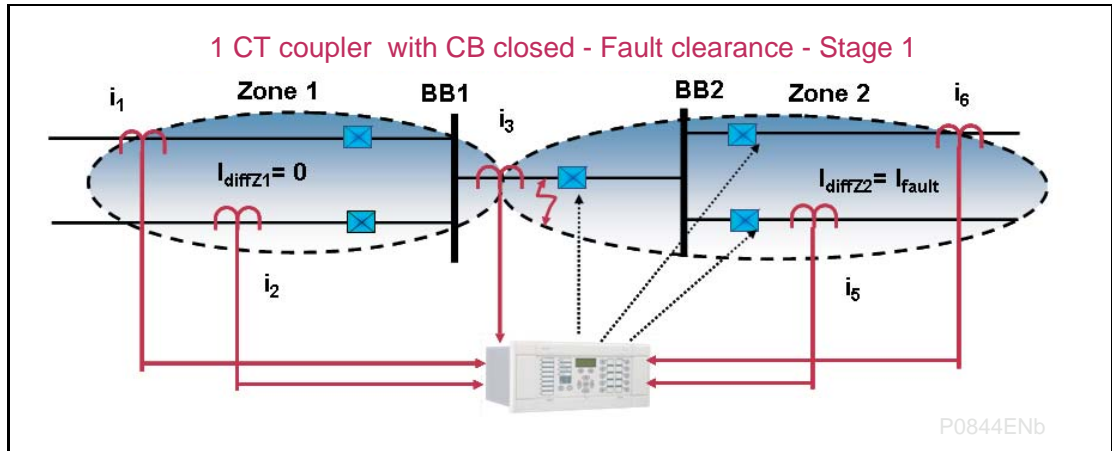
FIGURE 19: CT'S ON ONE SIDE OF BUS COUPLER,
CB CLOSED AND FAULT OCCURS BETWEEN THE CB & THE CT

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.
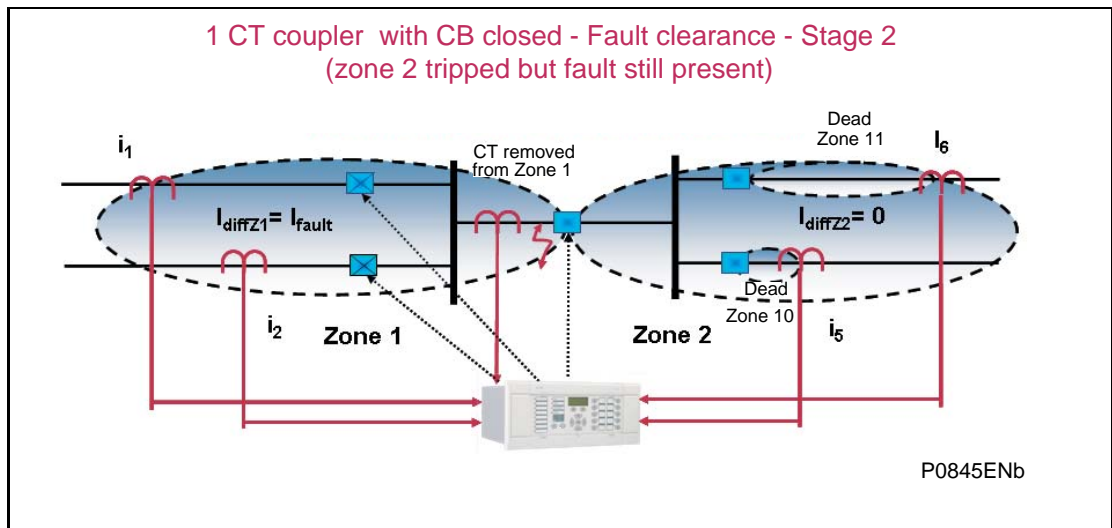
FIGURE 20: ZONE 2 TRIPPED, FAULT STILL PRESENT

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 $kCZ \times I_{Bias})$

Therefore, 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.
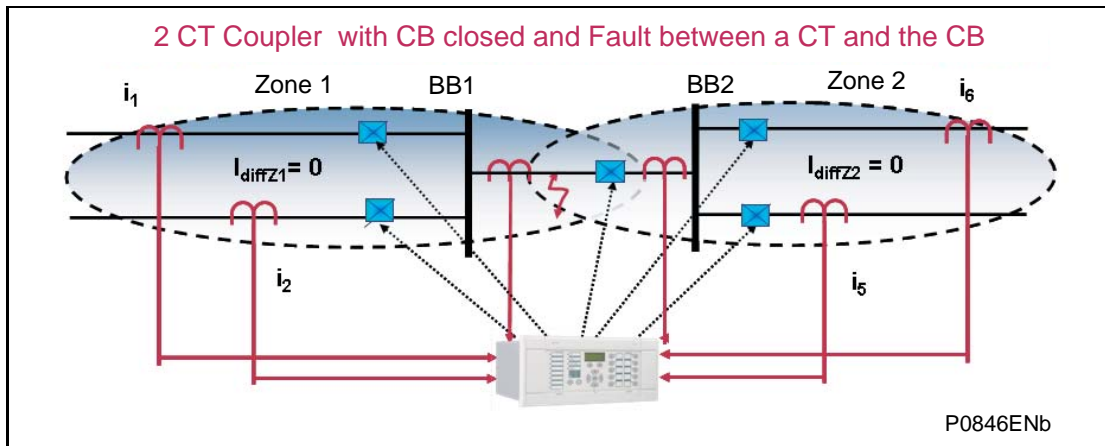
FIGURE 21: CT' ON BOTH SIDES OF BUS COUPLER,
CB CLOSED FAULT OCCURS BETWEEN A CT & THE CB

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 so 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.

(1) Therefore, the system reacts to a fault occurring between the CT and the CB simultaneously tripping both zones.
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 $I_{diff} = I_1 + I_2 + I_5 + I_6 = i_{diff}Zx = i_{fault}$

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 current inputs and can be connected to 6 three phase CTs or 18 single phase CTs.

A P746 embeds 3 voltage inputs.

<u>P746 mode selection</u>

Single bus or radial bus with no CT coupling (1 zone)

Set of CTs	Up to 6			Up to 18	
Set of VTs	0 or 1			0 or 1	
Mode	One box mode			3 boxes mode	

Radial bus with 1 or 2 CT coupling (2 zones)

Set of CTs	Up to 6		Up to 12	Up to 18		Up to 36
Set of VTs	0 or 1		0 to 2	0 or 2		0 to 2
Mode	One box mode		One box mode	3 boxes mode		3 boxes mode
Note			2 sets of			2 sets of

Double bus with no transfer bus (2 zones)

Set of CTs	Up to 6	Up to 6		Up to 18	Up to 18
Set of VTs	0 or 1	0 to 2		0 or 1	0 or 2
Mode	One box mode	3 boxes mode		3 boxes mode	3 boxes mode

One & half breaker (2 zones)

Set of CTs	Up to 6	Up to 6	Up to 12	Up to 18	Up to 18	Up to 36
Set of VTs	0 or 1	2	0 to 1	0 or 1	0 or 2	0 to 2
Mode	One box mode	3 boxes mode	One box mode	3 boxes mode	3 boxes mode	3 boxes mode
Note			2 sets of		1 sets of	2 sets of

Double bus with transfer bus or Triple bus (3 zones)

NOT POSSIBLE

Three buses (3 zones) or Four buses (4 zones), etc…

POSSIBLE if can be split in simpler bus topology.

AP

4 buses example:

P0854ENa

This scheme can be protected by 2 sets of 3 P746 connected as shown below:

Double busbar with bus couplers and bus ties

4 Zones
Maximum of 28 Feeders
36 CTs and Breakers and 64 isolators
(option 4 VTs)

P0847ENb
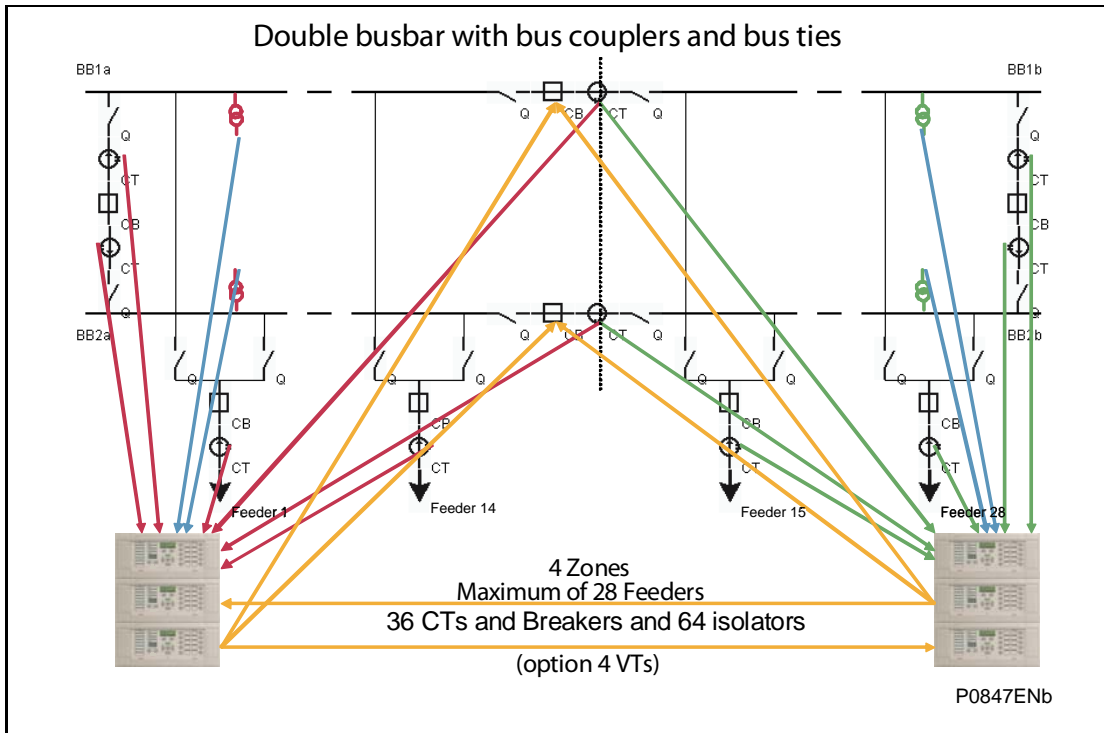
The trip information must be shared among the 2 sets of 3 P746 with high speed contact to the filtered or via goose messages with IEC 61850-8.1.

> Note: The P746 connected on the neutral does not allow sensitive differential earth fault protection.

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:
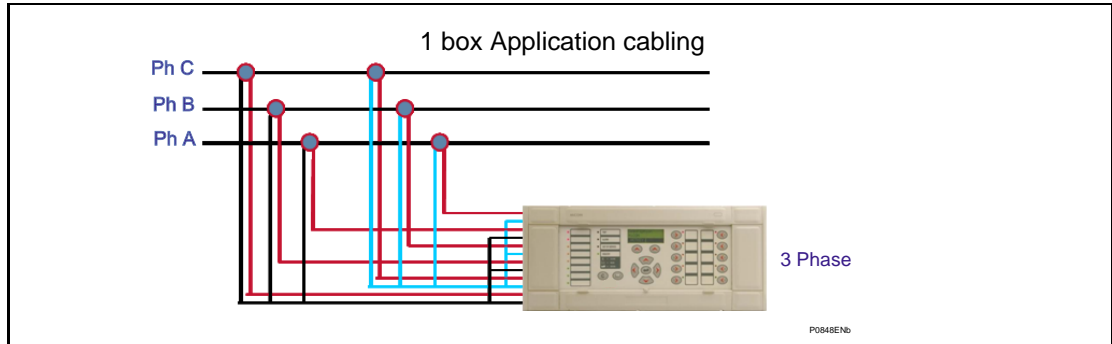
7.2.2 3 boxes mode:

Each phase inputs, all digital inputs and all relay outputs are connected to one p746:

AP
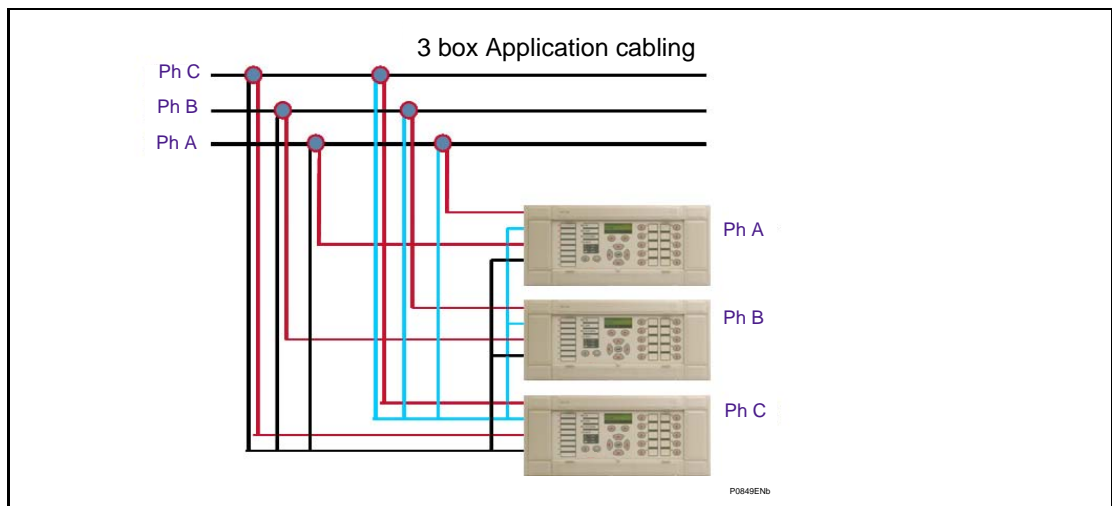
7.2.3   Voltage information

When the 3 boxes mode is set, voltage information (based on set criteria) must be shared among the 3 P746.
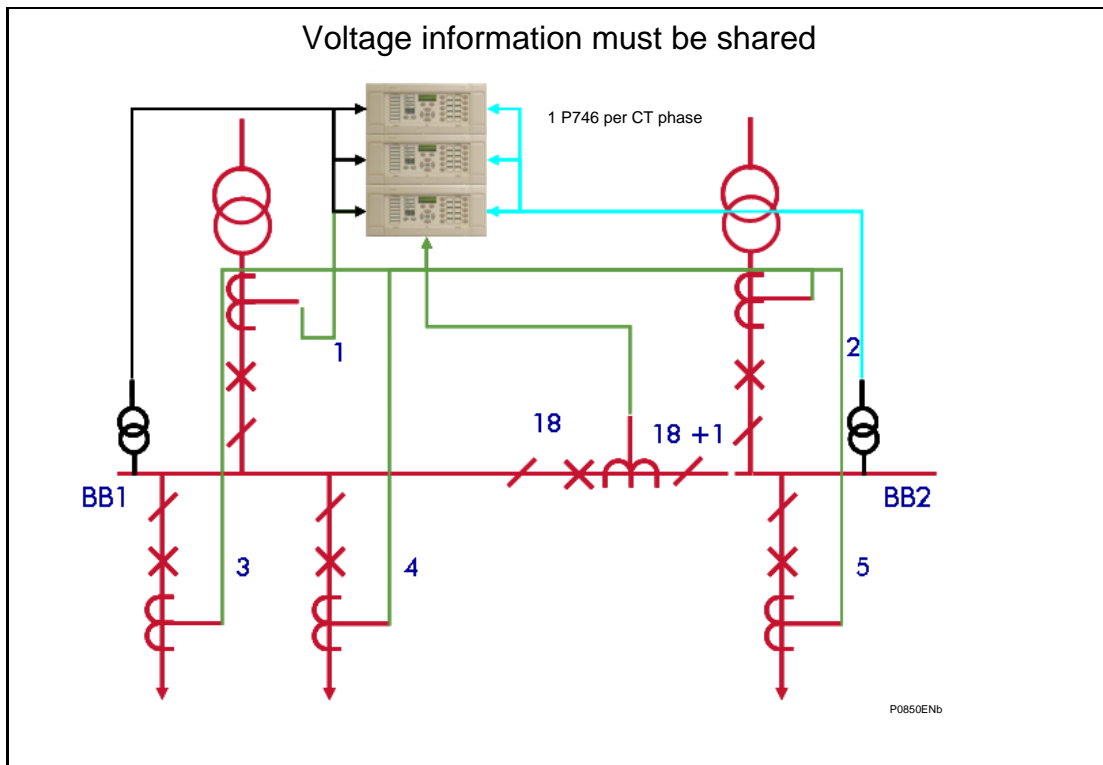
The information to be shared is the voltage algorithm output that allows the trip.

There are two ddbs outputs:

- VT Check Allow Zone 1
- VT Check Allow Zone 2

To be linked (inverted) to two ddbs inputs:

- Block Bus Diff Zone 1
- Block Bus Diff Zone 2

- To do so, the blocking information has to be sent from the connected P746 to the two other ones with the following methods:

- Goose messages with IEC 61850-8.1 (recommended):

AP
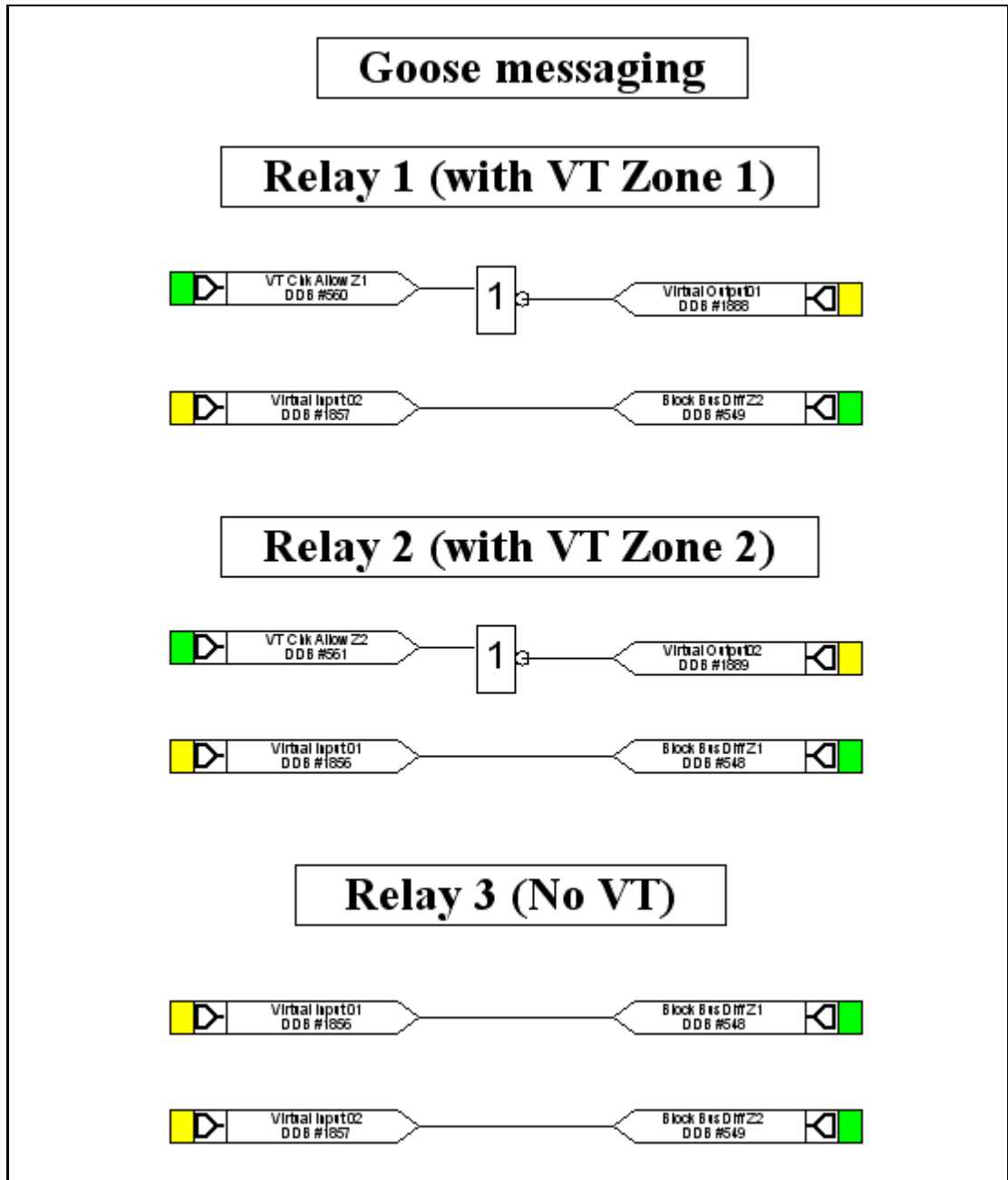
AP

• High speed contact to filtered optos:
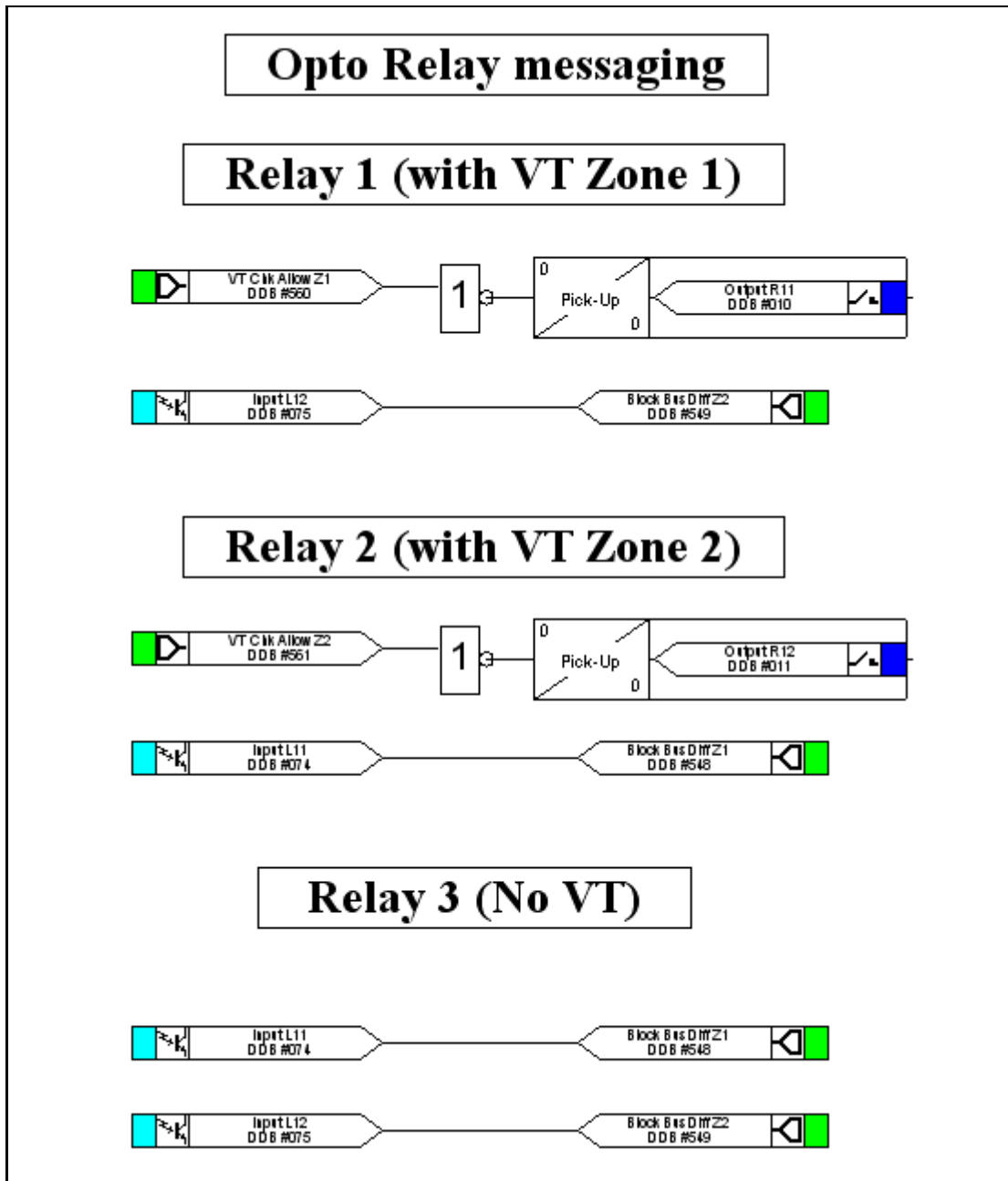
Note: The tripping time is delayed by around.

Standard relay: 5ms + opto filtering: 5ms = 10ms

High break/high speed relay: 0ms + opto filtering: 5ms = 5ms

- high speed contact to unfiltered optos:

Unfiltered Opto Relay messaging

Relay 1 (with VT Zone 1)

Relay 2 (with VT Zone 2)

Relay 3 (No VT)

Note: The tripping time is delayed by around 5ms for Standard relay.

AP
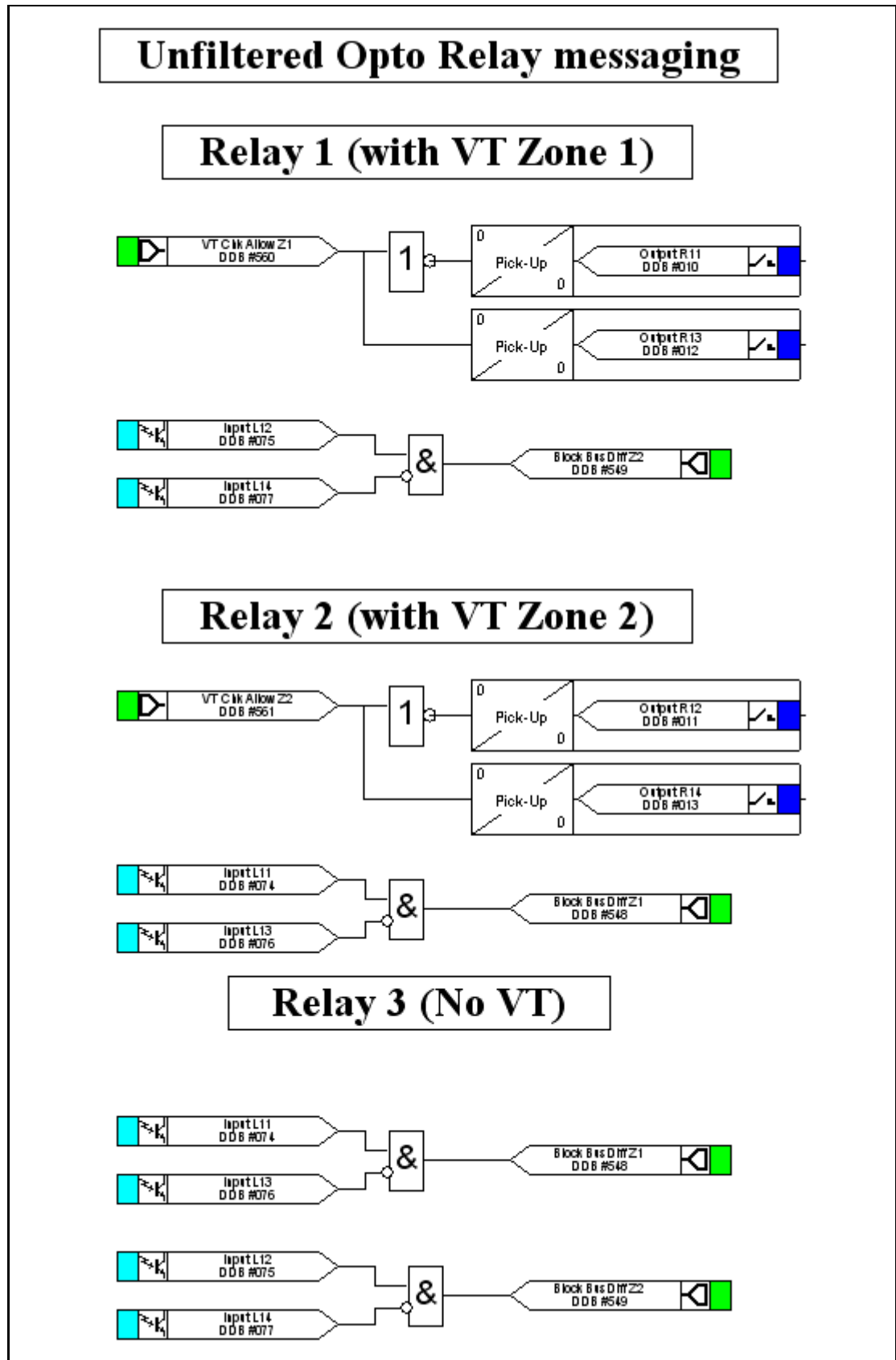
7.2.4   3 boxes mode and simple redundancy:

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.
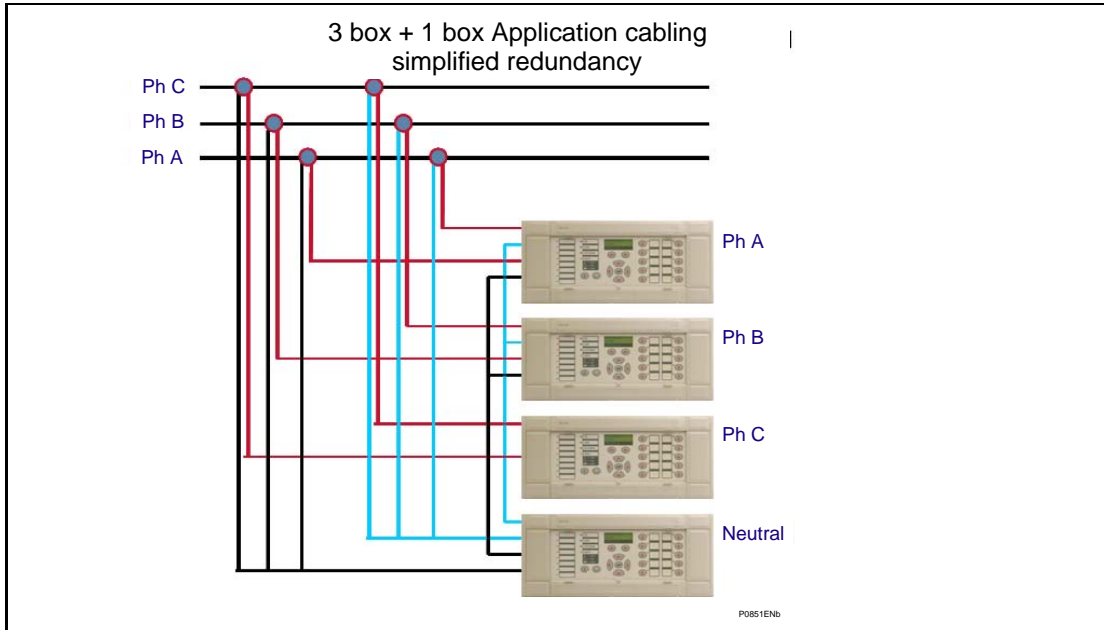
7.2.5   2 out of 2 solution:

Using the same principle, to have the 2 out of 2 solution, the following cabling can be done:
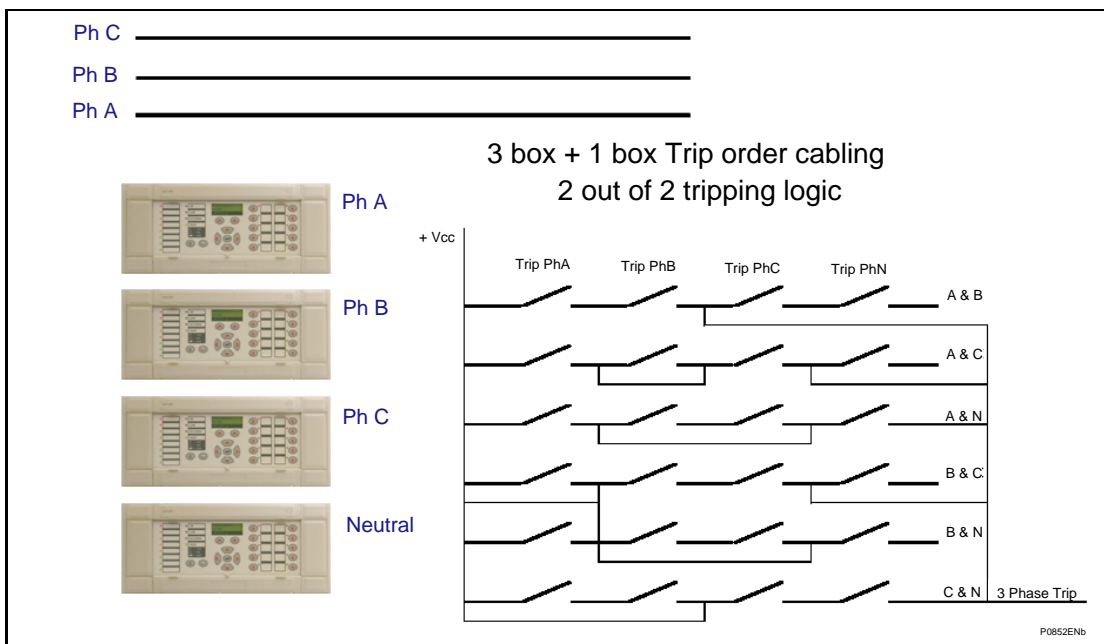
7.3   Check list

The following steps shall 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 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 & 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)

3.   Download the PSL file into the relay(s)
(using MiCOM S1)

4.   Test the PSLs & Analogue inputs
(using a Inputs / Outputs and current generator)

5.   Test the relay
(using MiCOM S1)

Commissioning phase:

1.   Check the inputs / outputs

2.   Check CT connections

3.   Check the measurements and the tripping slopes
(see documentation)

AP

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.

AP

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 Alstom Grid representative.

Here after is summarised the solution identification:

<u>P746 mode selection</u>

Single bus or radial bus with no CT coupling (1 zone)

Set of CTs	Up to 6			Up to 18	
Set of VTs	0 or 1			0 or 1	
Mode	One box mode			3 boxes mode	

Radial bus with 1 or 2 CT coupling (2 zones)

Set of CTs	Up to 6		Up to 12	Up to 18		Up to 36
Set of VTs	0 or 1		0 to 2	0 or 2		0 to 2
Mode	One box mode		One box mode	3 boxes mode		3 boxes mode
Note			2 sets of			2 sets of

Double bus with no transfer bus (2 zones)

Set of CTs	Up to 6	Up to 6		Up to 18	Up to 18
Set of VTs	0 or 1	0 to 2		0 or 1	0 or 2
Mode	One box mode	3 boxes mode		3 boxes mode	3 boxes mode

One & half breaker (2 zones)

Set of CTs	Up to 6	Up to 6	Up to 12	Up to 18	Up to 18	Up to 36
Set of VTs	0 or 1	2	0 to 1	0 or 1	0 or 2	0 to 2
Mode	One box mode	3 boxes mode	One box mode	3 boxes mode	3 boxes mode	3 boxes mode
Note			2 sets of		1 sets of	2 sets of

Double bus with transfer bus or Triple bus (3 zones)

NOT POSSIBLE

Three buses (3 zones) or Four buses (4 zones), etc…

POSSIBLE if can be split in simpler bus topology.

AP

The general rule to calculate the number of P746 to use is:

1 off P746 from 1 to 6 sets of CTs or 6 breakers (up to 7 isolators) and 2 sets of 1 P746 up to 12 sets of CTs when possible.

3 off P746 from 7 to.18 sets of CTs or 18 breakers (up to 37 isolators) and 2 sets of 3 P746 up to 36 sets of CTs when possible.
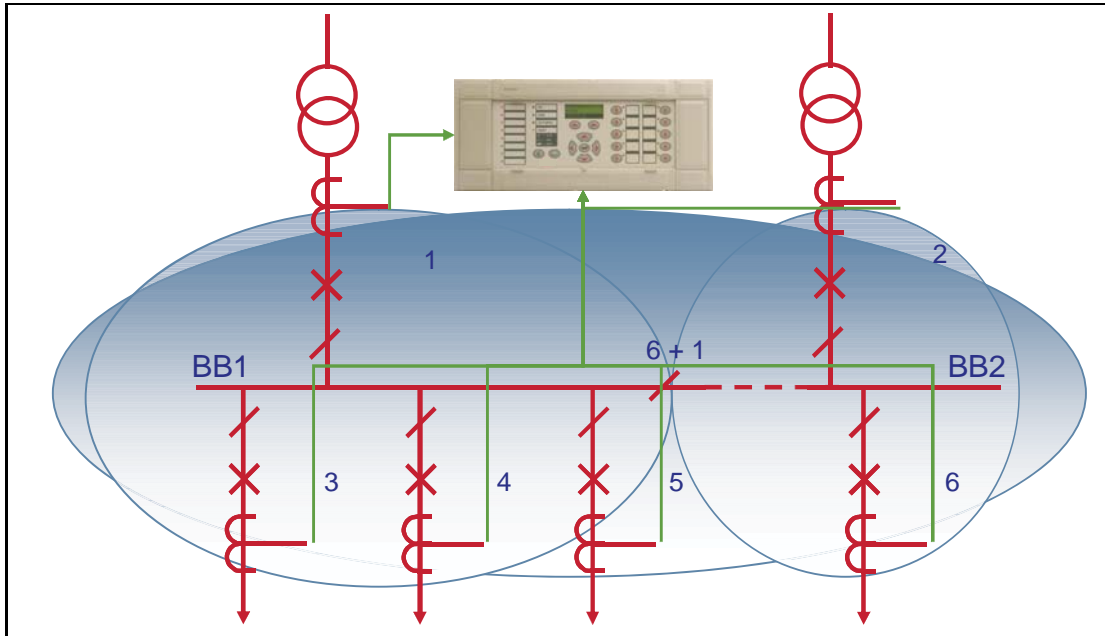
FIGURE 22: SINGLE BUSBAR APPLICATION WITH BUS SECTION ISOLATOR

The above example shows a single busbar with a bus section isolator. It is split into two zones.

There are up to 6 feeders connected to the busbar. This configuration requires 1 P746.

If it was up to 18 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.
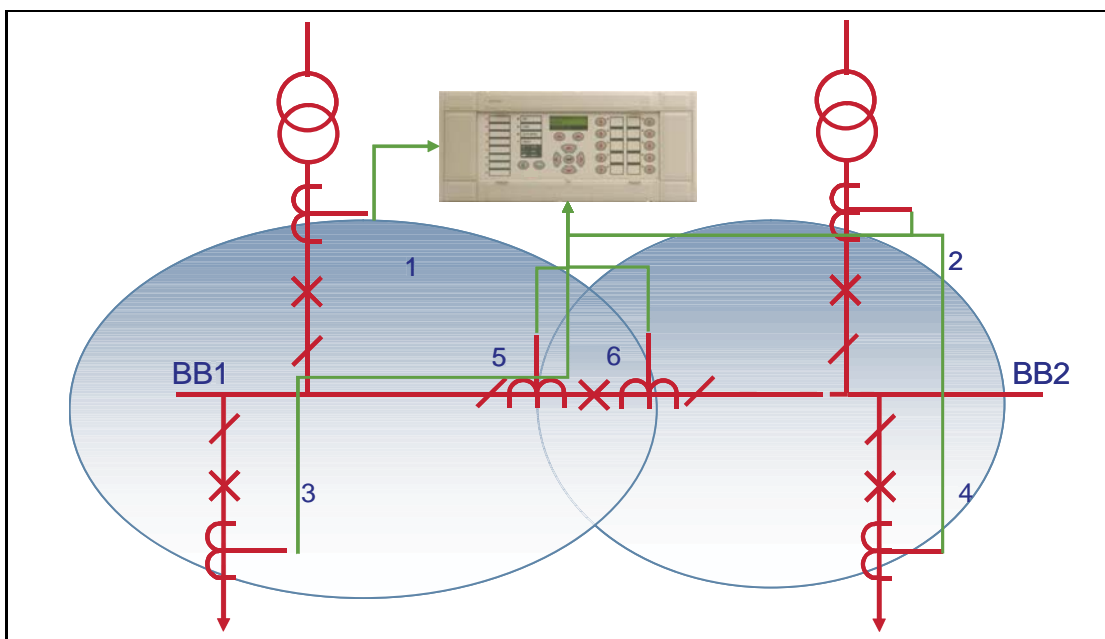
FIGURE 23: SINGLE BUSBAR APPLICATION WITH BUS SECTION CIRCUIT BREAKER

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 feeders connected to the busbar. This configuration would require 2 sets of 1 P746 or 3 P746.
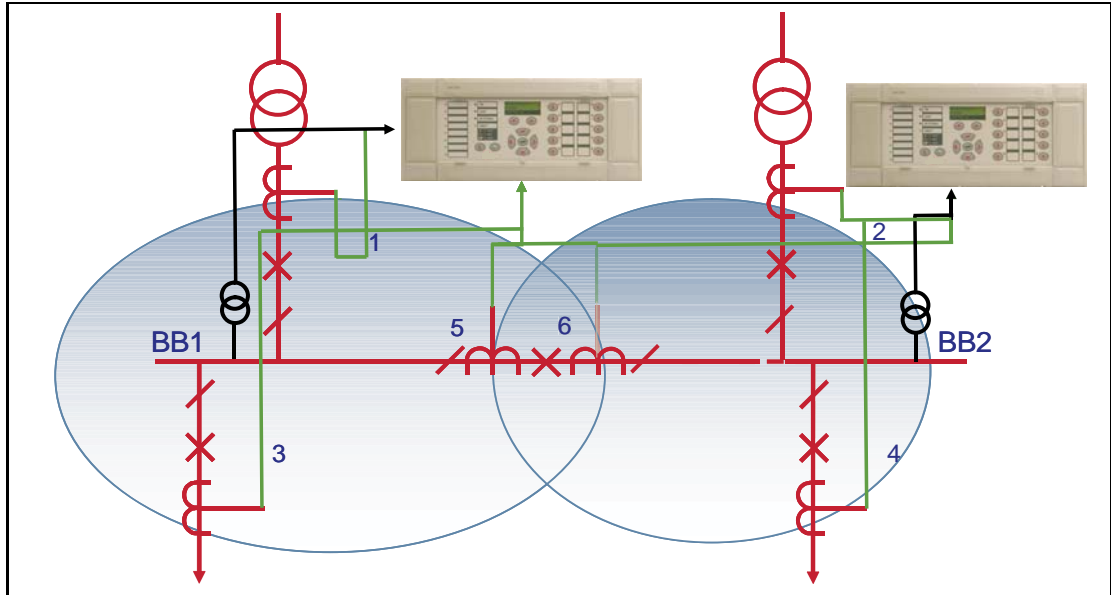
If it was up to 14 feeders connected to the busbar. This configuration would require 3 P746.

P0853ENb
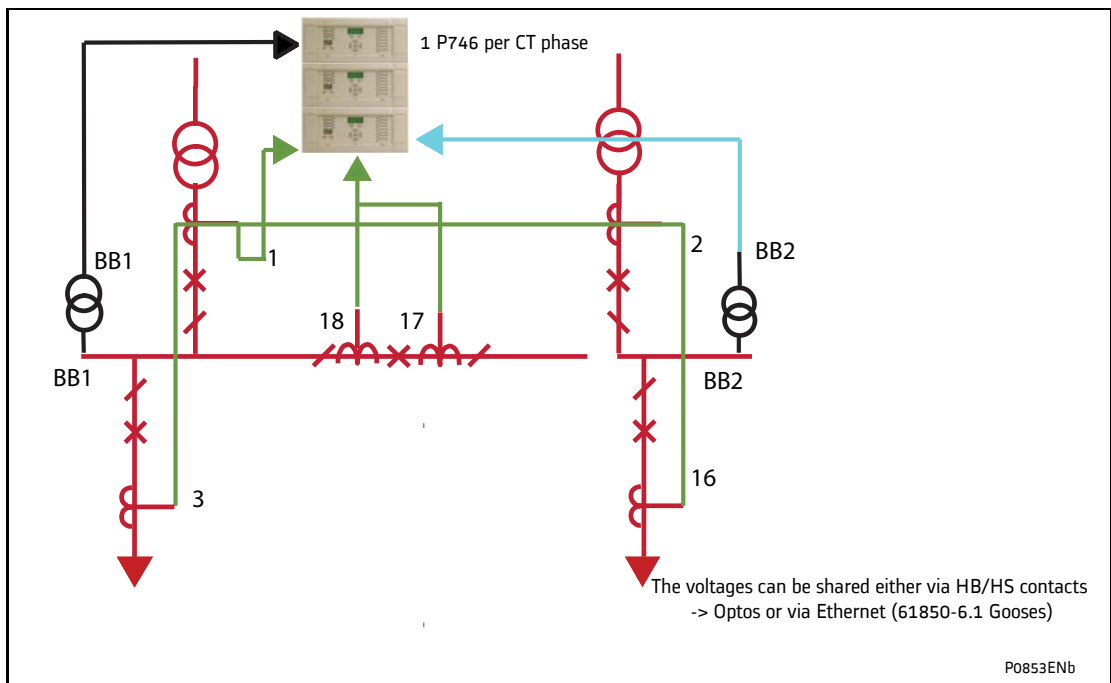
If it was up to 34 feeders connected to the busbar. This configuration would require 2 sets of 3 P746.

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.

AP
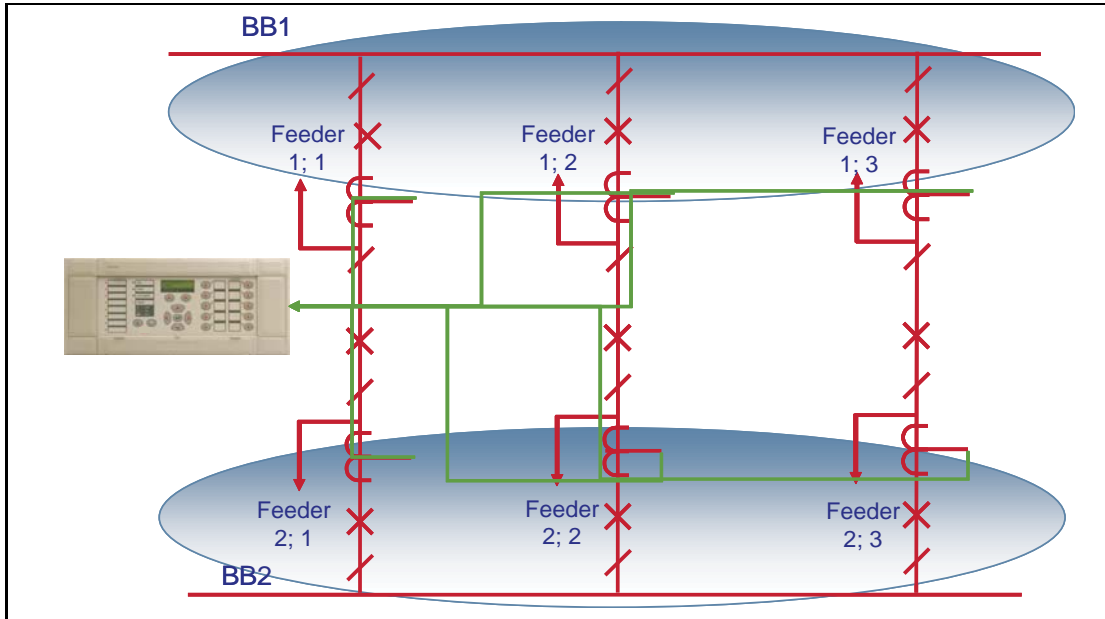
FIGURE 24: BREAKER AND A HALF SCHEME

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 feeders connected to the busbars, the scheme would require 2 sets of 1 P746 or 3 P746.

If it was up to 18 feeders connected to the busbars, the scheme would require 3 P746.

If it was up to 36 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.
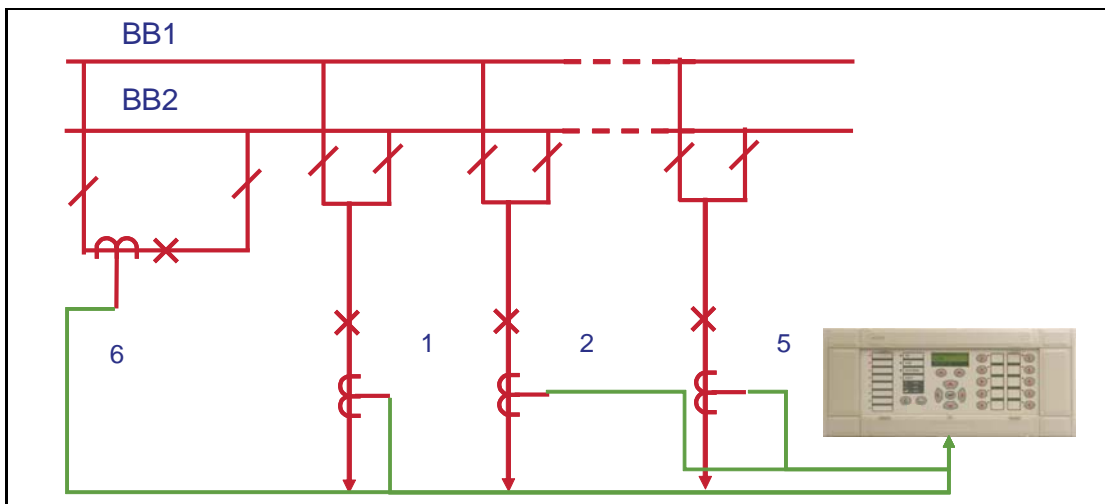
FIGURE 25: DOUBLE BUSBAR APPLICATION WITH BUS COUPLER

The above example shows a double busbar with a bus coupler. It is split into two zones.

If there is a bus coupler with a single CT (solution 1) and up to 5 feeders connected to the busbar. This configuration requires 1 P746

If there is a bus coupler with CTs on both sides (solution 2) and 4 feeders connected to the busbar. This configuration requires 1 P746

If there is a bus coupler with a single CT (solution 1) and up to 17 feeders connected to the busbar. This configuration requires 3 P746

If there is a bus coupler with CTs on both sides (solution 2) and 16 feeders connected to the busbar. This configuration requires 3 P746

The additional P746 being for the bus section isolators is optional.

The number of additional P746 being dependant on the number of bus section/bus coupler CTs. The type of P746 used for each bay will depend on the i/o requirements of the bay in question.

P0883ENa
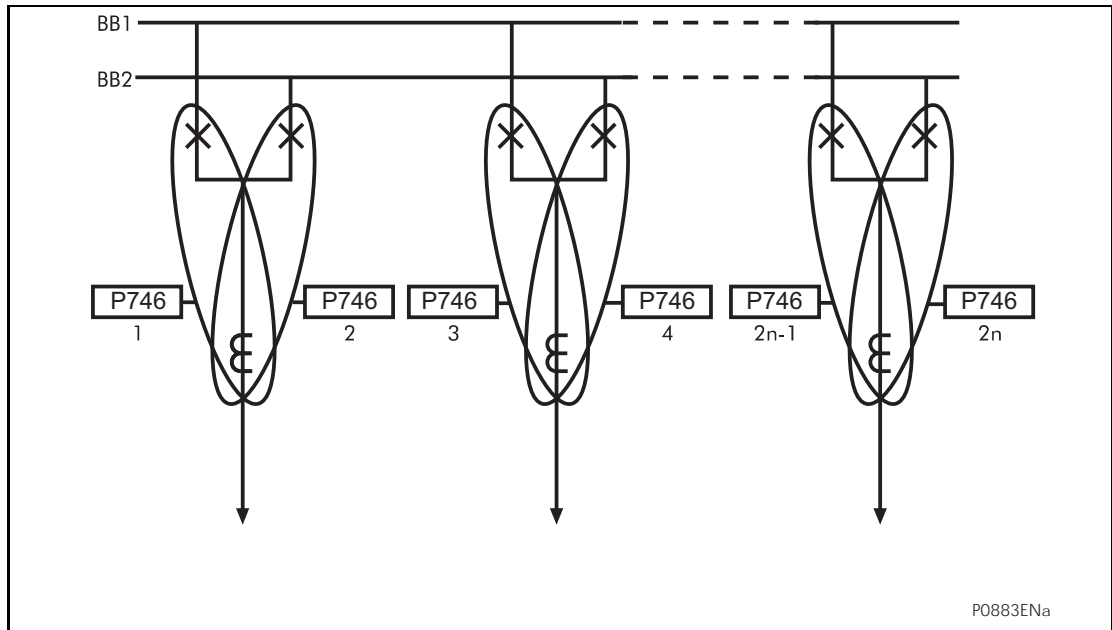
FIGURE 26: DOUBLE BUS BAR WITH TWO CIRCUIT BREAKERS PER FEEDER

9.   APPLICATION OF NON PROTECTION FUNCTIONS

The non-protection features for the scheme are summarised below:

- Scheme is centralised.

- 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.
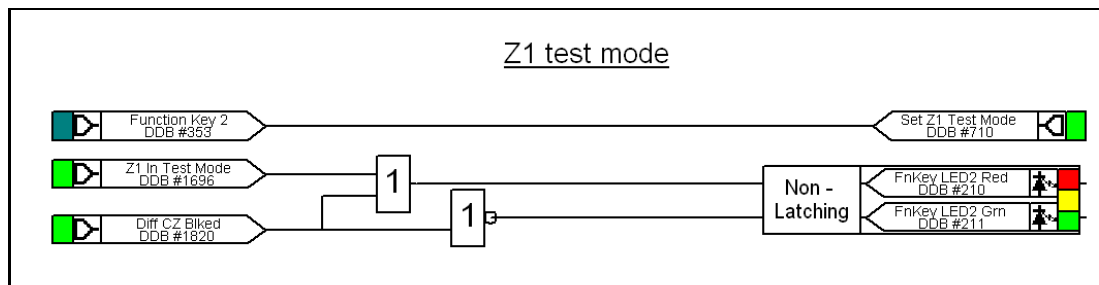
FIGURE 27: COMMISSIONING MODE DEFAULT PSL

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

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):

$Vk > I_{FeederMax} * (R_{CT} + R_B)$

     Note: This specification is valid for internal faults.

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10.2.2   CT Specification according to IEC 185, 44-6 and BS 3938 (British Standard)

   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.

   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]

This definition indicates that the composite error must be lower than 5%, for a primary
current of $20I_{np}$ when the external load is equal to 2 ohms (50VA to I_n). If secondary
resistance, R_{CT}, is known it is easy to calculate the magnetising EMF developed with the
fault current ($20I_n$). Actually if the error is 5% (= 5A) with this EMF, the point of operation is
beyond the knee point voltage for saturation. By convention one admits that the knee point
voltage, V_k, is 80% of this value. For a conversion between a class 5P (IEC) and a class X
(BS) CT one uses the relation:

$$V_k = 0.8 \times [(SVA \times K_{ssc})/I_n + (R_{CT} \times K_{ssc} \times I_n)]$$

$$SVA = (I_n \times V_k/0.8\, K_{ssc}) - R_{CT} \times I_n^2$$

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.

CT Ratio	RCT (ohm)	IEEE C57.13 – "C" Classification (volts)				
		C50	C100	C200	C400	C800
		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

TABLE 3: IEC/BS KNEE POINT VOLTAGE V_K OFFERED BY "C" CLASS CTS

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:

1. 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.
2. IEEE CTs are always rated at 5A secondary
3. The rated dynamic current output of a "C" class CT (Kssc) is always 20 x I_n

$$V_k = (C \times 1.05) + (I_n . R_{CT} . Kssc)$$

Where:

V_k = Equivalent IEC or BS knee point voltage

C = C Rating

I_n = 5A

R_{CT} = CT secondary winding resistance

Kssc = 20 times

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11.   AUXILIARY SUPPLY FUSE RATING

In the Safety section 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 (MCB) may be used to protect the auxiliary supply circuits.

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PROGRAMMABLE LOGIC

Date:	**2008**
Hardware Suffix:	**K**
Software Version:	**01**
Connection Diagrams:	**10P746xx (xx = 01 to 07)**

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MiCOM P746 PROGRAMMABLE SCHEME LOGIC   **32**

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1. PROGRAMMABLE LOGIC

1.1 Overview

The purpose of the programmable scheme logic (PSL) is to allow the relay user to configure an individual protection scheme to suit their own particular application. This is achieved through the use of programmable logic gates and delay timers.

The input to the PSL is any combination of the status of opto inputs. It is also used to assign the mapping of functions to the opto inputs and output contacts, the outputs of the protection elements, e.g. protection starts and trips, and the outputs of the fixed protection scheme logic. The fixed scheme logic provides the relay's standard protection schemes. The PSL itself consists of software logic gates and timers. The logic gates can be programmed to perform a range of different logic functions and can accept any number of inputs. The timers are used either to create a programmable delay, and/or to condition the logic outputs, e.g. to create a pulse of fixed duration on the output regardless of the length of the pulse on the input. The outputs of the PSL are the LEDs on the front panel of the relay and the output contacts at the rear.

The execution of the PSL logic is event driven; the logic is processed whenever any of its inputs change, for example as a result of a change in one of the digital input signals or a trip output from a protection element. Also, only the part of the PSL logic that is affected by the particular input change that has occurred is processed. This reduces the amount of processing time that is used by the PSL; even with large, complex PSL schemes the relay trip time will not lengthen.

This system provides flexibility for the user to create their own scheme logic design. However, it also means that the PSL can be configured into a very complex system, hence setting of the PSL is implemented through the PC support package MiCOM S1 Studio.

1.2 MiCOM S1 or MiCOM S1 Studio Px40 PSL editor

1.2.1 Micom S1 V2

To access the Px40 PSL Editor Menu, click on [icon].

1.2.2 MiCOM S1 Studio

To access the MiCOM S1 Studio V3 Px40 PSL Editor double click on the PSL file on the *Explorer* or click PSL Editor (Px40) from *Tools* Menu

P0855ENa
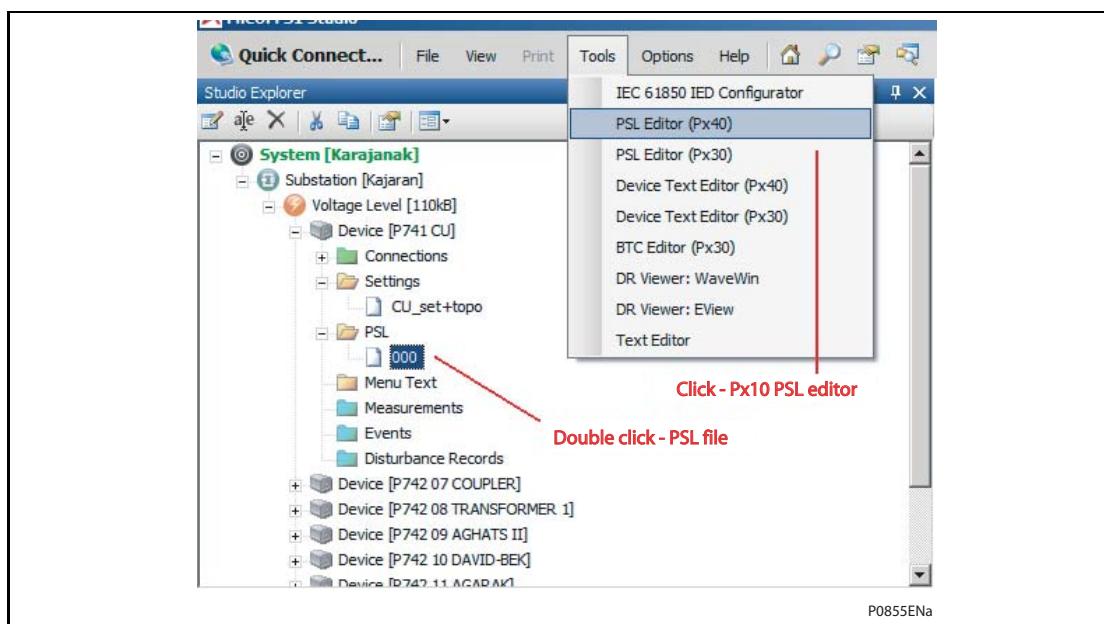
1.2.3   PSL Editor

The PSL Editor module enables you to connect to any MiCOM device front port, Rear port with courier protocol and Ethernet port with tunnelled courier protocol, retrieve and edit its Programmable Scheme Logic files and send the modified file back to a MiCOM Px40 device.

S0059ENa
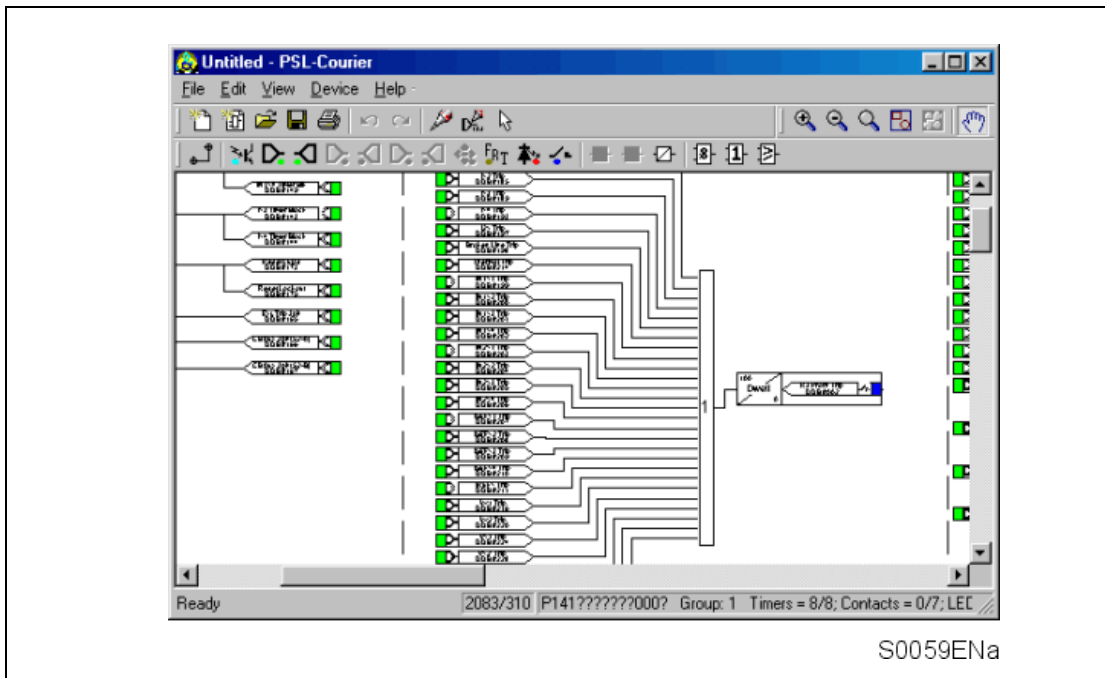
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1.3   **How to use MiCOM Px40 PSL editor**

With the MiCOM Px40 PSL Module you can:

- 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

- View DDB numbering for the signals

For a detailed discussion on how to use these functions, please refer to PSL Editor online help or S1 Users manual.

1.4   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, and then compares it with the stored model number. A "wildcard" comparison is employed. If a model mismatch occurs then a warning will be generated before sending commences. Both the stored model number and that read-in from the relay are displayed along with the warning; the onus is on you to decide if the settings to be sent are compatible with the connected relay. Wrongly ignoring the warning could lead to undesired behaviour in 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) exceed the number of inputs. A programmable gate has its ITT value set to greater than the number of actual inputs; the gate can never activate. Note that 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.

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1.5   Toolbar and commands

There are a number of toolbars available for easy navigation and editing of PSL.

1.5.1   Standard tools

- For file management and printing.

1.5.2   Alignment tools

- To snap logic elements into horizontally or vertically aligned groupings.
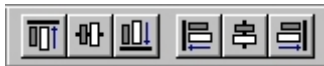
1.5.3   Drawing Tools

- To add text comments and other annotations, for easier reading of PSL schemes.

1.5.4   Nudge tools

- To move logic elements.

1.5.5   Rotation tools

- Tools to spin, mirror and flip.
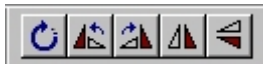
1.5.6   Structure tools

- To change the stacking order of logic components.
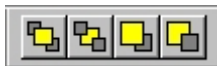
1.5.7   Zoom and pan tools

- For scaling the displayed screen size, viewing the entire PSL, or zooming to a selection.
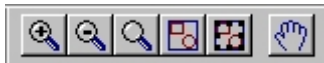
1.5.8   Logic symbols

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.

Link

Create a link between two logic symbols.

Opto Signal

Create an opto signal.

Input Signal

Create an input signal.

Output Signal

Create an output signal.

GOOSE In

Create an input signal to logic to receive a GOOSE message transmitted from another IED.
Used in IEC 61850 GOOSE applications only.

GOOSE Out

Create an output signal from logic to transmit a GOOSE message to another IED.
Used in IEC 61850 GOOSE applications only.

Control In

Create an input signal to logic that can be operated from an external command.

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 tri-colour LED.

Contact Signal

Create a contact signal.

LED Conditioner

Create an LED conditioner.

Contact Conditioner

Create a contact conditioner.

Timer

Create a timer.

AND Gate

Create an AND Gate.

OR Gate

Create an OR Gate.

Programmable Gate

Create a programmable gate.

SR latch Gate

Create an SR latch Gate.

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1.6   PSL logic signals properties

The logic signal toolbar is used for the selection of logic signals.

Performing a right-mouse click on any logic signal will open a context sensitive menu and one of the options for certain logic elements is the **Properties…** command. Selecting the Properties option will open a Component Properties window, the format of which will vary according to the logic signal selected.

Properties of each logic signal, including the Component Properties windows, are shown in the following sub-sections:

Signal properties menu

The **Signals List** tab is used for the selection of logic signals.

The signals listed will be appropriate to the type of logic symbol being added to the diagram. They will be of one of the following types:

1.6.1   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 via its properties window. An inverted link is indicated with a "bubble" on the input to the gate. It is not possible to invert a link that is not connected to the input of a gate.
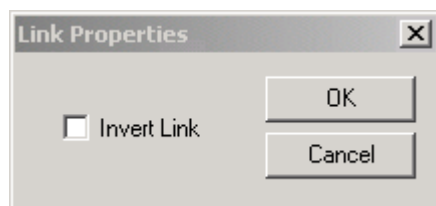
Links can only be started from the output of a signal, gate, or conditioner, and can only be ended on an input to any element.

Since signals can only be either an input or an output then the concept is somewhat different. In order to follow the convention adopted for gates and conditioners, input signals are connected from the left and output signals to the right. The Editor will automatically enforce this convention.

A link attempt will be refused where one or more rules would otherwise be broken. A link will be refused for the following reasons:

- An attempt to connect to a signal that is already driven. The cause of the refusal may not be obvious, since the signal symbol may appear elsewhere in the diagram. Use "Highlight a Path" to find the other signal.

- An attempt is made to repeat a link between two symbols. The cause of the refusal may not be obvious, since the existing link may be represented elsewhere in the diagram.

1.6.2   Opto signal properties

Opto Signal

Each opto input can be selected and used for programming in PSL. Activation of the opto input will drive an associated DDB signal.

For example activating opto input L1 will assert DDB 032 in the PSL.
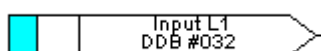
1.6.3   Input signal properties

Input Signal

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 will drive an associated DDB signal in PSL.

For example DDB 1142 will be asserted in the PSL should the active terminal1 earth fault , stage 1 protection operate/trip.
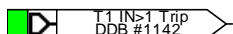
1.6.4   Output signal properties

Output Signal

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 651 is asserted in the PSL, it will block the terminal1 earth function stage 1 timer.
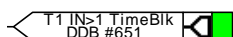
1.6.5   GOOSE input signal properties

GOOSE In

The Programmable Scheme Logic interfaces with the GOOSE Scheme Logic (see PSL Editor online help or S1 Users manual for more details) by means of 32 Virtual inputs. The Virtual Inputs can be used in much the same way as the Opto Input signals.

The logic that drives each of the Virtual Inputs is contained within the relay's GOOSE Scheme Logic file. It is possible to map any number of bit-pairs, from any subscribed device, using logic gates onto a Virtual Input (see S1 Users manual for more details).

For example DDB 832 will be asserted in PSL should virtual input 1 operate.
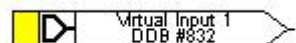
1.6.6   GOOSE output signal properties

GOOSE Out

The Programmable Scheme Logic interfaces with the GOOSE Scheme Logic by means of 32 Virtual outputs.

It is possible to map virtual outputs to bit-pairs for transmitting to any published devices (see PSL Editor online help or S1 Users manual for more details).

For example if DDB 865 is asserted in PSL, Virtual Output 32 and its associated mappings will operate.

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1.6.7   Control in signal properties

Control In

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 operate control input 1 to assert DDB 800 in the PSL.

1.6.8   Function key properties

Function Key

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 712 in the PSL.
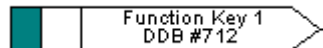
1.6.9   Fault recorder trigger properties

Fault Record Trigger

The fault recording facility can be activated, by driving the fault recorder trigger DDB signal.

For example assert DDB 144 to activate the fault recording in the PSL.
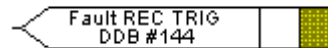
1.6.10   LED signal properties

LED

All programmable LEDs will drive associated DDB signal when the LED is activated.

For example DDB 652 will be asserted when LED 7 is activated.
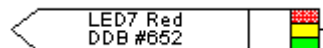
1.6.11   Contact signal properties

Contact Signal

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.

1.6.12   LED conditioner properties

LED Conditioner

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.

S0129ENa
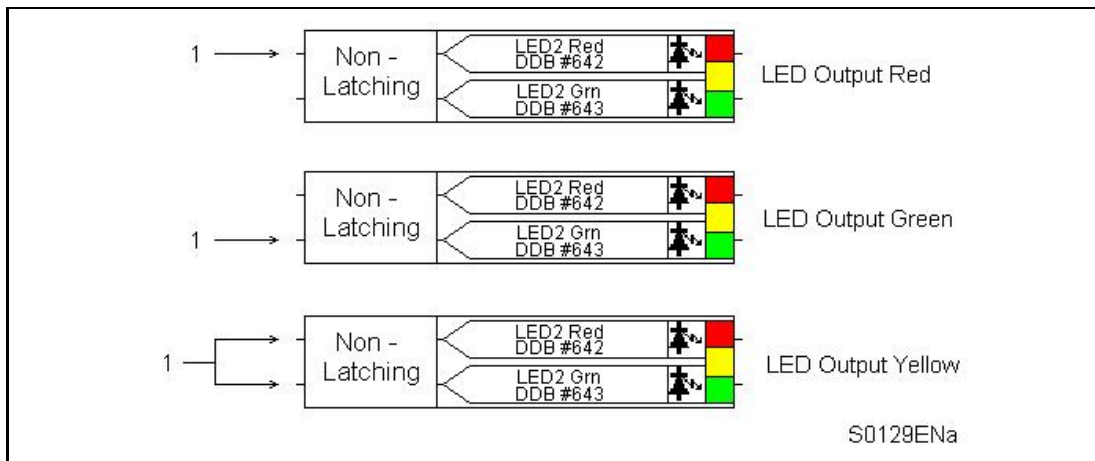
3. Configure the LED output to be latching or non-latching.

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1.6.13   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.

S0083ENa
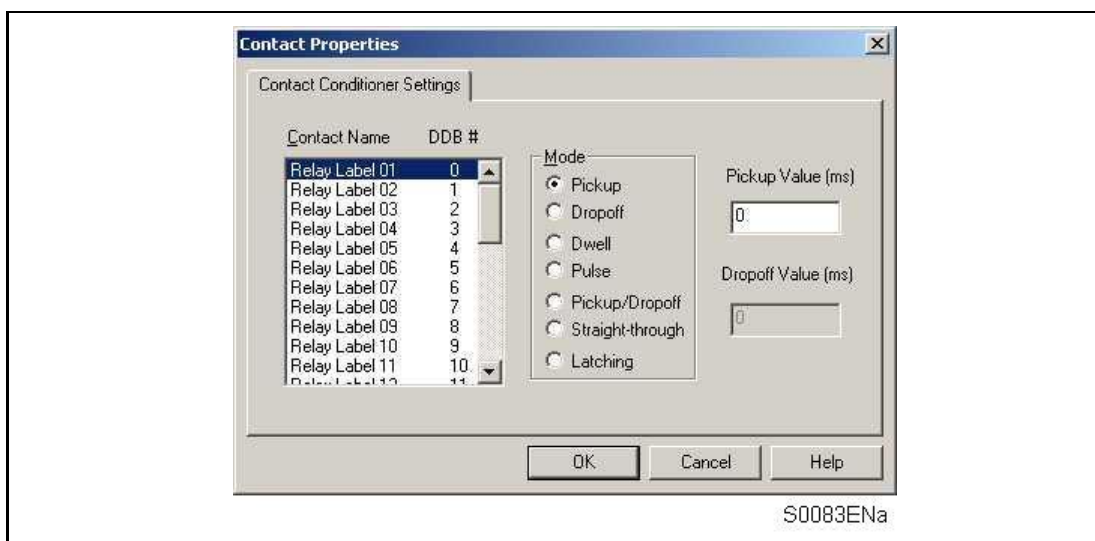
1. Select the contact **name** from the **Contact Name** list (only shown when inserting a new symbol).

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.

1.6.14   Timer properties

Each timer can be selected for pick up, drop off, dwell, pulse or pick-up/drop-off operation.
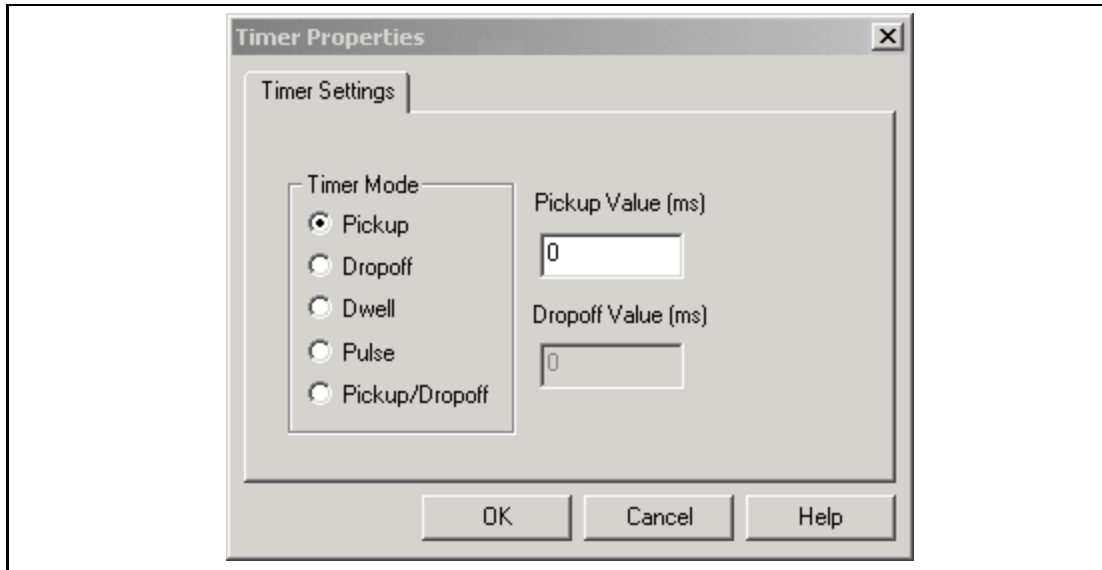
1.   Choose the operation mode from the **Timer Mode** tick list.

2.   Set the Pick-up Time (in milliseconds), if required.

3.   Set the Drop-off Time (in milliseconds), if required.

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1.6.15   Gate properties

A Gate may be an AND, OR, programmable gate or SR Latch .

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.

Three variants of the SR latch gate   are available. They are:

- Standard – no input dominant

- Set Input Dominant

- Reset Input Dominant

The output of the gate, Q is latched, i.e. its state is non-volatile upon power cycle.

The inversions of the input and output signals are supported.

The state of Q is reset when a new PSL is downloaded to the relay or when the active setting group is changed. The maximum number of SR Latch gates is 64.

The evaluation of the Q state is carried out after all the DDB changes have completed, i.e. at the end of the protection cycle and synchronised with protection task. Hence there is an inherent delay of a protection cycle in processing every one of the SR gates and the delay increases if the SR gates are connected one after another.

The user has to be aware that if there is a timer before the SR gate, then an additional delay of a protection cycle will be incurred before the Q state is changed.

The logic operations of the three variants of the gate are depicted in the diagram below:

Standard

S	R	Q
1	0	1
0	1	0
0	0	no change / last state
1	1	no change / last state

Set Input Dominant

S	R	Q
1	0	1
0	1	0
0	0	no change / last state
1	1	1

Reset Input Dominant

S	R	Q
1	0	1
0	1	0
0	0	no change / last state
1	1	0

P0737ENa
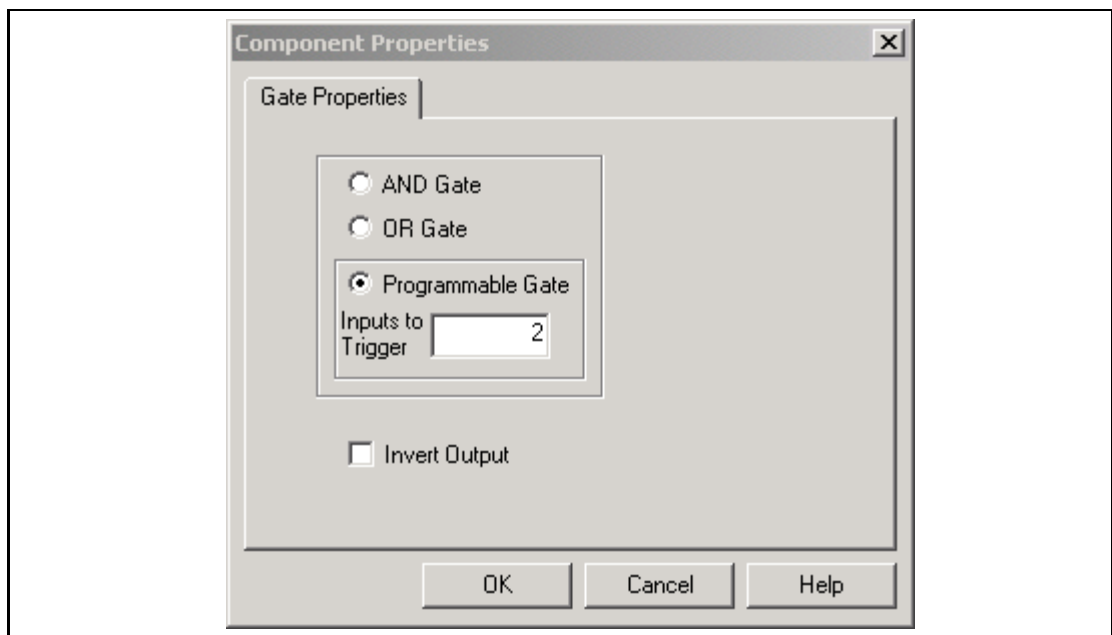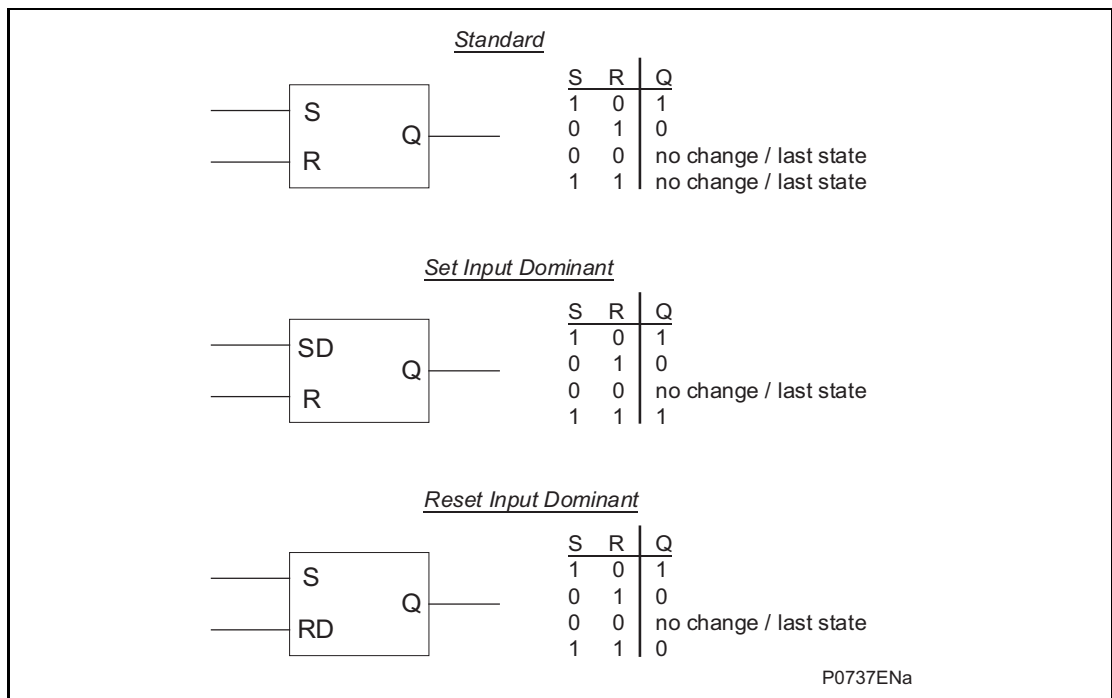
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1. Select the Gate type AND, OR, or Programmable.

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.

1.7 Description of P746 logic nodes

1.7.1 Sorted by DDB number

DDB No.	English Text	Source	Description
0	Relay 1	Relay Conditioner 1	Output Relay 1
31	Relay 32	Relay Conditioner 32	Output Relay 32
64	Opto Input 1	Opto Isolator Input 1	Opto Isolator Input 1
103	Opto Input 40	Opto Isolator Input 40	Opto Isolator Input 40
128	Relay Cond 1	PSL	Relay Conditioner 1
159	Relay Cond 32	PSL	Relay Conditioner 32
192	LED1 Red	PSL	Programmable Tri-LED 1 Red energized
193	LED1 Grn	PSL	Programmable Tri-LED 1 Green energized
206	LED8 Red	PSL	Programmable Tri-LED 8 Red energized
207	LED8 Grn	PSL	Programmable Tri-LED 8 Green energized
208	FnKey LED1 Red	PSL	Programmable function key Tri-LED 1 Red energized
209	FnKey LED1 Grn	PSL	Programmable function key Tri-LED 1 Green energized
226	FnKey LED10 Red	PSL	Programmable function key Tri-LED 10 Red energized
227	FnKey LED10 Grn	PSL	Programmable function key Tri-LED 10 Green energized
256	LED1 Con R	PSL	Assignment of signal to drive output Tri-LED 1 Red
257	LED1 Con G	PSL	Assignment of signal to drive output Tri-LED 1 Green
270	LED8 Con R	PSL	Assignment of signal to drive output Tri-LED 8 Red
271	LED8 Con G	PSL	Assignment of signal to drive output Tri-LED 8 Green
272	FnKey LED1 ConR	PSL	Assignment of signal to drive output FnKey Tri-LED 1 Red
273	FnKey LED1 ConG	PSL	Assignment of signal to drive output FnKey Tri-LED 1 Green
290	FnKey LED10 ConR	PSL	Assignment of signal to drive output FnKey Tri-LED 10 Red
291	FnKey LED10 ConG	PSL	Assignment of signal to drive output FnKey Tri-LED 10 Green
352	Function Key 1	User Control	Function Key 1 is activated. In 'Normal' mode it is high on keypress and in 'Toggle' mode remains high/low on single keypress
361	Function Key 10	User Control	Function Key 10 is activated. In 'Normal' mode it is high on keypress and in 'Toggle' mode remains high/low on single keypress
384	Timer out 1	Auxiliary Timer 1	Auxiliary Timer out 1
399	Timer out 16	Auxiliary Timer 16	Auxiliary Timer out 16
416	Timer in 1	PSL	Auxiliary Timer in 1
431	Timer in 16	PSL	Auxiliary Timer in 16
450	SG-DDB Invalid	Group Selection	Setting Group selection by DDB inputs invalid
451	CB Status Alarm	CB Status	CB Status Alarm (OR gate of all CB status alarm from CB1 to CB18 and Bus CB Alm)
465	Prot'n Disabled	OOS ALARM	Protection disabled
466	F out of range	Frequency tracking	Frequency out of range
467	Cct Fail Z1 Alm	BUSBAR Diff	Zone 1 Circuilty Fault Alarm
468	Cct Fail Z2 Alm	BUSBAR Diff	Zone 2 Circuilty Fault Alarm
469	Cct Fail CZ Alm	BUSBAR Diff	Check Zone Circuilty Fault Alarm
475	CT Fail Alarm	CT Supervision	CT Fail Alarm (CT Supervision)
477	VT Fail Alarm	VT Supervision	VT Fail Alarm (VT Supervision)
481	Breaker Fail	CB FAILURE	Breaker Fail Alarm (OR gate of all CB fail (CB1 to CB18, and BusCB fail)
482	CB Fail Alm T1	CB FAILURE	CB Fail Alarm of Terminal (feeder or coupler) 1
487	CB Fail Alm T6	CB FAILURE	CB Fail Alarm of Terminal (feeder or coupler) 6
499	CB Fail Alm T18	CB FAILURE	CB Fail Alarm of Terminal (feeder or coupler) 18
500	CBF Alarm Bus CB	CB FAILURE	CB Fail Alarm of the Bus CB
509	Z1 TestMode Alm	Commission Test	Zone 1 in Test Mode Alarm
510	Z2 TestMode Alm	Commission Test	Zone 2 in Test Mode Alarm
512	Battery Fail	Self Monitoring	Battery Fail alarm indication
513	Field Volts Fail	Self Monitoring	Relay 48V output Voltage Failure
514	GOOSE IED Absent	UCA2	The IED has not subscribed to a publishing IED

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DDB No.	English Text	Source	Description
515	NIC Not Fitted	UCA2	Network Interface Card not fitted/failed alarm
516	NIC No Response	UCA2	Network Interface Card not responding alarm
517	NIC Fatal Error	UCA2	Network Interface Card fatal error alarm indication
518	NIC Soft. Reload	UCA2	Network Interface Card software reload alarm
519	Bad TCP/IP Cfg.	UCA2	Bad TCP/IP Configuration Alarm
520	Bad OSI Config.	UCA2	Bad OSI Configuration Alarm
521	NIC Link Fail	UCA2	Network Interface Card link fail alarm indication
522	NIC SW Mis-Match	UCA2	Main card/NIC software mismatch alarm indication
523	IP Addr Conflict	UCA2	IP address conflict alarm indication
548	Block BusDiff Z1	PSL	Block the Differential protection of Zone 1
549	Block BusDiff Z2	PSL	Block the Differential protection of Zone 2
550	Block BusDiff CZ	PSL	Block the Differential protection of the Check Zone
558	Dead Bus Zone 1	SW	Dead Bus Zone 1 Detected
559	Dead Bus Zone 2	SW	Dead Bus Zone 2 Detected
560	VT Chk Allow Z1	SW	VT Check Allow Zone 1 to Trip
561	VT Chk Allow Z2	SW	VT Check Allow Zone 2 to Trip
571	Inhibit CTS	PSL	Inhibit CT Supervision
578	CTS Z1	PSL	Zone 1 Blocked By CT Supervison
579	CTS Z2	PSL	Zone 2 Blocked By CT Supervision
580	CTS T1	PSL	CT Supervision Terminal 1 (feeder or coupler)
585	CTS T6	PSL	CT Supervision Terminal 6 (feeder or coupler)
593	VTS Block Z1	BUSBAR Diff	Block Zone 1 VTS
597	VTS Block Z2	BUSBAR Diff	Block Zone 2 VTS
598	T1 I>1 Timer Blk	PSL	Terminal 1 (feeder or coupler) I>1 Timer Blocked
599	T1 I>2 Timer Blk	PSL	Terminal 1 (feeder or coupler) I>2 Timer Blocked
612	T6 I>1 Timer Blk	PSL	Terminal 6 (feeder or coupler) I>1 Timer Blocked
613	T6 I>2 Timer Blk	PSL	Terminal 6 (feeder or coupler) I>2 Timer Blocked
636	T18 I>1 TimerBlk	PSL	Terminal 18 (feeder or coupler) I>1 Timer Blocked
637	T18 I>2 TimerBlk	PSL	Terminal 18 (feeder or coupler) I>2 Timer Blocked
651	T1 IN>1 TimeBlk	PSL	Terminal 1 (feeder or coupler) IN>1 Timer Blocked
652	T1 IN>2 TimeBlk	PSL	Terminal 1 (feeder or coupler) IN>2 Timer Blocked
661	T6 IN>1 TimeBlk	PSL	Terminal 6 (feeder or coupler) IN>1 Timer Blocked
662	T6 IN>2 TimeBlk	PSL	Terminal 6 (feeder or coupler) IN>2 Timer Blocked
698	V<1 Timer Block	PSL	Not Used
699	V<2 Timer Block	PSL	Not Used
702	V>1 Timer Block	PSL	Not Used
703	V>2 Timer Block	PSL	Not Used
710	Set Z1 Test Mode	PSL	Set Zone 1 in Test Mode
711	Set Z2 Test Mode	PSL	Set Zone 2 in Test Mode
718	CB1 Alarm	PSL	CB1 Alarm
719	CB1 Closed	PSL	CB1 Closed
728	CB6 Alarm	PSL	CB6 Alarm
729	CB6 Closed	PSL	CB6 Closed
752	CB18 Alarm	PSL	CB18 Alarm
753	CB18 Closed	PSL	CB18 Closed
754	Q1 Z1 alarm	BUSBAR Diff	Isolator No 1 connected to Zone 1 alarm
755	Q1 Z1 Closed	BUSBAR Diff	Isolator No 1 connected to Zone 1 Closed
756	Q1 Z2 alarm	BUSBAR Diff	Isolator No 1 connected to Zone 2 alarm
757	Q1 Z2 Closed	BUSBAR Diff	Isolator No 1 connected to Zone 2 Closed
774	Q6 Z1 alarm	BUSBAR Diff	Isolator No 6 connected to Zone 1 alarm
775	Q6 Z1 Closed	BUSBAR Diff	Isolator No 6 connected to Zone 1 Closed
776	Q6 Z2 alarm	BUSBAR Diff	Isolator No 6 connected to Zone 2 alarm
777	Q6 Z2 Closed	BUSBAR Diff	Isolator No 6 connected to Zone 2 Closed
822	Q18 Z1 alarm	BUSBAR Diff	Isolator No 18 connected to Zone 1 alarm
823	Q18 Z1 Closed	BUSBAR Diff	Isolator No 18 connected to Zone 1 Closed
824	Q18 Z2 alarm	BUSBAR Diff	Isolator No 18 connected to Zone 2 alarm
825	Q18 Z2 Closed	BUSBAR Diff	Isolator No 18 connected to Zone 2 Closed
826	Q Busbar alarm	BUSBAR Diff	Tie Isolator Busbar alarm (coupling with one isolator only)
827	Q Busbar Closed	BUSBAR Diff	Tie Isolator Busbar Closed (coupling with one isolator only)

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DDB No.	English Text	Source	Description
828	Q Bus Z1 alarm	BUSBAR Diff	Isolator Bus Zone 1 alarm (coupling with one or isolator(s) and one breaker)
829	Q Bus Z1 Closed	BUSBAR Diff	Isolator Bus Zone 1 Closed (coupling with one or isolator(s) and one breaker)
830	Q Bus Z2 alarm	BUSBAR Diff	Isolator Bus Zone 2 alarm (coupling with one or isolator(s) and one breaker)
831	Q Bus Z2 Closed	BUSBAR Diff	Isolator Bus Zone 2 Closed (coupling with one or isolator(s) and one breaker)
832	Bus CB Alarm	PSL	Bus coupler CB Alarm
833	Bus CB Closed	PSL	Bus coupler CB Closed
834	CctFail Blk Z1 A	BUSBAR Diff	Zone 1 Phase A Circuity Fault
835	CctFail Blk Z1 B	BUSBAR Diff	Zone 1 Phase B Circuity Fault
836	CctFail Blk Z1 C	BUSBAR Diff	Zone 1 Phase C Circuity Fault
837	CctFail Blk Z2 A	BUSBAR Diff	Zone 2 Phase A Circuity Fault
838	CctFail Blk Z2 B	BUSBAR Diff	Zone 2 Phase B Circuity Fault
839	CctFail Blk Z2 C	BUSBAR Diff	Zone 2 Phase C Circuity Fault
840	CctFail Blk CZ A	BUSBAR Diff	Check Zone Phase A Circuity Fault
841	CctFail Blk CZ B	BUSBAR Diff	Check Zone Phase B Circuity Fault
842	CctFail Blk CZ C	BUSBAR Diff	Check Zone Phase C Circuity Fault
843	CctFail Blk Z1	BUSBAR Diff	Zone 1 Circuity Fault (OR gate of Z1 phase A CCTFail, Z1 phase B CCTFail, Z1 phase C CCTFail)
844	CctFail Blk Z2	BUSBAR Diff	Zone 2 Circuity Fault (OR gate of Z2 phase A CCTFail, Z2 phase B CCTFail, Z2 phase C CCTFail)
845	CctFail Blk A	BUSBAR Diff	Phase A Circuity Fault (OR gate of Phase A CCTFail Z1 and Z2)
846	CctFail Blk B	BUSBAR Diff	Phase B Circuity Fault (OR gate of Phase A CCTFail Z1 and Z2)
847	CctFail Blk C	BUSBAR Diff	Phase C Circuity Fault (OR gate of Phase A CCTFail Z1 and Z2)
848	CctFail Blk CZ	BUSBAR Diff	Check Zone Circuity Fault (OR gate of CZ phase A CCTFail, CZ phase B CCTFail, CZ phase C CCTFail)
849	Bus CB Not Ready	BUSBAR Diff	Bus CB Not Ready to open or close
864	Monitor Port 1	Commissioning Test	Monitor Port 1
865	Monitor Port 2	Commissioning Test	Monitor Port 2
866	Monitor Port 3	Commissioning Test	Monitor Port 3
867	Monitor Port 4	Commissioning Test	Monitor Port 4
868	Monitor Port 5	Commissioning Test	Monitor Port 5
869	Monitor Port 6	Commissioning Test	Monitor Port 6
870	Monitor Port 7	Commissioning Test	Monitor Port 7
871	Monitor Port 8	Commissioning Test	Monitor Port 8
874	MCB/VTS	PSL	Not Used
876	Reset Relays/LED	PSL	Reset Latched Relays & LEDs
879	Monitor Blocked	PSL	IEC60870-5-103 Monitoring Blocking
880	Command Blocked	PSL	IEC60870-5-103 Command Blocking
881	Time Synch	PSL	Time synchronise to nearest minute on 0-1 change
882	Test Mode	PSL	Set the Test Mode
883	Fault REC TRIG	PSL	Fault Record Trigger Input
884	SG Select x1	PSL	Setting Group Selector x1 (bit 0)
885	SG Select 1x	PSL	Setting Group Selector 1x (bit 1)
886	Any Trip	SW	Any Trip
891	Trip Initial	SW	Trip Initial (same as Any trip)
892	Reset CcT Fail	PSL	Reset Circuitry fault
893	Fault A	Fixed Logic	Phase A Fault
894	Fault B	Fixed Logic	Phase B Fault
895	Fault C	Fixed Logic	Phase C Fault
896	Fault N	Fixed Logic	Earth Fault
898	Z2 BusCB Trp	DIFF	Zone 2 BusCB Trip
899	Idiff Trip A	DIFF	Differential busbar Trip A (Or gate of Z1 Diff PhaseA, Z2 Diff PhaseA)
900	Idiff Trip B	DIFF	Differential busbar Trip B (Or gate of Z1 Diff PhaseB, Z2 Diff PhaseB)
901	Idiff Trip C	DIFF	Differential busbar Trip C (Or gate of Z1 Diff PhaseB, Z2 Diff PhaseB)
902	Idiff Trip	DIFF	Differential busbar Trip (Or gate of Z1 Diff and Z2 Diff)
903	Idiff TripA Z1	DIFF	Differential busbar Zone 1 Phase A Trip

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DDB No.	English Text	Source	Description
904	Idiff TripB Z1	DIFF	Differential busbar Zone 1 Phase B Trip
905	Idiff TripC Z1	DIFF	Differential busbar Zone 1 Phase C Trip
906	Idiff TripA Z2	DIFF	Differential busbar Zone 2 Phase A Trip
907	Idiff TripB Z2	DIFF	Differential busbar Zone 2 Phase B Trip
908	Idiff TripC Z2	DIFF	Differential busbar Zone 2 Phase C Trip
909	Z1 BusCB Trp	DIFF	Zone 1 BusCB Trip
912	Idiff Trip Z1	DIFF	Differential busbar Zone 1 Diff Trip
913	Idiff Trip Z2	DIFF	Differential busbar Zone 2 Diff Trip
915	Zone Trip T1	DIFF	Zone Trip Feeder 1 by Diff Trip or CBF Back Zone Trip or External Zone Trip
920	Zone Trip T6	DIFF	Zone Trip Feeder 6 by Diff Trip or CBF Back Zone Trip or External Zone Trip
932	Zone Trip T18	DIFF	Zone Trip Feeder 18 by Diff Trip or CBF Back Zone Trip or External Zone Trip
933	DeadZone 1 Trip	Dead Zone	Feeder 1 DeadZone Trip
938	DeadZone 6 Trip	Dead Zone	Feeder 6 DeadZone Trip
950	DeadZone18 Trip	DEADZONE	Feeder 18 DeadZone Trip
1008	T1 I>1 Trip	Phase Over Current	Terminal 1 (feeder or coupler) I>1 Trip
1009	T1 I>2 Trip	Phase Over Current	Terminal 1 (feeder or coupler) I>2 Trip
1018	T6 I>1 Trip	Phase Over Current	Terminal 6 (feeder or coupler) I>1 Trip
1019	T6 I>2 Trip	Phase Over Current	Terminal 6 (feeder or coupler) I>2 Trip
1042	T18 I>1 Trip	Phase Over Current	Terminal 18 (feeder or coupler) I>1 Trip
1043	T18 I>2 Trip	Phase Over Current	Terminal 18 (feeder or coupler) I>2 Trip
1104	CBF Retrip T1	CBF FAILURE	CBF Retrip Terminal 1 (feeder or coupler)
1109	CBF Retrip T6	CBF FAILURE	CBF Retrip Terminal 6 (feeder or coupler)
1121	CBF Retrip T18	CBF FAILURE	CBF Retrip Terminal 18 (feeder or coupler)
1122	CBF Bktrip Z1	CBF FAILURE	Zone 1 CBF Back Trip
1123	CBF Bktrip Z2	CBF FAILURE	Zone 2 CBF Back Trip
1124	RemoteTripT1	CBF FAILURE	Terminal 1 (feeder or coupler) Remote Trip By Busbar Diff or CBF
1129	RemoteTripT6	CBF FAILURE	Terminal 6 (feeder or coupler) Remote Trip By Busbar Diff or CBF
1141	RemoteTripT18	CBF FAILURE	Terminal 18 (feeder or coupler) Remote Trip By Busbar Diff or CBF
1142	T1 IN>1 Trip	Phase Over Current	Terminal 1 (feeder or coupler) IN>1 Trip
1143	T1 IN>2 Trip	Phase Over Current	Terminal 1 (feeder or coupler) IN>2 Trip
1152	T6 IN>1 Trip	Phase Over Current	Terminal 6 (feeder or coupler) IN>1 Trip
1153	T6 IN>2 Trip	Phase Over Current	Terminal 6 (feeder or coupler) IN>2 Trip
1262	Ext CBF INIT T1	External Trip	External CBF Init Terminal 1 (feeder or coupler)
1267	Ext CBF INIT T6	External Trip	External CBF Init Terminal 6 (feeder or coupler)
1279	Ext CBF INIT T18	External Trip	External CBF Init Terminal 18 (feeder or coupler)
1280	ExtCBFInit BusCB	External Trip	External CBF Init Bus CB
1281	Ext CBF Z1	External Trip	Zone 1 External CBF Trip
1282	Ext CBF Z2	External Trip	Zone 2 External CBF Trip
1283	CBF Retrp BusCB	CBF FAILURE	Bus CB CBF Retrip
1290	Int CBF Init T1	CBF FAILURE	Internal signal init CBF Terminal 1 (feeder or coupler)
1295	Int CBF Init T6	CBF FAILURE	Internal signal init CBF Terminal 6 (feeder or coupler)
1307	Int CBF Init T18	CBF FAILURE	Internal signal init CBF Terminal 18 (feeder or coupler)
1308	IntCBFInit BusCB	CBF FAILURE	Internal signal init CBF Bus CB
1312	Any Start	Protection Starts (most)	Any Start
1313	Id Bias Start A	DIFF	Busbar Diff Phase A Start
1314	Id Bias Start B	DIFF	Busbar Diff Phase B Start
1315	Id Bias Start C	DIFF	Busbar Diff Phase C Start
1316	DeadZone 1 Start	Dead Zone Over Current	Terminal 1 (feeder or coupler) DeadZone Over Current Start
1321	DeadZone 6 Start	Dead Zone Over Current	Terminal 6 (feeder or coupler) DeadZone Over Current Start
1333	DeadZone18 Start	Dead Zone Over Current	Terminal 18 (feeder or coupler) DeadZone Over Current Start
1340	T1 I>1 Start	Phase Over Current	Terminal 1 (feeder or coupler) I>1 Start
1341	T1 I>1 Start A	Phase Over Current	Terminal 1 (feeder or coupler) I>1 Start A
1342	T1 I>1 Start B	Phase Over Current	Terminal 1 (feeder or coupler) I>1 Start B
1343	T1 I>1 Start C	Phase Over Current	Terminal 1 (feeder or coupler) I>1 Start C

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DDB No.	English Text	Source	Description
1380	T6 I>1 Start	Phase Over Current	Terminal 6 (feeder or coupler) I>1 Start
1381	T6 I>1 Start A	Phase Over Current	Terminal 6 (feeder or coupler) I>1 Start A
1382	T6 I>1 Start B	Phase Over Current	Terminal 6 (feeder or coupler) I>1 Start B
1383	T6 I>1 Start C	Phase Over Current	Terminal 6 (feeder or coupler) I>1 Start C
1384	T6 I>2 Start	Phase Over Current	Terminal 6 (feeder or coupler) I>2 Start
1385	T6 I>2 Start A	Phase Over Current	Terminal 6 (feeder or coupler) I>2 Start A
1386	T6 I>2 Start B	Phase Over Current	Terminal 6 (feeder or coupler) I>2 Start B
1387	T6 I>2 Start C	Phase Over Current	Terminal 6 (feeder or coupler) I>2 Start C
1476	T18 I>1 Start	Phase Over Current	Terminal 18 (feeder or coupler) I>1 Start
1477	T18 I>1 Start A	Phase Over Current	Terminal 18 (feeder or coupler) I>1 Start A
1478	T18 I>1 Start B	Phase Over Current	Terminal 18 (feeder or coupler) I>1 Start B
1479	T18 I>1 Start C	Phase Over Current	Terminal 18 (feeder or coupler) I>1 Start C
1480	T18 I>2 Start	Phase Over Current	Terminal 18 (feeder or coupler) I>2 Start
1481	T18 I>2 Start A	Phase Over Current	Terminal 18 (feeder or coupler) I>2 Start A
1482	T18 I>2 Start B	Phase Over Current	Terminal 18 (feeder or coupler) I>2 Start B
1483	T18 I>2 Start C	Phase Over Current	Terminal 18 (feeder or coupler) I>2 Start C
1496	T1 IN>1 Start	Phase Over Current	Terminal 1 (feeder or coupler) IN>1 Start
1497	T1 IN>2 Start	Phase Over Current	Terminal 1 (feeder or coupler) IN>2 Start
1498	T2 IN>1 Start	Phase Over Current	Terminal 2 (feeder or coupler) IN>1 Start
1499	T2 IN>2 Start	Phase Over Current	Terminal 2 (feeder or coupler) IN>2 Start
1500	T3 IN>1 Start	Phase Over Current	Terminal 3 (feeder or coupler) IN>1 Start
1501	T3 IN>2 Start	Phase Over Current	Terminal 3 (feeder or coupler) IN>2 Start
1502	T4 IN>1 Start	Phase Over Current	Terminal 4 (feeder or coupler) IN>1 Start
1503	T4 IN>2 Start	Phase Over Current	Terminal 4 (feeder or coupler) IN>2 Start
1504	T5 IN>1 Start	Phase Over Current	Terminal 5 (feeder or coupler) IN>1 Start
1505	T5 IN>2 Start	Phase Over Current	Terminal 5 (feeder or coupler) IN>2 Start
1506	T6 IN>1 Start	Phase Over Current	Terminal 6 (feeder or coupler) IN>1 Start
1507	T6 IN>2 Start	Phase Over Current	Terminal 6 (feeder or coupler) IN>2 Start
1516	Id Start Z1 A	DIFF	Busbar Idiff Zone 1 StartA
1517	Id Start Z1 B	DIFF	Busbar Idiff Zone 1 StartB
1518	Id Start Z1 C	DIFF	Busbar Idiff Zone 1 StartC
1519	Id Start Z2 A	DIFF	Busbar Idiff Zone 2 StartA
1520	Id Start Z2 B	DIFF	Busbar Idiff Zone 2 StartB
1521	Id Start Z2 C	DIFF	Busbar Idiff Zone 2 StartC
1522	Idiff Start Z1	DIFF	Busbar Zone 2 Diff Start (OR gate of Z2 phase A, B, C Diff start)
1523	Idiff Start Z2	DIFF	Busbar Zone 1 Diff Start (OR gate of Z1 phase A, B, C Diff start)
1524	Idiff CZ StartA	DIFF	Busbar Check Zone Phase A Diff Start
1525	Idiff CZ StartB	DIFF	Busbar Check Zone Phase B Diff Start
1526	Idiff CZ StartC	DIFF	Busbar Check Zone Phase C Diff Start
1527	Idiff CZ Start	DIFF	Busbar Check Zone Diff Start (OR gate of CZ phase A, B, C Diff start)
1624	DeadZone1 StartA	Dead Zone Over Current	Terminal 1 (feeder or coupler) Phase A DeadZone Over Current start
1629	DeadZone6 StartA	Dead Zone Over Current	Terminal 6 (feeder or coupler) Phase A DeadZone Over Current start
1641	DeadZon18 StartA	Dead Zone Over Current	Terminal 18 (feeder or coupler) Phase A DeadZone Over Current start
1642	DeadZone1 startB	Dead Zone Over Current	Terminal 1 (feeder or coupler) Phase B DeadZone Over Current start
1647	DeadZone6 startB	Dead Zone Over Current	Terminal 6 (feeder or coupler) Phase B DeadZone Over Current start
1659	DeadZon18 startB	Dead Zone Over Current	Terminal 18 (feeder or coupler) Phase B DeadZone Over Current start
1660	DeadZone1 startC	Dead Zone Over Current	Terminal 1 (feeder or coupler) Phase C DeadZone Over Current start
1665	DeadZone6 startC	Dead Zone Over Current	Terminal 6 (feeder or coupler) Phase C DeadZone Over Current start
1677	DeadZon18 startC	Dead Zone Over Current	Terminal 18 (feeder or coupler) Phase C DeadZone Over Current start
1696	Z1 In Test Mode		Zone 1 in Test Mode
1697	Z2 In Test Mode		Zone 2 in Test Mode
1698	T1 In Test Mode		Terminal 1 (feeder or coupler) in Test Mode
1703	T6 In Test Mode		Terminal 6 (feeder or coupler) in Test Mode

PL

DDB No.	English Text	Source	Description
1715	T18 In Test Mode		Terminal 18 (feeder or coupler) in Test Mode
1716	PhComp Blk Z1 A		Zone 1 Phase A Phase Comparision Block
1717	PhComp Blk Z1 B		Zone 1 Phase B Phase Comparision Block
1718	PhComp Blk Z1 C		Zone 1 Phase C Phase Comparision Block
1719	PhComp Blk Z2 A		Zone 2 Phase A Phase Comparision Block
1720	PhComp Blk Z2 B		Zone 2 Phase B Phase Comparision Block
1721	PhComp Blk Z2 C		Zone 2 Phase C Phase Comparision Block
1728	CBF Z1 Blocked	BUSBAR CBF	Zone 1 CBF Blocked
1729	CBF Z2 Blocked	BUSBAR CBF	Zone 2 CBF Blocked
1730	Diff CZ C Blked	BUSBAR CBF	Check Zone Diff Phase C Blocked
1731	PhComp Blk Z1	Busbar Diff	Zone 1 Phase comparison blocked (AND gate of Phase A, B, C)
1732	PhComp Blk Z2	Busbar Diff	Zone 2 Phase comparison blocked (AND gate of Phase A, B, C)
1751	Freq High	Frequency Tracking	Frequnecy too High
1752	Freq Low	Frequency Tracking	Frequency too Low
1753	Freq Not found	Frequency Tracking	Frequncy Not Found
1754	CB1 Not Ready	CB Monitoring	CB1 Healthy
1759	CB6 Not Ready	CB Monitoring	CB6 Healthy
1771	CB18 Not Ready	CB Monitoring	CB18 not ready to open or close
1772	Termi1 Healthy	CB Monitoring	Terminal 1 (feeder or coupler) Healthy
1777	Termi6 Healthy	CB Monitoring	Terminal 6 (feeder or coupler) Healthy
1789	Termi18 Healthy	CB Monitoring	Terminal 18 (feeder or coupler) Healthy
1800	Diff Fault Z1	BUSBAR Diff	Zone 1 Busbar Diff any Phase Fault
1801	Diff Fault Z1 A	BUSBAR Diff	Zone 1 Busbar Diff Phase A Fault
1802	Diff Fault Z1 B	BUSBAR Diff	Zone 1 Busbar Diff Phase B Fault
1803	Diff Fault Z1 C	BUSBAR Diff	Zone 1 Busbar Diff Phase C Fault
1804	Diff Fault Z2	BUSBAR Diff	Zone 2 Busbar Diff Phase Fault
1805	Diff Fault Z2 A	BUSBAR Diff	Zone 2 Busbar Diff Phase A Fault
1806	Diff Fault Z2 B	BUSBAR Diff	Zone 2 Busbar Diff Phase B Fault
1807	Diff Fault Z2 C	BUSBAR Diff	Zone 2 Busbar Diff Phase C Fault
1808	Diff Fault CZ	BUSBAR Diff	Check Zone Busbar Diff Phase Fault
1809	Diff Fault CZ A	BUSBAR Diff	Check Zone Busbar Diff Phase A Fault
1810	Diff Fault CZ B	BUSBAR Diff	Check Zone Busbar Diff Phase B Fault
1811	Diff Fault CZ C	BUSBAR Diff	Check Zone Busbar Diff Phase C Fault
1812	Diff Z1 Blked	BUSBAR Diff	Zone 1 Busbar Diff in Block Status
1813	Diff Z1 A Blked	BUSBAR Diff	Zone 1 Busbar Diff Phase A Blocked
1814	Diff Z1 B Blked	BUSBAR Diff	Zone 1 Busbar Diff Phase B Blocked
1815	Diff Z1 C Blked	BUSBAR Diff	Zone 1 Busbar Diff Phase C Blocked
1816	Diff Z2 Blked	BUSBAR Diff	Zone 2 Busbar Diff Blocked
1817	Diff Z2 A Blked	BUSBAR Diff	Zone 2 Busbar Diff Phase A Blocked
1818	Diff Z2 B Blked	BUSBAR Diff	Zone 2 Busbar Diff Phase B Blocked
1819	Diff Z2 C Blked	BUSBAR Diff	Zone 2 Busbar Diff Phase C Blocked
1820	Diff CZ Blked	BUSBAR Diff	Check Zone Busbar Diff Blocked
1821	Diff CZ A Blked	BUSBAR Diff	Check Zone Busbar Diff Phase A Blocked
1822	Diff CZ B Blked	BUSBAR Diff	Check Zone Busbar Diff Phase B Blocked
1823	Diff CZ C Blked	BUSBAR Diff	Check Zone Busbar Diff Phase C Blocked
1824	Control Input 1	User Control 1	Control Input 1 - for SCADA and menu commands into PSL
1855	Control Input 32	User Control 32	Control Input 32 - for SCADA and menu commands into PSL
1856	Virtual Input 01	UCA2 GOOSE	GOOSE Input 01 - Allows binary signals to be mapped to interface into PSL
1887	Virtual Input 32	UCA2 GOOSE	GOOSE Input 32 - Allows binary signals to be mapped to interface into PSL
1888	Virtual Output01	PSL	GOOSE Output 01 - Allows binary signals to send to other devices
1919	Virtual Output32	PSL	GOOSE Output 32 - Allows binary signals to send to other devices
1920	PSL Int. 1	PSL	PSL Internal connection
2047	PSL Int. 128	PSL	PSL Internal connection

PL

1.7.2   Sorted by DDB name

English Text	DDB No.	Source	Description
Any Start	1312	Protection Starts (most)	Any Start
Any Trip	886	SW	Any Trip
Bad OSI Config.	520	UCA2	Bad OSI Configuration Alarm
Bad TCP/IP Cfg.	519	UCA2	Bad TCP/IP Configuration Alarm
Battery Fail	512	Self Monitoring	Battery Fail alarm indication
Block BusDiff CZ	550	PSL	Block the Differential protection of the Check Zone
Block BusDiff Z1	548	PSL	Block the Differential protection of Zone 1
Block BusDiff Z2	549	PSL	Block the Differential protection of Zone 2
Breaker Fail	481	CB FAILURE	Breaker Fail Alarm (OR gate of all CB fail (CB1 to CB18, and BusCB fail)
Bus CB Alarm	832	PSL	Bus coupler CB Alarm
Bus CB Closed	833	PSL	Bus coupler CB Closed
Bus CB Not Ready	849	BUSBAR Diff	Bus CB Not Ready to open or close
CB Fail Alm T1	482	CB FAILURE	CB Fail Alarm of Terminal (feeder or coupler) 1
CB Fail Alm T18	499	CB FAILURE	CB Fail Alarm of Terminal (feeder or coupler) 18
CB Fail Alm T6	487	CB FAILURE	CB Fail Alarm of Terminal (feeder or coupler) 6
CB Status Alarm	451	CB Status	CB Status Alarm (OR gate of all CB status alarm from CB1 to CB18 and Bus CB Alm)
CB1 Alarm	718	PSL	CB1 Alarm
CB1 Closed	719	PSL	CB1 Closed
CB1 Not Ready	1754	CB Monitoring	CB1 Healthy
CB18 Alarm	752	PSL	CB18 Alarm
CB18 Closed	753	PSL	CB18 Closed
CB18 Not Ready	1771	CB Monitoring	CB18 Healthy
CB6 Alarm	728	PSL	CB6 Alarm
CB6 Closed	729	PSL	CB6 Closed
CB6 Not Ready	1759	CB Monitoring	CB6 Healthy
CBF Alarm Bus CB	500	CB FAILURE	CB Fail Alarm of the Bus CB
CBF Bktrip Z1	1122	CBF FAILURE	Zone 1 CBF Back Trip
CBF Bktrip Z2	1123	CBF FAILURE	Zone 2 CBF Back Trip
CBF Retrip T1	1104	CBF FAILURE	CBF Retrip Terminal 1 (feeder or coupler)
CBF Retrip T18	1121	CBF FAILURE	CBF Retrip Terminal 18 (feeder or coupler)
CBF Retrip T6	1109	CBF FAILURE	CBF Retrip Terminal 6 (feeder or coupler)
CBF Retrp BusCB	1283	CBF FAILURE	Bus CB CBF Retrip
CBF Z1 Blocked	1728	BUSBAR CBF	Zone 1 CBF Blocked
CBF Z2 Blocked	1729	BUSBAR CBF	Zone 2 CBF Blocked
Cct Fail CZ Alm	469	BUSBAR Diff	Check Zone Circuilty Fault Alarm
Cct Fail Z1 Alm	467	BUSBAR Diff	Zone 1 Circuilty Fault Alarm
Cct Fail Z2 Alm	468	BUSBAR Diff	Zone 2 Circuilty Fault Alarm
CctFail Blk A	845	BUSBAR Diff	Phase A Circuity Fault (OR gate of Phase A CCTFail Z1 and Z2)
CctFail Blk B	846	BUSBAR Diff	Phase B Circuity Fault (OR gate of Phase A CCTFail Z1 and Z2)
CctFail Blk C	847	BUSBAR Diff	Phase C Circuity Fault (OR gate of Phase A CCTFail Z1 and Z2)
CctFail Blk CZ	848	BUSBAR Diff	Check Zone Circuity Fault (OR gate of CZ phase A CCTFail, CZ phase B CCTFail, CZ phase C CCTFail)
CctFail Blk CZ A	840	BUSBAR Diff	Check Zone Phase A Circuity Fault
CctFail Blk CZ B	841	BUSBAR Diff	Check Zone Phase B Circuity Fault
CctFail Blk CZ C	842	BUSBAR Diff	Check Zone Phase C Circuity Fault
CctFail Blk Z1	843	BUSBAR Diff	Zone 1 Circuity Fault (OR gate of Z1 phase A CCTFail, Z1 phase B CCTFail, Z1 phase C CCTFail)
CctFail Blk Z1 A	834	BUSBAR Diff	Zone 1 Phase A Circuity Fault
CctFail Blk Z1 B	835	BUSBAR Diff	Zone 1 Phase B Circuity Fault
CctFail Blk Z1 C	836	BUSBAR Diff	Zone 1 Phase C Circuity Fault
CctFail Blk Z2	844	BUSBAR Diff	Zone 2 Circuity Fault (OR gate of Z2 phase A CCTFail, Z2 phase B CCTFail, Z2 phase C CCTFail)
CctFail Blk Z2 A	837	BUSBAR Diff	Zone 2 Phase A Circuity Fault
CctFail Blk Z2 B	838	BUSBAR Diff	Zone 2 Phase B Circuity Fault

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English Text	DDB No.	Source	Description
CctFail Blk Z2 C	839	BUSBAR Diff	Zone 2 Phase C Circuity Fault
Command Blocked	880	PSL	IEC60870-5-103 Command Blocking
Control Input 1	1824	User Control 1	Control Input 1 - for SCADA and menu commands into PSL
Control Input 32	1855	User Control 32	Control Input 32 - for SCADA and menu commands into PSL
CT Fail Alarm	475	CT Supervision	CT Fail Alarm (CT Supervision)
CTS T1	580	PSL	CT Supervision Terminal 1 (feeder or coupler)
CTS T6	585	PSL	CT Supervision Terminal 6 (feeder or coupler)
CTS Z1	578	PSL	Zone 1 Blocked By CT Supervison
CTS Z2	579	PSL	Zone 2 Blocked By CT Supervison
Dead Bus Zone 1	558	SW	Dead Bus Zone 1 Detected
Dead Bus Zone 2	559	SW	Dead Bus Zone 2 Detected
DeadZon18 StartA	1641	Dead Zone Over Current	Terminal 18 (feeder or coupler) Phase A DeadZone Over Current start
DeadZon18 startB	1659	Dead Zone Over Current	Terminal 18 (feeder or coupler) Phase B DeadZone Over Current start
DeadZon18 startC	1677	Dead Zone Over Current	Terminal 18 (feeder or coupler) Phase C DeadZone Over Current start
DeadZone 1 Start	1316	Dead Zone Over Current	Terminal 1 (feeder or coupler) DeadZone Over Current Start
DeadZone 1 Trip	933	Dead Zone	Feeder 1 DeadZone Trip
DeadZone 6 Start	1321	Dead Zone Over Current	Terminal 6 (feeder or coupler) DeadZone Over Current Start
DeadZone 6 Trip	938	Dead Zone	Feeder 6 DeadZone Trip
DeadZone1 StartA	1624	Dead Zone Over Current	Terminal 1 (feeder or coupler) Phase A DeadZone Over Current start
DeadZone1 startB	1642	Dead Zone Over Current	Terminal 1 (feeder or coupler) Phase B DeadZone Over Current start
DeadZone1 startC	1660	Dead Zone Over Current	Terminal 1 (feeder or coupler) Phase C DeadZone Over Current start
DeadZone18 Start	1333	Dead Zone Over Current	Terminal 18 (feeder or coupler) DeadZone Over Current Start
DeadZone18 Trip	950	DEADZONE	Feeder 18 DeadZone Trip
DeadZone6 StartA	1629	Dead Zone Over Current	Terminal 6 (feeder or coupler) Phase A DeadZone Over Current start
DeadZone6 startB	1647	Dead Zone Over Current	Terminal 6 (feeder or coupler) Phase B DeadZone Over Current start
DeadZone6 startC	1665	Dead Zone Over Current	Terminal 6 (feeder or coupler) Phase C DeadZone Over Current start
Diff CZ A Blked	1821	BUSBAR Diff	Check Zone Busbar Diff Phase A Blocked
Diff CZ B Blked	1822	BUSBAR Diff	Check Zone Busbar Diff Phase B Blocked
Diff CZ Blked	1820	BUSBAR Diff	Check Zone Busbar Diff Blocked
Diff CZ C Blked	1730	BUSBAR CBF	Check Zone Diff Phase C Blocked
Diff CZ C Blked	1823	BUSBAR Diff	Check Zone Busbar Diff Phase C Blocked
Diff Fault CZ	1808	BUSBAR Diff	Check Zone Busbar Diff Phase Fault
Diff Fault CZ A	1809	BUSBAR Diff	Check Zone Busbar Diff Phase A Fault
Diff Fault CZ B	1810	BUSBAR Diff	Check Zone Busbar Diff Phase B Fault
Diff Fault CZ C	1811	BUSBAR Diff	Check Zone Busbar Diff Phase C Fault
Diff Fault Z1	1800	BUSBAR Diff	Zone 1 Busbar Diff any Phase Fault
Diff Fault Z1 A	1801	BUSBAR Diff	Zone 1 Busbar Diff Phase A Fault
Diff Fault Z1 B	1802	BUSBAR Diff	Zone 1 Busbar Diff Phase B Fault
Diff Fault Z1 C	1803	BUSBAR Diff	Zone 1 Busbar Diff Phase C Fault
Diff Fault Z2	1804	BUSBAR Diff	Zone 2 Busbar Diff Phase Fault
Diff Fault Z2 A	1805	BUSBAR Diff	Zone 2 Busbar Diff Phase A Fault
Diff Fault Z2 B	1806	BUSBAR Diff	Zone 2 Busbar Diff Phase B Fault
Diff Fault Z2 C	1807	BUSBAR Diff	Zone 2 Busbar Diff Phase C Fault
Diff Z1 A Blked	1813	BUSBAR Diff	Zone 1 Busbar Diff Phase A Blocked
Diff Z1 B Blked	1814	BUSBAR Diff	Zone 1 Busbar Diff Phase B Blocked
Diff Z1 Blked	1812	BUSBAR Diff	Zone 1 Busbar Diff in Block Status
Diff Z1 C Blked	1815	BUSBAR Diff	Zone 1 Busbar Diff Phase C Blocked
Diff Z2 A Blked	1817	BUSBAR Diff	Zone 2 Busbar Diff Phase A Blocked
Diff Z2 B Blked	1818	BUSBAR Diff	Zone 2 Busbar Diff Phase B Blocked
Diff Z2 Blked	1816	BUSBAR Diff	Zone 2 Busbar Diff Blocked
Diff Z2 C Blked	1819	BUSBAR Diff	Zone 2 Busbar Diff Phase C Blocked

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English Text	DDB No.	Source	Description
Ext CBF INIT T1	1262	External Trip	External CBF Init Terminal 1 (feeder or coupler)
Ext CBF INIT T18	1279	External Trip	External CBF Init Terminal 18 (feeder or coupler)
Ext CBF INIT T6	1267	External Trip	External CBF Init Terminal 6 (feeder or coupler)
Ext CBF Z1	1281	External Trip	Zone 1 External CBF Trip
Ext CBF Z2	1282	External Trip	Zone 2 External CBF Trip
ExtCBFInit BusCB	1280	External Trip	External CBF Init Bus CB
F out of range	466	Frequency tracking	Frequency out of range
Fault A	893	Fixed Logic	Phase A Fault
Fault B	894	Fixed Logic	Phase B Fault
Fault C	895	Fixed Logic	Phase C Fault
Fault N	896	Fixed Logic	Earth Fault
Fault REC TRIG	883	PSL	Fault Record Trigger Input
Field Volts Fail	513	Self Monitoring	Relay 48V output Voltage Failure
FnKey LED1 ConG	273	PSL	Assignment of signal to drive output FnKey Tri-LED 1 Green
FnKey LED1 ConR	272	PSL	Assignment of signal to drive output FnKey Tri-LED 1 Red
FnKey LED1 Grn	209	PSL	Programmable function key Tri-LED 1 Green energized
FnKey LED1 Red	208	PSL	Programmable function key Tri-LED 1 Red energized
FnKey LED10 ConG	291	PSL	Assignment of signal to drive output FnKey Tri-LED 10 Green
FnKey LED10 ConR	290	PSL	Assignment of signal to drive output FnKey Tri-LED 10 Red
FnKey LED10 Grn	227	PSL	Programmable function key Tri-LED 10 Green energized
FnKey LED10 Red	226	PSL	Programmable function key Tri-LED 10 Red energized
Freq High	1751	Frequency Tracking	Frequnecy too High
Freq Low	1752	Frequency Tracking	Frequency too Low
Freq Not found	1753	Frequency Tracking	Frequncy Not Found
Function Key 1	352	User Control	Function Key 1 is activated. In 'Normal' mode it is high on keypress and in 'Toggle' mode remains high/low on single keypress
Function Key 10	361	User Control	Function Key 10 is activated. In 'Normal' mode it is high on keypress and in 'Toggle' mode remains high/low on single keypress
GOOSE IED Absent	514	UCA2	The IED has not subscribed to a publishing IED
Id Bias Start A	1313	DIFF	Busbar Diff Phase A Start
Id Bias Start B	1314	DIFF	Busbar Diff Phase B Start
Id Bias Start C	1315	DIFF	Busbar Diff Phase C Start
Id Start Z1 A	1516	DIFF	Busbar Idiff Zone 1 StartA
Id Start Z1 B	1517	DIFF	Busbar Idiff Zone 1 StartB
Id Start Z1 C	1518	DIFF	Busbar Idiff Zone 1 StartC
Id Start Z2 A	1519	DIFF	Busbar Idiff Zone 2 StartA
Id Start Z2 B	1520	DIFF	Busbar Idiff Zone 2 StartB
Id Start Z2 C	1521	DIFF	Busbar Idiff Zone 2 StartC
Idiff CZ Start	1527	DIFF	Busbar Check Zone Diff Start (OR gate of CZ phase A, B, C Diff start)
Idiff CZ StartA	1524	DIFF	Busbar Check Zone Phase A Diff Start
Idiff CZ StartB	1525	DIFF	Busbar Check Zone Phase B Diff Start
Idiff CZ StartC	1526	DIFF	Busbar Check Zone Phase C Diff Start
Idiff Start Z1	1522	DIFF	Busbar Zone 2 Diff Start (OR gate of Z2 phase A, B, C Diff start)
Idiff Start Z2	1523	DIFF	Busbar Zone 1 Diff Start (OR gate of Z1 phase A, B, C Diff start)
Idiff Trip	902	DIFF	Differential busbar Trip (Or gate of Z1 Diff and Z2 Diff)
Idiff Trip A	899	DIFF	Differential busbar Trip A (Or gate of Z1 Diff PhaseA, Z2 Diff PhaseA)
Idiff Trip B	900	DIFF	Differential busbar Trip B (Or gate of Z1 Diff PhaseB, Z2 Diff PhaseB)
Idiff Trip C	901	DIFF	Differential busbar Trip C (Or gate of Z1 Diff PhaseB, Z2 Diff PhaseB)
Idiff Trip Z1	912	DIFF	Differential busbar Zone 1 Diff Trip
Idiff Trip Z2	913	DIFF	Differential busbar Zone 2 Diff Trip

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English Text	DDB No.	Source	Description
Idiff TripA Z1	903	DIFF	Differential busbar Zone 1 Phase A Trip
Idiff TripA Z2	906	DIFF	Differential busbar Zone 2 Phase A Trip
Idiff TripB Z1	904	DIFF	Differential busbar Zone 1 Phase B Trip
Idiff TripB Z2	907	DIFF	Differential busbar Zone 2 Phase B Trip
Idiff TripC Z1	905	DIFF	Differential busbar Zone 1 Phase C Trip
Idiff TripC Z2	908	DIFF	Differential busbar Zone 2 Phase C Trip
Inhibit CTS	571	PSL	Inhibit CT Supervision
Int CBF Init T1	1290	CBF FAILURE	Internal signal init CBF Terminal 1 (feeder or coupler)
Int CBF Init T18	1307	CBF FAILURE	Internal signal init CBF Terminal 18 (feeder or coupler)
Int CBF Init T6	1295	CBF FAILURE	Internal signal init CBF Terminal 6 (feeder or coupler)
IntCBFInit BusCB	1308	CBF FAILURE	Internal signal init CBF Bus CB
IP Addr Conflict	523	UCA2	IP address conflict alarm indication
LED1 Con G	257	PSL	Assignment of signal to drive output Tri-LED 1 Green
LED1 Con R	256	PSL	Assignment of signal to drive output Tri-LED 1 Red
LED1 Grn	193	PSL	Programmable Tri-LED 1 Green energized
LED1 Red	192	PSL	Programmable Tri-LED 1 Red energized
LED8 Con G	271	PSL	Assignment of signal to drive output Tri-LED 8 Green
LED8 Con R	270	PSL	Assignment of signal to drive output Tri-LED 8 Red
LED8 Grn	207	PSL	Programmable Tri-LED 8 Green energized
LED8 Red	206	PSL	Programmable Tri-LED 8 Red energized
MCB/VTS	874	PSL	Not Used
Monitor Blocked	879	PSL	IEC60870-5-103 Monitoring Blocking
Monitor Port 1	864	Commissioning Test	Monitor Port 1
Monitor Port 2	865	Commissioning Test	Monitor Port 2
Monitor Port 3	866	Commissioning Test	Monitor Port 3
Monitor Port 4	867	Commissioning Test	Monitor Port 4
Monitor Port 5	868	Commissioning Test	Monitor Port 5
Monitor Port 6	869	Commissioning Test	Monitor Port 6
Monitor Port 7	870	Commissioning Test	Monitor Port 7
Monitor Port 8	871	Commissioning Test	Monitor Port 8
NIC Fatal Error	517	UCA2	Network Interface Card fatal error alarm indication
NIC Link Fail	521	UCA2	Network Interface Card link fail alarm indication
NIC No Response	516	UCA2	Network Interface Card not responding alarm
NIC Not Fitted	515	UCA2	Network Interface Card not fitted/failed alarm
NIC Soft. Reload	518	UCA2	Network Interface Card software reload alarm
NIC SW Mis-Match	522	UCA2	Main card/NIC software mismatch alarm indication
Opto Input 1	64	Opto Isolator Input 1	Opto Isolator Input 1
Opto Input 40	103	Opto Isolator Input 40	Opto Isolator Input 40
PhComp Blk Z1	1731	Busbar DIff	Zone 1 Phase comparison blocked (AND gate of Phase A, B, C)
PhComp Blk Z1 A	1716		Zone 1 Phase A Phase Comparision Block
PhComp Blk Z1 B	1717		Zone 1 Phase B Phase Comparision Block
PhComp Blk Z1 C	1718		Zone 1 Phase C Phase Comparision Block
PhComp Blk Z2	1732	Busbar Diff	Zone 2 Phase comparison blocked (AND gate of Phase A, B, C)
PhComp Blk Z2 A	1719		Zone 2 Phase A Phase Comparision Block
PhComp Blk Z2 B	1720		Zone 2 Phase B Phase Comparision Block
PhComp Blk Z2 C	1721		Zone 2 Phase C Phase Comparision Block
Prot'n Disabled	465	OOS ALARM	Protection disabled
PSL Int. 1	1920	PSL	PSL Internal connection
PSL Int. 128	2047	PSL	PSL Internal connection
Q Bus Z1 alarm	828	BUSBAR Diff	Isolator Bus Zone 1 alarm (coupling with one or isolator(s) and one breaker)
Q Bus Z1 Closed	829	BUSBAR Diff	Isolator Bus Zone 1 Closed (coupling with one or isolator(s) and one breaker)
Q Bus Z2 alarm	830	BUSBAR Diff	Isolator Bus Zone 2 alarm (coupling with one or isolator(s) and one breaker)
Q Bus Z2 Closed	831	BUSBAR Diff	Isolator Bus Zone 2 Closed (coupling with one or isolator(s) and one breaker)
Q Busbar alarm	826	BUSBAR Diff	Tie Isolator Busbar alarm (coupling with one isolator only)

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English Text	DDB No.	Source	Description
Q Busbar Closed	827	BUSBAR Diff	Tie Isolator Busbar Closed (coupling with one isolator only)
Q1 Z1 alarm	754	BUSBAR Diff	Isolator No 1 connected to Zone 1 alarm
Q1 Z1 Closed	755	BUSBAR Diff	Isolator No 1 connected to Zone 1 Closed
Q1 Z2 alarm	756	BUSBAR Diff	Isolator No 1 connected to Zone 2 alarm
Q1 Z2 Closed	757	BUSBAR Diff	Isolator No 1 connected to Zone 2 Closed
Q18 Z1 alarm	822	BUSBAR Diff	Isolator No 18 connected to Zone 1 alarm
Q18 Z1 Closed	823	BUSBAR Diff	Isolator No 18 connected to Zone 1 Closed
Q18 Z2 alarm	824	BUSBAR Diff	Isolator No 18 connected to Zone 2 alarm
Q18 Z2 Closed	825	BUSBAR Diff	Isolator No 18 connected to Zone 2 Closed
Q6 Z1 alarm	774	BUSBAR Diff	Isolator No 6 connected to Zone 1 alarm
Q6 Z1 Closed	775	BUSBAR Diff	Isolator No 6 connected to Zone 1 Closed
Q6 Z2 alarm	776	BUSBAR Diff	Isolator No 6 connected to Zone 2 alarm
Q6 Z2 Closed	777	BUSBAR Diff	Isolator No 6 connected to Zone 2 Closed
Relay 1	0	Relay Conditioner 1	Output Relay 1
Relay 32	31	Relay Conditioner 32	Output Relay 32
Relay Cond 1	128	PSL	Relay Conditioner 1
Relay Cond 32	159	PSL	Relay Conditioner 32
RemoteTripT1	1124	CBF FAILURE	Terminal 1 (feeder or coupler) Remote Trip By Busbar Diff or CBF
RemoteTripT18	1141	CBF FAILURE	Terminal 18 (feeder or coupler) Remote Trip By Busbar Diff or CBF
RemoteTripT6	1129	CBF FAILURE	Terminal 6 (feeder or coupler) Remote Trip By Busbar Diff or CBF
Reset CcT Fail	892	PSL	Reset Circuitry fault
Reset Relays/LED	876	PSL	Reset Latched Relays & LEDs
Set Z1 Test Mode	710	PSL	Set Zone 1 in Test Mode
Set Z2 Test Mode	711	PSL	Set Zone 2 in Test Mode
SG Select 1x	885	PSL	Setting Group Selector 1x (bit 1)
SG Select x1	884	PSL	Setting Group Selector x1 (bit 0)
SG-DDB Invalid	450	Group Selection	Setting Group selection by DDB inputs invalid
T1 I>1 Start	1340	Phase Over Current	Terminal 1 (feeder or coupler) I>1 Start
T1 I>1 Start A	1341	Phase Over Current	Terminal 1 (feeder or coupler) I>1 Start A
T1 I>1 Start B	1342	Phase Over Current	Terminal 1 (feeder or coupler) I>1 Start B
T1 I>1 Start C	1343	Phase Over Current	Terminal 1 (feeder or coupler) I>1 Start C
T1 I>1 Timer Blk	598	PSL	Terminal 1 (feeder or coupler) I>1 Timer Blocked
T1 I>1 Trip	1008	Phase Over Current	Terminal 1 (feeder or coupler) I>1 Trip
T1 I>2 Timer Blk	599	PSL	Terminal 1 (feeder or coupler) I>2 Timer Blocked
T1 I>2 Trip	1009	Phase Over Current	Terminal 1 (feeder or coupler) I>2 Trip
T1 In Test Mode	1698		Terminal 1 (feeder or coupler) in Test Mode
T1 IN>1 Start	1496	Phase Over Current	Terminal 1 (feeder or coupler) IN>1 Start
T1 IN>1 TimeBlk	651	PSL	Terminal 1 (feeder or coupler) IN>1 Timer Blocked
T1 IN>1 Trip	1142	Phase Over Current	Terminal 1 (feeder or coupler) IN>1 Trip
T1 IN>2 Start	1497	Phase Over Current	Terminal 1 (feeder or coupler) IN>2 Start
T1 IN>2 TimeBlk	652	PSL	Terminal 1 (feeder or coupler) IN>2 Timer Blocked
T1 IN>2 Trip	1143	Phase Over Current	Terminal 1 (feeder or coupler) IN>2 Trip
T18 I>1 Start	1476	Phase Over Current	Terminal 18 (feeder or coupler) I>1 Start
T18 I>1 Start A	1477	Phase Over Current	Terminal 18 (feeder or coupler) I>1 Start A
T18 I>1 Start B	1478	Phase Over Current	Terminal 18 (feeder or coupler) I>1 Start B
T18 I>1 Start C	1479	Phase Over Current	Terminal 18 (feeder or coupler) I>1 Start C
T18 I>1 TimerBlk	636	PSL	Terminal 18 (feeder or coupler) I>1 Timer Blocked
T18 I>1 Trip	1042	Phase Over Current	Terminal 18 (feeder or coupler) I>1 Trip
T18 I>2 Start	1480	Phase Over Current	Terminal 18 (feeder or coupler) I>2 Start
T18 I>2 Start A	1481	Phase Over Current	Terminal 18 (feeder or coupler) I>2 Start A
T18 I>2 Start B	1482	Phase Over Current	Terminal 18 (feeder or coupler) I>2 Start B
T18 I>2 Start C	1483	Phase Over Current	Terminal 18 (feeder or coupler) I>2 Start C
T18 I>2 TimerBlk	637	PSL	Terminal 18 (feeder or coupler) I>2 Timer Blocked
T18 I>2 Trip	1043	Phase Over Current	Terminal 18 (feeder or coupler) I>2 Trip
T18 In Test Mode	1715		Terminal 18 (feeder or coupler) in Test Mode
T2 IN>1 Start	1498	Phase Over Current	Terminal 2 (feeder or coupler) IN>1 Start
T2 IN>2 Start	1499	Phase Over Current	Terminal 2 (feeder or coupler) IN>2 Start
T3 IN>1 Start	1500	Phase Over Current	Terminal 3 (feeder or coupler) IN>1 Start

PL

English Text	DDB No.	Source	Description
T3 IN>2 Start	1501	Phase Over Current	Terminal 3 (feeder or coupler) IN>2 Start
T4 IN>1 Start	1502	Phase Over Current	Terminal 4 (feeder or coupler) IN>1 Start
T4 IN>2 Start	1503	Phase Over Current	Terminal 4 (feeder or coupler) IN>2 Start
T5 IN>1 Start	1504	Phase Over Current	Terminal 5 (feeder or coupler) IN>1 Start
T5 IN>2 Start	1505	Phase Over Current	Terminal 5 (feeder or coupler) IN>2 Start
T6 I>1 Start	1380	Phase Over Current	Terminal 6 (feeder or coupler) I>1 Start
T6 I>1 Start A	1381	Phase Over Current	Terminal 6 (feeder or coupler) I>1 Start A
T6 I>1 Start B	1382	Phase Over Current	Terminal 6 (feeder or coupler) I>1 Start B
T6 I>1 Start C	1383	Phase Over Current	Terminal 6 (feeder or coupler) I>1 Start C
T6 I>1 Timer Blk	612	PSL	Terminal 6 (feeder or coupler) I>1 Timer Blocked
T6 I>1 Trip	1018	Phase Over Current	Terminal 6 (feeder or coupler) I>1 Trip
T6 I>2 Start	1384	Phase Over Current	Terminal 6 (feeder or coupler) I>2 Start
T6 I>2 Start A	1385	Phase Over Current	Terminal 6 (feeder or coupler) I>2 Start A
T6 I>2 Start B	1386	Phase Over Current	Terminal 6 (feeder or coupler) I>2 Start B
T6 I>2 Start C	1387	Phase Over Current	Terminal 6 (feeder or coupler) I>2 Start C
T6 I>2 Timer Blk	613	PSL	Terminal 6 (feeder or coupler) I>2 Timer Blocked
T6 I>2 Trip	1019	Phase Over Current	Terminal 6 (feeder or coupler) I>2 Trip
T6 In Test Mode	1703		Terminal 6 (feeder or coupler) in Test Mode
T6 IN>1 Start	1506	Phase Over Current	Terminal 6 (feeder or coupler) IN>1 Start
T6 IN>1 TimeBlk	661	PSL	Terminal 6 (feeder or coupler) IN>1 Timer Blocked
T6 IN>1 Trip	1152	Phase Over Current	Terminal 6 (feeder or coupler) IN>1 Trip
T6 IN>2 Start	1507	Phase Over Current	Terminal 6 (feeder or coupler) IN>2 Start
T6 IN>2 TimeBlk	662	PSL	Terminal 6 (feeder or coupler) IN>2 Timer Blocked
T6 IN>2 Trip	1153	Phase Over Current	Terminal 6 (feeder or coupler) IN>2 Trip
Termi1 Healthy	1772	CB Monitoring	Terminal 1 (feeder or coupler) Healthy
Termi18 Healthy	1789	CB Monitoring	Terminal 18 (feeder or coupler) Healthy
Termi6 Healthy	1777	CB Monitoring	Terminal 6 (feeder or coupler) Healthy
Test Mode	882	PSL	Set the Test Mode
Time Synch	881	PSL	Time synchronise to nearest minute on 0-1 change
Timer in 1	416	PSL	Auxiliary Timer in 1
Timer in 16	431	PSL	Auxiliary Timer in 16
Timer out 1	384	Auxiliary Timer 1	Auxiliary Timer out 1
Timer out 16	399	Auxiliary Timer 16	Auxiliary Timer out 16
Trip Initial	891	SW	Trip Initial (same as Any trip)
V<1 Timer Block	698	PSL	Not Used
V<2 Timer Block	699	PSL	Not Used
V>1 Timer Block	702	PSL	Not Used
V>2 Timer Block	703	PSL	Not Used
Virtual Input 01	1856	UCA2 GOOSE	GOOSE Input 01 - Allows binary signals to be mapped to interface into PSL
Virtual Input 32	1887	UCA2 GOOSE	GOOSE Input 32 - Allows binary signals to be mapped to interface into PSL
Virtual Output01	1888	PSL	GOOSE Output 01 - Allows binary signals to send to other devices
Virtual Output32	1919	PSL	GOOSE Output 32 - Allows binary signals to send to other devices
VT Chk Allow Z1	560	SW	VT Check Allow Zone 1 to Trip
VT Chk Allow Z2	561	SW	VT Check Allow Zone 2 to Trip
VT Fail Alarm	477	VT Supervision	VT Fail Alarm (VT Supervision)
VTS Block Z1	593	BUSBAR Diff	Block Zone 1 VTS
VTS Block Z2	597	BUSBAR Diff	Block Zone 2 VTS
Z1 BusCB Trp	909	DIFF	Zone 1 BusCB Trip
Z1 In Test Mode	1696		Zone 1 in Test Mode
Z1 TestMode Alm	509	Commission Test	Zone 1 in Test Mode Alarm
Z2 BusCB Trp	898	DIFF	Zone 2 BusCB Trip
Z2 In Test Mode	1697		Zone 2 in Test Mode
Z2 TestMode Alm	510	Commission Test	Zone 2 in Test Mode Alarm
Zone Trip T1	915	DIFF	Zone Trip Feeder 1 by Diff Trip or CBF Back Zone Trip or External Zone Trip
Zone Trip T18	932	DIFF	Zone Trip Feeder 18 by Diff Trip or CBF Back Zone Trip or External Zone Trip
Zone Trip T6	920	DIFF	Zone Trip Feeder 6 by Diff Trip or CBF Back Zone Trip or External Zone Trip

PL

1.8   Factory default programmable scheme logic

The following section 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	32	24	8
P746xxxE	24	24	24	--
P746xxxF	24	24	16	8
P746xxxG	24	24	8	16
P746xxxH	32	24	24	--
P746xxxJ	32	24	16	8
P746xxxK	40	24	24	--

1.9   Logic input mapping

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

Opto-Input Number	P746 Relay Text	Function
1	Input L1	CB1 Closed
2	Input L2	CB2 Closed
3	Input L3	CB3 Closed
4	Input L4	CB4 Closed
5	Input L5	CB5 Closed
6	Input L6	CB6 Closed
7	Input L7	T11 Closed
8	Input L8	T21 Closed
9	Input L9	T32 Closed
10	Input L10	T42 Closed
11	Input L11	T51 Closed
12	Input L12	T52 Closed
13	Input L13	T61 Closed
14	Input L14	T62 Closed
15	Input L15	Block CZ
16	Input L16	Not mapped
17	Input L17	Not mapped
18	Input L18	Not mapped
19	Input L19	Not mapped
20	Input L20	Not mapped
21	Input L21	Not mapped

PL

Opto-Input Number	P746 Relay Text	Function
22	Input L22	Not mapped
23	Input L23	Not mapped
24	Input L24	Not mapped
25	Input L25	Not mapped
26	Input L26	Not mapped
27	Input L27	Not mapped
28	Input L28	Not mapped
29	Input L29	Not mapped
30	Input L30	Not mapped
31	Input L31	Not mapped
32	Input L32	Not mapped
33	Input L33	Not mapped
34	Input L34	Not mapped
35	Input L35	Not mapped
36	Input L36	Not mapped
37	Input L37	Not mapped
38	Input L38	Not mapped
39	Input L39	Not mapped
40	Input L40	Not mapped

PL

1.10 Relay output contact mapping

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

Relay Contact Number	P746 Relay Text	P746 Relay Conditioner	Function
1	Relay R1	Pick-up 0/0	Trip CB1
2	Relay R2	Pick-up 0/0	Trip CB2
3	Relay R3	Pick-up 0/0	Trip CB3
4	Relay R4	Pick-up 0/0	Trip CB4
5	Relay R5	Pick-up 0/0	Trip CB5
6	Relay R6	Pick-up 0/0	Bus 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	Relay R16	Pick-up 0/0	CB Alarm
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

Note: It is essential that Relay 1, 2 and 3 are used for tripping purposes as this output is directly driven in the fixed logic to obtain the typical 13ms tripping time.

PL

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.

1.11 Function key input mapping

The default mappings for each of the function key inputs are as shown in the following 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	Disabled	Reset Indications
10	Function Key 10	Normal	Start DR

1.12 Programmable LED output mapping

PL

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

LED Number	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	CB6 closed CB6 Alarm CB6 open

PL

LED Number	LED Input Connection/Text	Latched	P746 LED Function Indication
7	LED7 Red	No	50BF Trip zone 1
	LED7 Yellow		87BB & 50 BF trip zone 1
	LED7 Green		87BB Trip zone 1
8	LED8 Red	No	50BF Trip zone 2
	LED8 Yellow		87BB & 50 BF trip zone 2
	LED8 Green		87BB Trip zone 2
9	FnKey LED1 Red	No	Zone 1: blocked
	FnKey LED1 Yellow		Zone 1: alarm (CZ not blocked)
	FnKey LED1 Green		Zone 1: healthy
10	FnKey LED2 Red	No	Zone 1 in test mode
	FnKey LED2 Yellow		Not used
	FnKey LED2 Green		Zone 1: healthy
11	FnKey LED3 Red	No	Fault on phase A
	FnKey LED3 Yellow		Not used
	FnKey LED3 Green		Not used
12	FnKey LED4 Red	No	Fault on phase B
	FnKey LED4 Yellow		Not used
	FnKey LED4 Green		Not used
13	FnKey LED5 Red	No	Fault on phase C
	FnKey LED5 Yellow		Not used
	FnKey LED5 Green		Not used
14	FnKey LED6 Red	No	Zone 2: blocked
	FnKey LED6 Yellow		Zone 2: alarm (CZ not blocked)
	FnKey LED6 Green		Zone 2: healthy
15	FnKey LED7 Red	No	Zone 2 in test mode
	FnKey LED7 Yellow		Not used
	FnKey LED7 Green		Zone 2: healthy
16	FnKey LED8 Red	No	Not used
	FnKey LED8 Yellow		Not used
	FnKey LED8 Green		Not used
17	FnKey LED9 Red	No	Trip latched
	FnKey LED9 Yellow		Not used
	FnKey LED9 Green		Indications resetting
18	FnKey LED10 Red	No	Not used
	FnKey LED10 Yellow		External disturbance record
	FnKey LED10 Green		Disturbance record started

1.13 Fault recorder start mapping

The default mapping for the signal which initiates a fault record is as shown in the following table:

Initiating Signal	Fault Trigger
Trip 87BB	Initiate fault recording from main protection trip
Trip 50BF	Initiate fault recording from main protection trip

1.14 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:

| Grp. PSL Ref. | When downloading a PSL to the relay, the user will be prompted to enter which group the PSL is for and a reference identifier. 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. |

PL

| 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.

MiCOM P746 PROGRAMMABLE SCHEME LOGIC

PL

INPUTS   P746

Isolator Q1 input mapping

Input L7
DDB #070   &   Q1 Z1 Closed
                             DDB #755

                             Q1 Z2 Closed
                             DDB #757

Isolator Q2 input mapping

Input L8
DDB #071   &   Q2 Z1 Closed
                             DDB #759

                             Q2 Z2 Closed
                             DDB #761

Isolator Q3 input mapping

                             Q3 Z1 Closed
                             DDB #763

Input L9
DDB #072   &   Q3 Z2 Closed
                             DDB #765

Isolator Q4 input mapping

                             Q4 Z1 Closed
                             DDB #767

Input L10
DDB #073   &   Q4 Z2 Closed
                             DDB #769

Isolator Q5 input mapping

Input L11
DDB #074   &   Q5 Z1 Closed
                             DDB #771

Input L12
DDB #075   &   Q5 Z2 Closed
                             DDB #773

Bus Isolator input mapping

Input L13
DDB #076   &   Q Bus Z1 Closed
                             DDB #829

Input L14
DDB #077   &   Q Bus Z2 Closed
                             DDB #831

Note: Even if they do not exist keep the Q Bus Zx Closed linked to the NAND Gate

Inhibit Check Zone

Input L15
DDB #078   Block BusDiff CZ
                             DDB #550

Input L16
DDB #079

2

LEFT-HAND LEDS 1/2   P746

Z1 trip LED

CBF Bktrip Z1
DDB #1122

Idiff Trip Z1
DDB #912

Non - Latching

LED7 Red
DDB #204

LED7 Grn
DDB #205

Z2 trip LED

CBF Bktrip Z2
DDB #1123

Idiff Trip Z2
DDB #913

Non - Latching

LED8 Red
DDB #206

LED8 Grn
DDB #207

RIGHT-HAND LEDS and FnKey

Z1 circuitry fault and reset circuitry fault FnKey

Z2 circuitry fault

Cct Fail CZ Alm
DDB #469

Cct Fail Z1 Alm
DDB #467

Cct Fail Z2 Alm
DDB #468

CctFail Blk Z1
DDB #843

CctFail Blk Z2
DDB #844

Non - Latching

FnKey LED8 Red
DDB #222

FnKey LED8 Grn
DDB #223

Function Key 8
DDB #359

Reset CcT Fail
DDB #892

Z1 test mode

Function Key 2
DDB #353

Set Z1 Test Mode
DDB #710

Z1 In Test Mode
DDB #1696

Diff CZ Blked
DDB #1820

Non - Latching

FnKey LED2 Red
DDB #210

FnKey LED2 Grn
DDB #211

Z2 test mode

Function Key 7
DDB #358

Set Z2 Test Mode
DDB #711

Z2 In Test Mode
DDB #1697

Diff CZ Blked
DDB #1820

Non - Latching

FnKey LED7 Red
DDB #220

FnKey LED7 Grn
DDB #221

PL

3

LEFT-HAND LEDS 2/2

P746

Fault phase A

Fault A
DDB #893

Latching

FnKey LED3 Red
DDB #212

FnKey LED3 Grn
DDB #213

Fault Phase B

Fault B
DDB #894

Latching

FnKey LED4 Red
DDB #214

FnKey LED4 Grn
DDB #215

Fault phase C

Fault C
DDB #895

Latching

FnKey LED5 Red
DDB #216

FnKey LED5 Grn
DDB #217

Reset Indication

Function Key 9
DDB #360

Reset Relays/LED
DDB #876

Non -
Latching

FnKey LED9 Red
DDB #224

FnKey LED9 Grn
DDB #225

Fault recorder trigger

Any Trip
DDB #886

Any Start
DDB #1312

Function Key 10
DDB #361

1

1

Non -
Latching

FnKey LED10 Red
DDB #226

FnKey LED10 Grn
DDB #227

Fault REC TRIG
DDB #883

ZONE 1 BLOCKED

Diff CZ Blked
DDB #1820

Diff Z1 Blked
DDB #1812

1

&

Non -
Latching

FnKey LED1 Red
DDB #208

FnKey LED1 Grn
DDB #209

ZONE 2 BLOCKED

Diff CZ Blked
DDB #1820

Diff Z2 Blked
DDB #1816

1

&

Non -
Latching

FnKey LED6 Red
DDB #218

FnKey LED6 Grn
DDB #219

PL

4

OUTPUT RELAYS 1/2

P746

Terminal CB1 trip mapping

T1 I>1 Trip
DDB #1008

T1 I>2 Trip
DDB #1009

T1 IN>1 Trip
DDB #1142

T1 IN>2 Trip
DDB #1143

Zone Trip T1
DDB #915

CBF Retrip T1
DDB #1104

T1 In Test Mode
DDB #1698

DeadZone 1 Trip
DDB #933

Int CBF Init T1
DDB #1290

200 Dwell 0

Output R1
DDB #000

Terminal CB2 trip mapping

T2 I>1 Trip
DDB #1010

T2 I>2 Trip
DDB #1011

T2 IN>1 Trip
DDB #1144

T2 IN>2 Trip
DDB #1145

Zone Trip T2
DDB #916

CBF Retrip T2
DDB #1105

T2 In Test Mode
DDB #1699

DeadZone 2 Trip
DDB #934

Int CBF Init T2
DDB #1291

200 Dwell 0

Output R2
DDB #001

Terminal CB3 trip mapping

T3 I>1 Trip
DDB #1012

T3 I>2 Trip
DDB #1013

T3 IN>1 Trip
DDB #1146

T3 IN>2 Trip
DDB #1147

Zone Trip T3
DDB #917

CBF Retrip T3
DDB #1106

T3 In Test Mode
DDB #1700

DeadZone 3 Trip
DDB #935

Int CBF Init T3
DDB #1292

200 Dwell 0

Output R3
DDB #002

PL

5

OUTPUT RELAYS 2/2

P746

Terminal CB4 trip mapping

T4 I>1 Trip
DDB #1014

T4 I>2 Trip
DDB #1015

T4 IN>1 Trip
DDB #1148

T4 IN>2 Trip
DDB #1149

Zone Trip T4
DDB #918

CBF Retrip T4
DDB #1107

T4 In Test Mode
DDB #1701

DeadZone 4 Trip
DDB #936

Int CBF Init T4
DDB #1293

200 Dwell 0

Output R4
DDB #003

Terminal CB5 trip mapping

T5 I>1 Trip
DDB #1016

T5 I>2 Trip
DDB #1017

T5 IN>1 Trip
DDB #1150

T5 IN>2 Trip
DDB #1151

Zone Trip T5
DDB #919

CBF Retrip T5
DDB #1108

T5 In Test Mode
DDB #1702

DeadZone 5 Trip
DDB #937

Int CBF Init T5
DDB #1294

200 Dwell 0

Output R5
DDB #004

Bus CB Trip

Z1 BusCB Trp
DDB #909

CBF Retrp BusCB
DDB #1283

Z1 In Test Mode
DDB #1696

Z2 BusCB Trp
DDB #898

CBF Retrp BusCB
DDB #1283

Z2 In Test Mode
DDB #1697

200 Dwell 0

Output R6
DDB #005

6

PL

Cct Fail Z1 Alm DDB #467	
Cct Fail Z2 Alm DDB #468	1
Cct Fail CZ Alm DDB #469	

Pick-Up → Output R7 DDB #006

Fault zone 1

Idiff Start Z1 DDB #1522

Pick-Up → Output R8 DDB #007

Fault zone 2

Idiff Start Z2 DDB #1523

Pick-Up → Output R9 DDB #008

CBF BkTrip

CBF Bktrip Z1 DDB #1122	1
CBF Bktrip Z2 DDB #1123	

Pick-Up → Output R10 DDB #009

87BB Trip

Idiff Trip DDB #902

Pick-Up → Output R11 DDB #010

Faulted Phase A

Fault A DDB #893

Pick-Up → Output R12 DDB #011

Faulted Phase B

Fault B DDB #894

Pick-Up → Output R13 DDB #012

Faulted Phase C

Fault C DDB #895

Pick-Up → Output R14 DDB #013

Test Mode

Z1 In Test Mode DDB #1696	1
Z2 In Test Mode DDB #1697	

Pick-Up → Output R15 DDB #014

CB Alarm

CB Status Alarm DDB #451

Pick-Up → Output R16 DDB #015

PL

7

MEASUREMENTS AND RECORDING

MR

Date:	**2008**
Hardware Suffix:	**K**
Software Version:	**01**
Connection Diagrams:	**10P746xx (xx = 01 to 07)**

CONTENTS

MR

MR

1. MEASUREMENTS AND RECORDING

1.1 Introduction

The P746 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 and are discussed below.

1.2 Event & fault records

The relay records and time tags up to 512 events and stores them in non-volatile (battery backed up) memory. This enables the system operator to establish the sequence of events that occurred within the relay following a particular power system condition, switching sequence etc. When the available space is exhausted, the oldest event is automatically overwritten by the new one.

The real time clock within the relay provides the time tag to each event, to a resolution of 1ms.

The event records are available for viewing either via the front plate LCD or remotely, via the communications port.

Local viewing on the LCD is achieved in the menu column entitled "VIEW RECORDS". This column allows viewing of event, fault and maintenance records.

VIEW RECORDS	
LCD Reference	Description
Select Event	Setting range from 0 to 511. This selects the required event record from the possible 512 that may be stored. A value of 0 corresponds to the latest event and so on.
Menu Cell Ref	Latched alarm active, Latched alarm inactive, Self reset alarm active, Self reset alarm inactive, Relay contact event, Opto-isolated input event, Protection event, General event, Fault record event, Maintenance record event
Time & Date	Time & Date Stamp for the event given by the internal Real Time Clock.
Event Text	Up to 16 Character description of the Event (refer to following sections).
Event Value	Up to 32 Bit Binary Flag or integer representative of the Event (refer to following sections).
Select Fault	Setting range from 0 to 4. This selects the required fault record from the possible 5 that may be stored. A value of 0 corresponds to the latest fault and so on.
	The following cells show all the fault flags, protection starts, protection trips, fault location, measurements etc. associated with the fault, i.e. the complete fault record.
Faulted Phase	Phase initiating fault recorder starts : Start A, Start B, Start C, Start N, Trip A, Trip B, Trip C, Trip N

MR

VIEW RECORDS	
LCD Reference	Description
Start Elements1	Id Bias Start A, Id Bias Start B, Id Bias Start C, DeadZone 1 Start, DeadZone 2 Start, DeadZone 3 Start, DeadZone 4 Start, DeadZone 5 Start, DeadZone 6 Start, DeadZone 7 Start, DeadZone 8 Start, DeadZone 9 Start, DeadZone10 Start, DeadZone11 Start, DeadZone12 Start, DeadZone13 Start, DeadZone14 Start, DeadZone15 Start, DeadZone16 Start, DeadZone17 Start, DeadZone18 Start, T1 I>1 Start, T1 I>2 Start, T2 I>1 Start, T2 I>2 Start, T3 I>1 Start, T3 I>2 Start, T4 I>1 Start, T4 I>2 Start, T5 I>1 Start, T5 I>2 Start, T6 I>1 Start
Start Elements2	T6 I>2 Start, T7 I>1 Start, T7 I>2 Start, T8 I>1 Start, T8 I>2 Start, T9 I>1 Start, T9 I>2 Start, T10 I>1 Start, T10 I>2 Start, T11 I>1 Start, T11 I>2 Start, T12 I>1 Start, T12 I>2 Start, T13 I>1 Start, T13 I>2 Start, T14 I>1 Start, T14 I>2 Start, T15 I>1 Start, T15 I>2 Start, T16 I>1 Start, T16 I>2 Start, T17 I>1 Start, T17 I>2 Start, T18 I>1 Start, T18 I>2 Start, T1 IN>1 Start, T1 IN>2 Start, T2 IN>1 Start, T2 IN>2 Start, T3 IN>1 Start, T3 IN>2 Start, T4 IN>1 Start
Start Elements3	T4 IN>2 Start, T5 IN>1 Start, T5 IN>2 Start, T6 IN>1 Start, T6 IN>2 Start
Trip Elements1	Id Bias Trip A, Id Bias Trip B, Id Bias Trip C, DeadZone 1 Trip, DeadZone 2 Trip, DeadZone 3 Trip, DeadZone 4 Trip, DeadZone 5 Trip, DeadZone 6 Trip, DeadZone 7 Trip, DeadZone 8 Trip, DeadZone 9 Trip, DeadZone10 Trip, DeadZone11 Trip, DeadZone12 Trip, DeadZone13 Trip, DeadZone14 Trip, DeadZone15 Trip, DeadZone16 Trip, DeadZone17 Trip, DeadZone18 Trip, T1 I>1 Trip, T1 I>2 Trip, T2 I>1 Trip, T2 I>2 Trip, T3 I>1 Trip, T3 I>2 Trip, T4 I>1 Trip, T4 I>2 Trip, T5 I>1 Trip, T5 I>2 Trip, T6 I>1 Trip
Trip Elements2	T6 I>2 Trip, T7 I>1 Trip, T7 I>2 Trip, T8 I>1 Trip, T8 I>2 Trip, T9 I>1 Trip, T9 I>2 Trip, T10 I>1 Trip, T10 I>2 Trip, T11 I>1 Trip, T11 I>2 Trip, T12 I>1 Trip, T12 I>2 Trip, T13 I>1 Trip, T13 I>2 Trip, T14 I>1 Trip, T14 I>2 Trip, T15 I>1 Trip, T15 I>2 Trip, T16 I>1 Trip, T16 I>2 Trip, T17 I>1 Trip, T17 I>2 Trip, T18 I>1 Trip, T18 I>2 Trip, T1 IN>1 Trip, T1 IN>2 Trip, T2 IN>1 Trip, T2 IN>2 Trip, T3 IN>1 Trip, T3 IN>2 Trip, T4 IN>1 Trip
Trip Elements3	T4 IN>2 Trip, T5 IN>1 Trip, T5 IN>2 Trip, T6 IN>1 Trip, T6 IN>2 Trip, T1 I2>1 Trip, T1 I2>2 Trip, T2 I2>1 Trip, T2 I2>2 Trip, T3 I2>1 Trip, T3 I2>2 Trip, T4 I2>1 Trip, T4 I2>2 Trip, T5 I2>1 Trip, T5 I2>2 Trip, T6 I2>1 Trip, T6 I2>2 Trip, V<1 Trip, V<2 Trip, V>1 Trip, V>2 Trip, VN>1 Trip, VN>2 Trip, F<1 Trip, F<2 Trip, F<3 Trip, F<4 Trip, F>1 Trip, F>2 Trip
Fault Alarms	CB1 ReTrip 3ph, CB1 BkTrip 3ph, CB2 ReTrip 3ph, CB2 BkTrip 3ph, CB3 ReTrip 3ph, CB3 BkTrip 3ph, CB4 ReTrip 3ph, CB4 BkTrip 3ph, CB5 ReTrip 3ph, CB5 BkTrip 3ph, VTS, CTS, Alarm RTD 1, Alarm RTD 2, Alarm RTD 3, Alarm RTD 4, Alarm RTD 5, Alarm RTD 6, Alarm RTD 7, Alarm RTD 8, Alarm RTD 9, Alarm RTD 10, Alarm CL Input 1, Alarm CL Input 2, Alarm CL Input 3, Alarm CL Input 4
Fault Time	Time and date of fault recorder start
Active Group	Active group when fault recorder starts

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VIEW RECORDS	
LCD Reference	Description
System Frequency	50.00 Hz, 60.00 Hz,
Fault duration	Duration of the fault
CB Operate Time	Duration of circuit breaker operation
Relay Trip Time	Time and date of fault relay tripping
Test Mode	none, Zone1, Zone2, Zone 1 and Zone2
IA-1 Magnitude	Magnitude of phase A current on terminal 1
IB-1 Magnitude	Magnitude of phase B current on terminal 1
IC-1 Magnitude	Magnitude of phase C current on terminal 1
IA-2 Magnitude	Magnitude of phase A current on terminal 2
IB-2 Magnitude	Magnitude of phase B current on terminal 2
IC-2 Magnitude	Magnitude of phase C current on terminal 2
IA-3 Magnitude	Magnitude of phase A current on terminal 3
IB-3 Magnitude	Magnitude of phase B current on terminal 3
IC-3 Magnitude	Magnitude of phase C current on terminal 3
IA-4 Magnitude	Magnitude of phase A current on terminal 4
IB-4 Magnitude	Magnitude of phase B current on terminal 4
IC-4 Magnitude	Magnitude of phase C current on terminal 4
IA-5 Magnitude	Magnitude of phase A current on terminal 5
IB-5 Magnitude	Magnitude of phase B current on terminal 5
IC-5 Magnitude	Magnitude of phase C current on terminal 5
IA-6 Magnitude	Magnitude of phase A current on terminal 6
IB-6 Magnitude	Magnitude of phase B current on terminal 6
IC-6 Magnitude	Magnitude of phase C current on terminal 6
I2-T1 Magnitude	Magnitude of negative current on terminal 1
I2-T2 Magnitude	Magnitude of negative current on terminal 2
I2-T3 Magnitude	Magnitude of negative current on terminal 3
I2-T4 Magnitude	Magnitude of negative current on terminal 4
I2-T5 Magnitude	Magnitude of negative current on terminal 5
I2-T6 Magnitude	Magnitude of negative current on terminal 6
VAN Magnitude	Magnitude of phase A voltage
VBN Magnitude	Magnitude of phase B voltage
VCN Magnitude	Magnitude of phase C voltage
V1 Magnitude	Magnitude of positive sequence voltage
V2 Magnitude	Magnitude of negative sequence voltage
VN Derived Magnitude	Magnitude of residual (neutral) voltage.
VAB Magnitude	Magnitude of phase A to phase B voltage
VBC Magnitude	Magnitude of phase B to phase V voltage
VCA Magnitude	Magnitude of phase C to phase A voltage

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VIEW RECORDS	
LCD Reference	Description
IA Z1 Diff	Differential phase A current of the zone 1
IB-Z1 Diff	Differential phase B current of the zone 1
IC Z1 Diff	Differential phase C current of the zone 1
IA Z1 Bias	Bias phase A current of the zone 1
IB-Z1 Bias	Bias phase B current of the zone 1
IC Z1 Bias	Bias phase C current of the zone 1
IA Z2 Diff	Differential phase A current of the zone 2
IB-Z2 Diff	Differential phase B current of the zone 2
IC Z2 Diff	Differential phase C current of the zone 2
IA Z2 Bias	Bias phase A current of the zone 2
IB-Z2 Bias	Bias phase B current of the zone 2
IC Z2 Bias	Bias phase C current of the zone 2
IA CZ Diff	Differential phase A current of the check zone
IB-CZ Diff	Differential phase B current of the check zone
IC CZ Diff	Differential phase C current of the check zone
IA CZ Bias	Bias phase A current of the check zone
IB-CZ Bias	Bias phase B current of the check zone
IC CZ Bias	Bias phase C current of the check zone
Reset Indication	Either Yes or No. 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.

For extraction from a remote source via communications, refer to the SCADA Communications section (P746/EN SC), where the procedure is fully explained.

1.2.1   Types of event

An event may be a change of state of a control input or output relay, an alarm condition, setting change etc. The following sections show the various items that constitute an event:

1.2.1.1   Change of state of opto-isolated inputs

If one or more of the opto (logic) inputs has changed state since the last time that the protection algorithm ran, the new status is logged as an event. When this event is selected to be viewed on the LCD, three applicable cells will become visible as shown below:

Time & date of event
"LOGIC INPUTS1"
"Event Value 0101010101010101"

The Event Value is a 32-bit word showing the status of the opto inputs, where the least significant bit (extreme right) corresponds to opto input 1 etc. The same information is present if the event is extracted and viewed via PC.

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1.2.1.2   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 that the protection algorithm ran, then the new status is logged as an event. When this event is selected to be viewed on the LCD, three applicable cells will become visible as shown below:

Time & date of event
"OUTPUT CONTACTS 1"
"Event Value 1010101010101010"

The Event Value is a 24 bit word showing the status of the output contacts, where the least significant bit (extreme right) corresponds to output contact 1 etc. The same information is present if the event is extracted and viewed via PC.

1.2.1.3   Relay alarm conditions

Any alarm conditions generated by the relays will also be logged as individual events. The following table shows examples of some of the alarm conditions and how they appear in the event list:

Alarm Condition	Event Text	Event Value
Battery Fail	Battery Fail ON/OFF	Bit position 0 in 32 bit field
Field Voltage Fail	Field Volt Fail ON/OFF	Bit position 1 in 32 bit field

The previous table shows the abbreviated description that is given to the various alarm conditions and also a corresponding value between 0 and 31. This value is appended to each alarm event in a similar way as for the input and output events previously described. It is used by the event extraction software, such as MiCOM S1 (V2 or Studio), to identify the alarm and is therefore invisible if the event is viewed on the LCD. Either ON or OFF is shown after the description to signify whether the particular condition has become operated or has reset.

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English	Français	Deutsch	Español	Русский	中国
CB Fail Alm T1	Alm défail.DJ T1	Mld LSV X1	Fallo INT Alm T1	УРОВ: СИГН.КЛ.1	失灵告警 T1
CB Fail Alm T2	Alm défail.DJ T2	Mld LSV X2	Fallo INT Alm T2	УРОВ: СИГН.КЛ.2	失灵告警 T2
CB Fail Alm T3	Alm défail.DJ T3	Mld LSV X3	Fallo INT Alm T3	УРОВ: СИГН.КЛ.3	失灵告警 T3
CB Fail Alm T4	Alm défail.DJ T4	Mld LSV X4	Fallo INT Alm T4	УРОВ: СИГН.КЛ.4	失灵告警 T4
CB Fail Alm T5	Alm défail.DJ T5	Mld LSV X5	Fallo INT Alm T5	УРОВ: СИГН.КЛ.5	失灵告警 T5
CB Fail Alm T6	Alm défail.DJ T6	Mld LSV X6	Fallo INT Alm T6	УРОВ: СИГН.КЛ.6	失灵告警 T6
CB Fail Alm T7	Alm défail.DJ T7	Mld LSV X7	Fallo INT Alm T7	УРОВ: СИГН.КЛ.7	失灵告警 T7
CB Fail Alm T8	Alm défail.DJ T8	Mld LSV X8	Fallo INT Alm T8	УРОВ: СИГН.КЛ.8	失灵告警 T8
CB Fail Alm T9	Alm défail.DJ T9	Mld LSV X9	Fallo INT Alm T9	УРОВ: СИГН.КЛ.9	失灵告警 T9
CB Fail Alm T10	Alm défailDJ T10	Mld LSV X10	Fallo INT AlmT10	УРОВ: СИГН.КЛ.10	失灵告警 T10
CB Fail Alm T11	Alm défailDJ T11	Mld LSV X11	Fallo INT AlmT11	УРОВ: СИГН.КЛ.11	失灵告警 T11
CB Fail Alm T12	Alm défailDJ T12	Mld LSV X12	Fallo INT AlmT12	УРОВ: СИГН.КЛ.12	失灵告警 T12
CB Fail Alm T13	Alm défailDJ T13	Mld LSV X13	Fallo INT AlmT13	УРОВ: СИГН.КЛ.13	失灵告警 T13
CB Fail Alm T14	Alm défailDJ T14	Mld LSV X14	Fallo INT AlmT14	УРОВ: СИГН.КЛ.14	失灵告警 T14
CB Fail Alm T15	Alm défailDJ T15	Mld LSV X15	Fallo INT AlmT15	УРОВ: СИГН.КЛ.15	失灵告警 T15
CB Fail Alm T16	Alm défailDJ T16	Mld LSV X16	Fallo INT AlmT16	УРОВ: СИГН.КЛ.16	失灵告警 T16
CB Fail Alm T17	Alm défailDJ T17	Mld LSV X17	Fallo INT AlmT17	УРОВ: СИГН.КЛ.17	失灵告警 T17
CB Fail Alm T18	Alm défailDJ T18	Mld LSV X18	Fallo INT AlmT18	УРОВ: СИГН.КЛ.18	失灵告警 T18

English	Français	Deutsch	Español	Русский	中国
CBF Alarm Bus CB	Alarm ADD DJ Bus	Mld. LSV LSSS	FINT Alm INTBarr	УРОВ: СИГН.ШСВ	母联 CB 失灵告警
CTS T1	STC T1	Mldg StW\d142 CZ	STI T1	КЦИ ТТ: КЛЕММА 1	T1 CT 断线
CTS T2	STC T2	Mldg StW\d142 X1	STI T2	КЦИ ТТ: КЛЕММА 2	T2 CT 断线
CTS T3	STC T3	Mldg StW\d142 X2	STI T3	КЦИ ТТ: КЛЕММА 3	T3 CT 断线
CTS T4	STC T4	Mldg StW\d142 X3	STI T4	КЦИ ТТ: КЛЕММА 4	T4 CT 断线
CTS T5	STC T5	Mldg StW\d142 X4	STI T5	КЦИ ТТ: КЛЕММА 5	T5 CT 断线
CTS T6	STC T6	Mldg StW\d142 X5	STI T6	КЦИ ТТ: КЛЕММА 6	T6 CT 断线

1.2.1.4   Protection element starts and trips

Any operation of protection elements, (either a start or a trip condition) will be logged as an event record, consisting of a text string indicating the operated element and an event value. Again, this value is intended for use by the event extraction software, such as MiCOM S1, rather than for the user, and is therefore invisible when the event is viewed on the LCD.

1.2.1.5   General events

A number of events come under the heading of 'General Events' - an example is shown below:

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 given in the Relay Menu Database (P746/EN MD), which is a separate document, available for downloaded from our website.

1.2.1.6   Fault records

Each time a fault record is generated, an event is also created. The event simply states that a fault record was generated, with a corresponding time stamp.

Note that viewing of the actual fault record is carried out in the "Select Fault'" cell further down the "VIEW RECORDS" column, which is selectable from up to 20 records. These records consist of fault flags, fault location, fault measurements etc. Also note that the time stamp given in the fault record itself will be 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 to any trip (87BB or 50BF trip in the P746). Note the fault measurements in the fault record are given at the time of the protection start. Also, 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.

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1.2.1.7   Setting changes

Changes to any setting within the relay are logged as an event. Two examples are shown in the following table:

Type of Setting Change	Displayed Text in Event Record	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 within the four setting groups. When any of these settings are changed, the event record is created simultaneously. However, changes to protection or disturbance recorder settings will only generate an event once the settings have been confirmed at the 'setting trap'.

1.2.2   Resetting of event/fault records

If it is required to delete either the event, fault or maintenance reports, this may be done from within the "RECORD CONTROL" column.

1.2.3   Viewing event records via MiCOM S1 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 a P746 example of how various events appear when displayed using MiCOM S1 V2 or Studio:

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As can be seen, the first line gives the description and time stamp for the event, whilst the additional information that is displayed below may be collapsed via the +/– symbol.

For further information regarding events and their specific meaning, refer to relay menu database document (P746/EN MR). This is a standalone document not included in this manual.

1.2.4   Event filtering

It is possible to disable the reporting of events from all interfaces that supports 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	Default Setting	Available Settings
RECORD CONTROL		
Clear Events	No	No or 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	No	No or Yes
Selecting "Yes" will cause the existing fault records to be erased from the relay.		
Clear Maint	No	No or Yes
Selecting "Yes" will cause the existing maintenance records to be erased from the relay.		
Alarm Event	Enabled	Enabled or Disabled
Disabling this setting means that all the occurrences that produce an alarm will result in no event being generated.		
Relay O/P Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any change in logic input state.		
Opto Input Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any change in logic input state.		
General Event	Enabled	Enabled or Disabled
Disabling this setting means that no General Events will be generated		
Fault Rec Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any fault that produces a fault record		
Maint Rec Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any occurrence that produces a maintenance record.		
Protection Event	Enabled	Enabled or Disabled
Disabling this setting means that any operation of protection elements will not be logged as an event.		
Clear Dist Recs	No	No or Yes
Selecting "Yes" will cause the existing disturbance records to be erased from the relay.		
DDB 31 - 0	11111111111111111111111111111111	
Displays the status of DDB signals 0 – 31.		
DDB 2047 - 2016	11111111111111111111111111111111	
Displays the status of DDB signals 2047 – 2016.		

Note that some occurrences will result in more than one type of event, e.g. a battery failure will produce an alarm event and a maintenance record event.

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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 regarding events and their specific meaning, refer to relay menu database document (P746/EN MD).

1.3 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.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
DISTURB. RECORDER				
Duration	600 s	100.0 ms	10.5 s	10.00 ms
This sets the overall recording time.				
Trigger Position	33.3%	0.0%	100.0%	0.10 %
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	Single	Single / Extended		
When set to single mode, if a further trigger occurs whilst a recording is taking place, the recorder will ignore the trigger.				
"ANALOG CHANNEL" submenus				
Analog. Channel 1	VAN	Any analog channel		
The Phase A calculated voltage is assigned to this channel.				
Analog. Channel 2	VBN	As above		
The Phase B calculated voltage is assigned to this channel.				
Analog. Channel 3	VCN	As above		
The Phase C calculated voltage is assigned to this channel.				
Analog. Channel 4	IA-T1/Ix-T1	As above		
The terminal 1 phase A calculated current is assigned to this channel.				
Analog. Channel 5	IB-T1/Ix-T1	As above		
The Terminal 1 Phase B calculated current is assigned to this channel.				
Analog. Channel 6	IC-T1/Ix-T2	As above		
The Terminal 1 Phase C calculated current is assigned to this channel.				
Analog. Channel 7	IA-T2 /Ix-T3	As above		
The Terminal 2 Phase A calculated current is assigned to this channel.				
Analog. Channel 8	IB-T2/Ix-T4	As above		
The Terminal 2 Phase B calculated current is assigned to this channel..				

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Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Analog. Channel 9	IC-T2/Ix-T5	As above		
The Terminal 2 Phase C calculated current is assigned to this channel.				
Analog. Channel 10	IA-T3/Ix-T6	As above		
The Terminal 3 Phase A calculated current is assigned to this channel.				
Analog. Channel 11	IB-T3/Ix-T7	As above		
The Terminal 3 Phase B calculated current is assigned to this channel.				
Analog. Channel 12	IC-T3/Ix-T8	As above		
The Terminal 3 Phase C calculated current is assigned to this channel.				
Analog. Channel 13	IA-T4/Ix-T9	As above		
The Terminal 4 Phase A calculated current is assigned to this channel.				
Analog. Channel 14	IB-T4/Ix-T10	As above		
The Terminal 4 Phase B calculated current is assigned to this channel.				
Analog. Channel 15	IC-T4/Ix-T11	As above		
The Terminal 4 Phase C calculated current is assigned to this channel.				
Analog. Channel 16	IA-T5/Ix-T12	As above		
The Terminal 5 Phase A calculated current is assigned to this channel.				
Analog. Channel 17	IB-T5/Ix-T13	As above		
The Terminal 5 Phase B calculated current is assigned to this channel.				
Analog. Channel 18	IC-T5/Ix-T14	As above		
The Terminal 5 Phase C calculated current is assigned to this channel.				
Analog. Channel 19	IA-T6/Ix-T15	As above		
The Terminal 6 Phase A calculated current is assigned to this channel.				
Analog. Channel 20	IB-T6/Ix-T16	As above		
The Terminal 6 Phase B calculated current is assigned to this channel.				
Analog. Channel 21	IC-T6/Ix-T17	As above		
The Terminal 6 Phase C calculated current is assigned to this channel.				
"DIGITAL INPUT" and "INPUT TRIGGER" submenus				
Digital Input 1	Output R1	Any O/P Contacts or Any Opto Inputs or Internal Digital Signals		
The relay 1 output digital channel is assigned to this channel. The digital channel will trigger the disturbance recorder when the corresponding assigned fault will occur. In this case, the digital recorder will trigger when the output R1will change. Following lines indicate default signals for the 32 channels.				
Input 1 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
This digital channel will not trigger the Disturbance recorder. When "Trigger L/H" is selected, the channel will trigger the disturbance recorder when changing from '0' (low Level) to '1' (High level). If "Trigger H/L" is selected, it will trigger when changing from '1' (high level) to '0' (low level). Following lines give default settings up to channel 32.				

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Digital Input 2	Output R2	As above		
The relay 2 output digital channel is assigned to this channel.				
Input 2 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 3	Output R3	As above		
Relay 3 output digital channel.				
Input 3 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 4	Output R4	As above		
Relay 4 output digital channel.				
Input 4 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 5	Output R5	As above		
Relay 5 output digital channel.				
Input 5 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 6	Output R6	As above		
Relay 6 output digital channel.				
Input 6 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 7	Output R7	As above		
Relay 7 output digital channel.				
Input 7 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 8	Output R8	As above		
Relay 8 output digital channel.				
Input 8 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 9	Any Trip	As above		
Any trip				
Input 9 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 10	Ouput R10	As above		
Relay 10 output digital channel.				
Input 10 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 11	Diff Fault Z1	As above		
Busbar Differential Fault in Zone 1				
Input 11 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 12	Diff Fault Z2	As above		
Busbar Differential Fault in Zone 2				
Input 12 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 13	Diff Fault CZ	As above		
Busbar Differential Fault in Check Zone				
Input 13 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 14	Idiff Start Z1	As above		
Differential current in main zone 1.				

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Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Input 14 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 15	Idiff Start Z2	As above		
Differential current in main zone 2.				
Input 15 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 16	Idiff CZ Start	As above		
Differential current in Check Zone.				
Input 16 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 17	PhComp Blk Z1.	As above		
Phase comparison Block in zone 1.				
Input 17 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 18	PhComp Blk Z2.	As above		
Phase comparison Block in zone 2.				
Input 18 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 19	Unused	As above		
Unused.				
Input 19 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 20	Idiff Trip Z1	As above		
Differential busbar trip or gate of Z1 Diff phase in zone 1				
Input 20 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 21	Idiff Trip Z2	As above		
Differential busbar trip or gate of Z1 Diff phase in zone 2				
Input 21 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 22	CCtFail Blk Z1	As above		
Circuity Fault in zone 1				
Input 22 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 23	CctFail Blk Z2	As above		
Circuity Fault in zone 2.				
Input 23 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 24	CctFail Blk CZ	As above		
Circuity Fault in check zone				
Input 24 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 25	Diff Z1 Blked	As above	10.5 s	0.01 s
Zone 1 Busbar Diff in Block Status				
Input 25 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 26	Diff Z2 Blked	As above	100.0%	0.1%
Zone 2 Busbar Diff in Block Status				

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Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Input 26 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 27	Diff CZ Blked	As above		
Check Zone Busbar Diff in Block Status				
Input 27 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 28	Fault A	As above		
Phase A fault.				
Input 28 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 29	Fault B	As above		
Phase B fault				
Input 29 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 30	Fault C	As above		
Phase C fault				
Input 30 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 31	Fault N	As above		
Earth fault				
Input 31 Trigger	No Trigger	No Trigger, Trigger L/H, Trigger H/L		
Digital Input 32	Function key 10	As above		
Function Key 10 activated (in 'Normal' mode it is high on keypress and in 'Toggle' mode remains high/low on single keypress)				
Input 32 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		

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The pre and post fault recording times are set by a combination of the "Duration" and "Trigger Position" cells. "Duration" sets the overall recording time and the "Trigger Position" sets the trigger point as a percentage of the duration. For example, the default settings show that the overall recording time is set to 1.5s with the trigger point being at 33.3% of this, giving 0.5s pre-fault and 1.0s post fault recording times.

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

As can be seen from the menu, each of the 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 a number of internal relay digital signals, such as protection starts, LEDs etc. The complete list of these signals may be found by viewing the available settings in the relay menu or via a setting file in MiCOM S1 V2 or MiCOM S1 Studio. Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition, via the "Input Trigger" cell.

It is not possible to view the disturbance records locally via the LCD; they must be extracted using suitable software such as MiCOM S1. This process is fully explained in the SCADA Communications section (P746/EN SC).

1.4   Measurements

The relay produces a variety of both directly measured and calculated system quantities. These measurement values are updated on a per second basis and can be viewed in the "Measurements" columns (up to three) of the relay or via MiCOM S1 Measurement viewer.

The P746 relay is able to measure and display the following quantities as summarized.

1.4.1   Check 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 relays is able to measure and display the following quantities as summarized.

−   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.

1.4.2   Measured currents

The P746 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.

1.4.3   Sequence voltages and currents

Sequence quantities are produced by the P746 relay from the measured Fourier values; these are displayed as magnitude and phase angle values.

1.4.4   Settings

The following settings under the heading measurement set-up can be used to configure the relay measurement function.

Menu Text	Default Settings	Available settings
MEASUREMENT SETUP		
Default Display	Description	Description / Phase Voltage / Date and Time / Plant reference / Frequency / Access Level
This setting can be used to select the default display from a range of options, note that it is also possible to view the other default displays whilst at the default level using the ◊ and ◊ keys. However once the 15 minute timeout elapses the default display will revert to that selected by this setting.		
Local Values	Primary	Primary/Secondary
This setting controls whether measured values via the front panel user interface and the front courier port are displayed as primary or secondary quantities.		
Remote Values	Primary	Primary/Secondary
This setting controls whether measured values via the rear communication port are displayed as primary or secondary quantities.		

Menu Text	Default Settings	Available settings
MEASUREMENT SETUP		
Measurement ref	VA	IA1 / IB1 / IC1 / VA / VB / VC / IA2 / IB2 / IC2 / IA3 / IB3 / IC3 / IA4 / IB4 / IC4 / IA5 / IB5 / IC5 / IA6 / IB6 / IC6
This menu sets the reference of the measure (phase reference and angle)		
Measurement Mode	0	0 / 1 / 2 / 3
Used to set the mode of measurement, according to the following diagram:		

1.4.5 Measurement display quantities

There are "Measurement" columns available in the relay for viewing of measurement quantities. These can also be viewed with MiCOM S1 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-2 Phase Angle	IX-4 Phase Angle	
IB-2 Magnitude	IX-5 Magnitude	
IB-2 Phase Angle	IX-5 Phase Angle	IA Z2 Diff
IC-2 Magnitude	IX-6 Magnitude	IB Z2 Diff
IC-2 Phase Angle	IX-6 Phase Angle	IC Z2 Diff
IA-3 Magnitude	IX-7 Magnitude	IA Z2 Bias
IA-3 Phase Angle	IX-7 Phase Angle	IB Z2 Bias
IB-3 Magnitude	IX-8 Magnitude	IC Z2 Bias
IB-3 Phase Angle	IX-8 Phase Angle	IA CZ Diff
IC-3 Magnitude	IX-9 Magnitude	IB CZ Diff
IC-3 Phase Angle	IX-9 Phase Angle	IC CZ Diff
IA-4 Magnitude	IX-10 Magnitude	IA CZ Bias
IA-4 Phase Angle	IX-10 Phase Angle	IB CZ Bias
IB-4 Magnitude	IX-11 Magnitude	IC CZ Bias
IB-4 Phase Angle	IX-11 Phase Angle	
IC-4 Magnitude	IX-12 Magnitude	
IC-4 Phase Angle	IX-12 Phase Angle	
IA-5 Magnitude	IX-13 Magnitude	
IA-5 Phase Angle	IX-13 Phase Angle	
IB-5 Magnitude	IX-14 Magnitude	
IB-5 Phase Angle	IX-14 Phase Angle	
IC-5 Magnitude	IX-15 Magnitude	
IC-5 Phase Angle	IX-15 Phase Angle	
IA-6 Magnitude	IX-16 Magnitude	
IA-6 Phase Angle	IX-16 Phase Angle	

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MEASUREMENTS 1		MEASUREMENTS 2
One box configuration	Three box configuration	
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		
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		

FIRMWARE DESIGN

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Date:	2008
Hardware Suffix:	K
Software Version:	01
Connection Diagrams:	10P746xx (xx = 01 to 07)

CONTENTS

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1. RELAY SYSTEM OVERVIEW

1.1 Hardware overview

The relay hardware is based on a modular design whereby the relay is made up of an assemblage of several modules that are drawn from a standard range. Some modules are essential while others are optional depending on the user's requirements.

The modules and the processor boards form a network. A data bus, used for data exchange and address selection, links this network. The processor controls and drives the input/output boards and the other modules of the relay. The following figure illustrates the data exchange.
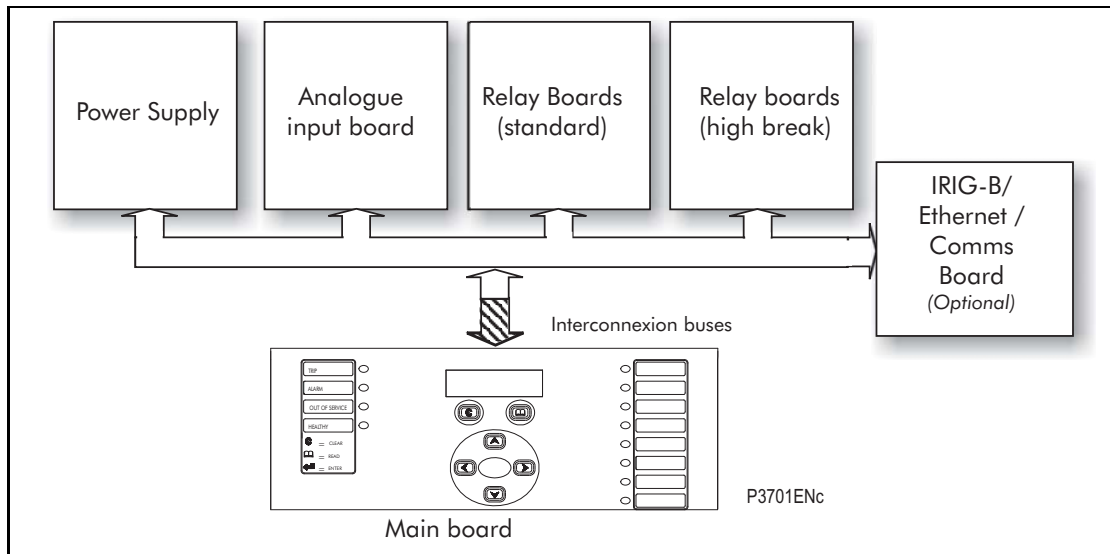
FIGURE 1: MiCOM P746 ARCHITECTURE

The different modules that can be present in the relay are as follows:

1.1.1 Processor board (Main board)

The main board performs some functions for the relay (fixed and programmable scheme logic…) and controls the operation of modules which are on its interconnection bus within the relay. The main board also contains and controls the user interfaces (LCD, LEDs, keypad and communication interfaces).

1.1.2 Analogue Input module

The input module converts the information contained in the analogue or digital input signals into a format suitable for the co-processor board. The standard input module consists of two boards:

- a Current transformer board to provide electrical isolation

- a main input board which provides analogue to digital conversion and the isolated digital inputs.

1.1.3   Input and output boards

Model	Opto-inputs	Relay outputs	
		normally open	change over
P746xxxA	16 x UNI [(1)]	12	4
P746xxxB	16 x UNI [(1)]	12	4
P746xxxC	16 x UNI [(1)]	24	8
P746xxxD	16 x UNI [(1)]	24	8
P746xxxE	24 x UNI [(1)]	18	6
P746xxxF	24 x UNI [(1)]	18	6
P746xxxG	24 x UNI [(1)]	18	6
P746xxxH	32 x UNI [(1)]	18	6
P746xxxJ	32 x UNI [(1)]	18	6
P746xxxK	40 x UNI [(1)]	18	6

[(1)] Universal voltage range opto inputs

1.1.4   Power supply module

The power supply module provides a power supply to all of the other modules in the relay, at three different voltage levels. The power supply board also provides the EIA(RS)485 electrical connection for the rear communication port.

On a second board the power supply module contains:

- relays which provide the output contacts,

The power supply module also provides a 48V external field supply output to drive the opto isolated digital inputs (or the substation battery may be used to drive the optos).

1.1.5   IRIG-B board

This board, which is optional, can be used where an IRIG-B signal is available to provide an accurate time reference for the relay The IRIG-B board and is controlled by the main board.

1.1.6   Second rear comms board (optional)

The optional second rear port is designed typically for dial-up modem access by protection engineers/operators, when the main port is reserved for SCADA traffic. Communication is via 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 by MiCOM S1 V2 or MiCOM S1 Studio software. The second rear port is also available with an on board IRIG-B input.

1.1.7   Ethernet board

This is a mandatory board for IEC 61850 enabled relays. It provides network connectivity through either copper or fiber media at rates of 10Mb/s (copper only) or 100Mb/s. There is also an option on this board to specify IRIG-B board port (modulated or un-modulated). This board and the second rear comms. board are mutually exclusive as they both utilize the same slot within the relay case.

Note: It is possible to connect to the Ethernet network any of the P746 without the embedded Ethernet board using the RS485 to Ethernet converter MiCOM I4X (Courier protocol)

1.2   Software overview

The busbar protection is a centralised system.

The software for the relay can be conceptually split into four elements; the real-time operating system, the system services software, the platform software and the protection and control software. These four elements are not distinguishable to the user, and are all processed. The distinction between the four parts of the software is made purely for the purpose of explanation here:
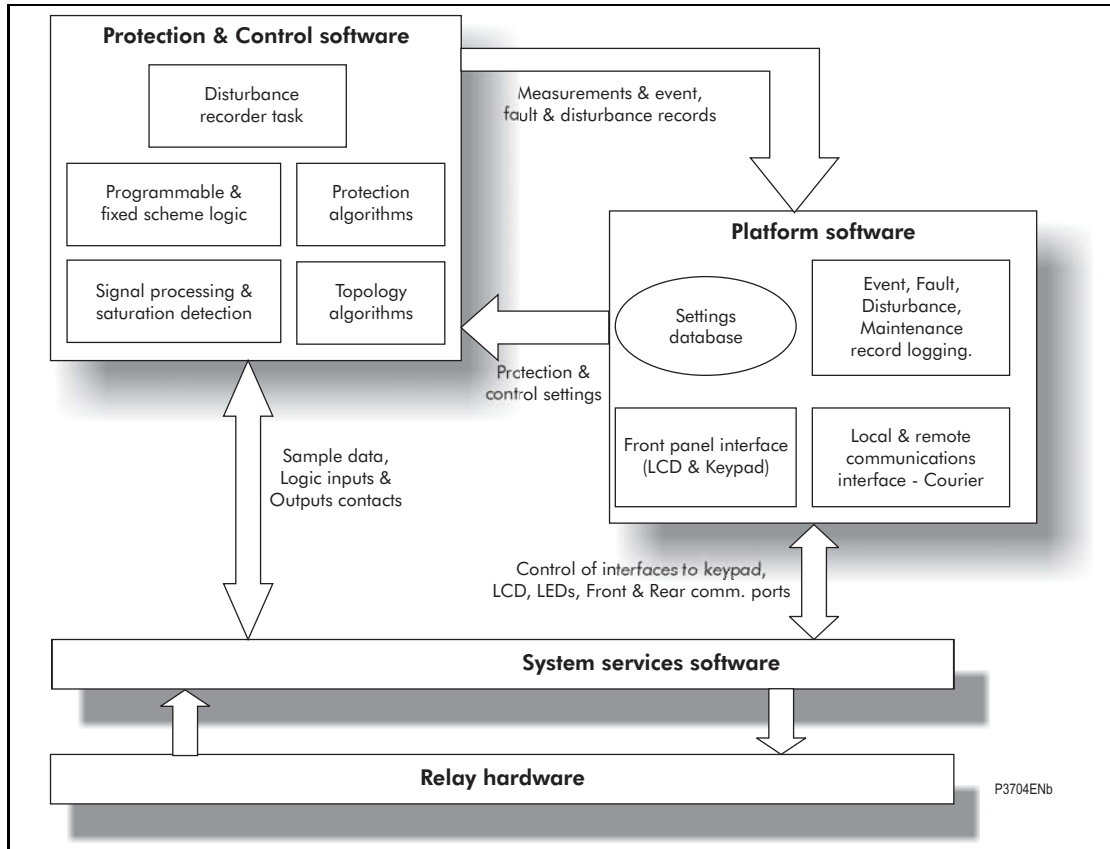
FIGURE 2: SOFTWARE OVERVIEW

1.2.1   Real-time operating system

As explain in the hardware overview, each relay contains one main board. A real time operating system is used to provide a framework for the different parts of the relay's software to operate within. To this end the software is split into tasks. The real-time operating system is responsible for scheduling the processing of these tasks such that they are carried out in the time available and in the desired order of priority.

The real-time operating system is responsible for scheduling the processing of these tasks such that they are carried out in the time available and in the desired order of priority. The operating system is also responsible for the exchange of information between tasks, in the form of messages.
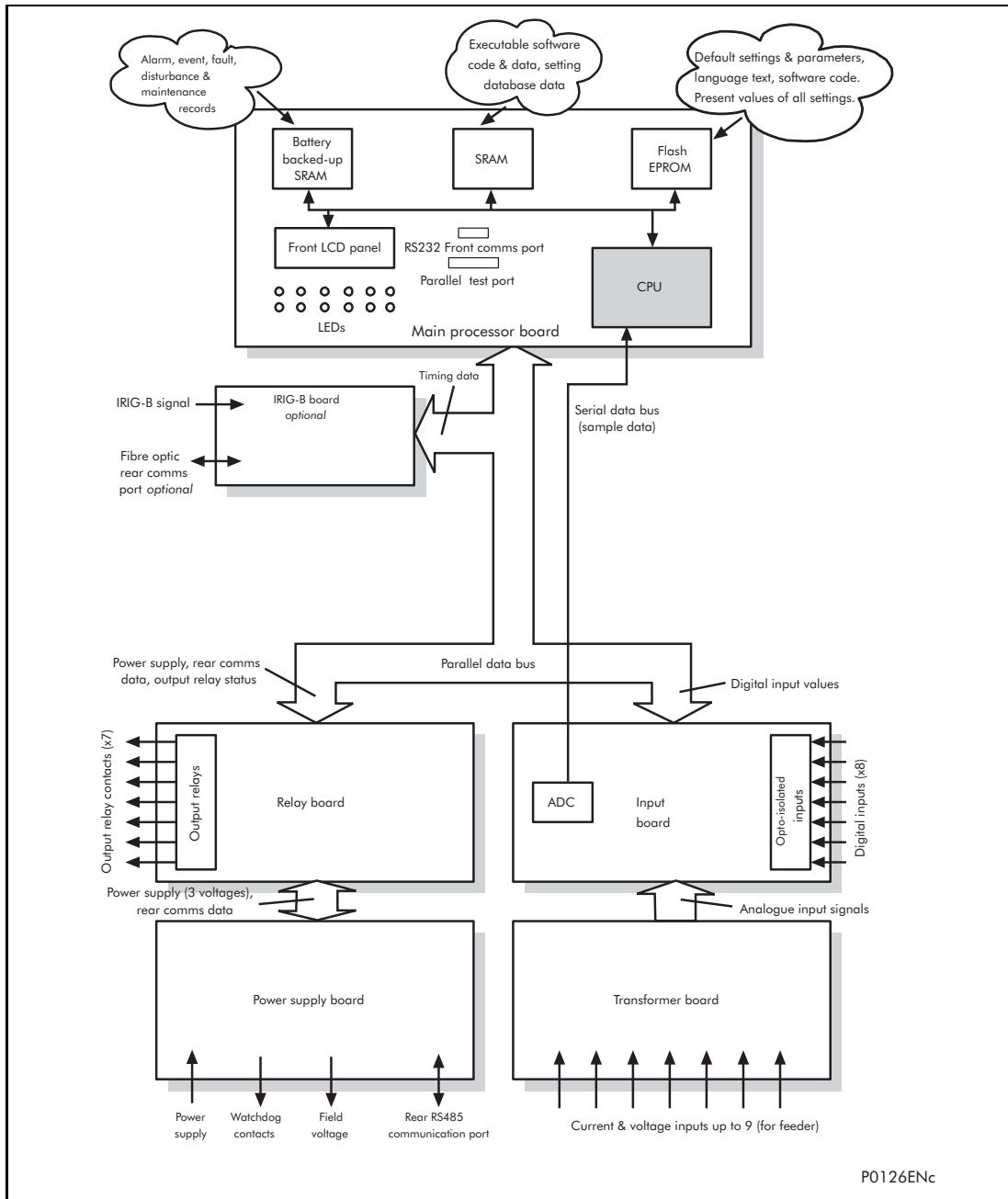
FIGURE 3: RELAY MODULES AND INFORMATION FLOW

1.2.2   System services software

The system services software provides the low-level control of the relay hardware. For example, the system services software controls the boot of the relay's software from the non-volatile flash EPROM memory at power-on, and provides driver software for the user interface via the LCD and keypad, and via the serial communication ports. The system services software provides an interface layer between the control of the relay's hardware and the rest of the relay software.

1.2.3   Platform software

The platform software deals with the management of the relay settings, the user interfaces and logging of event, alarm, fault and maintenance records. All of the relay settings are stored in a database within the relay that provides direct compatibility with Courier communications. For all other interfaces (i.e. the front panel keypad, LCD interface and IEC 61850) the platform software converts the information from the database into the format required. The platform software notifies the protection & control software of all settings changes and logs data as specified by the protection & control software.

1.2.4   Protection & control software

The protection and control software performs the calculations for all of the protection algorithms of the relays. This includes digital signal processing such as Fourier filtering and ancillary tasks such as the measurements. The protection & 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.

1.2.5   Disturbance recorder

The analogue values and logic signals are routed from the protection and control software to the disturbance recorder software. The platform software interfaces to the disturbance recorder to allow extraction of the stored records.

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2. HARDWARE MODULES

The relay is based on a modular hardware design where each module performs a separate function within the relay operation. This section describes the functional operation of the various hardware modules.

2.1 Processor board

The relay is based around a TMS320VC33 floating point, 32-bit digital signal processor (DSP) operating at a clock frequency of 75MHz. 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 located directly behind the relay's front panel which allows the LCD, function keys and LEDs to be mounted on the processor board along with the front panel communication ports. These comprise the 9-pin D-connector for EIA(RS)232 serial communications (e.g. using MiCOM S1 V2 or Studio and Courier communications) and the 25-pin D-connector relay test port for parallel communication. All serial communication is handled using a field programmable gate array (FPGA).

All serial communication is handled using a two-channel 85C30 serial communications controller (SCC).

The memory provided on the main processor board is split into two categories, volatile and non-volatile; the volatile memory is fast access SRAM which is used for the storage and execution of the processor software, and data storage as required during the processor's calculations. The non-volatile memory is sub-divided into 2 groups; 4MB of flash memory for non-volatile storage of software code, present setting values, text, configuration data, latched data signals (from control inputs, function keys, LEDs, relay outputs) and 4MB of battery backed-up SRAM for the storage of disturbance, event, fault and maintenance record data.

2.2 Internal communication bus

The internal interconnexion bus is controlled by the main board. Via its interconnection bus the main board controls also the IRIG-B board (if present).

This interconnection bus is based on 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 within the relay are slaves.

The DSP processor 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.

The main part of the bus is a parallel link with 6 address lines for board selection, 16 data lines and control lines. On the main controlled bus, main board drive address and control lines.

Other parts of the buses are:

- Power supply which are directly wired between the two interconnection buses.

- Serial lines for rear RS485 communication. So in any way main board keeps control of the rear RS485 communication.

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2.3 Input module

The input module provides the interface between the processor board and the analogue and digital signals coming into the relay. The input module consists of two PCBs; the main input board and a transformer board.

The P746 provides eighteen current inputs (6 times 3 phases or 18 times single phase).
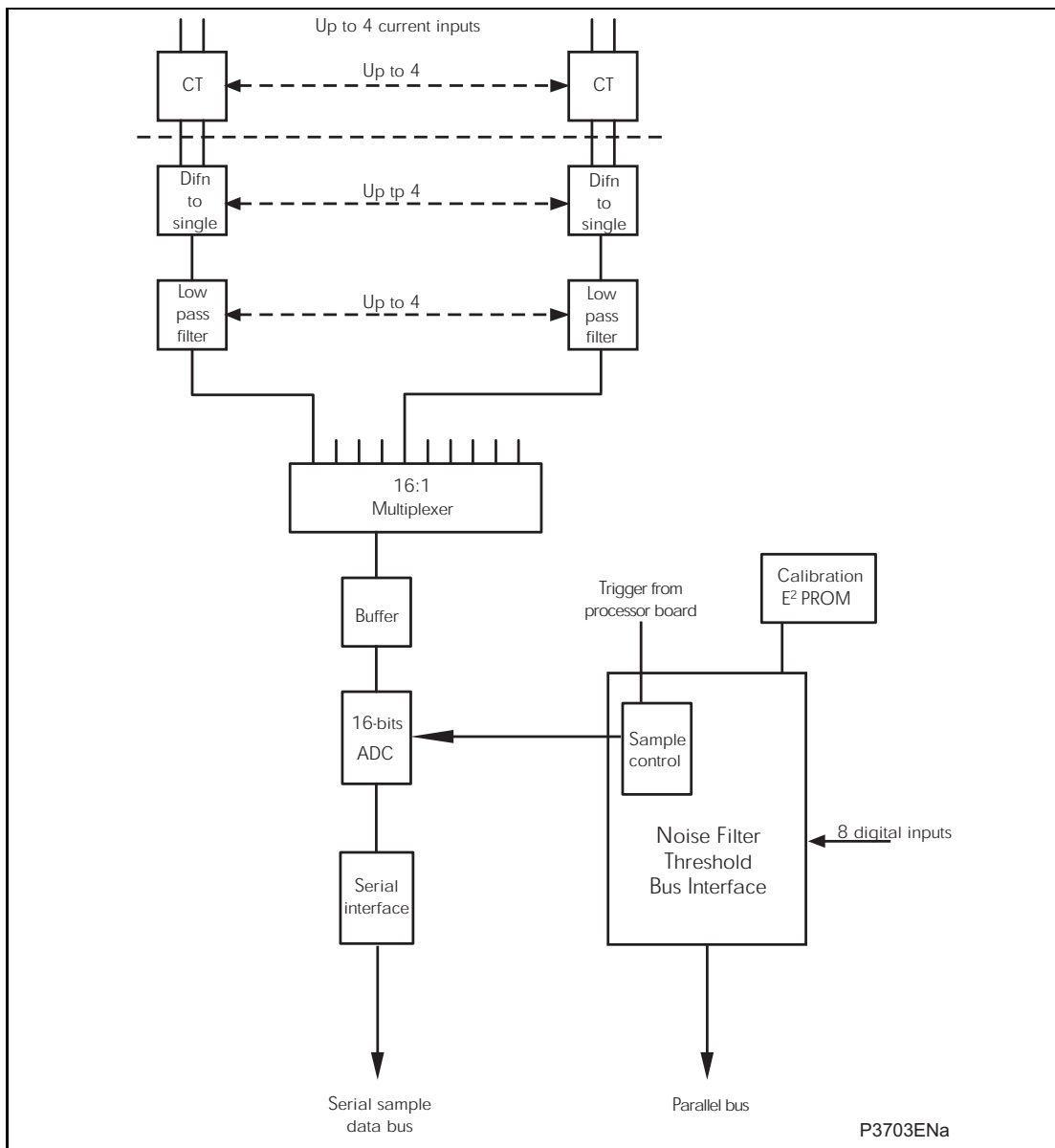
FIGURE 4: MAIN INPUT BOARD

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2.3.1   Transformer board

The transformer board holds 3 voltage transformers (VTs) and 18 current transformers (CTs). The current inputs will accept either 1A or 5A nominal current (menu and wiring options) and the voltage inputs can be specified for either 110V or 440V nominal voltage (order option). The transformers are used both to step-down the currents and voltages to levels appropriate to the relay's electronic circuitry and to provide effective isolation between the relay and the power system. The connection arrangements of both the current and voltage transformer secondaries provide differential input signals to the main input board to reduce noise.

2.3.2   Input board

The main input board is shown as a block diagram in Figure 2. It provides the circuitry for the digital input signals and the analogue-to-digital conversion for the analogue signals. Hence it takes the differential analogue signals from the CTs and VTs on the transformer board(s), converts these to digital samples and transmits the samples to the processor board via the serial data bus. On the input board the analogue signals are passed through an anti-alias filter before being multiplexed into a single analogue to digital converter chip. The A - D converter provides 16-bit resolution and a serial data stream output. The digital input signals are opto isolated on this board to prevent excessive voltages on these inputs causing damage to the relay's internal circuitry.
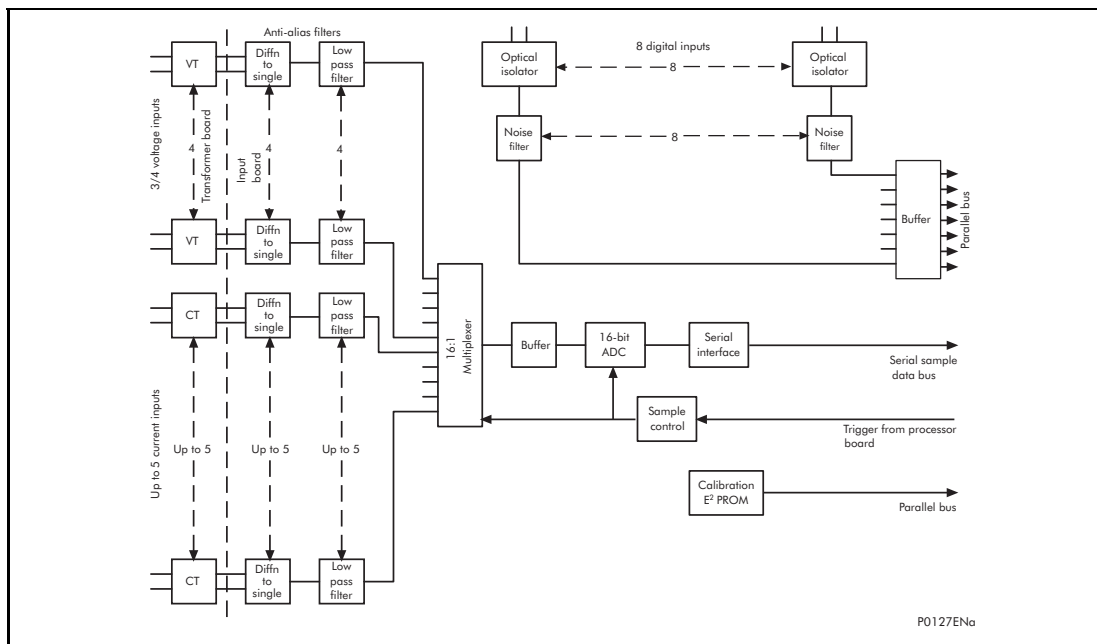
FIGURE 5: MAIN INPUT BOARD

The signal multiplexing arrangement provides for 21 analogue channels to be sampled. The P746 relay provides 18 current inputs and 3 voltage inputs. 3 spare channels are used to sample 3 different reference voltages for the purpose of continually checking the operation of the multiplexer and the accuracy of the A - D converter. The sample rate is maintained at 24 samples per cycle of the power waveform by a logic control circuit that is driven by the frequency tracking function on the main processor board. The calibration E2PROM holds the calibration coefficients that are used by the processor board to correct for any amplitude or phase errors introduced by the transformers and analogue circuitry.

The other function of the input board is to read the state of the signals present on the digital inputs and present this to the parallel data bus for processing. The input board holds 8 optical isolators for the connection of up to eight digital input signals. The opto-isolators are used with the digital signals for the same reason as the transformers with the analogue signals; to isolate the relay's electronics from the power system environment. The input board provides some hardware filtering of the digital signals to remove unwanted noise before buffering the signals for reading on the parallel data bus.

2.3.3   Universal opto isolated logic inputs

The P746 relay is fitted with universal opto isolated logic inputs that can be programmed for the nominal battery voltage of the circuit of which they are a part. i.e. thereby allowing different voltages for different circuits e.g. signalling, tripping. They nominally provide a Logic 1 or "ON" value for Voltages 80% of the set voltage and a Logic 0 or "OFF" value for the voltages 60% of the set voltage. This lower value eliminates fleeting pickups that may occur during a battery earth fault, when stray capacitance may present up to 50% of battery voltage across an input. Each input has filtering of 7ms. This renders the input immune to induced noise on the wiring: although this method is secure it can be slow.

In the Opto Config. menu the nominal battery voltage can be selected 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	Default Setting	Setting Range		Step Size
		Min.	Max.	
OPTO CONFIG				
Global Nominal V	48/54V	24/27V, 30/34V, 48/54V, 110/125V, 220/250V, Custom		
Opto Input x	48/54V	24/27V, 30/34V, 48/54V, 110/125V, 220/250V		

2.4   **Power supply module (including output relays)**

The power supply module contains two PCBs, one for the power supply unit itself and the other for the output relays. The power supply board also contains the input and output hardware for the rear communication port which provides an EIA(RS)485 communication interface.

2.5   **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 three options are shown in table 1 below:

Nominal dc Range	Nominal ac Range
24/54 V	DC only
48/125 V	30/100 Vrms
110/250 V	100/240 Vrms

Table 1:   Power supply options

The outputs from all versions of the power supply module are used to provide isolated power supply rails to all of the other modules within the relay. Three voltage levels are used within the relay, 5.1V for all of the digital circuits,   16V for the analogue electronics, e.g. on the input board, and 22V for driving the output relay coils and communication boards 3.3V power supply (through on board DC-DC converter).

All power supply voltages including the 0V ground line are distributed around the relay via the 64-way ribbon cables. One further voltage level is provided by the power supply board which is the field voltage of 48V. 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 RS485 communications interface and the watchdog contacts for the relay. The RS485 interface is used with the relay's rear communication port to provide communication using K Bus Courier. The RS485 hardware supports half-duplex communication and provides optical isolation of the serial data being transmitted and received.

All internal communication of data from the power supply board is conducted via the output relay board which is connected to the parallel bus.

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The watchdog facility provides two output relay contacts, one normally open and one normally closed that are driven by the processor board. These are provided to give an indication that the relay is in a healthy state.

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

2.6 Output relay board (standard)

The output relay board holds eight relays, six with normally open contacts and two with changeover contacts. The relays are driven from the 22V power supply line. The relays' state is written to or read from using the parallel data bus.

2.7 Output relay board (High speed / High break)

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.

A high speed output relay board contains 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 as 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 3.5ms and is used to carry the continuous load current; the SSD operates in <0.2ms and is switched off after 7.5ms. When the control input resets to open the contacts, the SSD is again turned on for 7.5ms. The miniature relay resets in nominally 3.5ms before the SSD and 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 (<0.2ms) then these high break output contacts have the added advantage of being very fast operating.
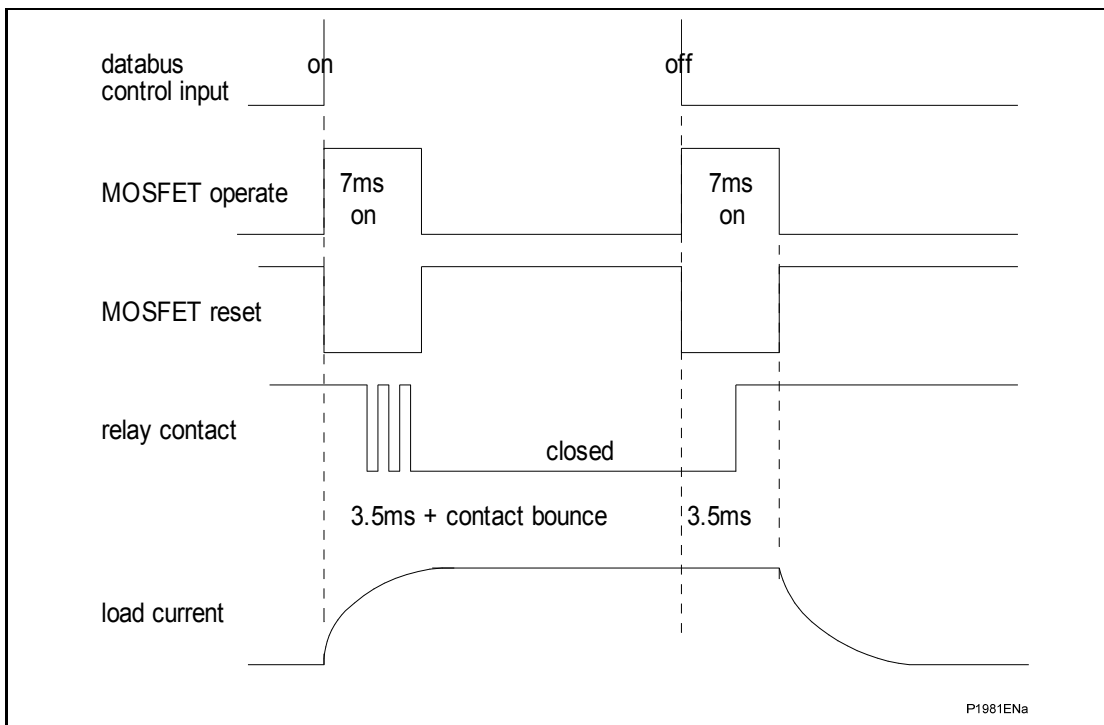
FIGURE 6: High break contact operation

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2.8 Auxiliary power supply

The three input voltage options are the same as for main supply. The relay board is provided as an alone board.

2.9 IRIG-B board

The IRIG-B board is an order option that can be fitted in the P746 to provide an accurate timing reference for the relay. This is available as a modulated or de-modulated option depending on the requirements. The IRIG-B signal is connected to the board via 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 1ms in the case of modulated. The internal clock is then used for the time tagging of the event, fault maintenance and disturbance records.

2.10 Second rear communications

On ordering this board within a relay, both 2nd rear communications will become connection and setting options. The user may then enable either one, or both, as demanded by the installation.

There is a 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 second rear comms. board and Ethernet board are mutually exclusive since they use the same hardware slot. For this reason two versions of second rear comms. board are available; one with an IRIG-B input and one without. The physical layout of the second rear comms. board is shown in Figure.
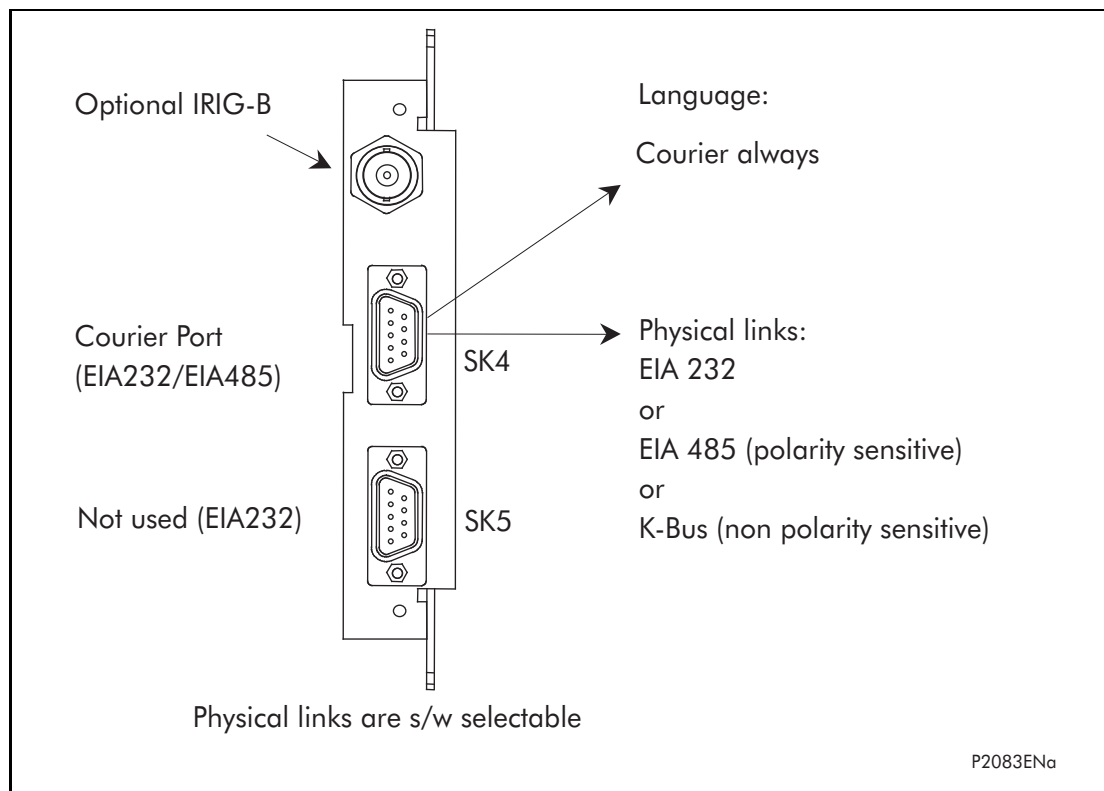
FIGURE 7: Rear comms. port

2.11   Ethernet board

The optional Ethernet board (ZN0049) has 3 variants which support the IEC 61850 implementation:

- 100 Mbits/s Fiber Optic + 10/100 Mbits/s Copper

- 100 Mbits/s Fiber Optic + 10/100 Mbits/s Copper + modulated IRIG-B

- 100 Mbits/s Fiber Optic + 10/100 Mbits/s Copper + demodulated IRIG-B

This card is fitted into Slot A of the relay, which is the optional communications slot. Each Ethernet card has a unique MAC address used for Ethernet communications. This is printed on the rear of the card, alongside the Ethernet sockets.

The 100 Mbits/s Fiber Optic ports use ST® type connectors and are suitable for 1300nm 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 meters and confined within one bay/cubicle.

When using IEC 61850 communications through the Ethernet card, the rear EIA(RS)485 and front EIA(RS)232 ports are also available for simultaneous use, both using the Courier protocol.

2.12   Mechanical layout

The case materials of the relay are constructed from pre-finished steel that has a conductive covering of aluminium and zinc. This provides good earthing at all joints giving a low impedance path to earth that is essential for performance in the presence of external noise. The boards and modules use a multi-point earthing strategy to improve the 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, the output relay contacts, the power supply and the 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 PCBs 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 are provided with internal shorting links inside the relay which will 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 LEDs mounted on an aluminium backing plate.

3. RELAY SOFTWARE

The relay software was introduced in the overview of the relay at the start of this manual (P746/EN FD). The software can be considered to be made up of four sections:

- The real-time operating system

- The system services software

- The platform software

- The protection & control software

This section describes in detail the latter two of these, the platform software and the protection & control software, which between them control the functional behaviour of the relay. The figure below shows the structure of the relay software.
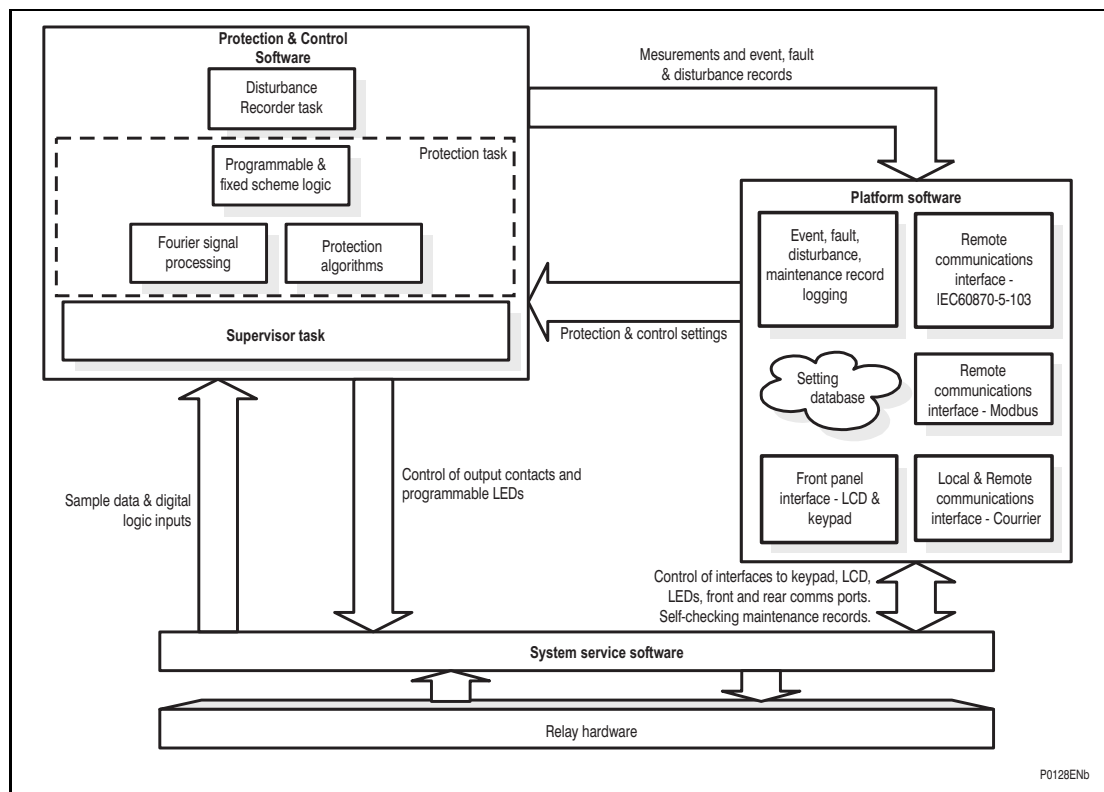
FIGURE 8: RELAY SOFTWARE STRUCTURE

3.1 Real-time operating system

Real-time operating system for main board: 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.

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.

3.2   System services software

As shown in Figure 8, the system services software provides the interface between the relay's hardware and the higher-level functionality of the platform software and the protection & control software. For example, the system services software provides drivers for items such as the LCD display, the keypad and the remote communication ports, and controls the boot of the processor and downloading of the processor code into SRAM from flash EPROM at power up.

3.3   Platform software

The platform software has three main functions:

- To control the logging of records that are generated by the protection software, including alarms and event, fault, 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, i.e. the front panel interface and the front and rear communication ports, using whichever communication protocol has been specified (Courier or IEC 60870-5-103).

3.3.1   Record logging

The logging function is provided to store all alarms, events, faults and maintenance records. The records for all of these incidents are logged in battery backed-up SRAM in order to provide a non-volatile log of what has happened. The relay maintains four logs: one each for up to 32 alarms, 512 event records, 5 fault records and 5 maintenance records. The logs are maintained such that the oldest record is overwritten with the newest record. The logging function can be initiated from the protection software or the platform software 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 function. See also the section on supervision and diagnostics later in this document (P746/EN FD).

3.3.2   Settings database

The settings database contains all of the settings and data for the relay, including the protection, disturbance recorder and control & support settings. The settings are maintained in non-volatile memory. The platform software's management of the settings database includes the responsibility of ensuring that only one user interface modifies the settings of the database at any one time. This feature is employed to avoid conflict 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 applied to the protection elements, disturbance recorder and saved in the database in non-volatile memory. (See also the Introduction to this manual (P746/EN IT) on the user interface). If a setting change affects the protection & control task, the database advises it of the new values.

3.3.3   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.

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3.4 Protection and control software

The protection and control software task is responsible for processing all of the protection elements and measurement functions of the relay. To achieve this it has to communicate with both the system services software and the platform software as well as organize its own operations. The protection software has the highest priority of any of the software tasks in the relay in order to provide the fastest possible protection response. The protection & control software 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.

3.4.1 Overview - protection and control scheduling

The figure **8** shows the parts of Alstom Grid software and their allocation on the different boards.

The P746 relay contained two global protections, busbar protection and circuit breaker failure, and additional functions such as overcurrent protection.

3.4.2 Topology processing

Topology algorithm determines dynamically the electric scheme of the substation from the auxiliary contact of circuit breaker and isolators. At the end of process, the P746 knows the node of current and zone to trip according to the fault location.

3.4.3 Signal processing

The sampling function provides filtering of the digital input signals from the opto-isolators and frequency tracking of the analog signals. The digital inputs are checked against their previous value over a period of half a cycle.

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 so as 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 & control task.

The protection and control calculates the Fourier components for the analogue 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, i.e. the most recent data is used. The DFT used in this way 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 in conjunction with the relay-input module which provides hardware anti-alias filtering to attenuate frequencies above the half sample rate. The Fourier components of the input current signals are stored in memory so that 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.

3.4.4 Programmable scheme logic

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 the digital input signals from the opto-isolators on the input board, the outputs of the protection elements, e.g. protection starts and trips, control inputs, function keys 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. 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 MiCOM S1 V2 or Studio.

3.4.5 Function key interface

The ten function keys interface directly into the PSL as digital input signals and are processed based on the PSL's 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 thus allowing the function Key state to be reinstated after power-up should relay power be inadvertently lost.

3.4.6 Event and fault recording

A change in any digital input signal or protection element output signal causes an event record to be created. When this happens, the protection and control task sends a message to the supervisor task to indicate that an event is available to be processed and writes the event data to a fast buffer in SRAM which 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 operation of the record logging to battery backed-up SRAM is slower than the supervisor's buffer. This means that the protection software is not delayed waiting for the records to be logged by the platform software. However, in the rare case when a large number of records to be logged are created in a short period of time, it is possible that some will 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 then an event is logged to indicate this loss of information.

3.4.7 Disturbance recorder

The disturbance recorder operates as a separate task from the protection and control task. It can record the waveforms for up to 21 analogue channels and the values of up to 32 digital signals. The recording time is user selectable up to a maximum of 10.5 seconds. The disturbance recorder is supplied with data by the protection and control task once per cycle. The disturbance recorder collates the data that it receives into the required length disturbance record. It attempts to limit the demands it places on memory space by saving the analogue data in compressed format whenever possible. This is done by detecting changes in the analogue input signals and compressing the recording of the waveform when it is in a steady-state condition. The disturbance records can be extracted by MiCOM S1 V2 or Studio that can also store the data in COMTRADE format, thus allowing the use of other packages to view the recorded data.

4. SELF TESTING & DIAGNOSTICS

The relay includes a number of 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 within the relay's hardware or software, the relay is able to detect and report the problem and attempt to resolve it by performing a re-boot. This involves the relay being out of service for a short period of time which is indicated by the 'Healthy' LED on the front of the relay being extinguished and the watchdog contact at the rear operating. If the restart fails to resolve the problem, then the relay will take itself permanently out of service. Again this will be indicated by the LED and watchdog contact.

If a problem is detected by the self-monitoring functions, the relay attempts to store a maintenance record in battery backed-up SRAM to allow the nature of the problem to be notified to the user.

The self-monitoring is implemented in two stages: firstly a thorough diagnostic check which is performed when the relay is booted-up, e.g. at power-on, and secondly a continuous self-checking operation which checks the operation of the relay's critical functions whilst it is in service.

4.1 Start-up self-testing

The self-testing which 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 signalled by the 'Healthy' LED on the front of the relay which will illuminate when the relay has passed all of the tests and entered operation. If the testing detects a problem, the relay will remain out of service until it is manually restored to working order.

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

4.1.1 System boot

The integrity of the flash memory is verified using a checksum before the program code and data stored in it is copied into SRAM to be used for execution by the processor. When the copy has been completed the data then held in SRAM is compared to that in the flash to ensure that the two are the same and that no errors have occurred in the transfer of data from flash to SRAM. The entry point of the software code in SRAM is then called which is the relay initialization code.

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4.1.2 Initialization software

The initialization process includes the operations of initializing the processor registers and interrupts, starting the watchdog timers (used by the hardware to determine whether the software is still running), starting the real-time operating system and creating and starting the supervisor task. In the course of the initialization process the relay checks:

- The status of the battery

- The integrity of the battery backed-up SRAM that is used to store event, fault and disturbance records

- The voltage level of the field voltage supply which is used to drive the opto-isolated inputs

- The operation of the LCD controller

- The watchdog operation

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

4.1.3   Platform software initialization & 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 analogue data acquisition system is checked through sampling the reference voltage.

At the successful conclusion of all of these tests the relay is entered into service and the protection started-up.

4.2   Continuous self-testing

When the relay is in service, it continually checks the operation of the critical parts of its hardware and software. The checking is carried out by the system services software (see section on relay software earlier in this document (P746/EN FD)) and the results reported to the platform software. The functions that are checked are as follows:

- The flash containing all program code setting values and language text is verified by a checksum

- The code and constant data held in SRAM is checked against the corresponding data in flash to check for data corruption

- The SRAM containing all data other than the code and constant data is verified with a checksum

- The battery status

- The level of the 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 analogue data acquisition system is continuously checked by the acquisition function every time it is executed, by means of sampling the reference voltages

- 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

- The operation of the Ethernet board is checked, where it is fitted, by the software on the main processor card. If the Ethernet board fails to respond an alarm is raised and the card is reset in an attempt to resolve the problem

In the unlikely event that one of the checks detects an error within 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 will continue in operation. However, for problems detected in any other area the relay will initiate a shutdown and re-boot. This will result in a period of up to 5 seconds when the protection is unavailable, but the complete restart of the relay including all initializations should clear most problems that could occur. As described above, 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, i.e. the restart has not cleared the problem, then the relay will take itself permanently out of service. This is indicated by the 'Healthy' LED on the front of the relay, which will extinguish, and the watchdog contact that will operate.

COMMISSIONING AND MAINTENANCE

CM

Date:	2008
Hardware Suffix:	K
Software Version:	01
Connection Diagrams:	10P746xx (xx = 01 to 07)

CONTENTS

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1. INTRODUCTION

The MiCOM P746 Busbar Differential Protection is fully numerical in its design, implementing all protection and non-protection functions in software. The relay employs a high degree of self-checking and, in the unlikely event of a failure, will give an alarm. As a result of this, the commissioning tests do not need to be as extensive as with non-numeric electronic or electromechanical relays.

To commission numerical 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 (PSL, topology, differential and breaker failure protection linked to the topology/PSL). 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) such as MiCOM S1 (V2 or Studio).

− Via the operator interface (HMI).

Unless previously agreed to the contrary, the customer will be responsible for determining the application-specific settings to be applied to the relay and for testing of any scheme logic applied by external wiring and/or configuration of the relay's internal programmable scheme logic.

Blank commissioning test and setting records are provided at the end of this chapter for completion as required.

As the relay's menu language is user-selectable, it is acceptable for the Commissioning Engineer to 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 will be 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 located in the System Data column (column 00) so it would be given as [SYSTEM DATA, Language].

Before carrying out any work on the equipment, the user should be familiar with the contents of the Safety Section/Safety Guide SFTY/4LM/H11 or later issue, the Technical Data section and the ratings on the equipment rating label.

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2.   SETTING FAMILIARISATION

When commissioning a MiCOM P746 Busbar protection for the first time, sufficient time should be allowed to become familiar with the method by which the settings are applied.

The Introduction (P746/EN IT) contains a detailed description of the menu structure of P746 relay.

With the secondary front cover in place all keys except the ⏎ key are accessible. All menu cells can be read. LED's 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, LED's and alarms reset, and fault and event records cleared. However, menu cells those have access levels higher than the default level will require the appropriate password to be entered before changes can be made.

Alternatively, if a portable PC is available together with suitable setting software (such as MiCOM S1 V2 or Studio), the menu can be viewed a 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 on a digital medium for future reference or printed to produce a setting 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.

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3.   EQUIPMENT REQUIRED FOR COMMISSIONING

3.1   Minimum equipment required

Overcurrent test set with interval timer

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 the multimeter)

> Note: Modern test equipment may contain many of the above features in one unit.

3.2   Optional equipment

Multi-finger test plug type P992 (if test block type P991 installed) or MMLB (if using MMLG blocks)

An electronic or brushless insulation tester with a dc output not exceeding 500V (for insulation resistance testing when required). This equipment will be required only if the dielectric test has not been done during the manufacturing process.

A portable PC, with appropriate software (this enables the rear communications port to be tested, if this is to be used, and will also save considerable time during commissioning).

A printer (for printing a setting record from the portable PC).

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4.   PRODUCT CHECKS

These product checks cover all aspects of the relay which should be checked to ensure that it has not been physically damaged prior to commissioning, is functioning correctly and all input quantity measurements are within the stated tolerances.

If the application-specific settings have been applied to the relay prior to commissioning, it is advisable to make a copy of the settings so as to allow their restoration later. This could be done by:

−   Obtaining a setting file on a digital medium 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 again requires a portable PC with appropriate setting software).

−   Manually creating a setting record. This could be done using a copy of the setting record located at the end of this chapter to record the settings as the relay's menu is sequentially stepped through via the front panel user interface.

If password protection is enabled and the customer has changed password 2 that prevents unauthorised changes to some of the settings, either the revised password 2 should be provided, or the customer should restore the original password prior to commencement of testing.

> Note: In the event that the password has been lost, a recovery password can be obtained from Alstom Grid by quoting the serial number of the relay. The recovery password is unique to that relay and is unlikely to work on any other relay.

4.1   With the relay de-energised

The following group of tests should be carried out without the auxiliary supply being applied to the relay and with the trip circuit isolated.

The current and voltage transformer connections must be isolated from the relay for these checks. If a P991 test block is provided, the required isolation can easily be achieved by inserting test plug type P992 which effectively open circuits all wiring routed through the test block, except CT circuits which are automatically short circuited.

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Before inserting the test plug, reference should be made to the scheme (wiring) diagram to ensure that this will not potentially cause damage or a safety hazard. CTs must be suitably short circuited on the MMLB test plug before inserting this into the MMLG test block, otherwise there is a danger of fatal electric shock and damage to the equipment. This is not required if using a MiCOM P991 test block and MiCOM P992 test plug, since CTs are automatically safety short circuited.

BEFORE CARRYING OUT ANY WORK ON THE EQUIPMENT, THE USER SHOULD BE FAMILIAR WITH THE CONTENTS OF THE SAFETY SECTION/SAFETY GUIDE SFTY/4LM/H11 OR LATER ISSUE, THE TECHNICAL DATA SECTION AND THE RATINGS ON THE EQUIPMENT RATING LABEL.

If a test block is not provided, the voltage transformer supply to the relay should be isolated by means of the panel links or connecting blocks. The line current transformers should be short-circuited and disconnected from the relay terminals. Where means of isolating the auxiliary supply and trip circuit (e.g. isolation links, fuses, MCB, etc.) are provided, these should be used. If this is not possible, the wiring to these circuits will have to be disconnected and the exposed ends suitably terminated to prevent them from being a safety hazard.

4.1.1   Visual inspection

Carefully examine the relay to see that no physical damage has occurred since installation.

The rating information given under the top access cover on the front of the relay should be checked to ensure it is correct for the particular installation.

Ensure the case earthing connections, 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 they close when the heavy duty terminal block is disconnected from the current input PCB.
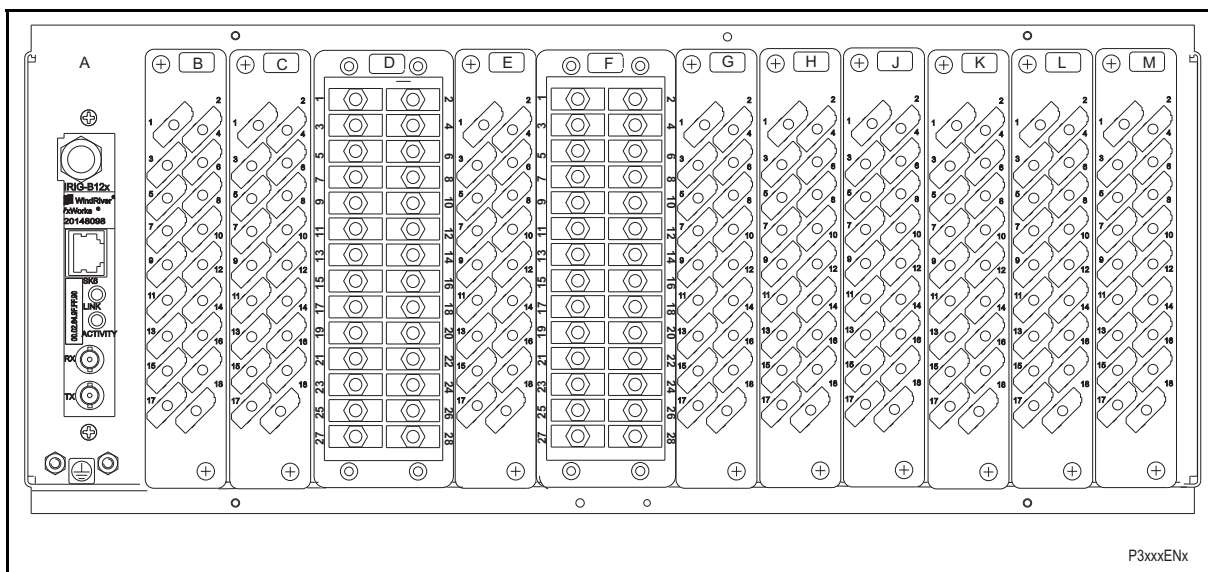
A – IRIG B / Ethernet / COMMS   G – Sigma Delta Opto Board
B – Opto \ high break   H – Relay \ Opto \ high break
C – Opto \ high break   J – Relay \ high break
D – Sigma Delta analogue input board   K – Relay \ high break
E – Sigma Delta Opto Board   L – Relay board
F – Sigma Delta analogue input board   M – Power supply board

FIGURE 1: REAR TERMINAL BLOCKS ON P746

The heavy duty terminal block is fastened to the rear panel using four crosshead screws. These are located top and bottom between the first and second, and third and fourth, columns of terminals (see Figure 2).

Note: The use of a magnetic bladed screwdriver is recommended to minimise the risk of the screws being left in the terminal block or lost.
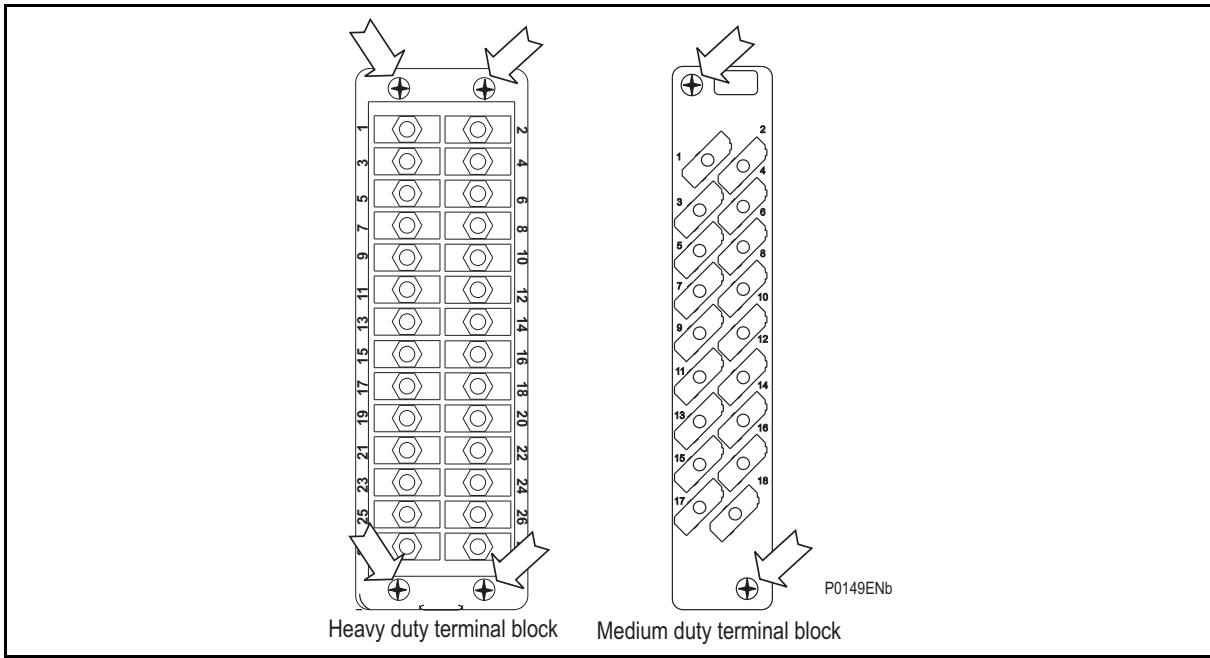
FIGURE 2: LOCATION OF SECURING SCREWS FOR HEAVY DUTY TERMINAL BLOCKS.

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. Table 1 shows the terminals between which shorting contacts are fitted.

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

TABLE 1: CURRENT TRANSFORMER SHORTING CONTACT LOCATIONS.

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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

Check that the external wiring is correct to the relevant relay diagram or scheme diagram. The relay diagram number appears on the rating label under the top access cover on the front of the relay. The corresponding connection diagram will have been supplied with the Alstom Grid order acknowledgement for the relay.

If a P991 test block is provided, the connections should be checked against the scheme (wiring) diagram. It is recommended that the supply connections are to the live side of the test block [coloured orange with the odd numbered terminals (1, 3, 5, 7 etc.). The auxiliary supply is normally routed via 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

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Using a continuity tester, check that the watchdog contacts are in the states given in Table 2 for a de-energised 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

The P746 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 Table 3.

Without energising the relay measure the auxiliary supply to ensure it is within the operating range.

Nominal supply rating DC [AC rms]		DC operating range	AC operating range
24 – 48V	[–]	19 to 65V	-
48 – 110V	[30 – 100V]	37 to 150V	24 to 110V
110 – 250V	[100 – 240V]	87 to 300V	80 to 265V

TABLE 3: OPERATIONAL RANGE OF AUXILIARY SUPPLY VX.

It should be noted that the P746 relay can withstand an ac ripple of up to 12% of the upper rated voltage on the dc auxiliary supply.

Do not energise the relay or interface unit using the battery charger with the battery disconnected as this can irreparably damage the relay's power supply circuitry.

Energise the relay only if the auxiliary supply is within the specified operating ranges. If a test block is provided, it may be necessary to link across the front of the test plug to connect the auxiliary supply to the relay.

4.2   With the relay energised

The following group of tests verifies that the relay hardware and software is functioning correctly and should be carried out with the auxiliary supply applied to the relay.

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.

4.2.1   Watchdog contacts

Using a continuity tester, check the watchdog contacts are in the states given in Table 2 for an energised relay.

4.2.2   Date and time

Before setting the date and time, ensure that the factory-fitted battery isolation strip, that prevents battery drain during transportation and storage, has been removed. With the lower access cover open, presence of the battery isolation strip can be checked by a red tab protruding from the positive side of the battery compartment. Whilst lightly pressing the battery, to prevent it from falling out of the battery compartment, pull the red tab to remove the isolation strip.

The date and time should now be set to the correct values. The method of setting will depend on whether accuracy is being maintained via the optional Inter-Range Instrumentation Group standard B (IRIG-B) port on the rear of the P746 relay.

4.2.2.1   With an IRIG-B signal

If a satellite time clock signal conforming to IRIG-B is provided and the P746 relay has the optional IRIG-B port fitted, the satellite clock equipment should be energised.

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 co-ordinated 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 [DATE and TIME, Date/Time]. The IRIG-B signal does not contain the current year so it will need to be set manually in this cell.

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.

To test this, remove the IRIG-B signal, then remove the auxiliary supply from the relay. Leave the relay de-energised for approximately 30 seconds. On re-energisation, the time in cell [DATE and TIME, Date/Time] should be correct.

Reconnect the IRIG-B signal.

4.2.2.2   Without an IRIG-B signal

If the time and date is not being maintained by an IRIG-B signal, ensure that cell [DATE and TIME, IRIG-B Sync] is set to 'Disabled'.

Set the date and time to the correct local time and date using cell [DATE and TIME, Date/Time].

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.

To test this, remove the auxiliary supply from the relay for approximately 30 seconds. On re-energisation, the time in cell [DATE and TIME, Date/Time] should be correct.

4.2.3   Light Emitting Diodes (LED's)

On power up the green LED should have illuminated and stayed on indicating that the relay is healthy. The relay has non-volatile memory which remembers the state (on or off) of the alarm, trip and, if configured to latch, user-programmable LED indicators when the relay was last energised from an auxiliary supply. Therefore these indicators may also illuminate when the auxiliary supply is applied.

If any of these LED's are on then they should be reset before proceeding with further testing. If the LED's successfully reset (the LED goes out), 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.

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4.2.3.1   Testing the alarm and out of service LED's

The alarm and out of service LED's can be tested using the COMMISSION TESTS menu column. Set cell [COMMISSION TESTS, Test Mode] to 'Out Of Service' on the P746. Check that the out of service LED illuminates continuously and the alarm LED flashes.

It is not necessary to return cell [COMMISSION TESTS, Test Mode] to 'Disabled' at this stage because the test mode will be required for later tests.

4.2.3.2   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.

4.2.3.3   Testing the user-programmable LEDS

To test the user-programmable LED's set cell [COMMISSION TESTS, Test LEDs] to 'Apply Test'. Check that all the LED's of the relay illuminate.

In the P746:

−   The 'Red LED Status' cell is an eighteen bit binary string that indicates which of the user-programmable LEDs on the relay are illuminated when accessing the relay from a remote location, a '1' indicating a particular Red LED is lit.

−   The 'Green LED Status' cell is an eighteen bit binary string that indicates which of the user-programmable LEDs on the relay are illuminated when accessing the relay 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.

4.2.4   Field voltage supply

The relay generates a field voltage of nominally 48V dc that can be used to energise the opto-isolated inputs (alternatively the substation battery may be used).

Measure the field voltage across the terminals 7 and 9 on the terminal block given in Table 4. Check that the field voltage is within the range 40V to 60V 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

4.2.5   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 external connection diagrams (P746/EN CO) 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.

4.2.6   Output relays

This test checks that all the output relays are functioning correctly.

See external connection diagrams in the Installation Chapter (P746/EN IN) 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 external connection diagram (P746/EN IN).

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'.

4.2.7 Rear communications port

This test should only be performed where the relay is to be accessed from a remote location and will vary 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.

4.2.7.1 Courier communications

If a K-Bus to EIA(RS)232 KITZ 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 Master Station, communications with the relay can be established.

Note: The first rear communication port (terminal M17-18) can be either K-Bus or EIA(RS)485.

4.2.8 Second rear communications port

This test should only be performed where the relay is to be accessed from a remote location and will vary 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 relays rear communications port and any protocol converter necessary.

4.2.8.1 K-Bus configuration

If a K-Bus to EIA(RS)232 KITZ protocol converter is installed, connect a portable PC running

the appropriate software (e.g. MiCOM S1 V2 or Studio or PAS&T) to the incoming (remote from relay) side of the protocol converter.

If a KITZ protocol converter is not installed, it may not be possible to connect the PC to the relay installed. In this case a KITZ protocol converter and portable PC running appropriate software should be temporarily connected to the relays second rear communications port configured for K-Bus. However, as the installed protocol converter is not being used in the test, only the correct operation of the relays K-Bus port will be confirmed.

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 [0E90: COMMUNICATIONS, RP2 Address] must be set to a value between 1 and 254. The second rear communications port configuration [0E88: COMMUNICATIONS RP2 Port Config.] must be set to K-Bus.

Check that communications can be established with this relay using the portable PC.

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4.2.8.2   EIA(RS)485 configuration

If an EIA(RS)485 to EIA(RS)232 converter (CK222) is installed, connect a portable PC running the appropriate software (e.g. MiCOM S1 V2 or 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.

Ensure that the communications baud rate and parity settings in the application software are set the same as those in the relay. The relays courier address in cell [0E90:COMMUNICATIONS, RP2 Address] must be set to a value between 1 and 254. The second rear communications port 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.

4.2.8.3   EIA(RS)232 configuration

Connect a portable PC running the appropriate software (e.g. MiCOM S1 V2 or Studio) to the rear EIA(RS)2321 port of the relay.

The second rear communications port connects via the 9-way female D-type connector (SK4). The connection is compliant to EIA(RS)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 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.

Ensure that the communications baud rate and parity settings in the application software are set the same as those in the relay. The relays courier address in cell [0E90:COMMUNICATIONS, RP2 Address] must be set to a value between 1 and 254. The second rear communications 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.

4.2.9   Current inputs

This test verifies that the accuracy of current measurement is within the acceptable tolerances.

All relays will leave the factory set for operation at a system frequency of 50Hz. If operation at 60Hz is required then this must be set in cell [SYSTEM DATA, Frequency].

Apply current equal to the line current transformer secondary winding rating to each current transformer input of the corresponding rating in turn, see Table 1 or external connection diagram (P746/EN CO) for appropriate terminal numbers, checking its magnitude using a multimeter. The corresponding reading can then be checked in the relay's MEASUREMENTS 1 column and value displayed recorded.

The measured current values displayed on the relay LCD or a portable PC connected to the front communication port will either be in primary or secondary Amperes. If cell [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 Table 5). If cell [MEASURE'T SETUP, Local Values] is set to 'Secondary', the value displayed should be equal to the applied current.

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The measurement accuracy of the relay is ±5%. However, an additional allowance must be made for the accuracy of the test equipment being used.

Cell in MEASUREMENTS 1 column (02)	Corresponding CT Ratio (in 'CT and VT RATIOS' column(0A) of menu)
[IA Magnitude] [IB Magnitude] [IC Magnitude]	[Phase CT Primary] [Phase CT Secondary]

TABLE 5: CT RATIO SETTINGS

5.   COMMISSIONING TEST MENU

5.1   Test mode

This cell is used to allow commissioning of busbar and general breaker failure protection. It also enables a facility to directly test the output contacts by applying menu controlled tests signals. During the test mode, opto inputs and outputs contacts remain in last known state before the test mode is selected.

To select test mode this cell should be set to 'Enabled' which takes the relay out of service causing an alarm condition to be recorded and the yellow 'Out of Service' LED to illuminate. Once testing is complete the cell must be set back to 'Disabled' to restore the relay back to service.

WHEN THE 'TEST MODE' CELL IS SET TO 'ENABLED', THE RELAY SCHEME LOGIC DOES NOT DRIVE THE OUTPUT RELAYS AND SO THE P746 WILL NOT TRIP THE ASSOCIATED CIRCUIT BREAKER IF A BUSBAR FAULT OCCURS (COMMISSIONING MODE 1 AND 2).

HOWEVER, THE COMMUNICATIONS CHANNELS WITH REMOTE RELAYS REMAIN ACTIVE, WHICH, IF SUITABLE PRECAUTIONS ARE NOT TAKEN, COULD LEAD TO THE REMOTE ENDS TRIPPING WHEN CURRENT TRANSFORMERS ARE ISOLATED OR INJECTION TESTS ARE PERFORMED.

5.2   Busbar (BB) & Circuit Breaker Fail (CBF) Disabled

The 'BB & CBF disabled' 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 disable busbar & 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 ' BB & CBF disabled' when other zone remains active.

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6. SETTING CHECKS

The setting checks ensure that all of the application-specific relay settings (i.e. both the relay's function and programmable scheme logic settings), for the particular installation, have been correctly applied to the relay.

Note 1: The trip circuits should remain isolated during these checks to prevent accidental operation of the associated circuit breaker.

Note 2: 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 two methods of applying the settings to the relay:

– Transferring them from a pre-prepared setting file to the relay using a portable PC running the appropriate software via the relay's front EIA(RS)232 port, located under the bottom access cover. This method is preferred for transferring function settings as it is much faster and there is less margin for error. If the programmable scheme logic other than the default settings with which the relay is supplied is to be used then this is the only way of changing the settings.
If a setting file has been created for the particular application and provided on a digital medium, this will further reduce the commissioning time and should always be the case where application-specific programmable scheme logic is to be applied to the relay.

– Enter them manually via the relay's operator interface. This method is not suitable for changing the programmable scheme logic.

Note: It is essential that where the installation needs application-specific Programmable Scheme Logic, that the appropriate .psl file is downloaded (sent) to the relay, for each and every 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, then 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 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 & I<] are all set to "Disabled". Make a note of which elements need to be re-enabled after testing.

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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:
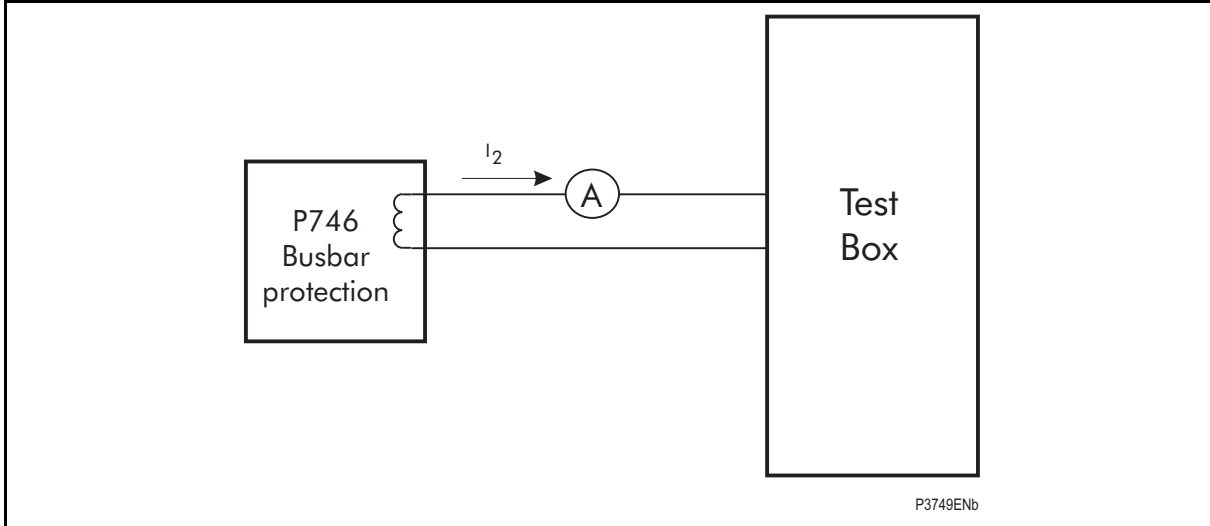
FIGURE 3: CONNECTION FOR BIAS CHARACTERISTIC TESTING
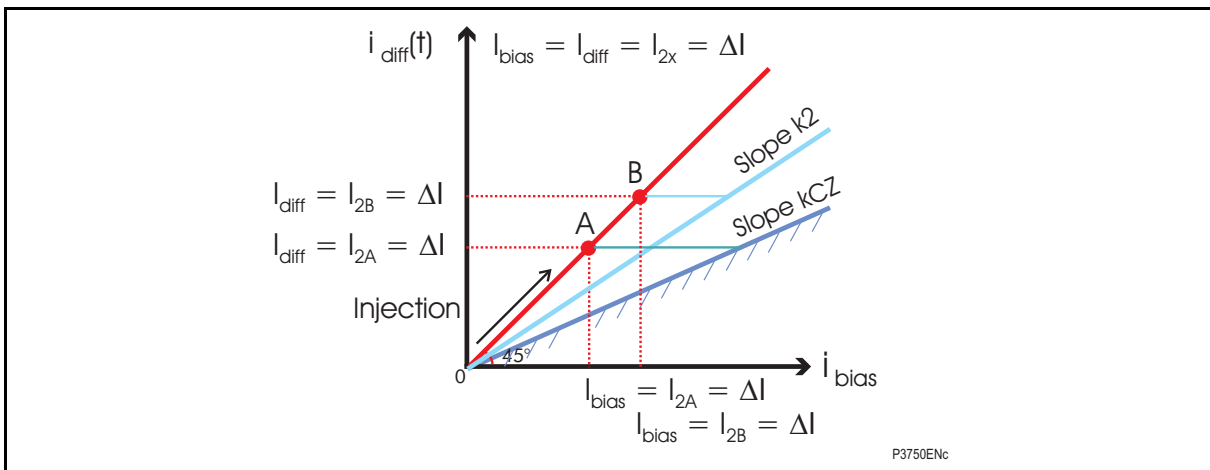
An increasing current I_2 is injected into a phase (and neutral) of the feeder 2 which is used as differential and bias current.

$I_{diff} = I_{bias} = I_2$

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 2 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.
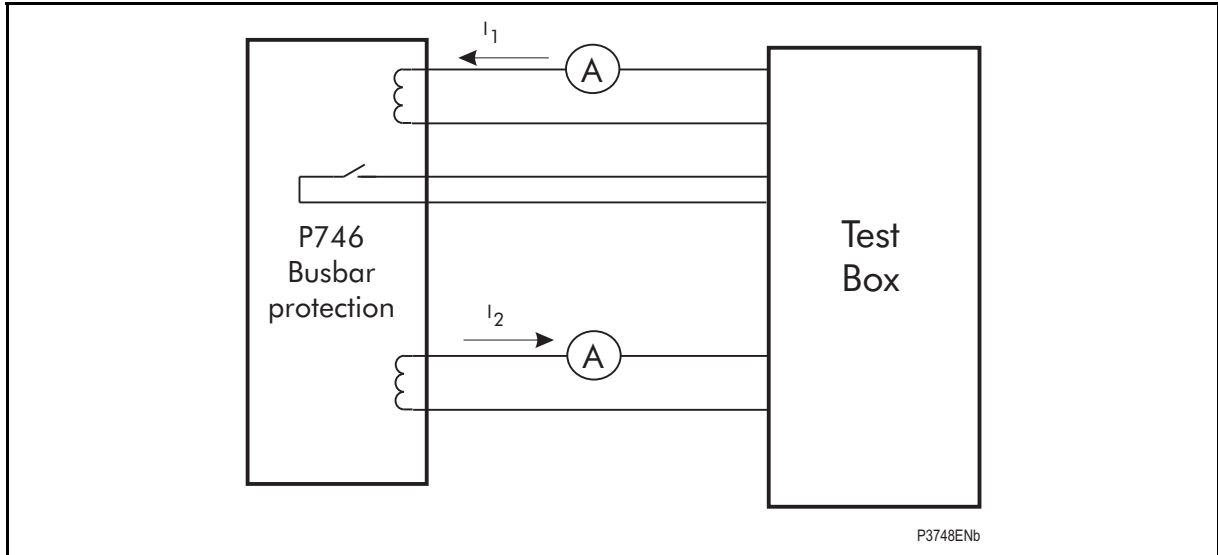
FIGURE 4: CONNECTION FOR BIAS CHARACTERISTIC TESTING
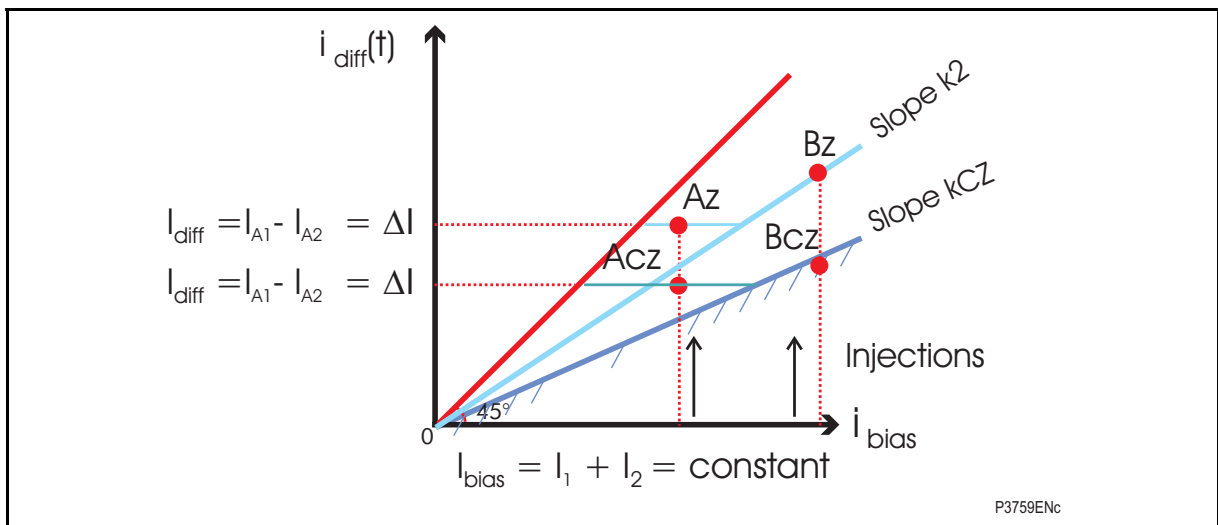
Note: The easiest way to test the thresholds is to inject an increasing slope for I_1 and a decreasing slope for I_2. The $I_{bias} = I_1 + I_2$ is thus constant and $\Delta I = I_{diff} = I_2 - I_1$ is increasing.

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)

1. 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 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:
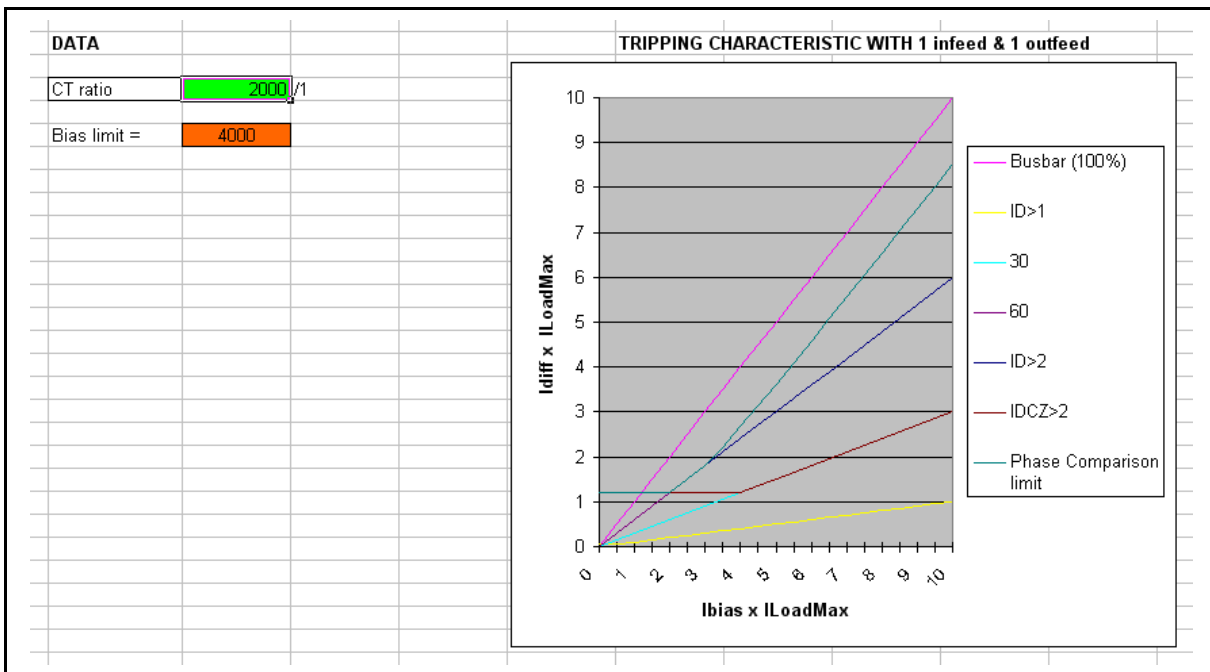
For example, if k2 is 60%, x% = 50% and if the CT ratio of the smallest injected current is 1000/1, $I_{biasmax}$ is 2500A (so ID>2 up to 1500 A).

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 1: I_D>1 alarm timer will be set to 100s during the test.

To test the tripping time, inject $4 \times I_D$>2 at 60Hz and $3.5 \times I_D$>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: $I_{bias} \geq$ 2 times x% of In /(1 - k2)

Note 2:   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 P746 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
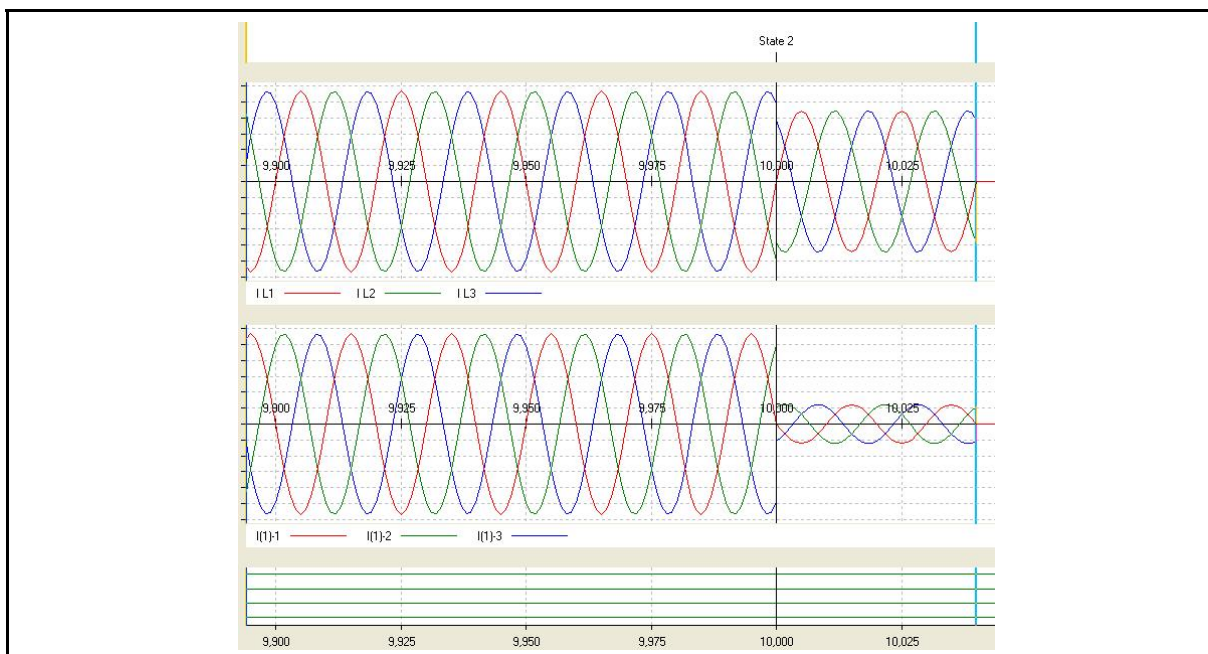
Second test:

- 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.
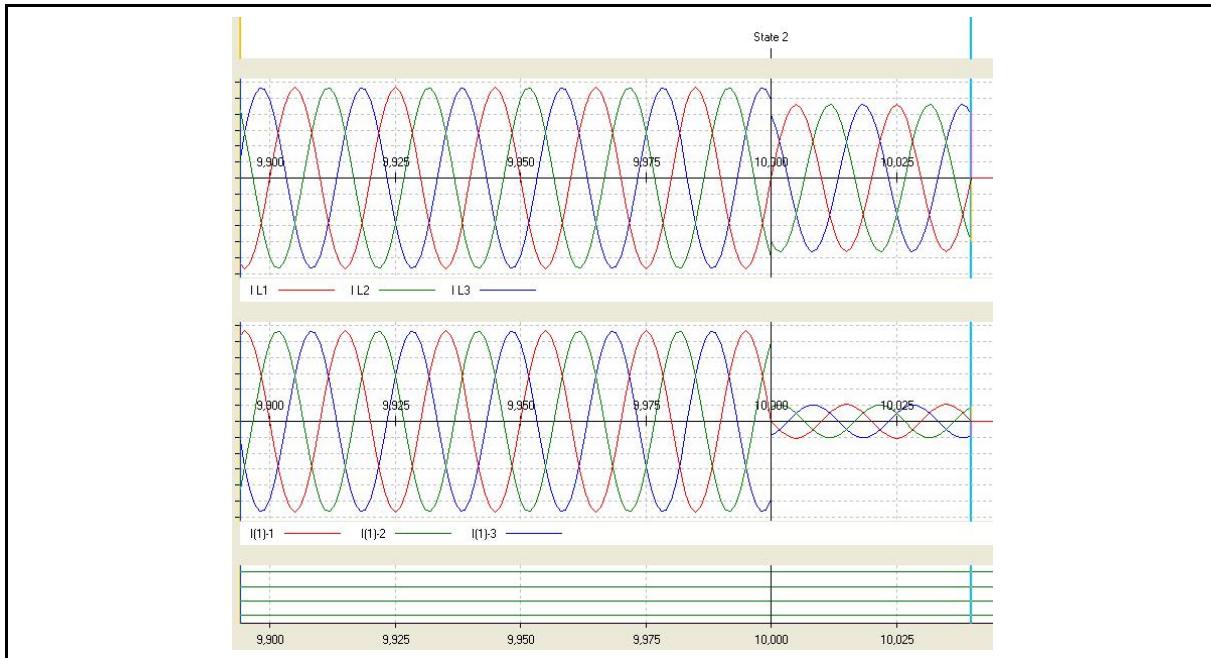
Example:

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

CM

To test the Phase comparison pick-up only:

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.

CM

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 (P746/EN IN).

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.

6.2.2.1.1 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.

6.2.2.1.2 Check the operating time

Check that the operating time recorded by the timer is within the range shown in Table 6.

> Note: Except for the definite time characteristic, the operating times given in Table 6 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 Table 6 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.

CM

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	0.64	0.61 – 0.67
IEEE V Inverse	1.42	1.35 – 1.50
IEEE E Inverse	1.46	1.39 – 1.54
US Inverse	0.46	0.44 – 0.49
US ST Inverse	0.26	0.25 – 0.28

TABLE 6: CHARACTERISTIC OPERATING TIMES FOR I>1

Re-perform the tests for the function I>2.

Upon completion of the tests any current differential, overcurrent, earth fault, breaker fail or supervision elements 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   Separate external 50BF protection to the busbar protection

Feeder 1   Feeder 2   Coupler   Feeder 3   Feeder 4
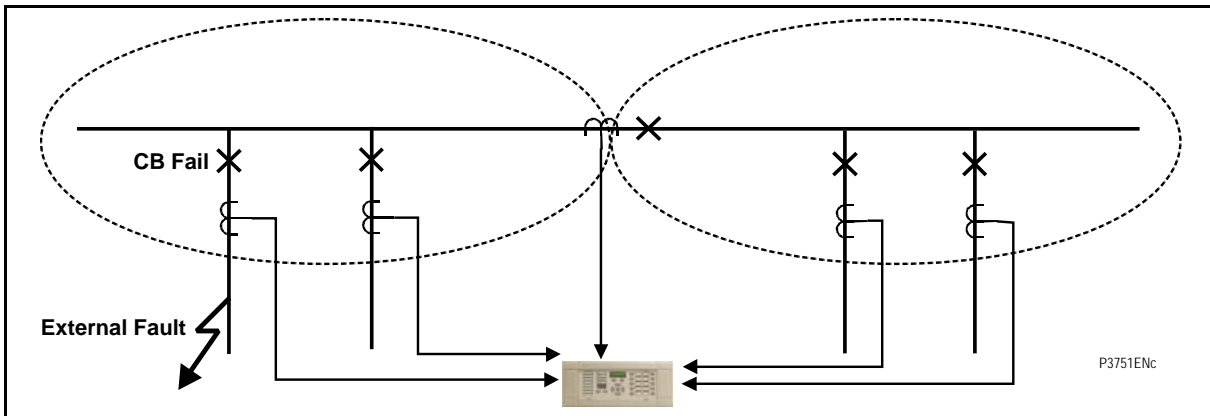
For example as shown in the above figure, we simulate a CB fail in feeder 1. Therefore, we energise the opto input "External CB Fail" of the feeder1 and we check that the P746 issues a tripping order to feeder 2 and the coupler.

The trip of the backup phase overcurrent or earth fault overcurrent protection initiates, as described above, the timers tBF3 and tBF4.

6.2.3.2   External initiation of BF Protection

P3752ENc
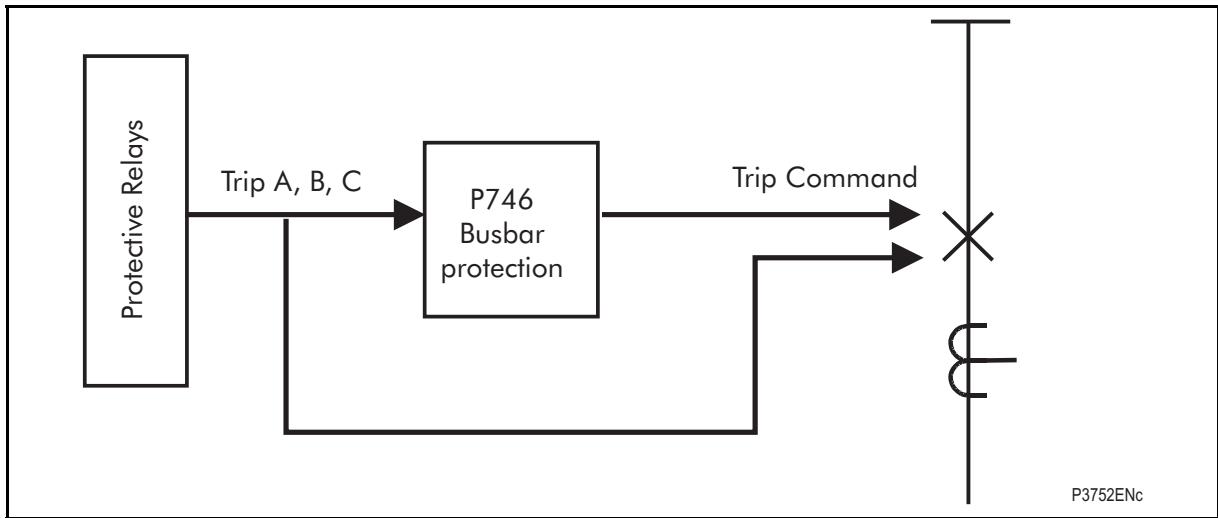
To test the retrip:

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.

6.2.3.3   CB unavailable:

Feeder 1   Feeder 2   Coupler   Feeder 3   Feeder 4

P3753ENc
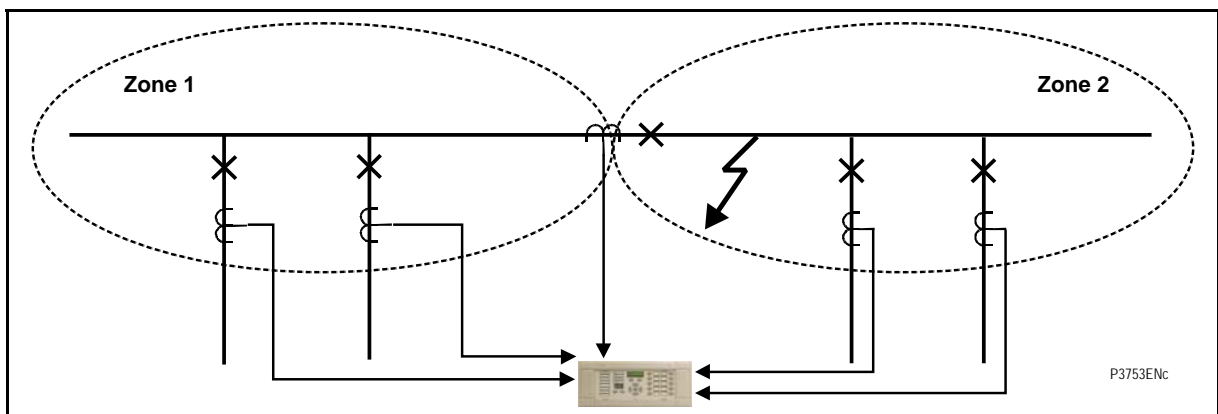
Apply an internal fault in zone 2 and energise the opto input "CB unavailable" of the coupler and check that both bus-sections are tripped simultaneously.

Note: If the input "CB unavailable" is energised, the CB will be not tripped and is normally used only for bus-coupler.

CM

The backtrip order is equal to (the maximum between the fault clearance time and 250 ms) – tBF4 pick-up time.

For example if tBF4 = 200ms and the fault is cleared before 450ms, the P746 will display 450ms.

For example if tBF4 = 200ms and the fault is cleared in 500ms, the P746 will display 500ms.

6.2.3.4   Internal initiation Breaker Failure Protection

This Breaker failure Protection can be initiated only by a trip command issued by the P746.

Feeder 1   Feeder 2   Coupler   Feeder 3   Feeder 4
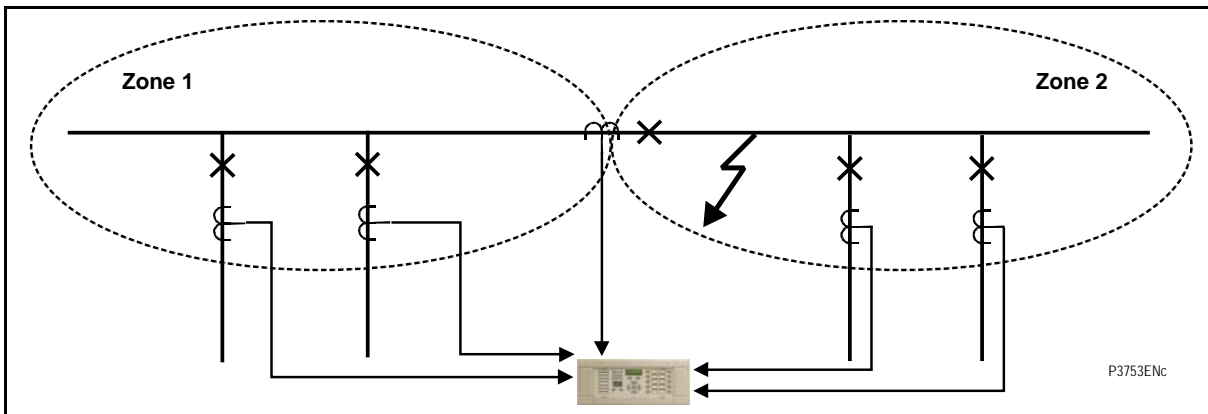
Simulate a busbar fault on the bus-section 2.

Continue to apply fault current in the bus-coupler until the timer tBF1 elapsed.

Check that the retrip signal is given by CT3 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 5 should have operated).

The backtrip order is equal to (the maximum between the fault clearance time and 250 ms) – tBF2 pick-up time.

For example if tBF2 = 150ms and the fault is cleared before 400ms, the displayed value will be 400ms.

For example if tBF2 = 150ms and the fault is cleared in 500ms, the displayed value will be 500ms.

6.3   Check Application Settings

The settings applied should be carefully checked against the required application-specific settings to ensure that they are correct, and have not been mistakenly altered during the injection test.

There are two methods of checking the settings:

–   Extract the settings from the relay using a portable PC running the appropriate software via the front EIA(RS)232 port, located under the bottom access cover. 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 programmable scheme logic will not be checked as part of the commissioning tests.

Due to the versatility and possible complexity of the programmable scheme logic, it is beyond the scope of these commissioning instructions to detail suitable test procedures. Therefore, when programmable scheme logic tests must be performed, written tests which

will satisfactorily demonstrate the correct operation of the application-specific scheme logic should be devised by the Engineer who created it. These should be provided to the Commissioning Engineer together with the digital medium containing the programmable scheme logic setting file.

CM

7.   ON-LOAD CHECKS

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.

Remove all test leads, temporary shorting leads, etc. and replace any external wiring that has been removed to allow testing.

If it has been necessary to disconnect any of the external wiring from the relay in order to perform any of the foregoing tests, it should be ensured that all connections are replaced in accordance with the relevant external connection or scheme diagram.

Confirm current transformer wiring:

Measure the current transformer secondary values for each input using a multimeter connected in series with the corresponding relay current input.

Check that the current transformer polarities are correct.

Ensure the current flowing in the neutral circuit of the current transformers is negligible.

Compare the values of the secondary phase currents 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 will measure little, if any, 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 [MEASURE'T SETUP, Local Values] is set to 'Secondary', the currents displayed on the LCD or a portable PC connected to the front EIA(RS)232 communication port of the relay should be equal to the applied secondary current. The values should be within 5% of the applied secondary currents. However, an additional allowance must be made for the accuracy of the test equipment being used.

If cell [MEASURE'T SETUP, Local Values] is set to 'Primary', the currents displayed on the relay should be equal to the applied secondary current multiplied by the corresponding current transformer ratio set in 'CT & VT RATIOS' menu column (see Table 5). Again the values should be within 5% of the expected value, plus an additional allowance for the accuracy of the test equipment being used.

> Note: If a single dedicated current transformer is used for the earth fault function, it is not possible to check the relay's measured values.

CM

8. FINAL CHECKS

The tests are now complete.

Remove all test or temporary shorting leads, etc. If it has been necessary to disconnect any of the external wiring from the relay in order to perform the wiring verification tests, it should be ensured that all connections are replaced in accordance with the relevant external connection or scheme diagram.

Ensure that the relay has been restored to service by checking that cell [COMMISSION TESTS, Test Mode] is set to 'Disabled'.

If the menu language has been changed to allow accurate testing it should be restored to the customer's preferred language.

If a P991/MMLG test block is installed, remove the P992/MMLB test plug and replace the cover so that the protection is put into service.

Ensure that all event records, fault records, disturbance records, alarms and LED's have been reset before leaving the relay.

If applicable, replace the secondary front cover on the relay.

CM

9.   COMMISSIONING TEST RECORD

Date: _____   Engineer: _____

Station: _____   Circuit: _____

                                 System Frequency: _____

Front Plate Information

Relay Type	P746
Model number	
Serial number	
Rated current In	
Auxiliary voltage Vx	

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:	
Optical power meter	Model:	
	Serial No:	
Insulation tester	Model:	
	Serial No:	
Setting software:	Type:	
	Version:	

CM

*Delete as appropriate

| | Have all relevant safety instructions been followed? | Yes/No* |

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* |

CM

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	Light Emitting Diodes	
4.2.3.1	Alarm (yellow) LED working?	Yes/No*
	Out of service (yellow) LED working?	Yes/No*

4.2.3.2	Trip (red) LED working?	Yes/No*

4.2.3.3	All 8 programmable LED's working?	Yes/No*

4.2.4   Field supply voltage

Value measured between terminals 7 and 9	_____V dc
Value measured between terminals 8 and 10	_____V dc

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/na*
Opto input 10 working?	Yes/No/na*
Opto input 11 working?	Yes/No/na*
Opto input 12 working?	Yes/No/na*
Opto input 13 working?	Yes/No/na*
Opto input 14 working?	Yes/No/na*
Opto input 15 working?	Yes/No/na*
Opto input 16 working?	Yes/No/na*
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*

CM

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/na*
	Contact resistance	(N/C)	____Ω/Not measured*
		(N/O)	____Ω/Not measured*
Relay 9	Working?		Yes/No*
	Contact resistance		____Ω/Not measured*
Relay 10	Working?		Yes/No*
	Contact resistance		____Ω/Not measured*
Relay 11	Working?		Yes/No*
	Contact resistance		____Ω/Not measured*

CM

Relay 12	Working?		Yes/No*
	Contact resistance		____Ω/Not measured*
Relay 13	Working?		Yes/No*
	Contact resistance		____Ω/Not measured*
Relay 14	Working?		Yes/No*
	Contact resistance		____Ω/Not measured*
Relay 15	Working?		Yes/No*
	Contact resistance	(N/C)	____Ω/Not measured*
		(N/O)	____Ω/Not measured*
Relay 16	Working?		Yes/No*
	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*

CM

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

Displayed Current   Primary/Secondary*

Phase CT Ratio   _____ /na*

Input CT	Applied value	Displayed value
IA	_____A	_____A
IB (one box mode)	_____A	_____A
IC (one box mode)	_____A	_____A
IA or IB or IC (three box mode)	_____A	_____A

5   Setting Checks

5.1   Application-specific function settings applied?   Yes/No*

Application-specific programmable scheme logic settings applied?   Yes/No/na*

5.2.1.2   Current Differential lower slope pickup   _____A

5.2.1.3   Current Differential upper slope pickup   _____A

5.2.5   Protection function timing tested?   Yes/No*

Applied current   _____A

Expected operating time   _____s

Measured operating time   _____s

7   On-load Checks

Test wiring removed?   Yes/No/na*

Disturbed customer wiring re-checked?   Yes/No/na*

CM

7.1   Confirm current transformer wiring

7.1.2   Current connections

CT wiring checked?		Yes/No/na*
CT polarities correct?		Yes/No*
Displayed current		Primary/Secondary*
Phase CT ratio		_____ /na*
Currents:	Applied value	Displayed value
IA	_____A	_____A
IB (one box mode)	_____A	_____A
IC (one box mode)	_____A	_____A
IA or IB or IC (three box mode)	_____A	_____A

7.3   Differential current checked?   Yes/ No*

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*

CM

Commissioning Engineer: Customer Witness:

Date: Date:

10. SETTING RECORD

Date: _____ Engineer: _____

Station: _____ Circuit: _____

System Frequency: _____

Front Plate Information

Type:	P746
Model Number	
Serial Number	
Rated Current In	
Auxiliary Voltage Vx	

*Delete as appropriate

Setting Groups Used

Group 1	Yes/No*
Group 2	Yes/No*
Group 3	Yes/No*
Group 4	Yes/No*

0000 SYSTEM DATA

	Language	English/Francais/Deutsch/Espanol*
	Description	
	Plant Reference	
	Model Number	
	Serial Number	
	Frequency	
	Comms Level	
	Relay Address	
	Software Ref.1	
	Password Control	
	Password Level 1	
	Password Level 2	

0800 DATE AND TIME

	IRIG-B Sync	Disabled/Enabled*
	IRIG-B Status	Inactive/Active*
	Battery Status	Dead/Healthy*
	Battery Alarm	Disabled/Enabled*

CM

0900   CONFIGURATION

	Setting Group	Select via Menu/Select via Optos*
	Active Settings	Group 1/Group 2/Group 3/Group 4*
	Setting Group 1	Disabled/Enabled*
	Setting Group 2	Disabled/Enabled*
	Setting Group 3	Disabled/Enabled*
	Setting Group 4	Disabled/Enabled*
	System config	Invisible/Visible*
	Diff Protection	Invisible/Visible*
	DEAD ZONE OC	Disabled/Enabled*
	Earth fault	Disabled/Enabled*
	CB Fail	Disabled/Enabled*
	Supervision	Disabled/Enabled*
	Input Labels	Invisible/Visible*
	Output Labels	Invisible/Visible*
	Record Control	Invisible/Visible*
	Disturb Recorder	Invisible/Visible*
	Measur't Setup	Invisible/Visible*
	Comms Setting	Invisible/Visible*
	Commission Tests	Invisible/Visible*
	Setting Values	Primary/Secondary*
	Control inputs	Invisible/Visible*
	Control I/P Config	Invisible/Visible*
	Control I/P Labels	Invisible/Visible*
	Direct Access	Disabled/Enabled*
	Function key	Invisible/Visible*
	LCD Contrast	

0A00   CT AND VT RATIOS

1 box mode:

	Main CT Primary	
	Main VT Sec'y	
	Ref current	
	T1 CT Polarity	Standard/inverted*
	T1 CT Primary	
	T1 CT Secondary	
	T2 CT Polarity	Standard/inverted*
	T2 CT Primary	
	T2 CT Secondary	
	T3 CT Polarity	Standard/inverted*

CM

	T3 CT Primary	
	T3 CT Secondary	
	T4 CT Polarity	Standard/inverted*
	T4 CT Primary	
	T4 CT Secondary	
	T5 CT Polarity	Standard/inverted*
	T5 CT Primary	
	T5 CT Secondary	
	T6 CT Polarity	Standard/inverted*
	T6 CT Primary	
	T6 CT Secondary	
3 box mode	T7 CT Polarity	Standard/inverted*
3 box mode	T7 CT Primary	
3 box mode	T7 CT Secondary	
3 box mode	T8 CT Polarity	Standard/inverted*
3 box mode	T8 CT Primary	
3 box mode	T8 CT Secondary	
3 box mode	T9 CT Polarity	Standard/inverted*
3 box mode	T9 CT Primary	
3 box mode	T9 CT Secondary	
3 box mode	T10 CT Polarity	Standard/inverted*
3 box mode	T10 CT Primary	
3 box mode	T10 CT Secondary	
3 box mode	T11 CT Polarity	Standard/inverted*
3 box mode	T11 CT Primary	
3 box mode	T11 CT Secondary	
3 box mode	T12 CT Polarity	Standard/inverted*
3 box mode	T12 CT Primary	
3 box mode	T12 CT Secondary	

CM

3 box mode	T13 CT Polarity	Standard/inverted*
3 box mode	T13 CT Primary	
3 box mode	T13 CT Secondary	
3 box mode	T14 CT Polarity	Standard/inverted*
3 box mode	T14 CT Primary	
3 box mode	T14 CT Secondary	
3 box mode	T15 CT Polarity	Standard/inverted*
3 box mode	T15 CT Primary	
3 box mode	T15 CT Secondary	
3 box mode	T16 CT Polarity	Standard/inverted*
3 box mode	T16 CT Primary	
3 box mode	T16 CT Secondary	
3 box mode	T17 CT Polarity	Standard/inverted*
3 box mode	T17 CT Primary	
3 box mode	T17 CT Secondary	
3 box mode	T18 CT Polarity	Standard/inverted*
3 box mode	T18 CT Primary	
3 box mode	T18 CT Secondary	

0B00   RECORD CONTROL

	Clear Events	No/Yes*
	Clear Faults	No/Yes*
	Clear Maint	No/Yes*
	Alarm Event	Enabled/Disabled*
	Relay O/P Event	Enabled/Disabled*
	Opto Input Event	Enabled/Disabled*
	General Event	Enabled/Disabled*
	Fault Rec Event	Enabled/Disabled*
	Maint Rec Event	Enabled/Disabled*

CM

	Protection Event	Enabled/Disabled*
	Clear Dist Recs	No/Yes*
	DDB 31 – 0	
	DDB 63 – 32	
	DDB 95 – 64	
	DDB 127 – 96	
	DDB 159 - 128	
	DDB 191 - 160	
	DDB 223 - 192	
	DDB 255 - 224	
	DDB 287 - 256	
	DDB 319 - 288	
	DDB 351 - 320	
	DDB 383 - 352	
	DDB 415 - 384	
	DDB 447 - 416	
	DDB 479 - 448	
	DDB 511 - 480	
	DDB 543 - 512	
	DDB 575 - 544	
	DDB 607 - 576	
	DDB 639 - 608	
	DDB 671 - 640	
	DDB 703 - 672	
	DDB 735 - 704	
	DDB 767 - 736	
	DDB 799 - 768	
	DDB 831 - 800	
	DDB 863 - 832	
	DDB 895 - 864	
	DDB 927 - 896	
	DDB 959 - 928	
	DDB 991 - 960	
	DDB 1022 - 992	
	DDB 1055 - 1024	
	DDB 1087 - 1056	
	DDB 1119 - 1088	
	DDB 1151 - 1120	
	DDB 1183 - 1152	
	DDB 1215 - 1184	

CM

	DDB 1247 - 1216	
	DDB 1279 - 1248	
	DDB 1311 - 1280	
	DDB 1343 - 1312	
	DDB 1375 - 1344	
	DDB 1407 - 1376	
	DDB 1439 - 1408	
	DDB 1471 - 1440	
	DDB 1503 - 1472	
	DDB 1535 - 1504	
	DDB 1567 - 1536	
	DDB 1599 - 1568	
	DDB 1631 - 1600	
	DDB 1663 - 1632	
	DDB 1695 - 1664	
	DDB 1727 - 1696	
	DDB 1759 - 1728	
	DDB 1791 - 1760	
	DDB 1823 - 1792	
	DDB 1855 - 1824	
	DDB 1887 - 1856	
	DDB 1919 - 1888	
	DDB 1951 - 1920	
	DDB 1983 - 1952	
	DDB 2015 - 1984	
	DDB 2047 - 2016	

0C00   DISTURB RECORDER

	Duration	
	Trigger Position	
	Trigger Mode	Single
	Analog Channel 1	
	Analog Channel 2	
	Analog Channel 3	
	Analog Channel 4	
	Analog Channel 5	
	Analog Channel 6	
	Analog Channel 7	
	Analog Channel 8	
	Analog Channel 4	

	Analog Channel 5	
	Analog Channel 6	
	Analog Channel 7	
	Analog Channel 8	
	Analog Channel 9	
	Analog Channel 10	
	Analog Channel 11	
	Analog Channel 12	
	Analog Channel 13	
	Analog Channel 14	
	Analog Channel 15	
	Analog Channel 16	
	Analog Channel 17	
	Analog Channel 18	
	Analog Channel 19	
	Analog Channel 20	
	Analog Channel 21	
	Digital Input 1	
	Input 1 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 2	
	Input 2 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 3	
	Input 3 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 4	
	Input 4 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 5	
	Input 5 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 6	
	Input 6 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 7	
	Input 7 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 8	
	Input 8 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 9	
	Input 9 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 10	
	Input 10 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 11	
	Input 11 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 12	
	Input 12 trigger	No trigger / Trigger L/H / Trigger H/L*

CM

	Digital Input 13	
	Input 13 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 14	
	Input 14 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 15	
	Input 15 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 16	
	Input 16 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 17	
	Input 17 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 18	
	Input 18 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 19	
	Input 19 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 20	
	Input 20 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 21	
	Input 21 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 22	
	Input 22 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 23	
	Input 23 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 24	
	Input 24 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 25	
	Input 25 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 26	
	Input 26 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 27	
	Input 27 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 28	
	Input 28 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 29	
	Input 29 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 30	
	Input 30 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 31	
	Input 31 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 32	
	Input 32 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 33	

CM

	Input 33 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 34	
	Input 34 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 35	
	Input 35 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 36	
	Input 36 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 37	
	Input 37 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 38	
	Input 38 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 39	
	Input 39 trigger	No trigger / Trigger L/H / Trigger H/L*
	Digital Input 40	
	Input 40 trigger	No trigger / Trigger L/H / Trigger H/L*

0D00   MEASURE'T SETUP

	Default Display	
	Local Values	Primary/Secondary*
	Remote Values	Primary/Secondary*
	Ibp Base Cur Pri	

0E00   COMMUNICATIONS

	RP1 Protocol	Courier*	☐	IEC870-5-103*		☐
		MODBUS*	☐	DNP3.0*		☐
	RP1 Address					
	RP1 InactivTimer					
	RP1 Baud Rate	1200* ☐	2400* ☐	4800* ☐		
		9600* ☐	19200* ☐	38400* ☐		
	RP1 Parity	Odd* ☐	Even* ☐	None* ☐		
	RP1 Meas. Period					
	RP1 PhysicalLink	EIA(RS)485* ☐	Fiber Optic* ☐			
	RP1 Time Sync.	Disabled* ☐	Enabled* ☐			
	NIC Tunl Timeout					
	NIC Link Report	Alarm* ☐ Event* ☐ None* ☐				
	NIC Link Timeout					

CM

0F00   COMMISSION TESTS

	Opto I/P Status	

	Opto I/P Status 2	
	Rly O/P Status	
	Rly O/P Status 2	
	Test Port Status	
	Monitor Bit 1	
	Monitor Bit 2	
	Monitor Bit 3	
	Monitor Bit 4	
	Monitor Bit 5	
	Monitor Bit 6	
	Monitor Bit 7	
	Monitor Bit 8	
	Test Mode	Disabled/Test Mode/Blocked*
	Test Pattern	
	DDB 31 – 0	
	DDB 63 – 32	
	DDB 95 – 64	
	DDB 127 – 96	
	DDB 159 - 128	
	DDB 191 - 160	
	DDB 223 - 192	
	DDB 255 - 224	
	DDB 287 - 256	
	DDB 319 - 288	
	DDB 351 - 320	
	DDB 383 - 352	
	DDB 415 - 384	
	DDB 447 - 416	
	DDB 479 - 448	
	DDB 511 - 480	
	DDB 543 - 512	
	DDB 575 - 544	
	DDB 607 - 576	
	DDB 639 - 608	
	DDB 671 - 640	
	DDB 703 - 672	
	DDB 735 - 704	
	DDB 767 - 736	
	DDB 799 - 768	
	DDB 831 - 800	
	DDB 863 - 832	

CM

	DDB 895 - 864	
	DDB 927 - 896	
	DDB 959 - 928	
	DDB 991 - 960	
	DDB 1022 - 992	
	DDB 1055 - 1024	
	DDB 1087 - 1056	
	DDB 1119 - 1088	
	DDB 1151 - 1120	
	DDB 1183 - 1152	
	DDB 1215 - 1184	
	DDB 1247 - 1216	
	DDB 1279 - 1248	
	DDB 1311 - 1280	
	DDB 1343 - 1312	
	DDB 1375 - 1344	
	DDB 1407 - 1376	
	DDB 1439 - 1408	
	DDB 1471 - 1440	
	DDB 1503 - 1472	
	DDB 1535 - 1504	
	DDB 1567 - 1536	
	DDB 1599 - 1568	
	DDB 1631 - 1600	
	DDB 1663 - 1632	
	DDB 1695 - 1664	
	DDB 1727 - 1696	
	DDB 1759 - 1728	
	DDB 1791 - 1760	
	DDB 1823 - 1792	
	DDB 1855 - 1824	
	DDB 1887 - 1856	
	DDB 1919 - 1888	
	DDB 1951 - 1920	
	DDB 1983 - 1952	
	DDB 2015 - 1984	
	DDB 2047 - 2016	

1100   OPTOS CONFIG

	Global Nominal V	
	Opto Filter Ctrl	
	Opto Filter Ctr2	

4B00   OUTPUT LABELS

Group Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
	Relay 1				
	Relay 2				
	Relay 3				
	Relay 4				
	Relay 5				
	Relay 6				
	Relay 7				
	Relay 8				
	Relay 9				
	Relay 10				
	Relay 11				
	Relay 12				
	Relay 13				
	Relay 14				
	Relay 15				
	Relay 16				
	Relay 17				
	Relay 18				
	Relay 19				
	Relay 20				
	Relay 21				
	Relay 22				
	Relay 23				
	Relay 24				
	Relay 25				
	Relay 26				
	Relay 27				
	Relay 28				
	Relay 29				
	Relay 30				
	Relay 31				
	Relay 32				

CM

GROUP PROTECTION SETTINGS

For Group 2, 3 or 4 the first address figure must be respectively: 5 and 6, 7and 8 or 9 and A

3000   SYSTEM CONFIG

Group Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
	Phase Sequence				
	Feed Numbers				
	Z1 terminals				
	Z2 terminals				
	Xfer Terminals				
	ChZONE terminal				
	Bus Coupling by				
	Z1 Bus CT				
	Z1 Bus CT Pol				
	Z2 Bus CT				
	Z2 Bus CT Pol				

3100   DIFF PROTECTION

Group Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
	Busbar Diff				
	ID>2 Current				
	Phase Slope k2				
	tDIFF				
	Check Zone Status				
	IDCZ>2 Current				
	KPhase Slope kCZ				
	Circuitry fail				
	ID>1 Current				
	Phase Slope k1				
	ID>1 Alarm Timer				
	CZ CCTFAIL MODE				
	Zx CCTFAIL MODE				
	cctFail Blk Mode				
	CCTFAIL tReset				
	Voltage check				

CM

3300   **DEAD ZONE OVERCURRENT**

Group 1 Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
	I> Status				
	I> Current Set				
	I> Time Delay				

3500   **NON DIRECTIONAL PHASE OVERCURRENT PROTECTION**

Group 1 Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
TERMINAL 1					
	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
TERMINAL 2					
	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
TERMINAL 3					
	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				

CM

Group 1 Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
TERMINAL 4					
	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
TERMINAL 5					
	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
TERMINAL 6					
	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				

CM

Group 1 Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
For 3 box mode only:					
TERMINAL 7					
	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
TERMINAL 8					
	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
TERMINAL 9					
	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				

CM

Group 1 Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
TERMINAL 10					
	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
TERMINAL 11					
	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
TERMINAL 12					
	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				

CM

Group 1 Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
	I>2 Time delay				
TERMINAL 13					
⌐	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
TERMINAL 14					
⌐	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
TERMINAL 15					
⌐	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				

CM

Group 1 Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
TERMINAL 16					
⌐	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
TERMINAL 17					
⌐	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				
TERMINAL 18					
⌐	I>1 Function				
	I>1 Current				
US/IEEE	I>1 Time Dial				
US/IEEE	I>1 Reset Char				
RI	I>1 k(RI)				
UK/IEC	I>1 TMS				
TD	I>1 Time Delay				
	I>1 tReset				
	I>2 Function				
	I>2 Current				
	I>2 Time delay				

CM

3700   EARTH FAULT

Only in one box mode

Group 1 Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
TERMINAL 1					
⌐	IN>1 Function				
	IN>1 Current				
US/IEEE	IN>1 Time Dial				
US/IEEE	IN>1 Reset Char				
RI	IN>1 k(RI)				
UK/IEC	IN>1 TMS				
TD	IN>1 Time Delay				
IDG	IN>1 IDG IS				
	IN>1 tReset				
	IN>2 Function				
	IN>2 Current				
	IN>2 Time delay				
TERMINAL 2					
⌐	IN>1 Function				
	IN>1 Current				
US/IEEE	IN>1 Time Dial				
US/IEEE	IN>1 Reset Char				
RI	IN>1 k(RI)				
UK/IEC	IN>1 TMS				
TD	IN>1 Time Delay				
IDG	IN>1 IDG IS				
	IN>1 tReset				
	IN>2 Function				
	IN>2 Current				
	IN>2 Time delay				
TERMINAL 3					
⌐	IN>1 Function				
	IN>1 Current				
US/IEEE	IN>1 Time Dial				
US/IEEE	IN>1 Reset Char				
RI	IN>1 k(RI)				
UK/IEC	IN>1 TMS				
TD	IN>1 Time Delay				
IDG	IN>1 IDG IS				

CM

	IN>1 tReset				
	IN>2 Function				
	IN>2 Current				
	IN>2 Time delay				
TERMINAL 4					
↰	IN>1 Function				
	IN>1 Current				
US/IEEE	IN>1 Time Dial				
US/IEEE	IN>1 Reset Char				
RI	IN>1 k(RI)				
UK/IEC	IN>1 TMS				
TD	IN>1 Time Delay				
IDG	IN>1 IDG IS				
	IN>1 tReset				
	IN>2 Function				
	IN>2 Current				
	IN>2 Time delay				
TERMINAL 5					
↰	IN>1 Function				
	IN>1 Current				
US/IEEE	IN>1 Time Dial				
US/IEEE	IN>1 Reset Char				
RI	IN>1 k(RI)				
UK/IEC	IN>1 TMS				
TD	IN>1 Time Delay				
IDG	IN>1 IDG IS				
	IN>1 tReset				
	IN>2 Function				
	IN>2 Current				
	IN>2 Time delay				
TERMINAL 6					
↰	IN>1 Function				
	IN>1 Current				
US/IEEE	IN>1 Time Dial				
US/IEEE	IN>1 Reset Char				
RI	IN>1 k(RI)				
UK/IEC	IN>1 TMS				
TD	IN>1 Time Delay				
IDG	IN>1 IDG IS				
	IN>1 tReset				

CM

IN>2 Function				
IN>2 Current				
IN>2 Time delay				

4500　　　CB FAIL & I<

Group 1 Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
	CBF Control by				
	I< Current Set				
	CB Fail 1 Timer				
	CB Fail 2 Timer				
	CB Fail 3 Timer				
	CB Fail 4 Timer				
	I> Status				
	I> Current Set				

4600　　　　SUPERVISION

Group 1 Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
	VTS Status				
	VTS Reset Mode				
	VTS Time Delay				
	Diff CTS				
	CTS Status				
	CTS Time Delay				
	CTS I1				
	CTS I2/I1>1				
	CTS I2/I1>1				

4A00　　　INPUT LABELS

Group 1 Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
	Opto Input 1				
	Opto Input 2				
	Opto Input 3				
	Opto Input 4				
	Opto Input 5				
	Opto Input 6				
	Opto Input 7				
	Opto Input 8				
	Opto Input 9				

CM

Group 1 Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
	Opto Input 10				
	Opto Input 11				
	Opto Input 12				
	Opto Input 13				
	Opto Input 14				
	Opto Input 15				
	Opto Input 16				
	Opto Input 17				
	Opto Input 18				
	Opto Input 19				
	Opto Input 20				
	Opto Input 21				
	Opto Input 22				
	Opto Input 23				
	Opto Input 24				
	Opto Input 25				
	Opto Input 26				
	Opto Input 27				
	Opto Input 28				
	Opto Input 29				
	Opto Input 30				
	Opto Input 31				
	Opto Input 32				
	Opto Input 33				
	Opto Input 34				
	Opto Input 35				
	Opto Input 36				
	Opto Input 37				
	Opto Input 38				
	Opto Input 39				
	Opto Input 40				

4B00   OUTPUT LABELS

Group 1 Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
	Relay 1				
	Relay 2				
	Relay 3				
	Relay 4				

CM

Group 1 Settings		Group 1 Settings	Group 2 Settings	Group 3 Settings	Group 4 Settings
	Relay 5				
	Relay 6				
	Relay 7				
	Relay 8				
	Relay 9				
	Relay 10				
	Relay 11				
	Relay 12				
	Relay 13				
	Relay 14				
	Relay 15				
	Relay 16				
	Relay 17				
	Relay 18				
	Relay 19				
	Relay 20				
	Relay 21				
	Relay 22				
	Relay 23				
	Relay 24				
	Relay 25				
	Relay 26				
	Relay 27				
	Relay 28				
	Relay 29				
	Relay 30				
	Relay 31				
	Relay 32				

CM

Commissioning Engineer: _____   Customer Witness: _____

Date: _____   Date: _____

1100   OPTOS SETUP

1300   CTRL. I/P CONFIG.

	Ctrl I/P Status	
	Control Input 1	Latched / Pulsed *
	Ctrl Command 1	
	Control Input 2	Latched / Pulsed *
	Ctrl Command 2	
	Control Input 3	Latched / Pulsed *
	Ctrl Command 3	
	Control Input 4	Latched / Pulsed *
	Ctrl Command 4	
	Control Input 5	Latched / Pulsed *
	Ctrl Command 5	
	Control Input 6	Latched / Pulsed *
	Ctrl Command 6	
	Control Input 7	Latched / Pulsed *
	Ctrl Command 7	
	Control Input 8	Latched / Pulsed *
	Ctrl Command 8	
	Control Input 9	Latched / Pulsed *
	Ctrl Command 9	
	Control Input 10	Latched / Pulsed *
	Ctrl Command 10	
	Control Input 11	Latched / Pulsed *
	Ctrl Command 11	
	Control Input 12	Latched / Pulsed *
	Ctrl Command 12	
	Control Input 13	Latched / Pulsed *
	Ctrl Command 13	
	Control Input 14	Latched / Pulsed *
	Ctrl Command 14	
	Control Input 15	Latched / Pulsed *
	Ctrl Command 15	
	Control Input 16	Latched / Pulsed *
	Ctrl Command 16	
	Control Input 17	Latched / Pulsed *
	Ctrl Command 17	
	Control Input 18	Latched / Pulsed *
	Ctrl Command 18	
	Control Input 19	Latched / Pulsed *

CM

1300   CTRL. I/P CONFIG.

	Ctrl Command 19	
	Control Input 20	Latched / Pulsed *
	Ctrl Command 20	
	Control Input 21	Latched / Pulsed *
	Ctrl Command 21	
	Control Input 22	Latched / Pulsed *
	Ctrl Command 22	
	Control Input 23	Latched / Pulsed *
	Ctrl Command 23	
	Control Input 24	Latched / Pulsed *
	Ctrl Command 24	
	Control Input 25	Latched / Pulsed *
	Ctrl Command 25	
	Control Input 26	Latched / Pulsed *
	Ctrl Command 26	
	Control Input 27	Latched / Pulsed *
	Ctrl Command 27	
	Control Input 28	Latched / Pulsed *
	Ctrl Command 28	
	Control Input 29	Latched / Pulsed *
	Ctrl Command 29	
	Control Input 30	Latched / Pulsed *
	Ctrl Command 30	
	Control Input 31	Latched / Pulsed *
	Ctrl Command 31	
	Control Input 32	Latched / Pulsed *
	Ctrl Command 32	

1700   FUNCTION KEYS

	Fn Key Status	
	Fn. Key 1	Disabled / Locked / Unlock *
	Fn. Key 1 Mode	Toggled / Normal *
	Fn. Key 1 Label	
	Fn. Key 2	Disabled / Locked / Unlock *
	Fn. Key 2 Mode	Toggled / Normal *
	Fn. Key 2 Label	
	Fn. Key 3	Disabled / Locked / Unlock *
	Fn. Key 3 Mode	Toggled / Normal *
	Fn. Key 3 Label	

CM

1700 FUNCTION KEYS

	Fn. Key 4	Disabled / Locked / Unlock *
	Fn. Key 4 Mode	Toggled / Normal *
	Fn. Key 4 Label	
	Fn. Key 5	Disabled / Locked / Unlock *
	Fn. Key 5 Mode	Toggled / Normal *
	Fn. Key 5 Label	
	Fn. Key 6	Disabled / Locked / Unlock *
	Fn. Key 6 Mode	Toggled / Normal *
	Fn. Key 6 Label	
	Fn. Key 7	Disabled / Locked / Unlock *
	Fn. Key 7 Mode	Toggled / Normal *
	Fn. Key 7 Label	
	Fn. Key 8	Disabled / Locked / Unlock *
	Fn. Key 8 Mode	Toggled / Normal *
	Fn. Key 8 Label	
	Fn. Key 9	Disabled / Locked / Unlock *
	Fn. Key 9 Mode	Toggled / Normal *
	Fn. Key 9 Label	
	Fn. Key 10	Disabled / Locked / Unlock *
	Fn. Key 10 Mode	Toggled / Normal *
	Fn. Key 10 Label	

1900 IED CONFIGURATOR

	Switch Conf.Bank	No Action*	☐	Switch Banks*	
	GoEna	Disabled*	☐	Enabled*	☐
	Test Mode	Disabled* Forced*☐	☐	Pass Through*	☐
	VOP Test Pattern				
	Ignore Test Flag	No*	☐	Yes*	☐

CM

2900 CTRL. I/P LABELS

	Control Input 1	
	Control Input 2	
	Control Input 3	
	Control Input 4	
	Control Input 5	
	Control Input 6	
	Control Input 7	
	Control Input 8	

2900   CTRL. I/P LABELS

	Control Input 9	
	Control Input 10	
	Control Input11	
	Control Input 12	
	Control Input 13	
	Control Input 14	
	Control Input 15	
	Control Input 16	
	Control Input 17	
	Control Input 18	
	Control Input 19	
	Control Input 20	
	Control Input 21	
	Control Input 22	
	Control Input 23	
	Control Input 24	
	Control Input 25	
	Control Input 26	
	Control Input 27	
	Control Input 28	
	Control Input 29	
	Control Input 30	
	Control Input 31	
	Control Input 32	

CM

Commissioning Engineer: Customer Witness:

Date: Date:

MAINTENANCE

MT

Date: 2008

Hardware Suffix: K

Software Version: 01

Connection Diagrams: 10P746xx (xx = 01 to 07)

CONTENTS

MT

MT

1. MAINTENANCE

1.1 Maintenance period

It is recommended that products supplied by Alstom Grid Information receive periodic monitoring after installation. As with all products some deterioration with time is inevitable. In view of the critical nature of protective relays and their infrequent operation, it is desirable to confirm that they are operating correctly at regular intervals.

Alstom Grid protective relays are designed for a life in excess of 20 years.

MiCOM P746 current differential relays are self-supervising and so require less maintenance than earlier designs of relay. 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 relay is functioning correctly and the external wiring is intact.

If a Preventive Maintenance Policy exists within the customer's organisation then the recommended product checks should be included in the regular programme. Maintenance periods will depend on many factors, such as:

- operating environment

- accessibility of the site

- amount of available manpower

- importance of the installation in the power system

- consequences of failure

1.2 Maintenance checks

It is recommended that maintenance checks are performed locally (i.e. at the substation itself).

⚠ **Before carrying out any work on the equipment, the user should be familiar with the contents of the safety section/safety guide SFTY/4LM/H11 or later issue, the technical data section and the ratings on the equipment rating label**

1.2.1 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.

1.2.2 Opto-isolators

The opto-isolated inputs can be checked to ensure that the relay responds to their energisation by repeating the commissioning test.

1.2.3 Output relays

The output relays can be checked to ensure that they operate by repeating the commissioning test.

1.2.4 Measurement accuracy

If the power system is energised, the values measured by the relay can be compared with known system values to check that they are in the approximate range that is expected. If they are then the analogue/digital conversion and calculations are being performed correctly by the relay.

Alternatively, the values measured by the relay can be checked against known values injected into the relay via the test block, if fitted, or injected directly into the relay terminals. These tests will prove the calibration accuracy is being maintained.

MT

1.3   Method of repair

If the relay 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 PCBs should be replaced as it is not possible to perform repairs on damaged circuits. Therefore either the complete relay or just the faulty PCB, identified by the in-built diagnostic software, can be replaced. Advice about identifying the faulty PCB can be found in the Problem Analysis.

The preferred method is to replace the complete relay 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 an installed relay due to limited access in the back of the cubicle and 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. However, if the repair is not performed by an approved service centre, the warranty will be invalidated.

⚠ **Before carrying out any work on the equipment, the user should be familiar with the contents of the safety section/safety guide SFTY/4LM/H11 or later issue, the technical data section and the ratings on the equipment rating label**

1.3.1   Replacing the complete relay

The case and rear terminal blocks have been designed to facilitate removal of the complete relay should replacement or repair become necessary without having to disconnect the scheme wiring.

Before working at the rear of the relay, isolate all voltage and current supplies to the relay.

⚠   Note: The MiCOM relay range has integral current transformer shorting switches which will close when the module containing the block is removed.

Disconnect the relay earth, IRIG-B (Central unit only) and fibre optic connections, as appropriate, from the rear of the relay.

Heavy duty terminal block   Medium duty terminal block

P0149ENb
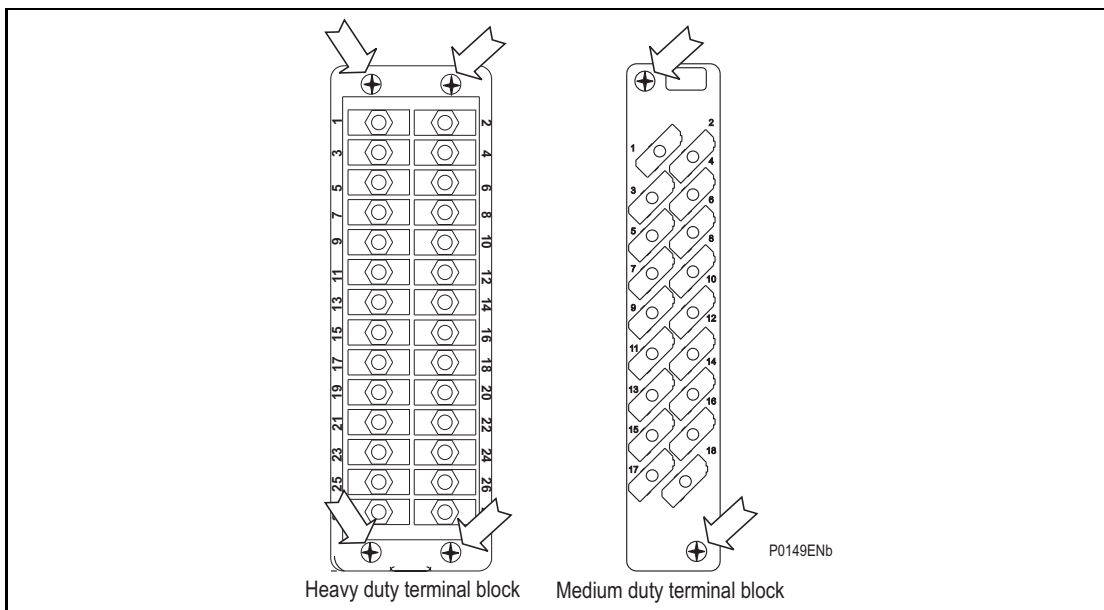
FIGURE 1: LOCATION OF SECURING SCREWS FOR TERMINAL BLOCK

          Note: The use of a magnetic bladed screwdriver is recommended to minimise the risk of the screws being left in the terminal block or lost

Without exerting excessive force or damaging the scheme wiring, pull the terminal blocks away from their internal connectors.

Remove the screws used to fasten the relay 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.

⚠ **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 relay.**

Withdraw the relay carefully from the panel, rack, etc. because it will be heavy due to the internal transformers.

To reinstall the repaired or replacement relay, follow the above instructions in reverse, ensuring that each terminal block is relocated in the correct position and the case earth, IRIG-B (Central Unit only) and fibre 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 relay should be recommissioned using the instructions in sections 1 to 8 inclusive of this chapter.

1.3.2   Replacing a PCB

If the relay fails to operate correctly refer to the Problem Analysis chapter, to help determine which PCB has become faulty.

To replace any of the relay's PCBs it is necessary to first remove the front panel.

⚠ **Before removing the front panel to replace a PCB the auxiliary supply must be removed. It is also strongly recommended that the voltage and current transformer connections and trip circuit are isolated.**

Open the top and bottom access covers. With size 80TE cases the access covers have two hinge-assistance T-pieces which clear the front panel moulding when the access covers are opened by more than 90°, therefore allowing their removal.

If fitted, remove the transparent secondary front cover. A description of how to do this is given in the 'Introduction'.

By applying outward pressure to the middle of the access covers, they can be bowed sufficiently so as to disengage the hinge lug allowing the access cover to be removed. The screws that fasten the front panel to the case are now accessible.

The size 80TE case has an additional two screws, one midway along each of the top and bottom edges of the front plate. Undo and remove the screws.

MT

⚠ **Do not remove the screws with the larger diameter heads which are accessible when the access covers are fitted and open. These screws hold the relay in its mounting (panel or cubicle).**

When the screws have been removed, the complete front panel can be pulled forward and separated from the metal case.

Caution should be observed at this stage because the front panel is connected to the rest of the relay circuitry by a 64-way ribbon cable.

Additionally, from here on, the internal circuitry of the relay is exposed and not protected against electrostatic discharges, dust ingress, etc. Therefore ESD precautions and clean working conditions should be maintained at all times.

The ribbon cable is fastened to the front panel using an IDC connector; a socket on the cable itself and a plug with locking latches on the front panel. Gently push the two locking latches outwards which will eject the connector socket slightly. Remove the socket from the plug to disconnect the front panel.

The PCBs within the relay are now accessible.

Note: The numbers above the case outline identify the guide slot reference
               for each printed circuit board. Each printed circuit board has a label
               stating the corresponding guide slot number to ensure correct
               re-location after removal. To serve as a reminder of the slot
               numbering there is a label on the rear of the front panel metallic
               screen.
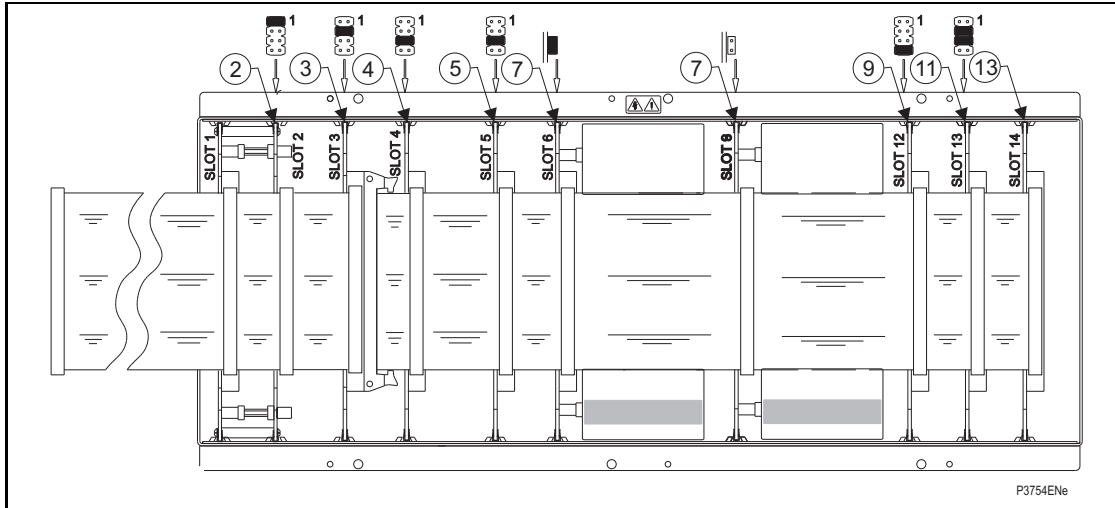
REF	DESCRIPTION	MATERIAL
1	Assy Power Supply	ZN0021
2 – 3 – 4	Assy Relay output	ZN0019
5 – 9 – 11	Assy Opto Input	ZN0017
7	Sigma delta input board Transformer PCB	ZN0067 ZN0068
13	Assy IRIG-B/Ethernet or (exclusive or) Assy IRIG-B/2nd rear port	ZN0007 001 IRIG-B modulated only or ZN0049 004 IRIG-B demodulated only or ZN0049 001 Ethernet (100Mbps) only or ZN0049 002 Ethernet (100Mbps) + IRIG-B (mod) or ZN0049 003 Ethernet (100Mbps) IRIG-B (demod) or ZN0025 001 2nd rear port + IRIG-B (mod) or ZN0025 002 2nd rear port only

FIGURE 2: P746 – PCB/MODULE LOCATIONS (VIEWED FROM FRONT)

MT

1.3.2.1   Replacement of the main processor board

⚠ **ESD precautions should be taken to avoid damage to the microprocessor based circuits.**

The main processor board is located in the front panel, not within the case as with all the other PCBs. Place the front panel with the user interface face-down and remove the six screws from the metallic screen, as shown in figure 3. Remove the metal plate.

There are two further screws, one each side of the rear of the battery compartment recess, that hold the main processor PCB in position. Remove these screws.

The user interface keypad is connected to the main processor board via a flex-strip ribbon cable. Carefully disconnect the ribbon cable at the PCB-mounted connector as it could easily be damaged by excessive twisting.

The front panel can then be re-assembled with a replacement PCB using the reverse procedure. Ensure that the ribbon cable is reconnected to the main processor board and all eight screws are re-fitted.

P3007ENa
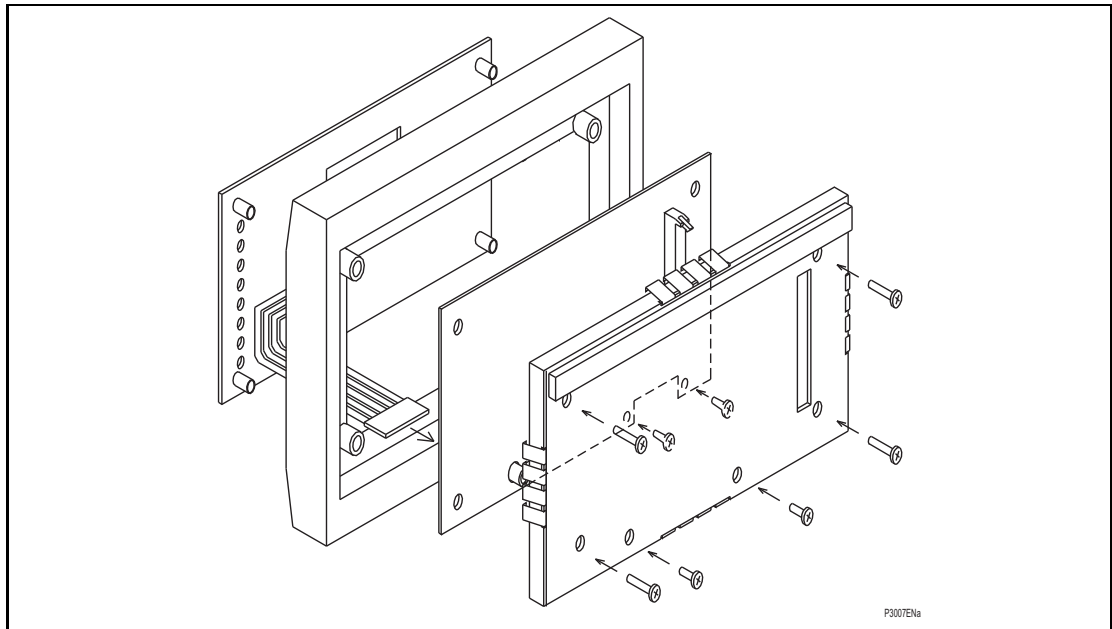
FIGURE 3: FRONT PANEL ASSEMBLY

MT

Refit the front panel using the reverse procedure to that given before. After refitting and closing the access covers on size 80TE cases, press at the location of the hinge-assistance T-pieces so that they click back into the front panel moulding.

After replacement of the main processor board, all the settings required for the application will need to be re-entered. Therefore, it is useful if an electronic copy of the application-specific settings is available on a digital medium. Although this is not essential, it can reduce the time taken to re-enter the settings and hence the time the protection is out of service.

Once the relay has been reassembled after repair, it should be recommissioned in accordance with the instructions in sections 1 to 8 inclusive (commissioning and maintenance section P746/EN CM).

1.3.2.2   Replacement of the optional board in P746

To replace a faulty board, disconnect all connections at the rear of the relay.

The board is secured in the case by two screws accessible from the rear of the relay, one at the top and another at the bottom, as shown in Figure 5. Remove these screws carefully as they are not captive in the rear panel of the relay.

Gently pull the optional board forward and out of the case.

To help identify that the correct board has been removed, Figure 4 illustrates the layout of the IRIG-B board with IRIG-B (ZN0007 001 or ZN0049 004) or Ethernet (ZN0049001) or Ethernet and IRIG-B (ZN0049001 or ZN0049 002 or ZN0049 003) or second rear port.
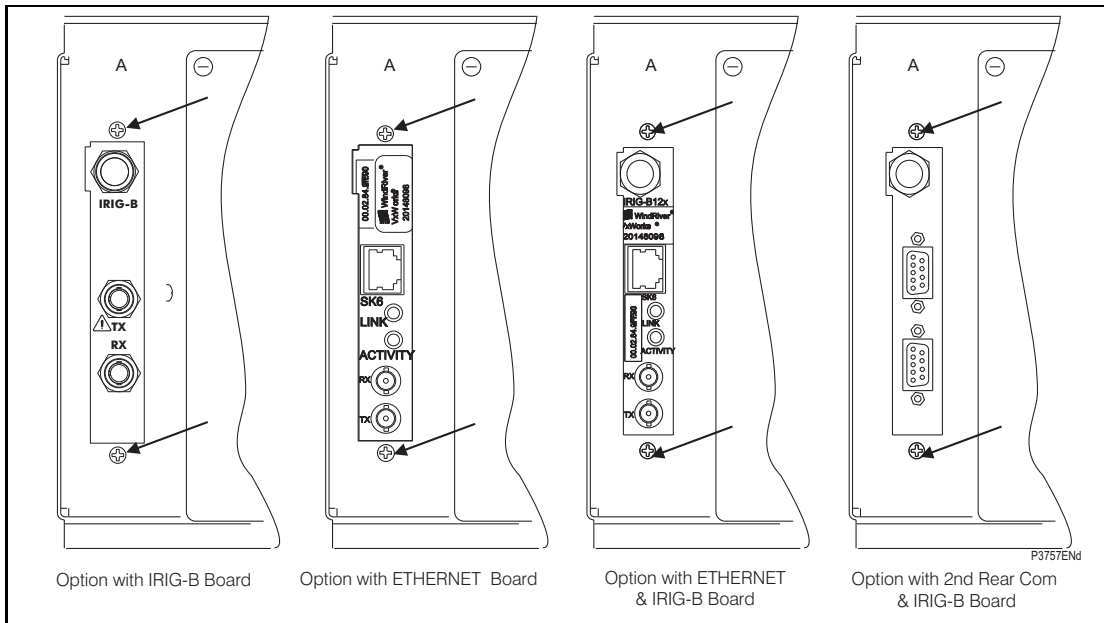
FIGURE 4: LOCATION OF SECURING SCREWS FOR OPTIONAL BOARD
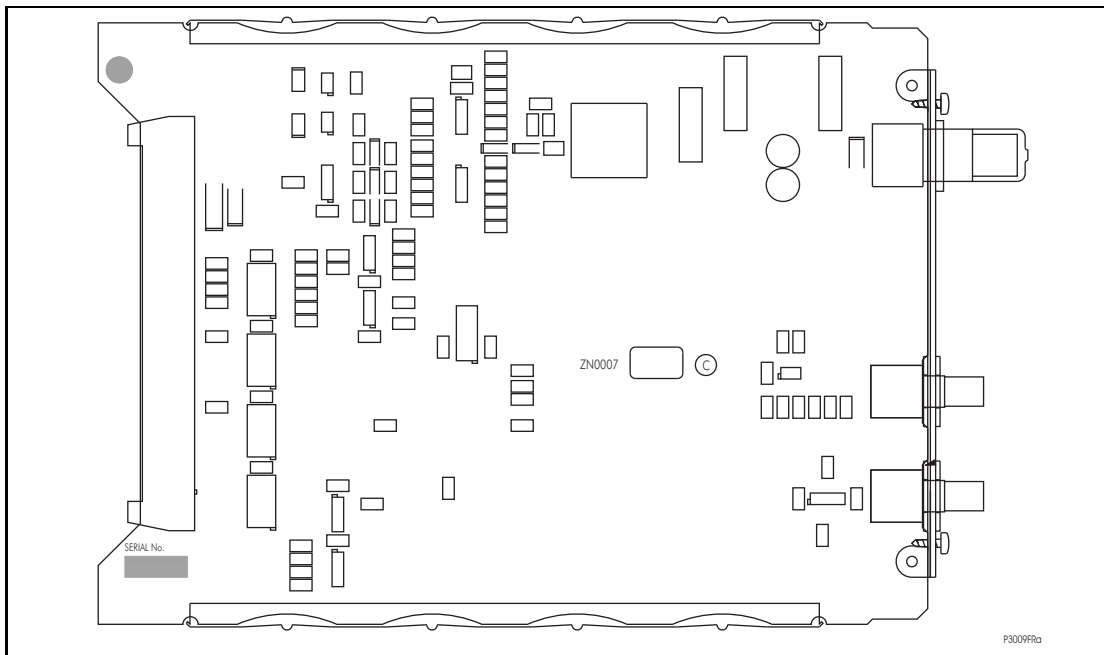
FIGURE 5: TYPICAL IRIG-B BOARD

Before fitting the replacement PCB check that the number on the round label adjacent to the front edge of the PCB matches the slot number into which it will be fitted. If the slot number is missing or incorrect write the correct slot number on the label.

The replacement PCB should be carefully slotted into the appropriate slot, ensuring that it is pushed fully back on to the rear terminal blocks and the securing screws are re-fitted.

Reconnect the connections at the rear of the relay.

Refit the front panel using the reverse procedure to that given in section 1.3.2.1. After refitting and closing the access covers on size 80TE cases, press at the location of the hinge-assistance T-pieces so that they click back into the front panel moulding.

Once the relay has been reassembled after repair, it should be recommissioned in accordance with the instructions in sections 1 to 8 inclusive (commissioning and maintenance section P746/EN CM).

1.3.2.3   Replacement of the sigma delta input module

The Sigma delta input module comprises of two boards fastened together, the sigma delta input board (figure 6) and the transformer PCB (figure 7).

Note: The sigma delta input board and the transformer PCB within the module are calibrated together with the calibration data being stored on the input board. Therefore it is recommended that the complete module is replaced to avoid on-site recalibration having to be performed.
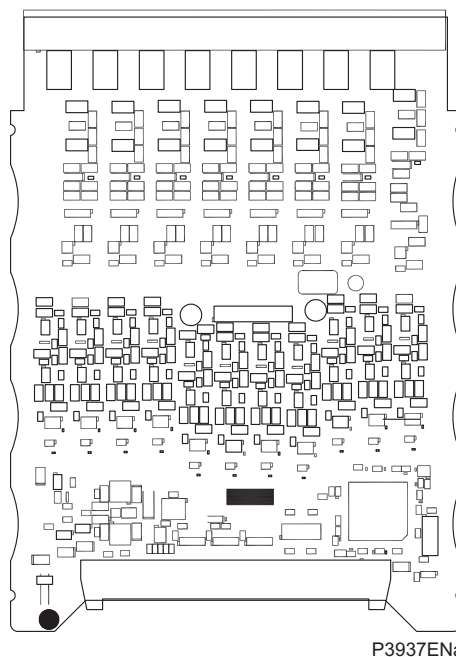
FIGURE 6: SIGMA DELTA INPUT BOARD   FIGURE 7: TRANSFORMER PCB
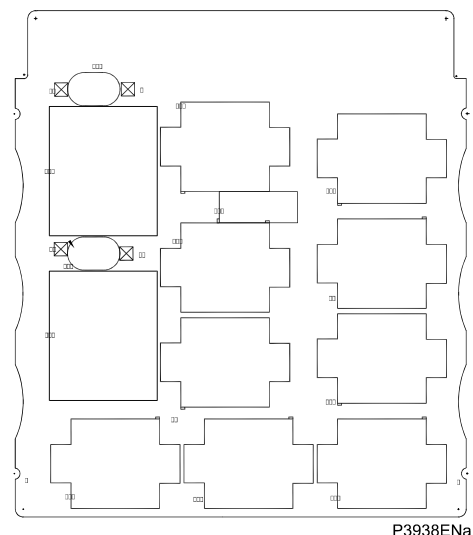
On the right-hand side of the sigma delta input module, there is a small metal tab (figure 8) which brings out a handle. Grasping this handle firmly, pull the module forward, away from the rear terminal blocks. A reasonable amount of force will be required to achieve this due to the friction between the contacts of two terminal blocks, one medium duty and one heavy duty.

Note: Care should be taken when withdrawing the input module as it will suddenly come loose once the friction of the terminal blocks has been overcome. This is particularly important with unmounted relays as the metal case will need to be held firmly whilst the module is withdrawn.
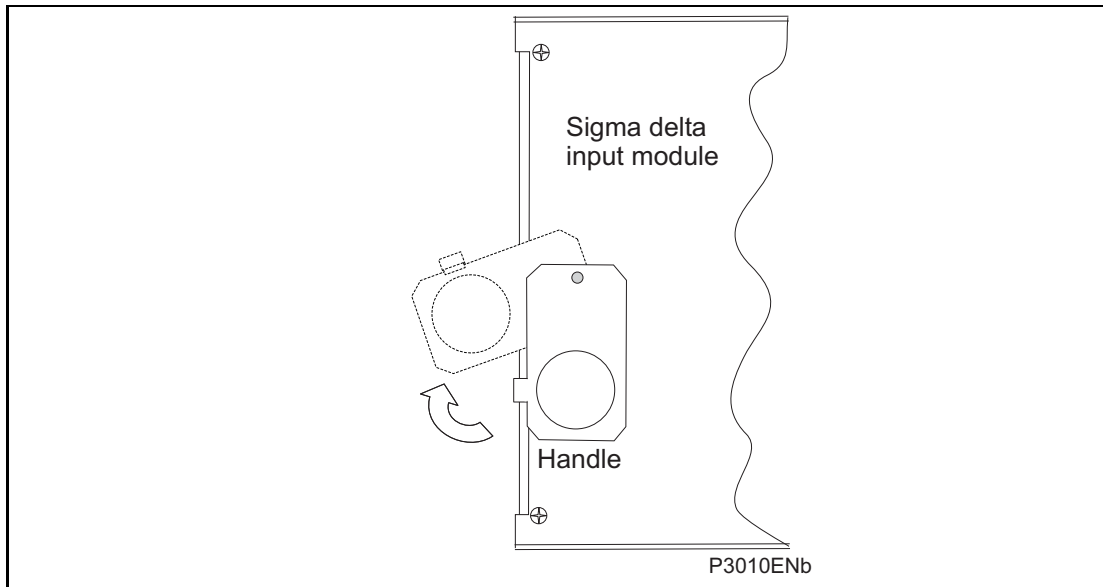
FIGURE 8: LOCATION OF HANDLE FOR SIGMA DELTA INPUT MODULE

Remove the module from the case, taking care as it is heavy because it contains all the relay's input voltage and current transformers.

Before fitting the replacement module check that the number on the round label adjacent to the front edge of the PCB matches the slot number into which it will be fitted. If the slot number is missing or incorrect write the correct slot number on the label.

The replacement module can be slotted in using the reverse procedure, ensuring that it is pushed fully back on to the rear terminal blocks. To help confirm that the module has been inserted fully there is a V-shaped cut-out in the bottom plate of the case that should be fully visible. Refit the securing screws.

Refit the front panel using the reverse procedure to that given in section. After refitting and closing the access covers on size 80TE cases, press at the location of the hinge-assistance T-pieces so that they click back into the front panel moulding.

Once the relay has been reassembled after repair, it should be recommissioned in accordance with the instructions in sections 1 to 8 inclusive (commissioning and maintenance section P746/EN CM).

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1.3.2.4   Replacement of the power supply board

The power supply board is fastened to a relay board to form the power supply module and is located on the extreme left-hand side of all MiCOM differential busbar relays.

Pull the power supply module forward, away from the rear terminal blocks and out of the case. A reasonable amount of force will be required to achieve this due to the friction between the contacts of the two medium duty terminal blocks.

The two boards are held together with push-fit nylon pillars and can be separated by pulling them apart. Care should be taken when separating the boards to avoid damaging the inter-board connectors located near the lower edge of the PCBs towards the front of the power supply module.

The power supply board is the one with two large electrolytic capacitors on it that protrude through the other board that forms the power supply module. To help identify that the correct board has been removed, Figure 9 illustrates the layout of the power supply board for all voltage ratings.

Before re-assembling the module with a replacement PCB check that the number on the round label adjacent to the front edge of the PCB matches the slot number into which it will be fitted. If the slot number is missing or incorrect write the correct slot number on the label.

Re-assemble the module with a replacement PCB ensuring the inter-board connectors are firmly pushed together and the four push-fit nylon pillars are securely located in their respective holes in each PCB.
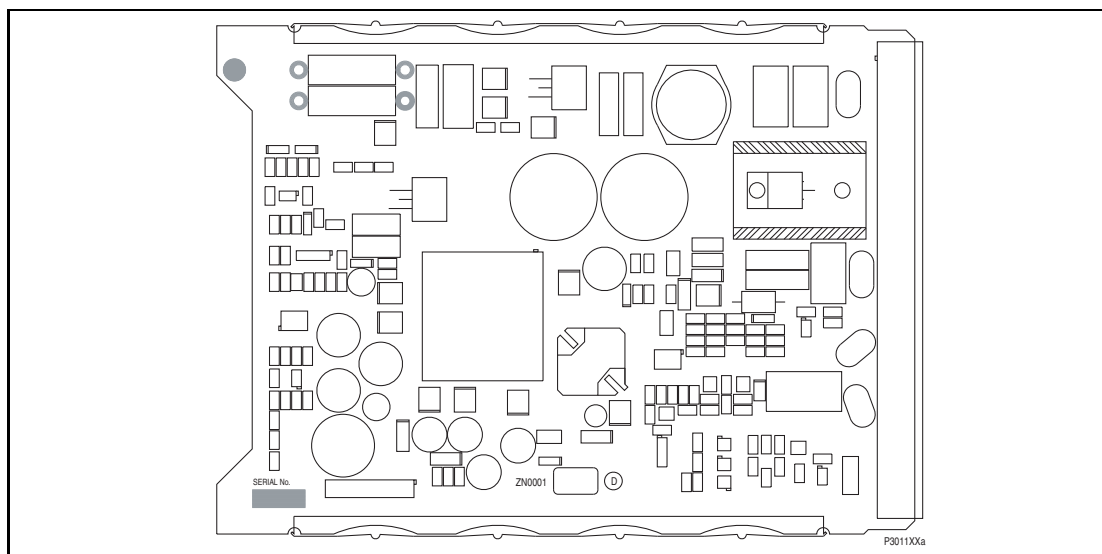
FIGURE 9: TYPICAL POWER SUPPLY BOARD

Slot the power supply module back into the relay case, ensuring that it is pushed fully back on to the rear terminal blocks.

Refit the front panel using the reverse procedure to that given in section. After refitting and closing the access covers on size 80TE cases, press at the location of the hinge-assistance T-pieces so that they click back into the front panel moulding.

Once the relay has been reassembled after repair, it should be recommissioned in accordance with the instructions in in sections 1 to 8 inclusive (commissioning and maintenance section P746/EN CM).

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1.3.2.5   Replacement of the relay board in the power supply module

Remove and replace the relay board in the power supply module as described in above.

The relay board is the one with holes cut in it to allow the transformer and two large electrolytic capacitors of the power supply board to protrude through. To help identify that the correct board has been removed, Figure 10 illustrates the layout of the relay board.

Before re-assembling the module with a replacement relay board check that the number on the round label adjacent to the front edge of the PCB matches the slot number into which it will be fitted. If the slot number is missing or incorrect write the correct slot number on the label.

Ensure the setting of the link (located above IDC connector) on the replacement relay board is the same as the one being replaced before replacing the module in the relay case.

Once the relay has been reassembled after repair, it should be recommissioned in accordance with the instructions in sections 1 to 8 inclusive (commissioning and maintenance section P746/EN CM).
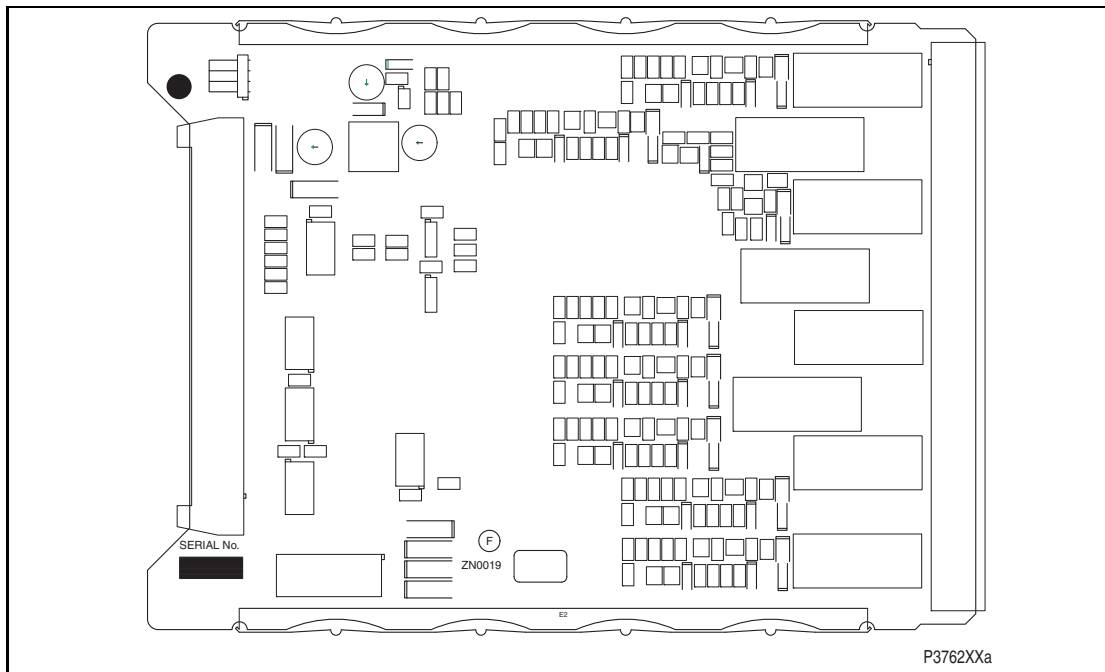
FIGURE 10: TYPICAL RELAY BOARD

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1.3.2.6   Replacement of the opto and separate relay boards

To remove either, gently pull the faulty PCB forward and out of the case.

If the relay board is being replaced, ensure the setting of the link (located above IDC connector) on the replacement relay board is the same as the one being replaced. To help identify that the correct board has been removed, Figure 11 illustrates the layout of the opto board.

Before fitting the replacement PCB check that the number on the round label adjacent to the front edge of the PCB matches the slot number into which it will be fitted. If the slot number is missing or incorrect write the correct slot number on the label.

The replacement PCB should be carefully slid into the appropriate slot, ensuring that it is pushed fully back on to the rear terminal blocks.

Refit the front panel using the reverse procedure to that given in section. After refitting and closing the access covers on size 80TE cases, press at the location of the hinge-assistance T-pieces so that they click back into the front panel moulding.

Once the relay has been reassembled after repair, it should be recommissioned in accordance with the instructions in sections 1 to 8 inclusive (commissioning and maintenance section P746/EN CM).
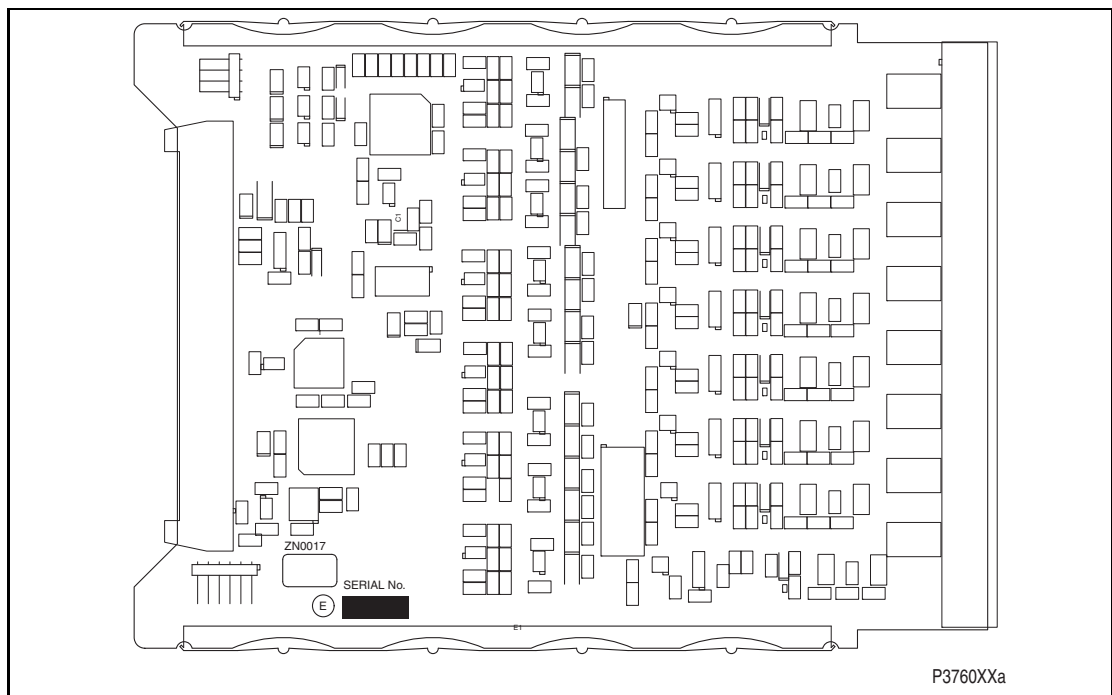
FIGURE 11: TYPICAL OPTO BOARD

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1.4 Recalibration

1.4.1 P746 relay

Recalibration 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.

Although it is possible to carry out recalibration 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 is carried out by the manufacturer, or entrusted to an approved service centre.

1.5 Changing the relay battery

Each relay 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 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.

⚠ **Before carrying out any work on the equipment, the user should be familiar with the contents of the safety section/safety guide SFTY/4LM/H11 or later issue, the technical data section and the ratings on the equipment rating label.**

1.5.1 Instructions for replacing the battery.

Open the bottom access cover on the front of the relay.

Gently extract the battery from its socket. If necessary, use a small insulated screwdriver to prize the battery free.

Ensure that the metal terminals in the battery socket are free from corrosion, grease and dust.

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.

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⚠ Note: Only use a type ½AA Lithium battery with a nominal voltage of 3.6V and safety approvals such as UL (Underwriters Laboratory), CSA (Canadian Standards Association) or VDE (Vereinigung Deutscher Elektrizitätswerke).

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.

Close the bottom access cover.

1.5.2 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'.

Additionally, if further confirmation that the replacement battery is installed correctly is required, the commissioning test described in chapter, 'Date and Time', can be performed.

1.5.3 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 relay is installed.

1.6   Cleaning

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 dampened 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.

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MT

TROUBLESHOOTING

TS

Date:	**2008**
Hardware Suffix:	**K**
Software Version:	**01**
Connection Diagrams:	**10P746xx (xx = 01 to 07)**

CONTENTS

TS

TS

1.   INTRODUCTION

Before carrying out any work on the equipment, the user should be familiar with the contents of the safety section/safety guide SFTY/4LM/H11 or later issue, the technical data section and the ratings on the equipment rating label

The purpose of this section of the service manual is to allow an error condition on the relay to be identified so that appropriate corrective action can be taken.

Should the relay have developed a fault, it should be possible in most cases to identify which relay module requires attention. The Maintenance section (P746/EN MT), 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 centres, completed copy of the Repair/Modification Return Authorization Form located at the end of this section should be included.

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2.   INITIAL PROBLEM IDENTIFICATION

Consult the table below 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	Section 4
Relay powers up - but indicates error and halts during power-up sequence	Section 5
Relay Powers up but Out of Service LED is illuminated	Section 6
Error during normal operation	Section 7
Mal-operation of the relay during testing	Section 8

Table 1:   Problem identification

TS

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

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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 then 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 then 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 centre 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 The following hex error codes relate to errors detected in specific relay modules: 0c140005/0c0d0000 0c140006/0c0e0000 Last 4 digits provide details on the actual error.	These messages indicate that a problem has been detected on the main processor board of the relay (located in the front panel). Input Module (inc. Opto-isolated inputs) Output Relay Cards Other error codes relate to problems within the main processor board hardware or software. It will be necessary to contact Alstom Grid 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 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 programmable logic for feedback paths. Other error codes will relate to software errors on the main processor board, contact Alstom Grid.

Table 3:   Power-up self-test error

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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 Enabled. Otherwise proceed to test 2.	If the setting is Enabled 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

TS

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.

Error codes (as reported by the relay via the front panel or in the Maintenance Records) can offer a considerable amount of information about the source of the error.

The Hex Code is reported on the front user interface of the relay immediately prior to a reboot sequence. If this code could not be observed, use the Maintenance Records section of the View Records column to display the corresponding Decimal Code.

Hex Code	Decimal Code	Meaning
0x0C140001	202637313	The serial driver failed to initialise properly. Check the serial port hardware on the power supply board and the main processor board.
0x0C140002	202637314	The LCD driver failed to initialise properly. Check the LCD on the main processor board.
0x0C140003	202637315	The Flash memory driver failed to initialise properly. Check the Flash memory on the main processor board.
0x0C140004	202637316	The date and time driver failed to initialise properly. Check the real-time clock and battery-backed SRAM on the main processor board.
0x0C140008	202637320	The database failed to initialise properly. Check the EEPROM on the main processor board.
0x0C140009	202637321	The database took too long to commit a change. Check the EEPROM on the main processor board.
0x0C14000A	202637322	The IRIG-B driver failed to initialise properly. Check the IRIG-B interface hardware on the IRIG-B board.
0x0C160010	202768400	The continuous self-checks have found an error in the RAM bus. Check the RAM on the main processor board.
0x0C160011	202768401	The continuous self-checks have found an error in the RAM block. Check the RAM on the main processor board.
0x0C160012	202768402	The continuous self-checks have found an error in the Flash EPROM checksum. Check the Flash EPROM on the main processor board, and then try downloading a new program.

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Hex Code	Decimal Code	Meaning
0x0C160013	202768403	The continuous self-checks have found an error in the code comparison. Check the Flash EPROM on the main processor board, and then try downloading a new program.
0x0C160014	202768404	The continuous self-checks have found an error in the battery backed SRAM. Check the battery, then the RAM on the main processor board.
0x0C160015	202768405	The continuous self-checks have found an error in the EEPROM. Check the EEPROM on the main processor board.
0x0C1600A0	202768544	The continuous self-checks have found an error on the acquisition board. Check the input board.
0x0C170016	202833942	Secondary initialisation tests detected a fast watchdog failure. Check the Flash EPROM on the main processor board.
0x0C170017	202833943	Secondary initialisation tests detected a battery backed SRAM failure. Check the battery backed SRAM on the main processor board.
0x0C170018	202833944	Secondary initialisation tests detected a bus reset test failure. Check the main processor board.
0x0C170019	202833945	Secondary initialisation tests detected a slow watchdog failure.

Table 5: Error Codes

Other error codes relate to problems within the main processor board software. It will be necessary to contact Alstom Grid through the Worldwide Contact Centre at www.alstom.com/grid/contactcentre/, tel. +44 1785 25 00 70 with details of the problem for a full analysis.

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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 that 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 in test mode or that the protection has been disabled due to a hardware verify error (see Table 4).
2	Examine the Contact status in the Commissioning section of the menu.	If the relevant bits of the contact status are operated then 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 then it will be necessary to check the programmable logic, 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 then 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 6: Failure of output contacts

7.2 Failure of opto-isolated inputs

The opto-isolated inputs are mapped onto the relay internal signals using the programmable scheme logic. 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 programmable logic.

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. 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.

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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 in 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

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.

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8.   REPAIR AND MODIFICATION PROCEDURE

Please follow these 5 steps to return an Automation product to us:

1.   Get the Repair and Modification Authorization Form (RMA)

Find a copy of the RMA form at the end of this section.

➢   To obtain an electronic version of the RMA form for e-mailing, please visit the following URL:

www.alstom.com/grid/productrepair

2.   Fill in RMA form

Fill in only the white part of the form.

Please ensure that all fields marked **(M)** are completed such as:

➢   Equipment model

➢   Model No. and Serial No.

➢   Description of failure or modification required (please be specific)

➢   Value for customs (in case the product requires export)

➢   Delivery and invoice addresses

➢   Contact details

3.   Send RMA form to your local contact

Find enclosed a list of local service contacts, worldwide.

4.   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 n°

➢   Repair centre address

If required, an acceptance of the quote must be delivered before going to next stage.

5.   Send the product to the repair centre

➢   Address the shipment to the repair centre 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.

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SCADA COMMUNICATIONS

SC

Date:	**2008**
Hardware Suffix:	**K**
Software Version:	**01**
Connection Diagrams:	**10P746xx (xx = 01 to 07)**

CONTENTS

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FIGURES

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1.   SCADA COMMUNICATIONS

1.1   Introduction

This section outlines the remote communications interfaces of the MiCOM relay. The relay supports a choice of one of five protocols via the rear communication interface, selected via the model number when ordering. This is in addition to the front serial interface and 2nd rear communications port, which supports the Courier protocol only.

The rear EIA(RS)485 interface is isolated and is suitable for permanent connection whichever protocol is selected. The advantage of this type of connection is that up to 32 relays can be 'daisy chained' together using a simple twisted pair electrical connection.

It should be noted that the descriptions contained within this section do not aim to fully detail the protocol itself. The relevant documentation for the protocol should be referred to for this information. This section serves to describe the specific implementation of the protocol in the relay.

1.2   Rear port information and connection advice – EIA(RS)485 protocols

1.2.1   Rear communication port EIA(RS)485 interface

The rear EIA(RS)485 communication port is provided by a 3-terminal screw connector located on the back of the relay. See section P746/EN IN 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 centre. Of the three connections, two are for the signal connection, and the other is for the earth shield of the cable. When the K-Bus option is selected for the rear port, the two signal connections are not polarity conscious, however for MODBUS, IEC60870-5-103 and DNP3.0 care must be taken to observe the correct polarity.

The protocol provided by the relay is indicated in the relay menu in the 'Communications' column. Using the keypad and LCD, firstly check that the 'Comms. 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 being used by the rear port.

1.2.1.1   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 whilst the product's connection diagrams indicate the polarization of the connection terminals it should be borne in mind that there is no agreed definition of which terminal is which. If the master is unable to communicate with the product, and the communication parameters match, then it is possible that the two-wire connection is reversed.

1.2.1.2   Bus termination

The EIA(RS)485 bus must have 120Ω (Ohm) ½ Watt terminating resistors fitted at either end across the signal wires – see Figure 1. Some devices may be able to provide the bus terminating resistors by different connection or configuration arrangements, in which case separate external components will not be required. However, this product does not provide such a facility, so if it is located at the bus terminus then an external termination resistor will be required.

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1.2.1.3   Bus connections & topologies

The EIA(RS)485 standard requires that each device 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 will be dependent on the application, although a multi-strand 0.5mm² per core is normally adequate. Total cable length must not exceed 1000m. The screen must be continuous and connected to ground 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 a signal ground connection is present in the bus cable then it must be ignored, although it must have continuity for the benefit of other devices connected to the bus. At no stage must the signal ground be connected to the cables screen or to the product's chassis. This is for both safety and noise reasons.

1.2.1.4   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 turn 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 be weakly pulled to a defined voltage level of about 1V. 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 will be injected. Note that some devices may (optionally) be able to provide the bus bias, in which case external components will not be required.
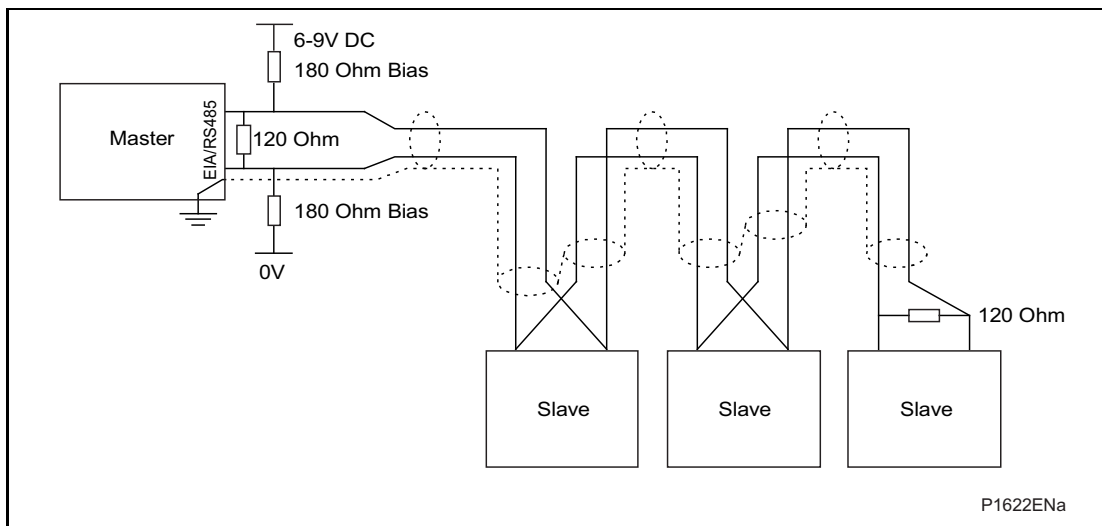
FIGURE 1: EIA(RS)485 BUS CONNECTION ARRANGEMENTS

It is possible to use the products field voltage output (48V DC) to bias the bus using values of 2.2kΩ (½W) as bias resistors instead of the 180Ω resistors shown in the above diagram.

Note the following warnings apply:

- It is extremely important that the 120Ω termination resistors are fitted. Failure to do so will result in an excessive bias voltage that may damage the devices connected to the bus.

- As the field voltage is much higher than that required, Alstom Grid 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 that the field voltage is not being used for other purposes (i.e. powering logic inputs) as this may cause noise to be passed to the communication network.

1.2.2 Courier communication

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, MiCOM S1 Studio, MiCOM S10, PAS&T or a SCADA system.

To use the K-Bus rear port to communicate with a PC-based master station using Courier, a KITZ K-Bus to EIA(RS)232 protocol converter is required. This unit is available from Alstom Grid. A typical connection arrangement is shown in Figure 2. 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 1000m in length and have up to 32 relays connected to it.
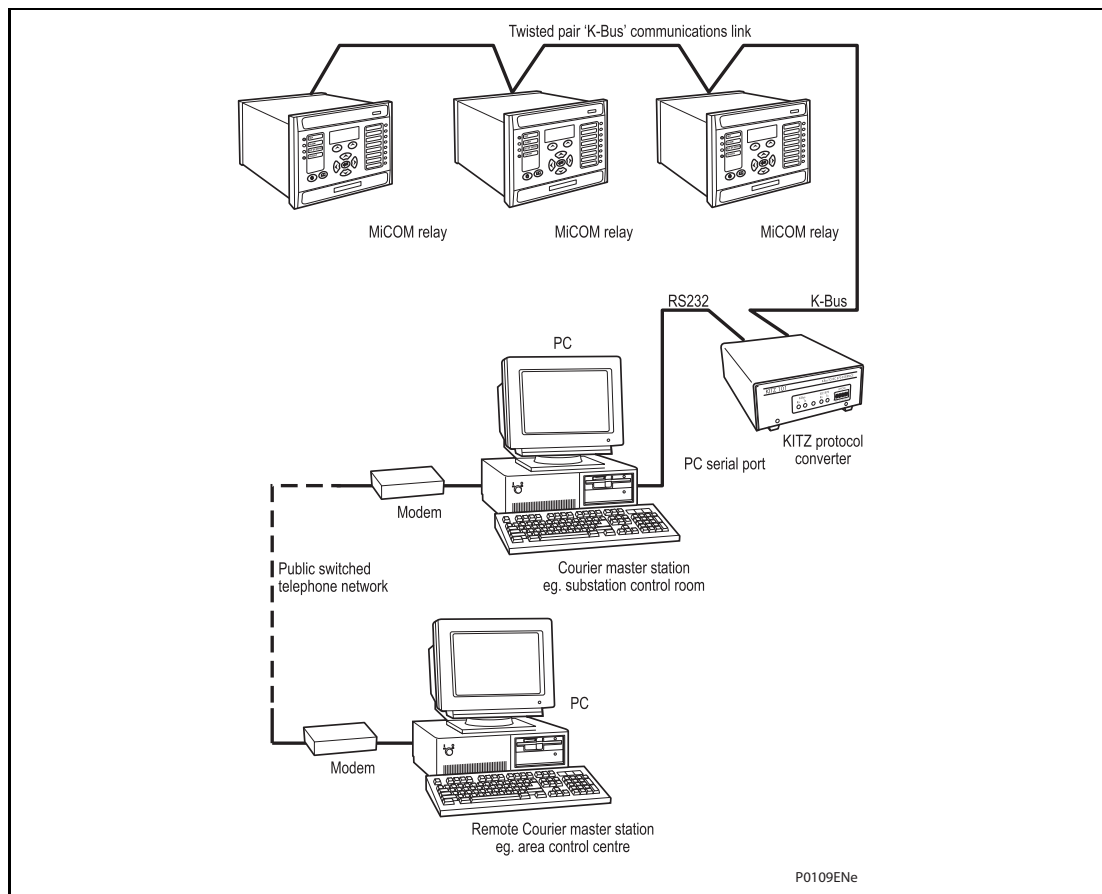
FIGURE 2: REMOTE COMMUNICATION CONNECTION ARRANGEMENTS

Having made the physical connection to the relay, the relay's communication settings must be configured. To do this use the keypad and LCD user interface. In the relay menu firstly check that the 'Comms. settings' cell in the 'Configuration' column is set to 'Visible', then move to the 'Communications' column. Only two settings apply to the rear port using Courier, the relay's address and the inactivity timer. Synchronous communication is used at a fixed baud rate of 64kbits/s.

Move down the 'Communications' column from the column heading to the first cell down which indicates the communication protocol:

```
Protocol
Courier
```

The next cell down the column controls the address of the relay:

```
Remote address
1
```

Since up to 32 relays can be connected to one K-bus spur, as indicated in Figure 2, 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. Courier uses an integer number between 0 and 254 for the relay address, which is set with this cell. It is important that no two relays have the same Courier address. The Courier address is then used by the master station to communicate with the relay. Default value of remote address is 255 and must be changed.

The next cell down controls the inactivity timer:

```
Inactivity timer
10.00 min.
```

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.

Note that 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 V2 or Studio do not require this action for the setting changes to take effect.

1.2.3   MODBUS communication

MODBUS is a master/slave communication protocol, which can be used for network control. In a similar fashion to Courier, the system works by the master device initiating all actions and the slave devices, (the relays), responding to the master by supplying the requested data or by taking the requested action. MODBUS communication is achieved via a twisted pair EIA(RS)485 connection to the rear port and can be used over a distance of 1000m with up to 32 slave devices.

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1.2.4   IEC60870-5 CS 103 communication

The IEC specification IEC60870-5-103: Telecontrol Equipment and Systems, Part 5: Transmission Protocols Section 103 defines the use of standards IEC60870-5-1 to IEC60870-5-5 to perform communication with protection equipment. The standard configuration for the IEC60870-5-103 protocol is to use a twisted pair EIA(RS)485 connection over distances up to 1000m. The relay operates as a slave in the system, responding to commands from a master station.

1.2.5   DNP3.0 communication

The DNP 3.0 protocol is defined and administered by the DNP User Group. Information about the user group, DNP 3.0 in general and protocol specifications can be found on their website: www.dnp.org

1.3   Second rear communication port (SK4)

There is a 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 previous sections of P746/EN IT. Move down the settings until the following sub heading is displayed.

```
┌─────────────────────────┐
│                         │
│   REAR PORT2 (RP2)      │
│                         │
└─────────────────────────┘
```

The next cell down indicates the language, which is fixed at Courier for RP2.

```
┌─────────────────────────┐
│   RP2 protocol          │
│   Courier               │
│                         │
└─────────────────────────┘
```

The next cell down indicates the status of the hardware, e.g.

```
┌─────────────────────────┐
│   RP2 card status       │
│   EIA(RS)232 OK         │
│                         │
└─────────────────────────┘
```

The next cell allows for selection of the port configuration.

```
┌─────────────────────────┐
│   RP2 port config.      │
│   EIA(RS)232            │
│                         │
└─────────────────────────┘
```

The port can be configured for EIA(RS)232, EIA(RS)485 or K-Bus.

In the case of EIA(RS)232 and EIA(RS)485 the next cell selects the communication mode.

```
┌─────────────────────────┐
│   RP2 comms. mode       │
│   IEC60870 FT1.2        │
│                         │
└─────────────────────────┘
```

The choice is either IEC60870 FT1.2 for normal operation with 11-bit modems, or 10-bit no parity.

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The next cell down controls the comms. port address.

```
RP2 address
255
```

Since up to 32 relays can be connected to one K-bus spur, as indicated in Figure 2, 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. Courier uses an integer number between 0 and 254 for the relay address that is set with this cell. It is important that no two relays have the same Courier address. The Courier address is then used by the master station to communicate with the relay. The default value is 255 and must be changed in the range 0 to 254 before use.

The next cell down controls the inactivity timer.

```
RP2 inactivity timer
15 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.

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. Three baud rates are supported by the relay, '9600 bits/s', '19200 bits/s' and '38400 bits/s'.

1.4 Ethernet communication

1.4.1 Legacy Protocols

It is possible to communicate through an Ethernet network using an Alstom Grid I4XS4UE
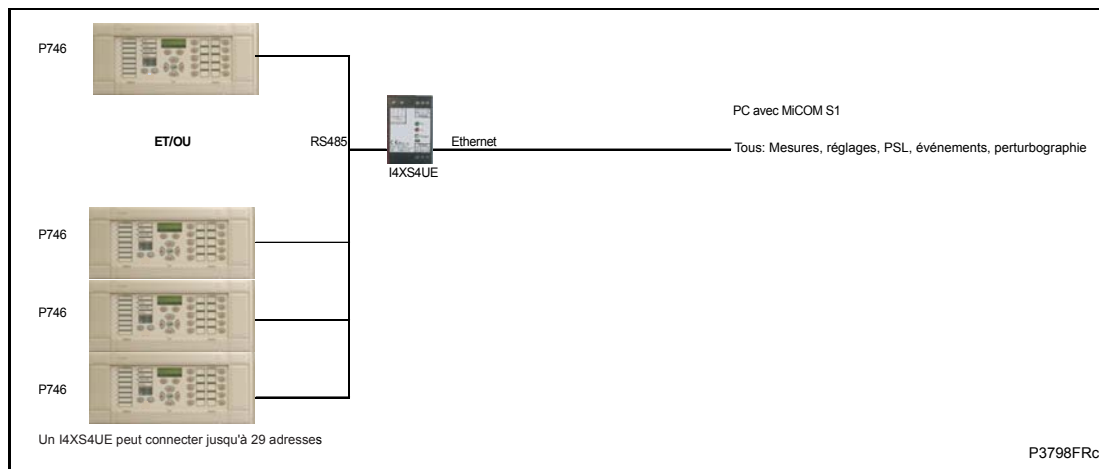
FIGURE 3: ETHERNET CONNEXION EXAMPLE

1.4.2 IEC 61850-8.1 Protocol
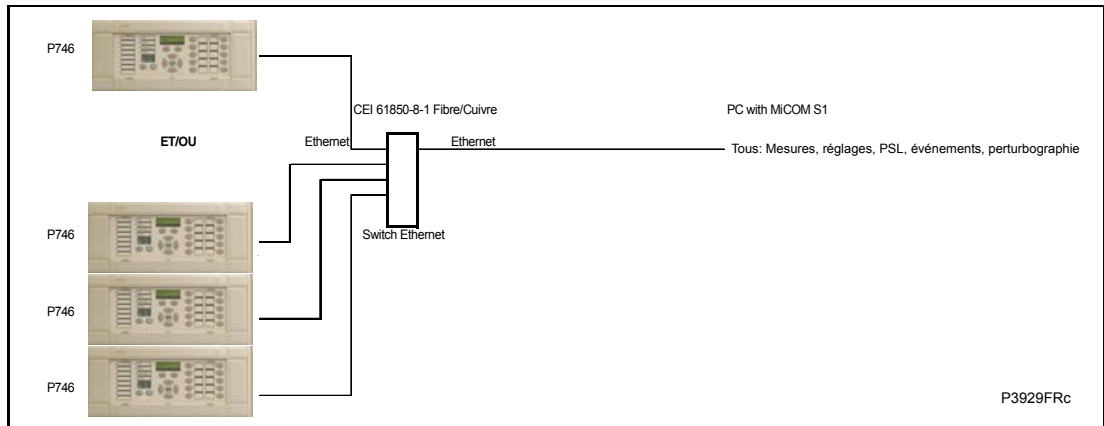
FIGURE 4: ETHERNET CONNEXION

2.   COURIER INTERFACE

2.1   Courier protocol

K-Bus is based on EIA(RS)485 voltage levels with HDLC FM0 encoded synchronous signalling 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. It should be noted that 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. Nor is it possible to connect K-Bus to an EIA(RS)485 computer port. A protocol converter, such as the KITZ101, should be employed for this purpose.

Alternatively for direct connections, the fibre optic converter card may be used to convert the rear EIA(RS)485 port into a fibre optic (ST) port.

2.2   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

SC

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 indicated with a * are not supported via the front Courier port.

2.3   Relay courier database

The Courier database is a two dimensional structure with each cell in the database being 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; e.g. 0A02 is column 0A (10 decimal) row 02. Associated settings/data will be part of the same column, row zero of the column contains a text string to identify the contents of the column, i.e. a column heading.

P746/EN MD contains the complete database definition for the relay. For each cell location the following information is stated:

− Cell text

− Cell datatype

− 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)

SC

2.4   **Setting changes**

(See R6512, Courier User Guide - Chapter 9)

There are three categories of settings within 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.

2.4.1   Setting transfer mode

If it is necessary to transfer all of the relay settings to or from the relay a cell within 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.

2.5   **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.

2.5.1   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 via the rear Courier port.

When new event information is created the event bit is set within 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 will respond with the event data, which will be 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 then the event bit will reset, if there are more events still to be extracted the next event can be accessed using the send event command as before.

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2.5.2   Event types

Events will be created by the relay under the following 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)

2.5.3   Event format

The send event command results in the following fields being returned by the relay:

−   Cell reference

−   Timestamp

−   Cell text

−   Cell value

The menu database, P746/EN MD, 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 will return a Courier Type 3 event, which contains the above fields together 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 within the record; the extended data can be extracted from the relay by uploading the text and data from the column.

2.5.4   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 will 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.

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Event Record Selection (Row 01) - This cell can be set to a value between 0 to 511 to select which of the 512 stored events is selected, 0 will select the most recent record; 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) then the remainder of the column will contain the additional information.

Fault Record Selection (Row 05) – This cell can be used to directly select a fault record using a value between 0 and 4 to select one of up to five stored fault records. (0 will be the most recent fault and 4 will be the oldest). The column will then contain 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 and operates in a similar way to the fault record selection.

It should be noted that if this column is used to extract event information from the relay the number associated with a particular record will change when a new event or fault occurs.

2.6 Disturbance record extraction

Select Record Number (Row 01) - This cell can be used to select the record to be extracted. Record 0 will be the oldest unextracted record, already extracted older records will be assigned positive values, and negative values will be used for more recent records. To facilitate automatic extraction via 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 itself can be extracted using the block transfer mechanism from cell B00B.

As has been stated, the rear Courier port can be used to automatically extract disturbance records as they occur. This operates using the standard Courier mechanism defined in 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.

2.7 Programmable scheme logic settings

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

The following 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/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/download.

The programmable scheme logic settings can be uploaded and downloaded to and from the relay using this mechanism. If it is necessary to edit the settings MiCOM S1 (V2 or Studio) must be used as the data format is compressed. MiCOM S1 also performs checks on the validity of the settings before they are downloaded to the relay.

SC

3.   MODBUS INTERFACE

The MODBUS interface is a master/slave protocol and it is defined by MODBUS.org: See

www.modbus.org

MODBUS Serial Protocol Reference Guide: PI-MBUS-300 Rev. E

3.1   Communication link

This interface also uses the rear EIA(RS)485 port (or converted fiber optic port) for communication using 'RTU' mode communication rather than 'ASCII' mode as this provides more efficient use of the communication bandwidth. This mode of communication is defined by the MODBUS standard.

In summary, the character framing is 1 start bit, 8 bit data, either 1 parity bit and 1 stop bit, or two stop bits. This gives 11 bits per character.

The following parameters can be configured for this port using either the front panel interface or the front Courier port:

−   Baud rate

−   Device address

−   Parity

−   Inactivity time

3.2   MODBUS functions

The following MODBUS function codes are supported by the relay:

01	Read Coil Status	
02	Read Input Status	
03	Read Holding Registers	
04	Read Input Registers	
06	Preset Single Register	
08	Diagnostics	
11	Fetch Communication Event Counter	
12	Fetch Communication Event Log	
16	Preset Multiple Registers 127 max	

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

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

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3.3 Response codes

Code	MODBUS Description	MiCOM Interpretation
01	Illegal Function Code	The function code transmitted is not supported by the slave.
02	Illegal Data Address	The start data address in the request is not an allowable value. If any of the addresses in the range cannot be accessed due to password protection then all changes within the request are discarded and this error response will be returned. Note: If the start address is correct but the range includes non–implemented addresses this response is not produced.
03	Illegal Value	A value referenced in the data field transmitted by the master is not within range. Other values transmitted within the same packet will be executed if inside range.
06	Slave Device Busy	The write command cannot be implemented due to the database being locked by another interface. This response is also produced if the relay software is busy executing a previous request.

3.4 Register mapping

The relay supports the following memory page references:

Memory Page   Interpretation

0xxxx   Read and write access of the output relays

1xxxx   Read only access of the opto inputs

3xxxx   Read only access of data

4xxxx   Read and write access of settings

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

Note that the "extended memory file" (6xxxx) is not supported.

A complete map of the MODBUS addresses supported by the relay is contained in menu database, P746/EN MD, of this service manual.

Note that MODBUS convention is to document register addresses as ordinal values whereas the actual protocol addresses are literal values. The MiCOM relays begin their register addresses at zero. Thus, the first register in a memory page is register address zero. The second register is register address 1 and so on. Note that the page number notation is not part of the address.

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3.5 Event extraction

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

3.5.1 Manual selection

There are three registers available to manually select stored records, there are also three read only registers allowing the number of stored records to be determined.

40100 - Select Event, 0 to 249

40101 - Select Fault, 0 to 4

40102 - Select Maintenance Record, 0 to 4

For each of the above registers a value of 0 represents the most recent stored record. The following registers can be read to indicate the numbers of the various types of record stored.

30100 - Number of stored records

30101 - Number of stored fault records

30102 - Number of stored maintenance records

Each fault or maintenance record logged causes an event record to be created by the relay. If this event record is selected the additional registers allowing the fault or maintenance record details will also become populated.

3.5.2 Automatic extraction

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

The MODBUS master can determine whether the relay has any events stored that have not yet been extracted. This is performed by reading the relay status register 30001 (G26 data type). If the event bit of this register is set then the relay has unextracted events available. To select the next event for sequential extraction the master station writes a value of 1 to the record selection register 40400 (G18 data type). The event data together with any fault/maintenance data can be read from the registers specified below. Once the data has been read the event record can be marked as having been read by writing a value of 2 to register 40400.

3.5.3 Record data

The location and format of the registers used to access the record data is the same whether they have been selected using either of the two mechanisms detailed above.

Event Description	MODBUS Address	Length	Comments
Time and Date	30103	4	See G12 data type description in section 3.8.
Event Type	30107	1	See G13 data type. Indicates type of event.
Event Value	30108	2	Nature of value depends on event type. This will contain the status as a binary flag for contact, opto, alarm, and protection events.
MODBUS Address	30110	1	This indicates the MODBUS register address where the change occurred. Alarm 30011 Relays 30723 Optos 30725 Protection events – like the relay and opto addresses this will map onto the MODBUS address of the appropriate DDB status register depending on which bit of the DDB the change occurred. These will range from 30727 to 30785. For platform events, fault events and maintenance events the default is 0.

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Event Description	MODBUS Address	Length	Comments
Event Index	30111	1	This register will contain the DDB ordinal for protection events or the bit number for alarm events. The direction of the change will be indicated by the most significant bit; 1 for 0 – 1 change and 0 for 1 – 0 change.
Additional Data Present	30112	1	0 means that there is no additional data. 1 means fault record data can be read from 30113 to 30199 (number of registers depends on the product). 2 means maintenance record data can be read from 30036 to 30039.

If a fault record or maintenance record is directly selected using the manual mechanism then the data can be read from the register ranges specified above. The event record data in registers 30103 to 30111 will not be available.

It is possible using register 40401(G6 data type) to 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.

3.6 Disturbance record extraction

The relay provides facilities for both manual and automatic extraction of disturbance records. The extraction mechanisms are explained below:

3.6.1 Extraction mechanism

Records extracted over MODBUS from Px40 platform relays will be presented in COMTRADE format. This involves extracting an ASCII text configuration file and then extracting a binary data file.

Each file is extracted by reading a series of data pages from the relay. The data page is made up of 127 registers, giving a maximum transfer of 254 bytes per page.

3.6.1.1 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.

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MODBUS Register	Name	Description
3x00800	N^o 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 'N^o 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 N^o 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	N^o 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.

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Note: Register addresses are provided in reference code + address format. E.g. 4x00001 is reference code 4x, address 1 (which is specified as function code 03, address 0x0000 in the MODBUS specification).

The disturbance record status register will report one of the following values:

State	Description
Idle	This will be the state reported when no record is selected; such as after power on or after a record has been marked as extracted.
Busy	The relay is currently processing data.
Page ready	The data page has been populated and the master station can now safely read the data.
Configuration complete	All of the configuration data has been read without error.
Record complete	All of the disturbance data has been extracted.
Disturbance overwritten	An error occurred during the extraction process where the disturbance being extracted was overwritten by a new record.
No unextracted disturbances	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	An attempt was made by the master station to manually select a record that did not exist in the relay.
Command out of sequence	The master station issued a command to the relay that was not expected during the extraction process.

3.6.2   Extraction procedure

The following procedure will be used to extract disturbances from the relay. 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)

SC

3.6.2.1   Manual extraction procedure

The procedure used to extract a disturbance manually is shown in the following figure. The manual method of extraction does not allow for the acceptance of disturbance records.
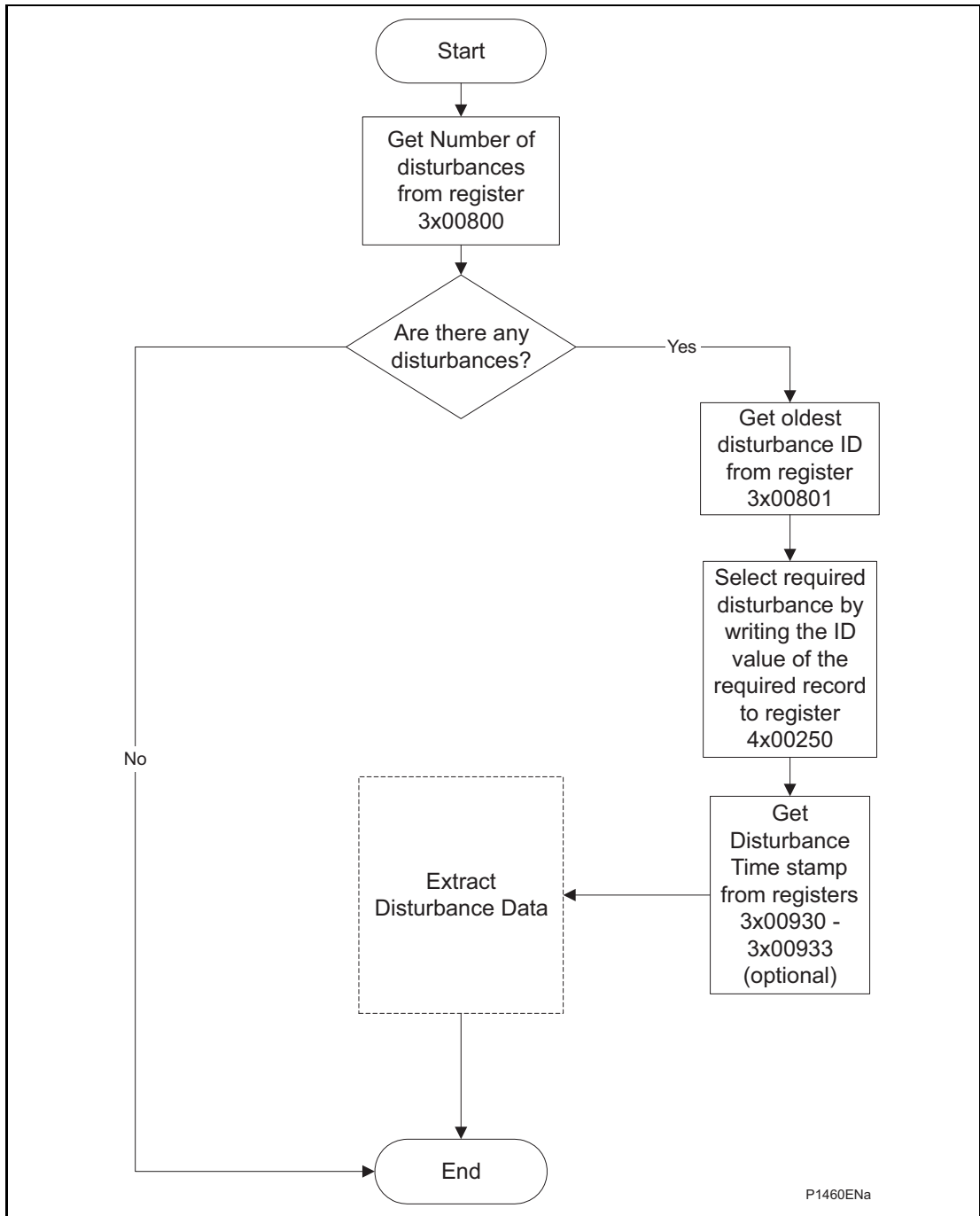
FIGURE 5: MANUAL SELECTION OF A DISTURBANCE RECORD

3.6.2.2   Automatic extraction procedure

There are two methods that can be used for automatically extracting disturbances. Option 1 is simpler and is better at extracting single disturbance records, i.e. when the disturbance recorder is polled regularly. Option 2, however, is more complex to implement but is more efficient at extracting large quantities of disturbance records. This may be useful when the disturbance recorder is polled only occasionally and hence may have many stored records.

3.6.2.3   Automatic extraction procedure – option 1

The procedure for the first method is shown in the following figure. This also shows the acceptance of the disturbance record once the extraction is complete.
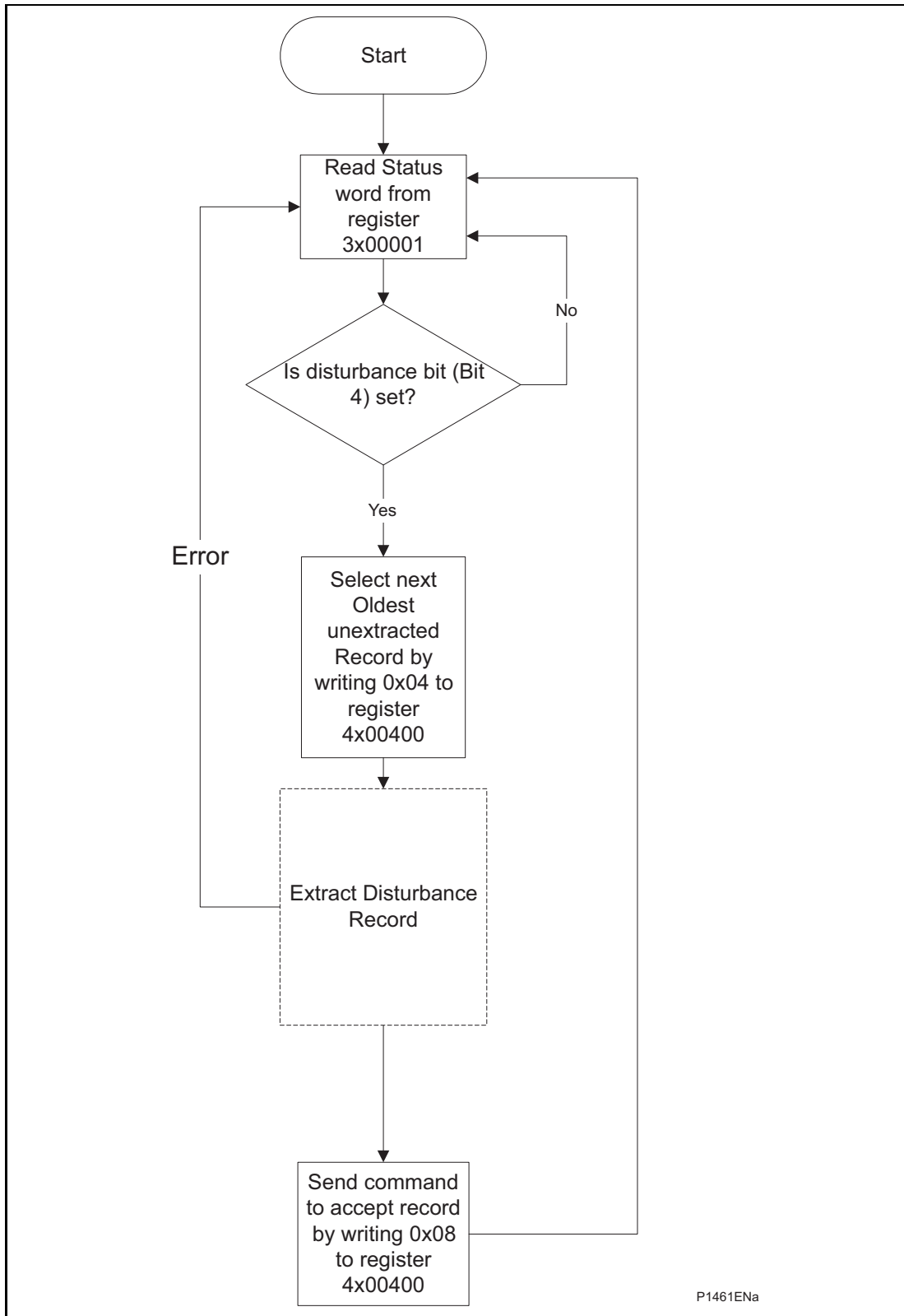
FIGURE 6: AUTOMATIC SELECTION OF A DISTURBANCE – OPTION 1

3.6.2.4   Automatic extraction procedure – option 2

The second method that can be used for automatic extraction is shown in the following figure. This also shows the acceptance of the disturbance record once the extraction is complete:
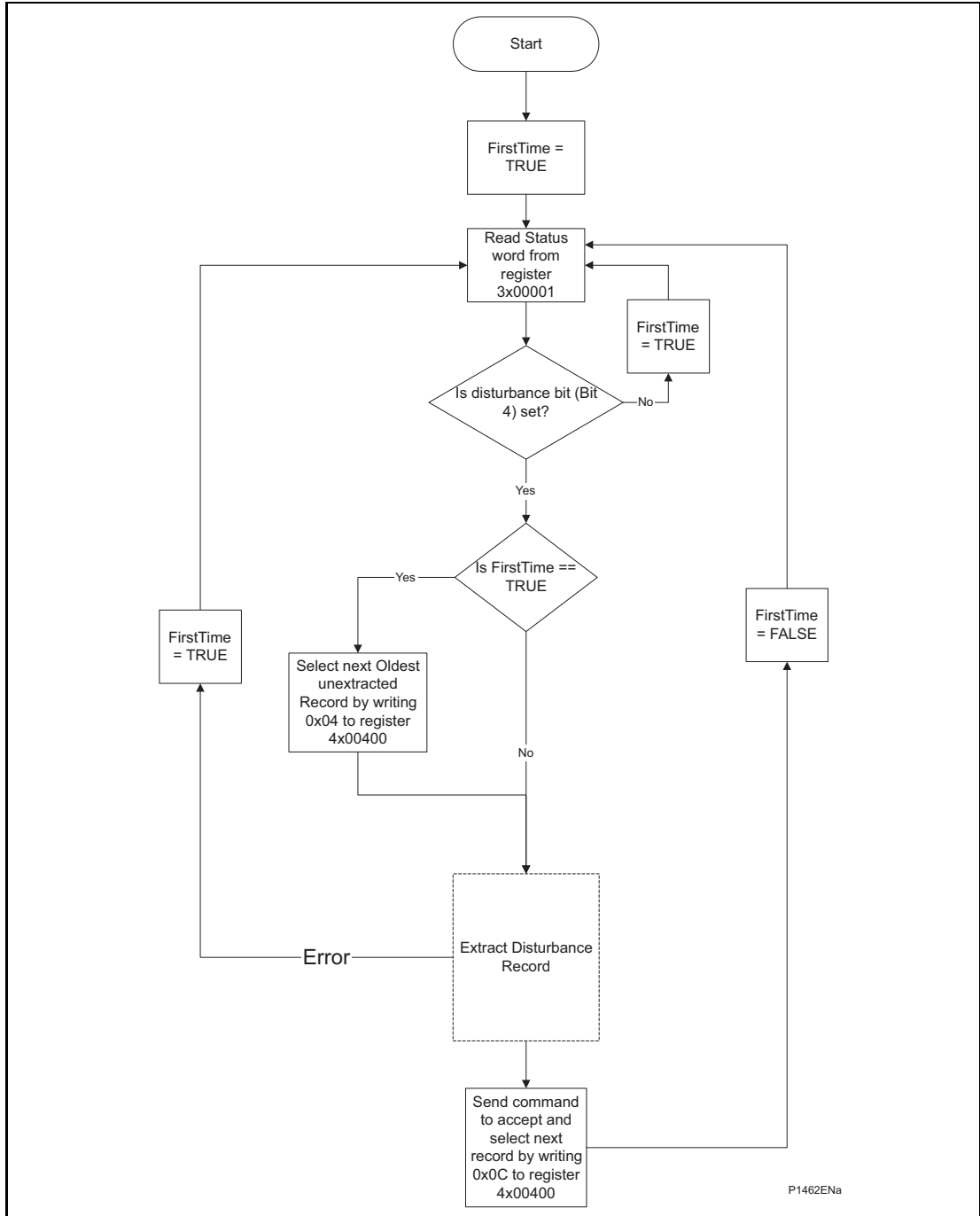
FIGURE 7: AUTOMATIC SELECTION OF A DISTURBANCE – OPTION 2

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3.6.3 Extracting the disturbance data

The extraction of the disturbance record, as shown in the three figures above, is a two-stage process that involves extracting the configuration file first and then the data file.

The following figure shows how the configuration file is extracted from the relay:
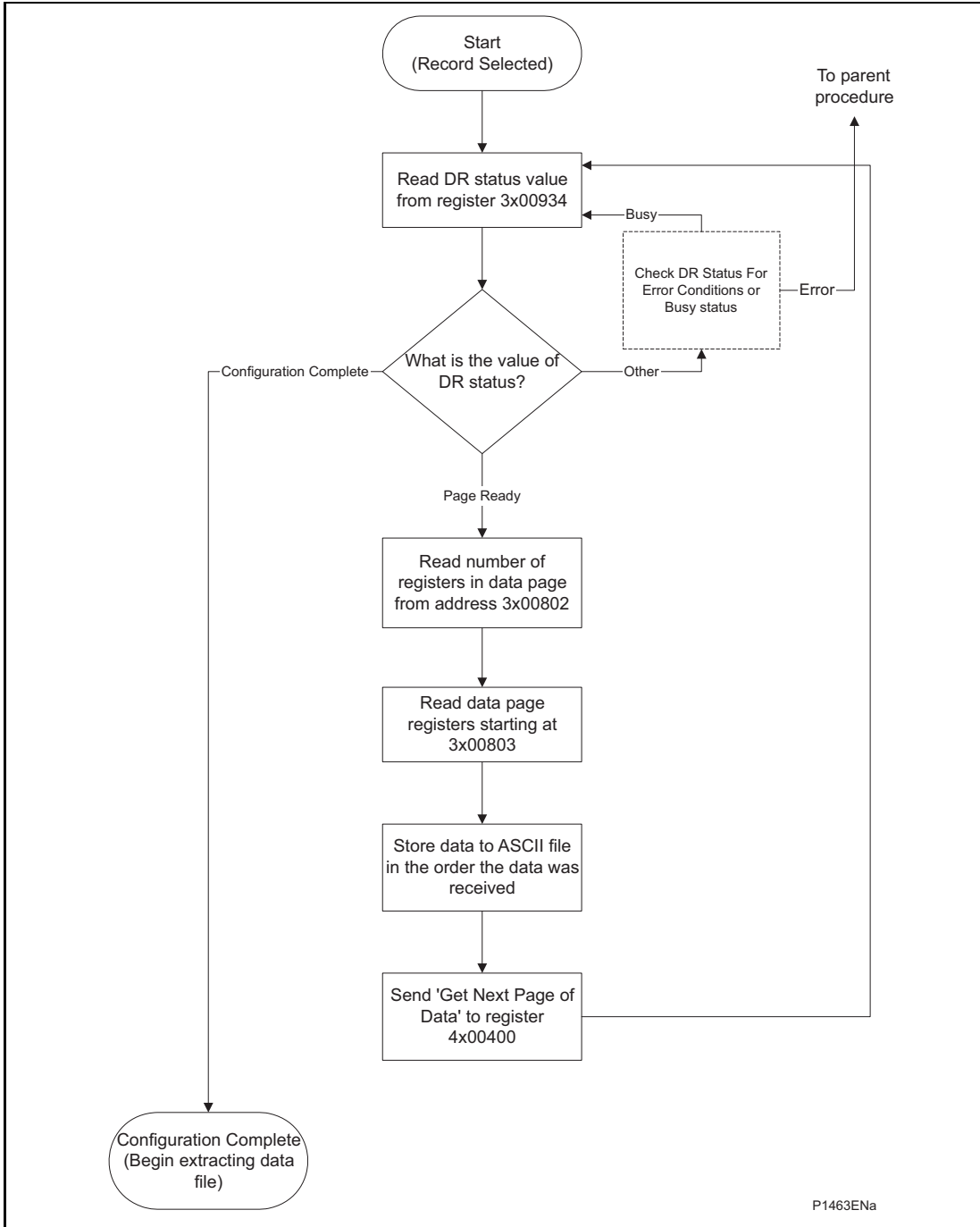
FIGURE 8: EXTRACTING THE COMTRADE CONFIGURATION FILE

The following figure shows how the data file is extracted:
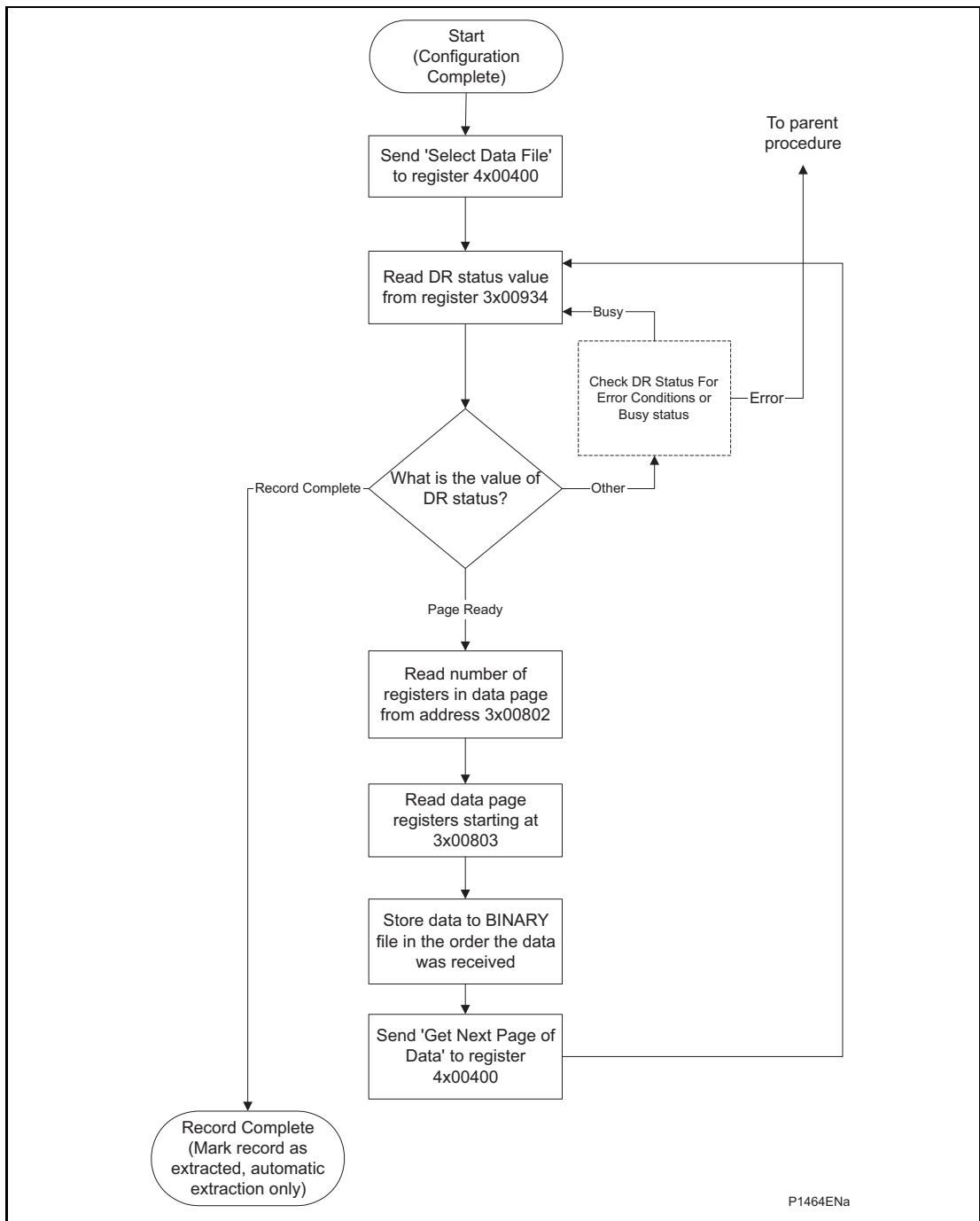
FIGURE 9: EXTRACTING THE COMTRADE BINARY DATA FILE

During the extraction of the COMTRADE files, an error may occur that will be reported on the DR Status register 3x00934. This can be caused by the relay overwriting the record being extracted or due to the master station issuing a command that is not within the bounds of the extraction procedure.

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3.7   Setting changes

The relay settings can be split into two categories:

−   Control and support settings

−   Disturbance record settings and protection setting groups

Changes to settings within 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 relay settings are 4xxxx page addresses. The following points should be noted when changing settings:

−   Settings implemented using multiple registers must be written to using a multi-register write operation.

−   The first address for a multi-register write must be a valid address, if there are unmapped addresses within the range being written to then the data associated with these addresses will be discarded.

−   If a write operation is performed with values that are out of range then the illegal data response will be produced. Valid setting values within the same write operation will be executed.

−   If a write operation is performed attempting to change registers that require a higher level of password access than is currently enabled then all setting changes in the write operation will be discarded.

3.7.1   Password protection

As described in the introduction to this service manual, the relay settings can be subject to password protection. The level of password protection required to change a setting is indicated in the relay setting database (P746/EN MD). Level 2 is the highest level of password access, level 0 indicates that no password is required.

The following registers are available to control password protection:

40001 & 40002   Password entry

40022   Default password level

40023 & 40024   Setting to change password level 1

40025 & 40026   Setting to change password level 2

30010   Can be read to indicate current access level

3.7.2   Control and support settings

Control and support settings are executed immediately on the write operation.

3.7.3   Protection and disturbance recorder settings

Setting changes to either of these areas are stored in a scratchpad area and will not be used by the relay unless a confirm or an abort operation is performed. Register 40405 can be used either to confirm or abort the setting changes within the scratchpad area. It should be noted that the relay supports four groups of protection settings. The MODBUS addresses for each of the four groups are repeated within the following address ranges:

Group 1   41000 - 42999

Group 2   43000 - 44999

Group 3   45000 - 46999

Group 4   47000 - 48999

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.

3.8   Date and time format (data type G12)

The date-time data type G12 allows *real* date and time information to be conveyed down to a resolution of 1ms. The structure of the data type is shown in

Table 3-1 and is compliant with the IEC60870-5-4 "Binary Time 2a" format.

The seven bytes of the structure are packed into four 16-bit registers, such that byte 1 is transmitted first, followed by byte 2 through to byte 7, followed by a null (zero) byte to make eight bytes in total. Since register data is usually transmitted in big-endian format (high order byte followed by low order byte), byte 1 will be in the high-order byte position followed by byte 2 in the low-order position for the first register. The last register will contain just byte 7 in the high order position and the low order byte will have a value of zero.

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

Table 3-1 G12 date & time data type structure

Where:

−   m   = 0…59,999ms

−   I   = 0…59 minutes

−   H   = 0…23 Hours

−   W   = 1…7 Day of week; Monday to Sunday, 0 for not calculated

−   D   = 1…31 Day of Month

−   M   = 1…12 Month of year; January to December

−   Y   = 0…99 Years (year of century)

−   R   = Reserved bit = 0

−   SU   = summertime: 0 = standard time, 1 = summer time

−   IV   = invalid value: 0 = valid, 1 = invalid

−   range = 0ms…99 years

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Since the range of the data type is only 100 years, the century must be deduced. The century is calculated as the one that will produce the nearest time value to the current date. For example: 30-12-99 is 30-12-1999 when received in 1999 & 2000, but is 30-12-2099 when received in 2050. This technique allows 2 digit years to be accurately converted to 4 digits in a ±50 year window around the current datum.

The invalid bit has two applications:

1.   It can indicate that the date-time information is considered inaccurate, but is the best information available.

2.   Date-time information is not available.

The summertime bit is used to indicate that summertime (day light saving) is being used and, more importantly, to resolve the alias and time discontinuity which occurs when summertime starts and ends. This is important for the correct time correlation of time stamped records.

The day of the week field is optional and if not calculated will be set to zero.

The concept of time zone is not catered for by this data type and hence by the relay. It is up to the end user to determine the time zone utilized by the relay. Normal practice is to use UTC (universal co-ordinated time), which avoids the complications with day light saving time-stamp correlation's.

3.9   Power & energy measurement data formats (G29 & G125)

The power and energy measurements are available in two data formats; G29 integer format and G125 IEEE754 floating point format. For historical reasons the registers listed in the main part of the "Measurements 2" column of the menu database (see P746/EN MD) are of the G29 format. The floating point, G125, versions appear at the end of the column.

3.9.1   Data type G29

Data type G29 consists of three registers. The first register is the per unit power or energy measurement and is of type G28, which is a signed 16 bit quantity. The second and third registers contain a multiplier to convert the per unit value to a real value. The multiplier is of type G27, which is an unsigned 32-bit quantity. Thus, the overall value conveyed by the G29 data type must be calculated as G29 = G28×G27.

The relay calculates the G28 per unit power or energy value as G28 = ((measured secondary quantity)/(CT secondary) × (110V/(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 will saturate a long time before the equivalent G125 does.

The associated G27 multiplier is calculated as G27 = (CT primary) × (VT primary/110V) when primary value measurements are selected, and as G27 = (CT secondary) × (VT secondary/110V) 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 that 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 30300 - 30302) for a 110V relay, In = 1A, VT ratio = 110V:110V and CT ratio = 1A:1A.

Applying A-phase 1A @ 63.51V

A-phase Watts = ((63.51V × 1A)/In = 1A) × (110/Vn = 110V) = 63.51 Watts

The G28 part of the value is the truncated per unit quantity, which will be equal to 64 (40h).

SC

The multiplier is derived from the VT and CT ratios set in the relay, with the equation ((CT Primary) $\times$ (VT Primary)/110V). Thus, the G27 part of the value will equal 1. Hence the overall value of the G29 register set is 64$\times$1 = 64W

The registers would contain:

> 30300 - 0040h
>
> 30301 - 0000h
>
> 30302 - 0001h

Using the previous example with a VT ratio = 110,000V; 110V and CT ratio = 10,000A:1A the G27 multiplier would be 10,000A $\times$ 110,000V/110 = 10,000,000. The overall value of the G29 register set is 64 $\times$ 10,000,000 = 640MW. (Note that there is an actual error of 49MW in this calculation due to loss of resolution.)

The registers would contain:

> 30300 - 0040h
>
> 30301 - 0098h
>
> 30302 - 9680h

3.9.2   Data type G125

Data type G125 is a short float IEEE754 floating point format, which occupies 32 bits in two consecutive registers. The high order byte of the format is in the first (low order) register and the low order byte in the second register.

The value of the G125 measurement is as accurate as the relay's ability to resolve the measurement after it has applied the secondary or primary scaling factors as require. It does not suffer from the truncation errors or dynamic range limitations associated with the G29 data format.

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4. 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.

The following 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

4.1 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. Should the fiber optic port be fitted the selection of the active port can be made via the front panel menu or the front Courier port, however the selection will only be effective following the next relay power up.

For either of the two modes of connection it is possible to select both the relay address and baud rate using the front panel menu/front Courier. Following a change to either of these two settings a reset command is required to re-establish communications, see reset command description below.

4.2 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 will respond to either of the two reset commands (Reset CU or Reset FCB), the difference being that the Reset CU will clear any unsent messages in the relay's transmit buffer.

The relay will respond to the reset command with an identification message ASDU 5, the Cause Of Transmission COT of this response will be either Reset CU or Reset FCB depending on the nature of the reset command. The content of ASDU 5 is described in the IEC60870-5-103 section of the menu database, P746/EN MD.

In addition to the above identification message, if the relay has been powered up it will also produce a power up event.

4.3 Time synchronization

The relay time and date can be set using the time synchronization feature of the IEC60870-5-103 protocol. The relay will correct for the transmission delay as specified in IEC60870-5-103. If the time synchronization message is sent as a send/confirm message then the relay will respond 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 will be generated/produced.

If the relay clock is being synchronized using the IRIG-B input then it will not be possible to set the relay time using the IEC60870-5-103 interface. An attempt to set the time via the interface will cause the relay to create an event with the current date and time taken from the IRIG-B synchronized internal clock.

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4.4   Spontaneous events

Events are categorized using the following information:

−   Function type

−   Information number

The IEC60870-5-103 profile in the menu database, P746/EN MD, contains a complete listing of all events produced by the relay.

4.5   General interrogation

The GI request can be used to read the status of the relay, the function numbers, and information numbers that will be returned during the GI cycle are indicated in the IEC60870-5-103 profile in the menu database, P746/EN MD.

4.6   Cyclic measurements

The relay will produce measured values using ASDU 9 on a cyclical basis, 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/front Courier port and is active immediately following a change.

It should be noted that the measurands transmitted by the relay are sent as a proportion of 2.4 times the rated value of the analog value.

4.7   Commands

A list of the supported commands is contained in the menu database, P746/EN MD. The relay will respond to other commands with an ASDU 1, with a cause of transmission (COT) indicating 'negative acknowledgement'.

4.8   Test mode

It is possible using either the front panel menu or the front Courier port 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 will be produced to indicate both entry to and exit from test mode. Spontaneous events and cyclic measured data transmitted whilst the relay is in test mode will have a COT of 'test mode'.

4.9   Disturbance records

The disturbance records are stored in uncompressed format and can be extracted using the standard mechanisms described in IEC60870-5-103.

Note: IEC60870-5-103 only supports up to 8 records.

SC

4.10   Blocking of monitor direction

The relay supports a facility to block messages in the monitor direction and also 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.

5.   DNP3.0 INTERFACE

5.1   DNP3.0 protocol

The descriptions given here are intended to accompany the device profile document that is included in the menu database, P746/EN MD. 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 via 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 or fiber optic 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).

5.2   DNP3.0 menu setting

The settings shown below are available in the menu for DNP3.0 in the 'Communications' column.

Setting	Range	Description
Remote Address	0 – 65534	DNP3.0 address of relay (decimal)
Baud Rate	1200, 2400, 4800, 9600, 19200, 38400	Selectable baud rate for DNP3.0 communication
Parity	None, Odd, Even	Parity setting
Time Sync.	Enabled, Disabled	Enables or disables the relay requesting time sync. from the master via IIN bit 4 word 1

5.3   Object 1 binary inputs

Object 1, binary inputs, contains information describing the state of signals within 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 that is also found in the menu database, P746/EN MD. The binary input points can also be read as change events via object 2 and object 60 for class 1-3 event data.

5.4   Object 10 binary outputs

Object 10, binary outputs, contains commands that can be operated via DNP3.0. As such the points accept commands of type pulse on [null, trip, close] and latch on/off as detailed in the device profile in the menu database, P746/EN MD and execute the command once for either command. The other fields are ignored (queue, clear, trip/close, in time and off time).

Due to that fact that many of the relay's functions are configurable, it may be the case that some of the object 10 commands described below are not available for operation. In the case of a read from object 10 this will result in the point being reported as off-line and an operate command to object 12 will generate 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

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5.5   **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.

5.6   **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).

5.7   **DNP3.0 configuration using MiCOM S1**

A PC support package for DNP3.0 is available as part of the settings and records module of MiCOM S1. The S1 module allows configuration of the relay's DNP3.0 response. The PC is connected to the relay via a serial cable to the 9-pin front part of the relay – see Introduction (P746/EN IT). The configuration data is uploaded from the relay to the PC in a block of compressed format data and downloaded to the relay in a similar manner after modification. The new DNP3.0 configuration takes effect in the relay after the download is complete. The default configuration can be restored at any time by choosing 'All Settings' from the 'Restore Defaults' cell in the menu 'Configuration' column. In S1, the DNP3.0 data is displayed on a three-tabbed screen, one screen each for object 1, 20 and 30. Object 10 is not configurable.

5.7.1   Object 1

For every point included in the device profile document there is a check box for membership of class 0 and radio buttons for class 1, 2 or 3 membership. Any point that is in class 0 must be a member of one of the change event classes 1, 2 or 3.

Points that are configured out of class 0 are by default not capable of generating change events. Furthermore, points that are not part of class 0 are effectively removed from the DNP3.0 response by renumbering the points that are in class 0 into a contiguous list starting at point number 0. The renumbered point numbers are shown at the left-hand side of the screen in S1 and can be printed out to form a revised device profile for the relay. This mechanism allows best use of available bandwidth by only reporting the data points required by the user when a poll for all points is made.

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5.7.2   Object 20

The running counter value of object 20 points can be configured to be in or out of class 0. Any running counter that is in class 0 can have its frozen value selected to be in or out of the DNP3.0 response, but a frozen counter cannot be included without the corresponding running counter. As with object 1, the class 0 response will be renumbered into a contiguous list of points based on the selection of running counters. The frozen counters will also be renumbered based on the selection; note that if some of the counters that are selected as running are not also selected as frozen then the renumbering will result in the frozen counters having different point numbers to their running counterparts. For example, object 20 point 3 (running counter) might have its frozen value reported as object 21 point 1.

5.7.3   Object 30

For the analog inputs, object 30, the same selection options for classes 0, 1, 2 and 3 are available as for object 1. In addition to these options, which behave in exactly the same way as for object 1, it is possible to change the deadband setting for each point. The minimum and maximum values and the resolution of the deadband settings are defined in the device profile document; MiCOM S1 will allow the deadband to be set to any value within these constraints.

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6. IEC 61850 ETHERNET INTERFACE

6.1 Introduction

IEC 61850 is the international standard for Ethernet-based communication in substations. It enables integration of all protection, control, measurement and monitoring functions within a substation, and additionally 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 Alstom Grid Automation's offer of a full IEC 61850 solution for the substation. The majority of MiCOM 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.

6.2 What is IEC 61850?

IEC 61850 is an international standard, comprising 14 parts, which defines a communication architecture for substations.

The standard defines and offers much more than just a protocol. It provides:

- Standardized models for IEDs and other equipment within the substation

- Standardized communication services (the methods used to access and exchange data)

- Standardized formats for configuration files

- Peer-to-peer (e.g. 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 10's of kbits/s or less used by most serial protocols)

- Multiple masters (called "clients")

- Ethernet is an open standard in every-day use

Alstom Grid has been involved in the Working Groups which formed the standard, building on experience gained with UCA2.0, the predecessor of IEC 61850.

6.2.1 Interoperability

A major benefit of IEC 61850 is interoperability. IEC 61850 standardizes the data model of substation IEDs. This responds to the utilities' desire of having easier integration for different vendors' products, i.e. interoperability. It means that data is accessed in the same manner in different IEDs from either the same or different IED vendors, even though, for example, the protection algorithms of different vendors' relay types remain different.

When a device is described as IEC 61850-compliant, this does not mean that it is interchangeable, but does mean that it is interoperable. You cannot simply replace one product with another, however the terminology is pre-defined and anyone with prior knowledge of IEC 61850 should be able very quickly integrate a new device without the need for mapping of all of the new data. IEC 61850 will inevitably bring improved substation communications and interoperability, at a lower cost to the end user.

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6.2.2   The 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.

The levels of this hierarchy can be described as follows:

–	Physical Device	– Identifies the actual IED within a system. Typically t the device's name or IP address can be used (for e example **Feeder_1** or **10.0.0.2**).
–	Logical Device	– Identifies groups of related Logical Nodes within t the Physical Device. For the MiCOM relays, 5 Logi Logical Devices exist: **Control, Measurements, Protection, Records, System**.
–	Wrapper/Logical Node Instance	– Identifies the major functional areas within the IEC 61850 data model. Either 3 or 6 characters are used as a prefix to define the functional group (wrapper) while the actual functionality is identified by a 4 character Logical Node name suffixed by an instance number. For example, XCBR1 (circuit breaker), MMXU1 (measurements), FrqPTOF2 (overfrequency protection, stage 2).
–	Data Object	– This next layer is used to identify the type of data you will be presented with. For example, **Pos** (position) of Logical Node type **XCBR**.
–	Data Attribute	– This is the actual data (measurement value, status, description, etc.). For example, **stVal** (status value) indicating actual position of circuit breaker for Data Object type **Pos** of Logical Node type **XCBR**.

6.3   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.

In order to communicate with an IEC 61850 IED on Ethernet, it is necessary only to know its IP address. This can then be configured into either:

- An IEC 61850 "client" (or master), for example a 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

6.3.1   Capability

The IEC 61850 interface provides the following capabilities:

3.   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.

4.   Generation of unbuffered reports on change of status/measurement

Unbuffered reports, when enabled, report any change of state in statuses and/or measurements (according to deadband settings).

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5.   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.

6.   GOOSE peer-to-peer communication

GOOSE communications of statuses are included as part of the IEC 61850 implementation. Please see section 6.6 for more details.

7.   Disturbance record extraction

Extraction of disturbance records, by file transfer, is supported by the MiCOM relays. The record is extracted as an ASCII format COMTRADE file.

Setting changes (e.g. of protection settings) are not supported in the current IEC 61850 implementation. In order to keep this process as simple as possible, such setting changes are done using MiCOM S1 (V2 or 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").

6.3.2   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 varying 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 aid in this process, the MiCOM S1 Support Software provides an IED Configurator tool which allows the pre-configured IEC 61850 configuration file (an SCD file or CID file) to be imported and transferred to the IED. Alongside this, the requirements of manual configuration are satisfied by allowing the manual creation of configuration files for MiCOM relays 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 which ensures that the configuration data is valid for sending to the IED and that the IED will function within the context of the substation.

To aid 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.

6.3.2.1 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 into the inactive configuration bank, therefore not immediately affecting the current configuration. Both active and inactive configuration banks can be extracted at anytime.

When the upgrade or maintenance stage is complete, the IED Configurator tool can be used to transmit a command (to a single IED) authorizing 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 via 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.

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6.3.2.2   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, so if these parameters are not available via an SCL file, they must be configured manually.

If the assigned IP address is duplicated elsewhere on the same network, the remote communications will operate in an indeterminate way. However, the relay will check for a conflict on every IP configuration change and at power up. An alarm will be raised if an IP conflict is detected.

The relay can be configured to accept data from networks other than the local network by using the 'Gateway' setting.

6.4   The data model of MiCOM relays

The data model naming adopted in the Px40 relays has been standardized for consistency. Hence 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 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.

6.5   The communication services of MiCOM relays

The IEC 61850 communication services which are implemented in the 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.

6.6   Peer-to-peer (GSE) communications

The implementation of IEC 61850 Generic Substation Event (GSE) sets the way for cheaper and faster inter-relay communications. The generic substation event model provides the possibility for a fast and reliable system-wide distribution of input and output data values. The generic substation event model is based on the concept of an autonomous decentralization, providing an efficient method allowing the simultaneous delivery of the same generic substation event information to more than one physical device through the use of 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 (i.e. sends) a new message. Any device that is interested in the information subscribes (i.e. listens) to the data it contains.

> Note: *   Multicast messages cannot be routed across networks without specialized equipment.

Each new message is re-transmitted at user-configurable intervals until the maximum interval is reached, in order 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 GSE schemes before or during commissioning, in just the same way a hardwired scheme must be tested.

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6.6.1 Scope

A maximum of 32 virtual inputs are available within the PSL which can be mapped directly to a published dataset in a GOOSE message (only 1 fixed dataset is supported). All published GOOSE signals are BOOLEAN values.

Each GOOSE signal contained in a subscribed GOOSE message can be mapped to any of the 32 virtual inputs within the PSL. The virtual inputs allow the mapping to internal logic functions for protection control, directly to output contacts or LEDs for monitoring.

The MiCOM relay can subscribe to all GOOSE messages but only the following data types can be decoded and mapped to a virtual input:

- BOOLEAN
- BSTR2
- INT16
- INT32
- INT8
- UINT16
- UINT32
- UINT8

6.6.2 IEC 61850 GOOSE configuration

All GOOSE configuration is performed via the IED Configurator tool available within the MiCOM S1 Support Software.

All GOOSE publishing configuration can be found under the 'GOOSE Publishing' tab in the configuration editor window. All GOOSE subscription configuration can be found under the 'External Binding' tab in the configuration editor window. Care should be taken to ensure that the configuration is correct, to ensure efficient GOOSE scheme operation.

Settings to enable GOOSE signalling and to apply Test Mode are available via the relay user interface.

6.7 Ethernet functionality

Settings relating to a failed Ethernet link are available in the 'COMMUNICATIONS' column of the relay user interface.

6.7.1 Ethernet disconnection

IEC 61850 'associations' are unique and made to the relay between the client (master) and server (IEC 61850 device). In the event that the Ethernet is disconnected, such associations are lost, and will need to 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.

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6.7.2 Loss of power

The relay allows the re-establishment of associations by the client without a negative impact on the relay's operation after having its power removed. As the relay acts as a server in this process, the client must request the association. Uncommitted settings are cancelled when power is lost, and reports requested by connected clients are reset and must be re-enabled by the client when it next creates the new association to the relay.

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SYMBOLS AND GLOSSARY

Date:	**2008**
Hardware Suffix:	**K**
Software Version:	**01**
Connection Diagrams:	**10P746xx (xx = 01 to 07)**

SG

Logic Symbols used

Symbols	Explanation
&	**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.
<	**Less than:** Used to indicate an "under" threshold, such as undercurrent (current dropout).
>	**Greater than:** Used to indicate an "over" threshold, such as overcurrent (current overload).
1	**Logical "OR":** Used in logic diagrams to show an OR-gate function.
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.
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.
ACSI	**Abstract Communication Service Interface:** In IEC 61850, the ACSI provides abstract definitions of a hierarchical data model and the services that operate on the data.
BAR	Block auto-reclose signal.
BN>	**Neutral over susceptance protection element:** Reactive component of admittance calculation from neutral current and residual voltage.
BU	**Backup:** Typically a back-up protection element.
C/O	**A changeover contact having normally closed and normally open connections:** Often called a "form C" contact.
CB	Circuit breaker.
CB Aux.	**Circuit breaker auxiliary contacts:** Indication of the breaker open/closed status.
CBF	Circuit breaker failure protection.
CLP	Cold load pick-up.
CS	Check synchronism.
CT	Current transformer.
CTRL.	**Abbreviation of "Control":** As used for the Control Inputs function.

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Symbols	Explanation
CTS	**Current transformer supervision:** To detect CT input failure.
CZ	**Abbreviation of "Check Zone":** Zone taking into account only the feeders.
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.
DEF	**Directional earth fault protection:** A directionalised ground fault aided scheme.
Df/dt	Rate of change of frequency protection (ROCOF).
Dly	Time delay.
DR	Abbreviation of "Disturbance Record"
DT	**Abbreviation of "Definite Time":** An element which always responds with the same constant time delay on operation.
DZ	**Abbreviation of "Dead Zone":** Area between a CT and an open breaker or an open isolator.
E/F	**Earth fault:** Directly equivalent to ground fault.
F<	**An underfrequency element:** Could be labelled 81U in ANSI terminology.
F>	**An overfrequency element:** Could be labelled 81O in ANSI terminology.
FLC	**Full load current:** The nominal rated current for the circuit.
Flt.	**Abbreviation of "Fault":** Typically used to indicate faulted phase selection.
FN	Function.
Fwd.	Indicates an element responding to a flow in the "Forward" direction.
GN>	**Neutral over conductance protection element:** Real component of admittance calculation from neutral current and residual voltage.
Gnd.	**Abbreviation of "Ground":** Used in distance settings to identify settings that relate to ground (earth) faults.
GOOSE	**Generic Object Oriented Substation Event:** In IEC 61850, a specific definition of a type of generic substation event, for peer-peer communication.
GRP.	**Abbreviation of "Group":** Typically an alternative setting group.
GSE	**Generic Substation Event:** In IEC 61850, the generic substation event model provides the possibility for a fast and reliable system-wide distribution of input and output data values (peer-peer communication).

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Symbols	Explanation
HMI	**Human Machine Interface:** The graphical user interface of the control system.
I	Current.
I^	**Current raised to a power:** Such as when breaker statistics monitor the square of ruptured current squared ($^\wedge$ power = 2).
I/O	**Abbreviation of "Inputs and Outputs":** Used in connection with the number of optocoupled inputs and output contacts within the relay.
I/P	Abbreviation of "Input".
I<	**An undercurrent element:** Responds to current dropout.
I>	**An overcurrent element:** Detects phase faults; Optionally used by the 50BF protection.
I>1	**First stage of phase overcurrent protection:** Could be labelled 51-1 in ANSI terminology.
I>2	**Second stage of phase overcurrent protection:** Could be labelled 51-2 in ANSI terminology.
I>3	**Third stage of phase overcurrent protection:** Could be labelled 51-3 in ANSI terminology.
I>4	**Fourth stage of phase overcurrent protection:** Could be labelled 51-4 in ANSI terminology.
I>BB	Minimum pick-up phase threshold for the local trip order confirmation.
I>DZ	Minimum pick-up phase threshold for the Dead Zone protection.
I_0	**Zero sequence current:** Equals one third of the measured neutral/residual current.
I_1	Positive sequence current.
I_2	Negative sequence current.
I2>	Negative sequence overcurrent protection (NPS element).
I2pol	Negative sequence polarizing current.
IA	**Phase A current:** Might be phase L1, red phase. or other, in customer terminology.
IB	**Phase B current:** Might be phase L2, yellow phase. or other, in customer terminology.
IbiasPh>Cur.	SDEF blocking bias current threshold.
IC	**Phase C current:** Might be phase L3, blue phase. or other, in customer terminology.
ID	**Abbreviation of "Identifier":** Often a label used to track a software version installed.
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.

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Symbols	Explanation
IDMT	**Inverse definite minimum time:** A characteristic whose trip time depends on the measured input (e.g. current) according to an inverse-time curve.
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.
IED	**Intelligent Electronic Device:** For example a MiCOM relay
In	**The rated nominal current of the relay:** Software selectable as 1 amp or 5 amps to match the line CT input.
IN	**Neutral current, or residual current:** This results from an internal summation of the three measured phase currents.
IN>	**A neutral (residual) overcurrent element:** Detects earth/ground faults.
IN>1	**First stage of ground overcurrent protection:** Could be labelled 51N-1 in ANSI terminology.
IN>2	**Second stage of ground overcurrent protection:** Could be labelled 51N-2 in ANSI terminology.
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.
Inh	An inhibit signal.
Inst.	**An element with "instantaneous" operation:** i.e. having no deliberate time delay.
ISEF>	Sensitive earth fault overcurrent element.
K1	Slope of the phase circuitry fault function.
K2	Slope of the differential phase element for all the zones.
KCZ	Slope of the differential phase element for the Check Zone.
KN1	Slope of the neutral circuitry fault function.
KN2	Slope of the differential neutral element for all the zones.
KNCZ	Slope of the differential neutral element for the Check Zone.
KZN	**The residual compensation factor:** Ensuring correct reach for ground distance elements.
LCD	**Liquid crystal display:** The front-panel text display on the relay.
LD	**Abbreviation of "Level Detector":** An element responding to a current or voltage below its set threshold.
LED	**Light emitting diode:** **Bicolour:** Red/black or green/black or orange/black indicator on the relay front-panel. **Tricolour:** Red/orange/green/black indicator on the relay front-panel.
MCB	**A "miniature circuit breaker":** Used instead of a fuse to protect VT secondary circuits.

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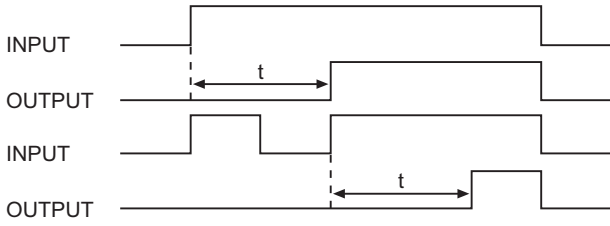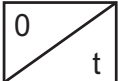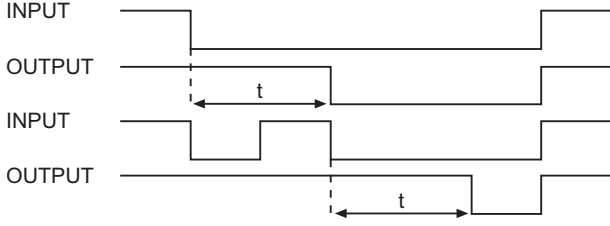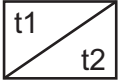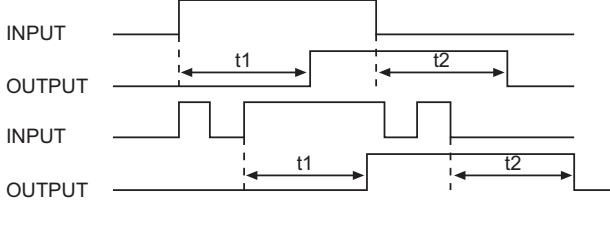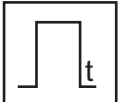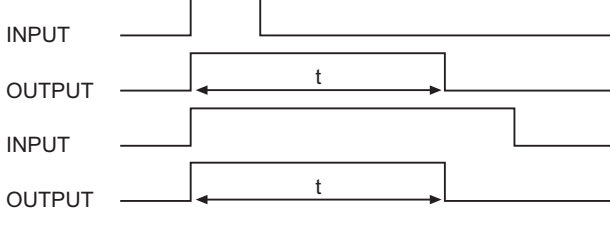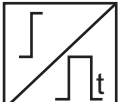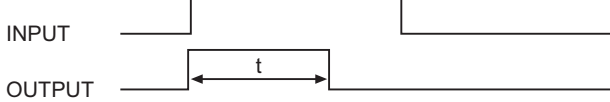
Symbols	Explanation
MICS	**Model Implementation Conformance Specification:** Defines the IEC 61850 data model implemented in an IED.
MMS	**Manufacturing Message Specification:** A protocol used to transport the data of IEC 61850 across an Ethernet network.
N	**Indication of "Neutral" involvement in a fault:** i.e. a ground (earth) fault.
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.
NIC	**Network Interface Card:** i.e. the Ethernet card of the IED
NPS	**Negative phase sequence.**
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/P	Abbreviation of "output".
Opto	**An optocoupled logic input:** Alternative terminology: binary input.
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.
PCB	Printed circuit board.
Ph	**Abbreviation of "Phase":** Used in distance settings to identify settings that relate to phase-phase faults.
PICS	**Protocol Implementation Conformance Specification:** Defines the IEC 61850 services implemented in an IED, with reference to the ACSI.
PN>	**Wattmetric earth fault protection:** Calculated using residual voltage and current quantities.
Pol	**Abbreviation of "Polarizing":** Typically the polarizing voltage used in making directional decisions.
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.
Qx	Isolator number x (from 1 to 6).
R	A resistance.

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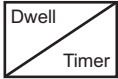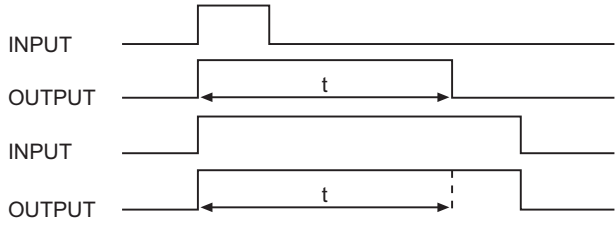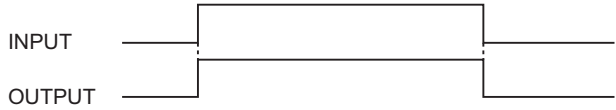
Symbols	Explanation
R Gnd.	**A distance zone resistive reach setting:** Used for ground (earth) faults.
RBN	Lead burden for the neutral.
RBPh	Lead burden for the phases.
RCA	**Abbreviation of "Relay Characteristic Angle":** The centre of the directional characteristic.
RCT	Current Transformer secondary resistance.
REF	Restricted earth fault protection.
Rev.	Indicates an element responding to a flow in the "reverse" direction.
RMS	**The equivalent a.c. current:** Taking into account the fundamental, plus the equivalent heating effect of any harmonics. Abbreviation of "root mean square".
RP	**Abbreviation of "Rear Port":** The communication ports on the rear of the relay.
Rx	**Abbreviation of "Receive":** Typically used to indicate a communication receive line/pin.
S1	**Used in IEC terminology to identify the secondary CT terminal polarity:** Replace by a dot when using ANSI standards.
S2	**Used in IEC terminology to identify the secondary CT terminal polarity:** The non-dot terminal.
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).
SDEF	Sensitive Differential Earth Fault Protection.
SEF	Sensitive Earth Fault Protection.
SSD	Solid State Device
T	A time delay.
TCS	Trip circuit supervision.
TD	**The time dial multiplier setting:** Applied to inverse-time curves (ANSI/IEEE).
TE	**A standard for measuring the width of a relay case:** One inch = 5TE units.
TMS	The time multiplier setting applied to inverse-time curves (IEC).
Tx	**Abbreviation of "Transmit":** Typically used to indicate a communication transmit line/pin.
V	Voltage.
V<	An undervoltage element.
V<1	**First stage of undervoltage protection:** Could be labelled 27-1 in ANSI terminology.

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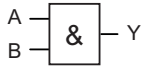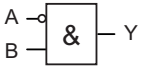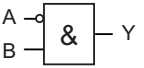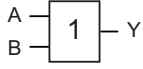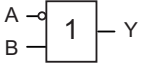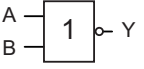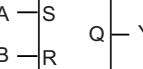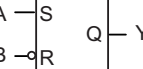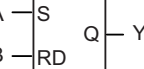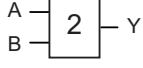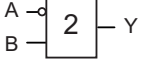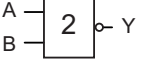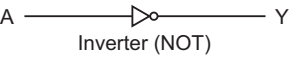
Symbols	Explanation
V<2	**Second stage of undervoltage protection:** Could be labelled 27-2 in ANSI terminology.
V>	An overvoltage element.
V>1	**First stage of overvoltage protection:** Could be labelled 59-1 in ANSI terminology.
V>2	**Second stage of overvoltage protection:** Could be labelled 59-2 in ANSI terminology.
V_0	**Zero sequence voltage:** Equals one third of the measured neutral/residual voltage.
V_1	Positive sequence voltage.
V_2	Negative sequence voltage.
V2pol	Negative sequence polarizing voltage.
VA	**Phase A voltage:** Might be phase L1, red phase. or other, in customer terminology.
VB	**Phase B voltage:** Might be phase L2, yellow phase. or other, in customer terminology.
VC	**Phase C voltage:** Might be phase L3, blue phase. or other, in customer terminology.
VCO	Voltage controlled overcurrent element.
Vk	IEC knee point voltage of a current transformer.
Vn	**The rated nominal voltage of the relay:** To match the line VT input.
VN	Neutral voltage displacement or residual voltage.
VN>1	First stage of residual (neutral) overvoltage protection.
VN>2	Second stage of residual (neutral) overvoltage protection.
Vres.	Neutral voltage displacement or residual voltage.
VT	Voltage transformer.
VTS	**Voltage transformer supervision:** To detect VT input failure.
Vx	**An auxiliary supply voltage:** Typically the substation battery voltage used to power the relay.
YN>	**Neutral overadmittance protection element:** Non-directional neutral admittance protection calculated from neutral current and residual voltage.
Z_0	Zero sequence impedance.
Z_1	Positive sequence impedance.
Z_2	Negative sequence impedance.

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Logic Timers

Logic Symbols	Explanation	Time Chart
t / 0	Delay on pick-up timer, t	
0 / t	Delay on drop-off timer, t	
t1 / t2	Delay on pick-up/drop-off timer	
Pulse timer symbol	Pulse timer	
Pulse pick-up falling edge symbol	Pulse pick-up falling edge	
Pulse pick-up raising edge symbol	Pulse pick-up raising edge	
Latching	Latch	

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Logic Symbols	Explanation	Time Chart
Dwell Timer	Dwell timer	INPUT OUTPUT t INPUT OUTPUT t
Straight	**Straight (non latching):** Hold value until input reset signal	INPUT OUTPUT

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Logic Gates

AND GATE

Symbol	Truth Table	Symbol	Truth Table	Symbol	Truth Table

AND gate (A, B → & → Y)

IN		OUT
0	1	0
0	1	0
0	1	0
1	0	0
1	1	1

AND gate with inverted A input (A –o, B → & → Y)

IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	0
1	1	0

AND gate with inverted A input (A –o, B → & → Y)

IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

OR GATE

OR gate (A, B → 1 → Y)

IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

OR gate with inverted A input (A –o, B → 1 → Y)

IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	0
1	1	1

OR gate with inverted output (A, B → 1 → o Y)

IN		OUT
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

R - S FLIP-FLOP

R-S flip-flop (A → S, B → R, Q → Y)

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

R-S flip-flop (A → S, B → o R, Q → Y)

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

R-S flip-flop (A → S, B → RD, Q → Y)

* RD = Reset Dominant

A	B	QN	QN+	Active Mode
0	0			Hold Mode
0	1			0
		0	1	Set
1	0	1		Hold Mode
1	1			0

EXCLUSIVE OR GATE

XOR gate (A, B → XOR → Y)

IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

XOR gate with inverted A input (A –o, B → XOR → Y)

IN		OUT
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

XOR gate with inverted output (A, B → XOR → o Y)

IN		OUT
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

MULTI INPUT GATE

Multi input gate (A, B → 2 → Y)

IN		OUT
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

Multi input gate with inverted A input (A –o, B → 2 → Y)

IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	0
1	1	0

Multi input gate with inverted output (A, B → 2 → o Y)

IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

NOT GATE

Symbol	Truth Table

A ———▷o——— Y
Inverter (NOT)

IN	OUT
A	Y
0	1
1	0

SG

INSTALLATION

Date:	**2008**
Hardware Suffix:	**K**
Software Version:	**01**
Connection Diagrams:	**10P746xx (xx = 01 to 07)**

IN

CONTENTS

IN

IN

1. RECEIPT OF RELAYS

Protective relays, although generally of robust construction, require careful treatment prior to installation on site. On 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 Alstom Grid 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.

Section 3 of this chapter gives more information about the storage of relays.

IN

2.   HANDLING OF ELECTRONIC EQUIPMENT

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 relay's electronic circuits 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 unnecessarily.

Each printed circuit board incorporates the highest practicable protection for its semiconductor devices. However, if it becomes necessary to remove a printed circuit board, the following precautions should be taken to preserve the high reliability and long life for which the relay has been designed and manufactured.

1.   Before removing a printed circuit board, ensure that you are at the same electrostatic potential as the equipment by touching the case.

2.   Handle analogue input modules by the front panel, frame or edges of the circuit boards. Printed circuit boards should only be handled by their edges. Avoid touching the electronic components, printed circuit tracks or connectors.

3.   Do not pass the module to another person without first ensuring you are both at the same electrostatic potential. Shaking hands achieves equipotential.

4.   Place the module on an anti-static surface, or on a conducting surface which is at the same potential as yourself.

5.   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 BS EN 100015: Part 1:1992. 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 British Standard document.

IN

3.   STORAGE

If relays are not to be installed immediately on 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.

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.

> 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.

IN

5. 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 (GN0037 001) and 60TE (GN0038 001). Note that the 60TE cover also fits the 80TE case size of the relay.

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 P991 or MMLG test block is to be included, it is recommended that, when viewed from the front, it is positioned on the right-hand side of the relay (or relays) with which it is associated. 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.
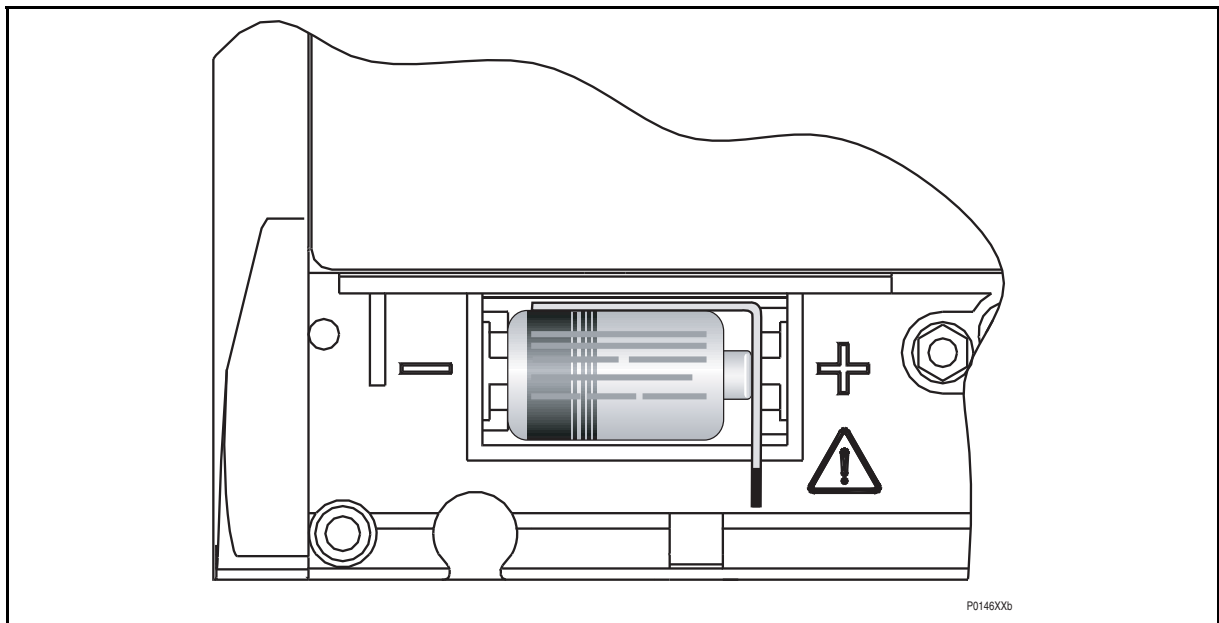
FIGURE 1: LOCATION OF BATTERY ISOLATION STRIP

If it is necessary 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 Figure 1, i.e. with the strip behind the battery with the red tab protruding.

IN

5.1   Rack mounting

MiCOM relays may be rack mounted using single tier rack frames (our part number FX0121 001), as illustrated in Figure 2. These frames have been designed to have dimensions in accordance with IEC60297 and are supplied pre-assembled ready to use. On a standard 483mm (19") rack system this enables combinations of widths of case 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 26mm intervals and the relays are attached via their mounting flanges using M4 Taptite self-tapping screws with captive 3mm thick washers (also known as a SEMS unit). These fastenings are available in packs of 5 (our part number ZA0005 104).

> Note: Conventional self-tapping screws, including those supplied for mounting MIDOS relays, have marginally larger heads which can damage the front cover moulding if used.

Once the tier is complete, the frames are fastened into the racks using mounting angles at each end of the tier.
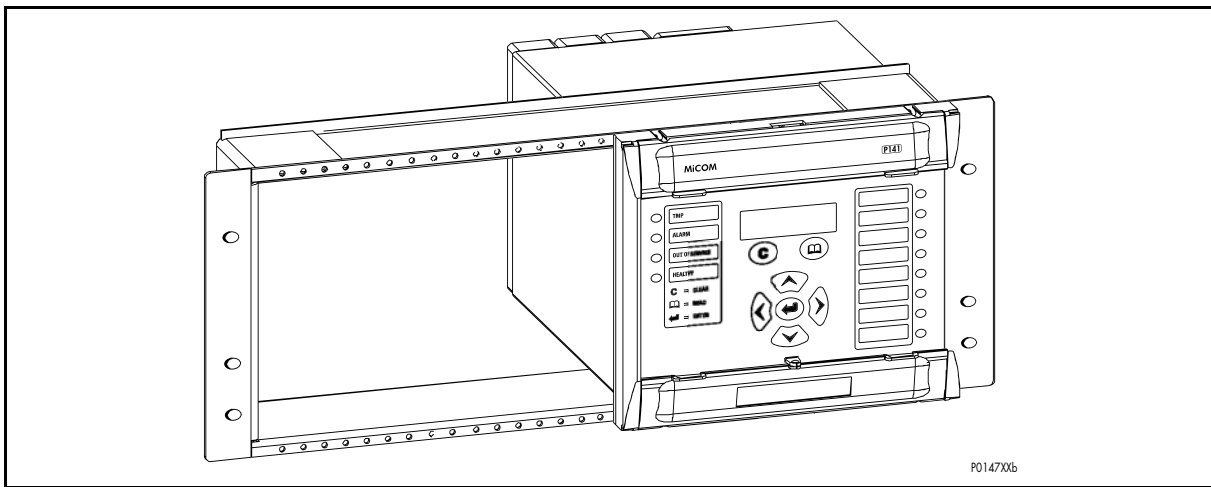
FIGURE 2: RACK MOUNTING OF RELAYS

Relays can be mechanically grouped into single tier (4U) or multi-tier arrangements by means of the rack frame. This enables schemes using products from the MiCOM and MiDOS product ranges to be pre-wired together prior to mounting.

Where the case size summation is less than 80TE on any tier, or space is to be left for installation of future relays, blanking plates may be used. These plates can also be used to mount ancillary components. Table 1 shows the sizes that can be ordered.

Further details on mounting MiDOS relays can be found in publication R7012, "MiDOS Parts Catalogue and Assembly Instructions".

Case size summation	Blanking plate part number
5TE	GJ2128 001
10TE	GJ2128 002
15TE	GJ2128 003
20TE	GJ2128 004
25TE	GJ2128 005
30TE	GJ2128 006
35TE	GJ2128 007
40TE	GJ2128 008

TABLE 1: BLANKING PLATES

5.2   Panel mounting

The relays can be flush mounted into panels using M4 SEMS Taptite self-tapping screws with captive 3mm thick washers (also known as a SEMS unit).

These fastenings are available in packs of 5 (our part number ZA0005 104).

> Note: Conventional self-tapping screws, including those supplied for mounting MIDOS relays, have marginally larger heads which can damage the front cover moulding if used.

Alternatively tapped holes can be used if the panel has a minimum thickness of 2.5mm.

For applications where relays need to be semi-projection or projection mounted, a range of collars are available.

Where several relays are to mounted in a single cut-out in the panel, it is advised that they are mechanically grouped together horizontally and/or vertically to form rigid assemblies prior to mounting in the panel.

> Note: It is not advised that MiCOM relays are fastened using pop rivets as this will not allow the relay to be easily removed from the panel in the future if repair is necessary.

If it is required to mount a relay assembly on a panel complying to BS EN60529 IP52, it will be necessary to fit a metallic sealing strip between adjoining relays (Part no GN2044 001) and a sealing ring selected from Table 2 around the complete assembly.

Width	Single tier	Double tier
10TE	GJ9018 002	GJ9018 018
15TE	GJ9018 003	GJ9018 019
20TE	GJ9018 004	GJ9018 020
25TE	GJ9018 005	GJ9018 021
30TE	GJ9018 006	GJ9018 022
35TE	GJ9018 007	GJ9018 023
40TE	GJ9018 008	GJ9018 024
45TE	GJ9018 009	GJ9018 025
50TE	GJ9018 010	GJ9018 026
55TE	GJ9018 011	GJ9018 027
60TE	GJ9018 012	GJ9018 028
65TE	GJ9018 013	GJ9018 029
70TE	GJ9018 014	GJ9018 030
75TE	GJ9018 015	GJ9018 031
80TE	GJ9018 016	GJ9018 032

TABLE 2: IP52 SEALING RINGS

Further details on mounting MiDOS relays can be found in publication R7012, "MiDOS Parts Catalogue and Assembly Instructions".

IN

6.   RELAY WIRING

⚠ **Before carrying out any work on the equipment, the user should be familiar with the contents of the Safety Section or Safety Guide SFTY/4LM/H11 or later issue, the Technical Data chapter and the ratings on the equipment rating label."**

6.1   Medium and heavy duty terminal block connections

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, Alstom Grid can supply M4 90° crimp ring terminals in three different sizes depending on wire size (see Table 3). 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*

TABLE 3: M4 90° CRIMP RING TERMINALS

*   To maintain the terminal block insulation requirements for safety, an insulating sleeve should be fitted over the ring terminal after crimping.

The following minimum wire sizes are recommended:

−   Current Transformers $2.5mm^2$

−   Auxiliary Supply, Vx $1.5mm^2$

−   RS485 Port   See separate section

−   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 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.

6.2   RS485 port

Connections to the RS485 port are made using ring terminals. It is recommended that a 2 core screened cable is used 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

IN

6.3 IRIG-B connections

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.

6.4 RS232 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.

6.5 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.

6.6 Earth connection

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.

Before carrying out any work on the equipment, the user should be familiar with the contents of the Safety Section or Safety Guide SFTY/4LM/H11 or later issue, the Technical Data chapter and the ratings on the equipment rating label."

IN
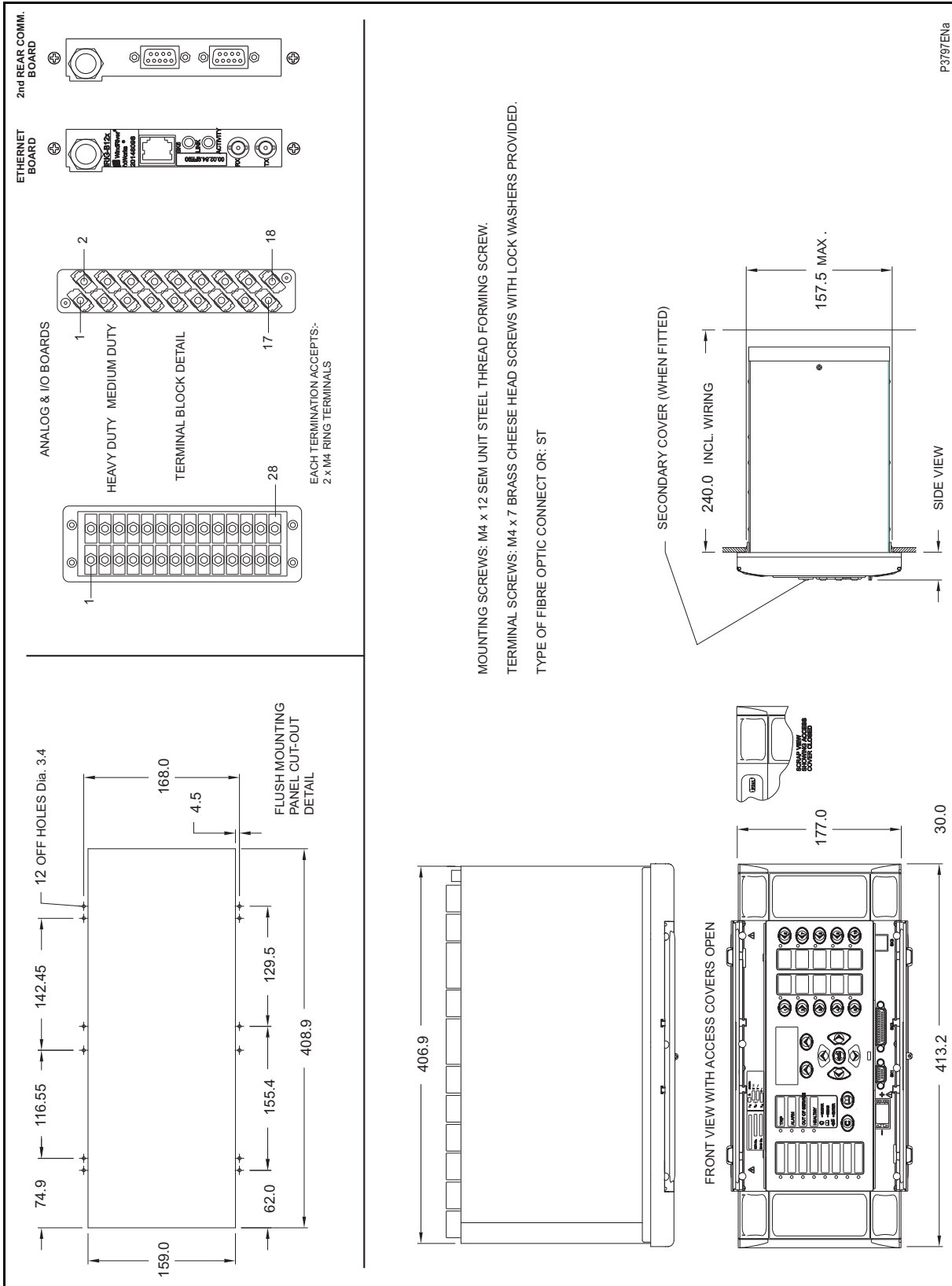
7.   MiCOM P746

FIGURE 3: MiCOM P746 (80TE) – HARDWARE DESCRIPTION
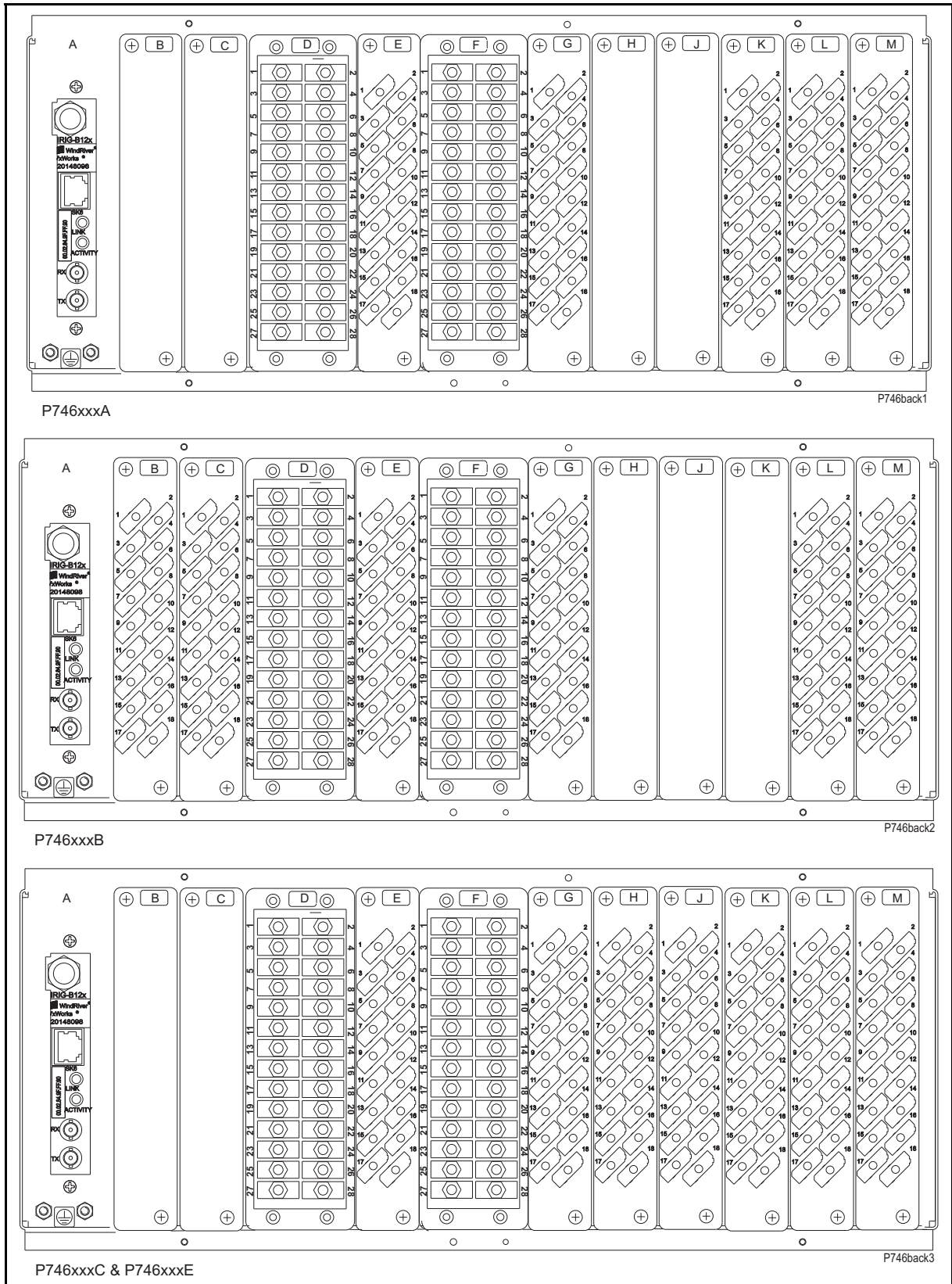
P746xxxA

P746back1

P746xxxB

P746back2

P746xxxC & P746xxxE

P746back3

IN

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

FIGURE 4: MiCOM P746 (80TE) – REAR VIEW
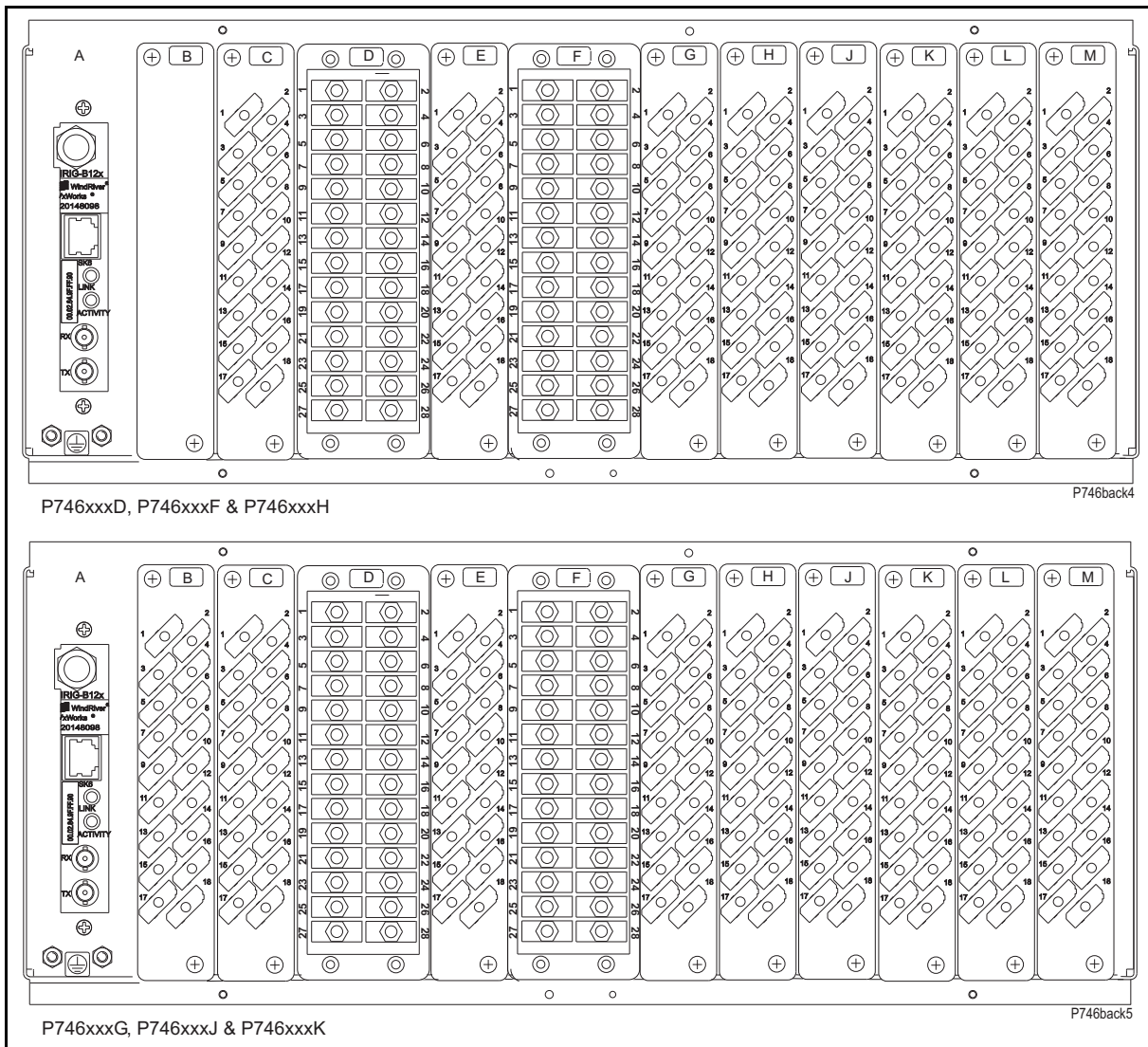
P746xxxD, P746xxxF & P746xxxH

P746xxxG, P746xxxJ & P746xxxK

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

FIGURE 5: MiCOM P746 (80TE) – REAR VIEW

IN
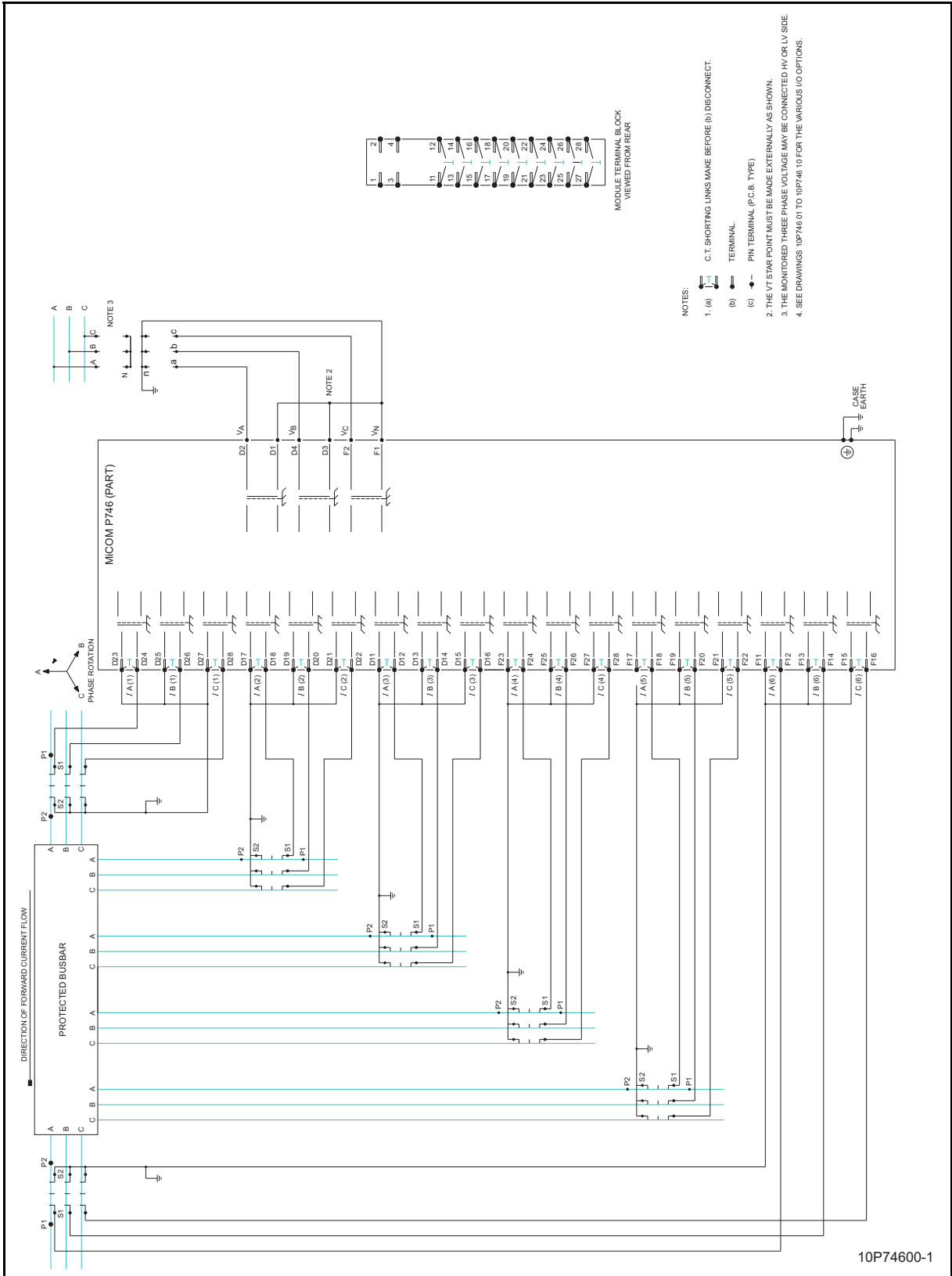
FIGURE 6: MiCOM P746 (80TE) – CONNECTION DIAGRAM 1/2
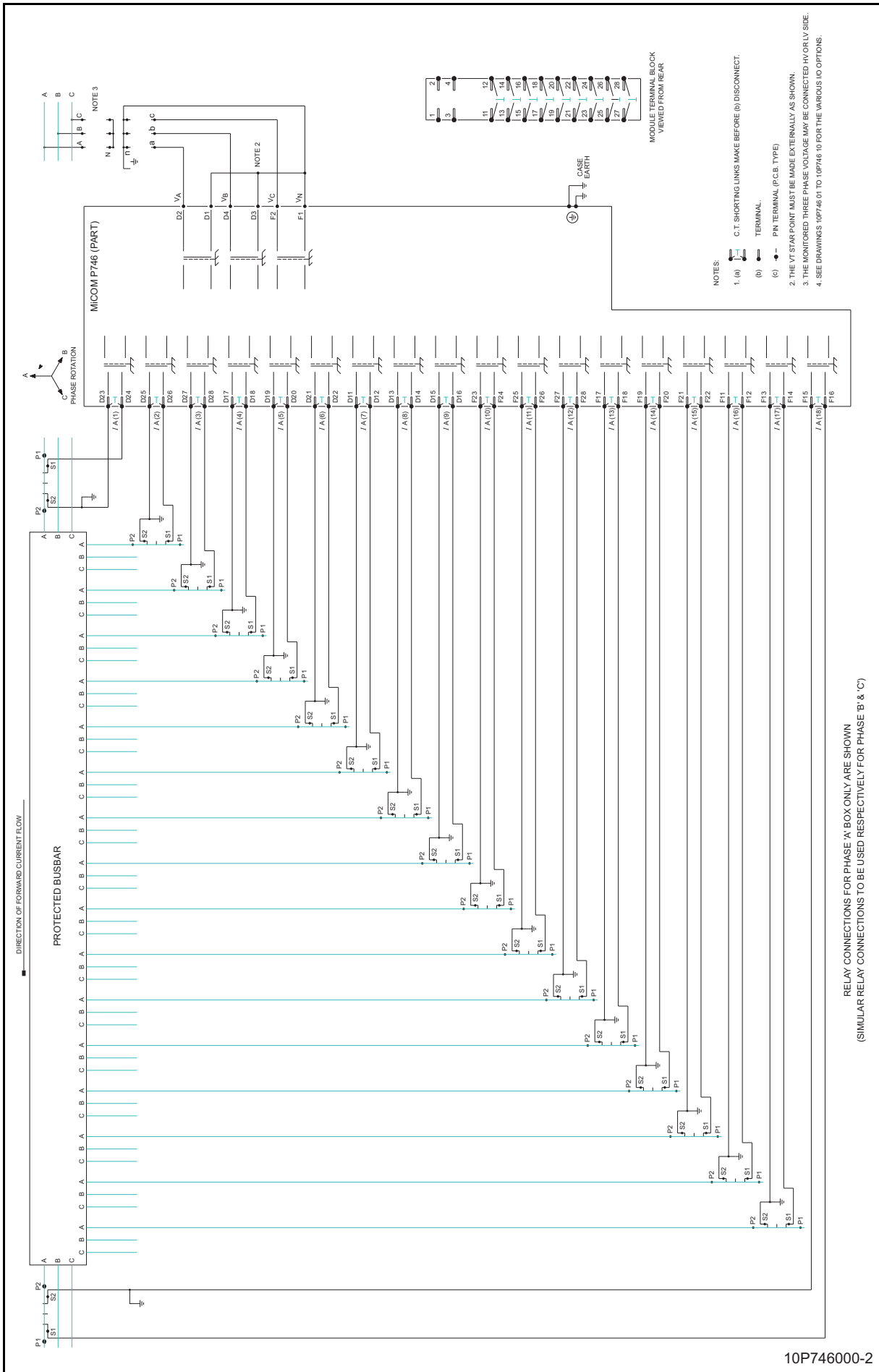
FIGURE 7: MiCOM P746 (80TE) – CONNECTION DIAGRAM 2/2
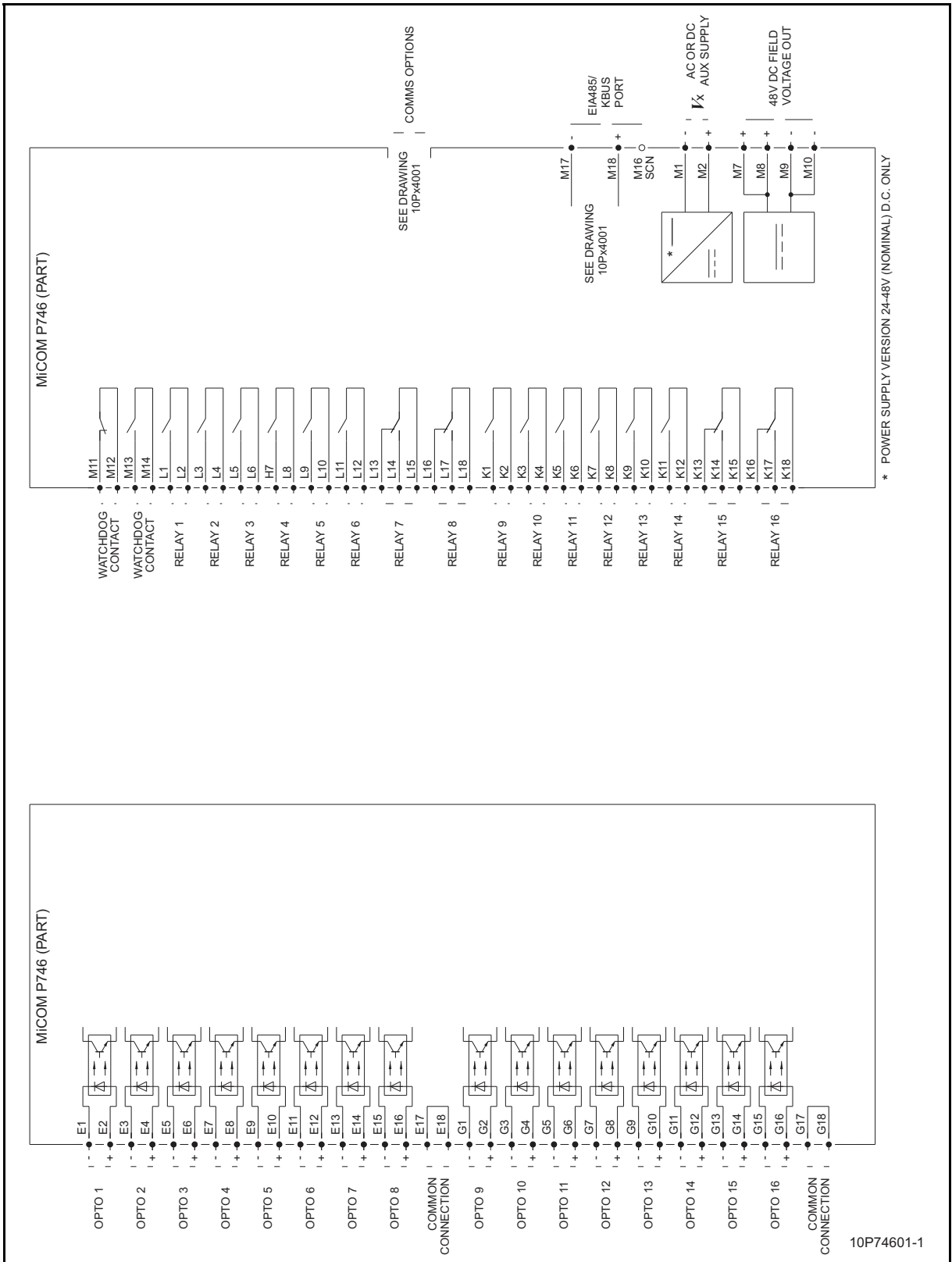
FIGURE 8: MiCOM P746 (80TE) – WIRING DESCRIPTION (P746xxxA)
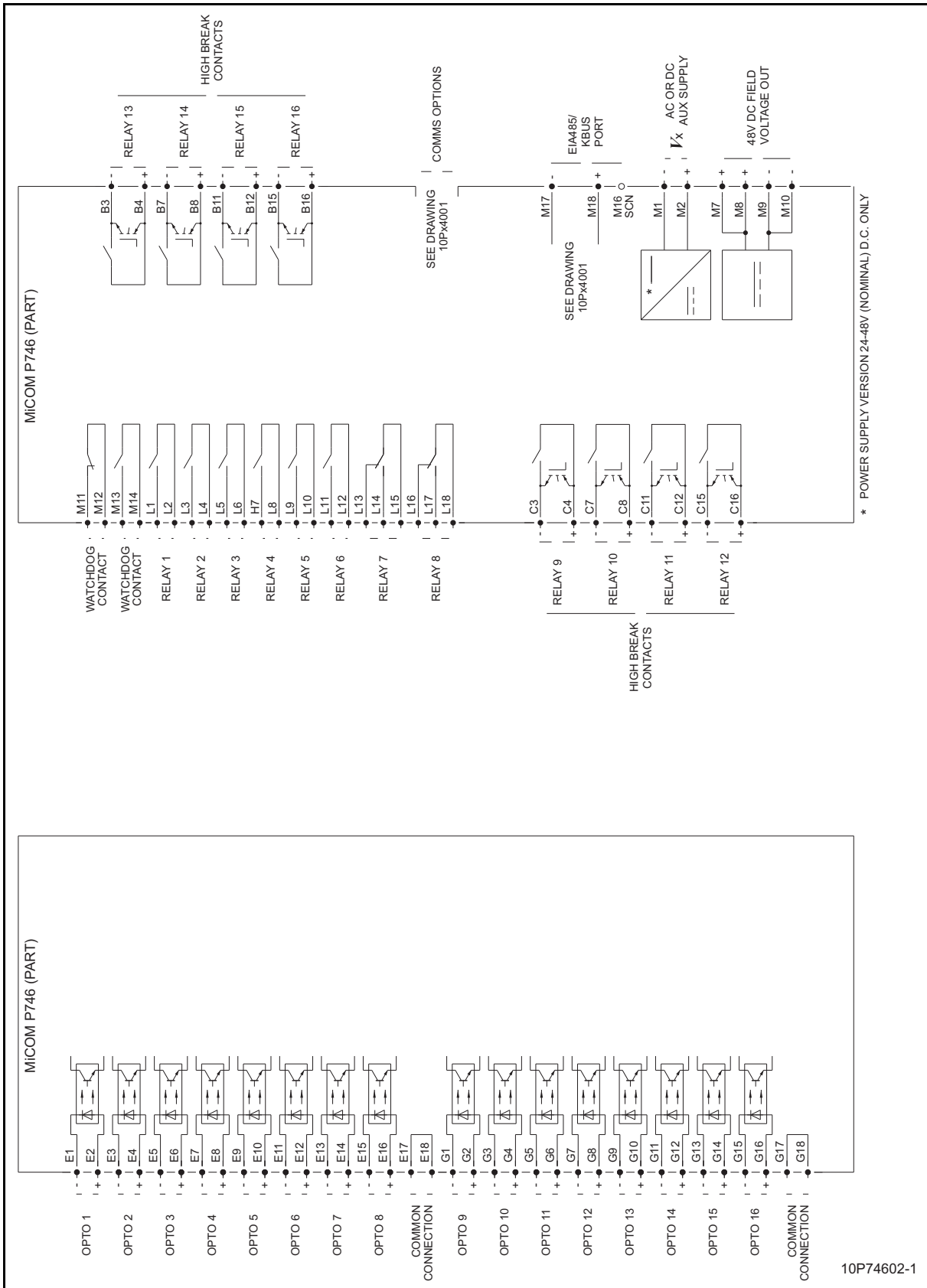
FIGURE 9: MiCOM P746 (80TE) – WIRING DESCRIPTION (P746xxxB)
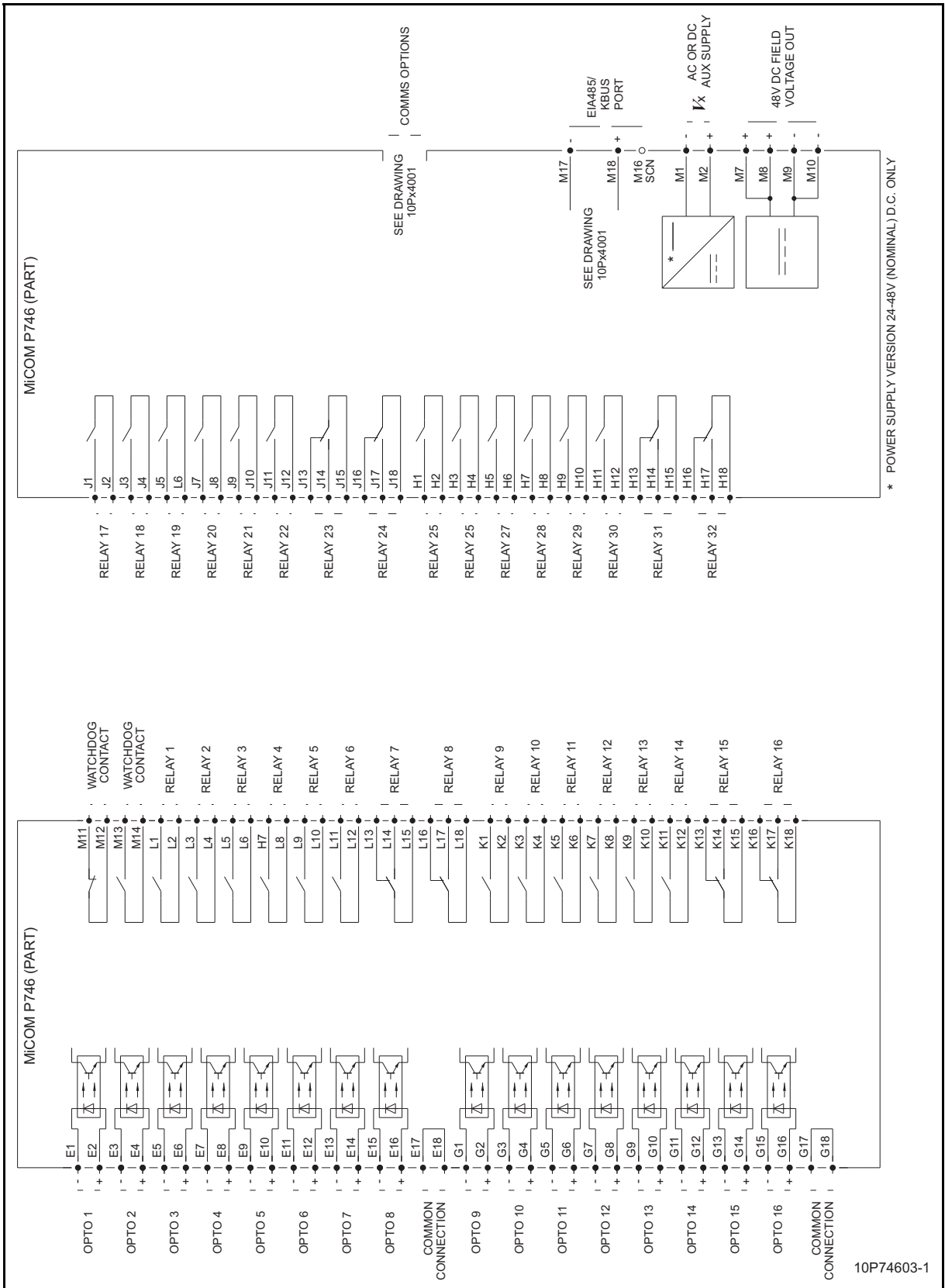
FIGURE 10: MiCOM P746 (80TE) – WIRING DESCRIPTION (P746xxxC)

IN
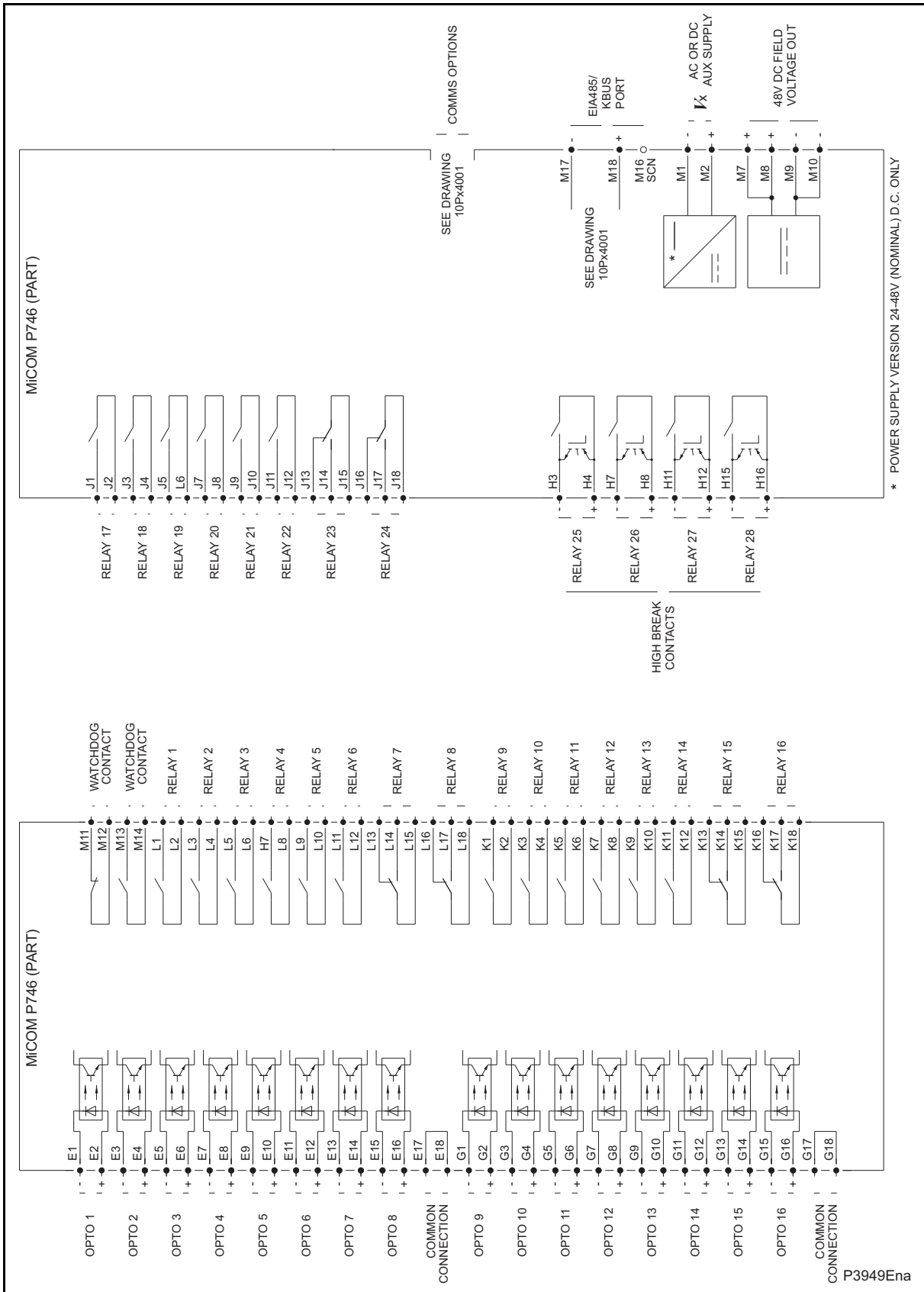
FIGURE 11: MiCOM P746 (80TE) – WIRING DESCRIPTION (P746xxxD)
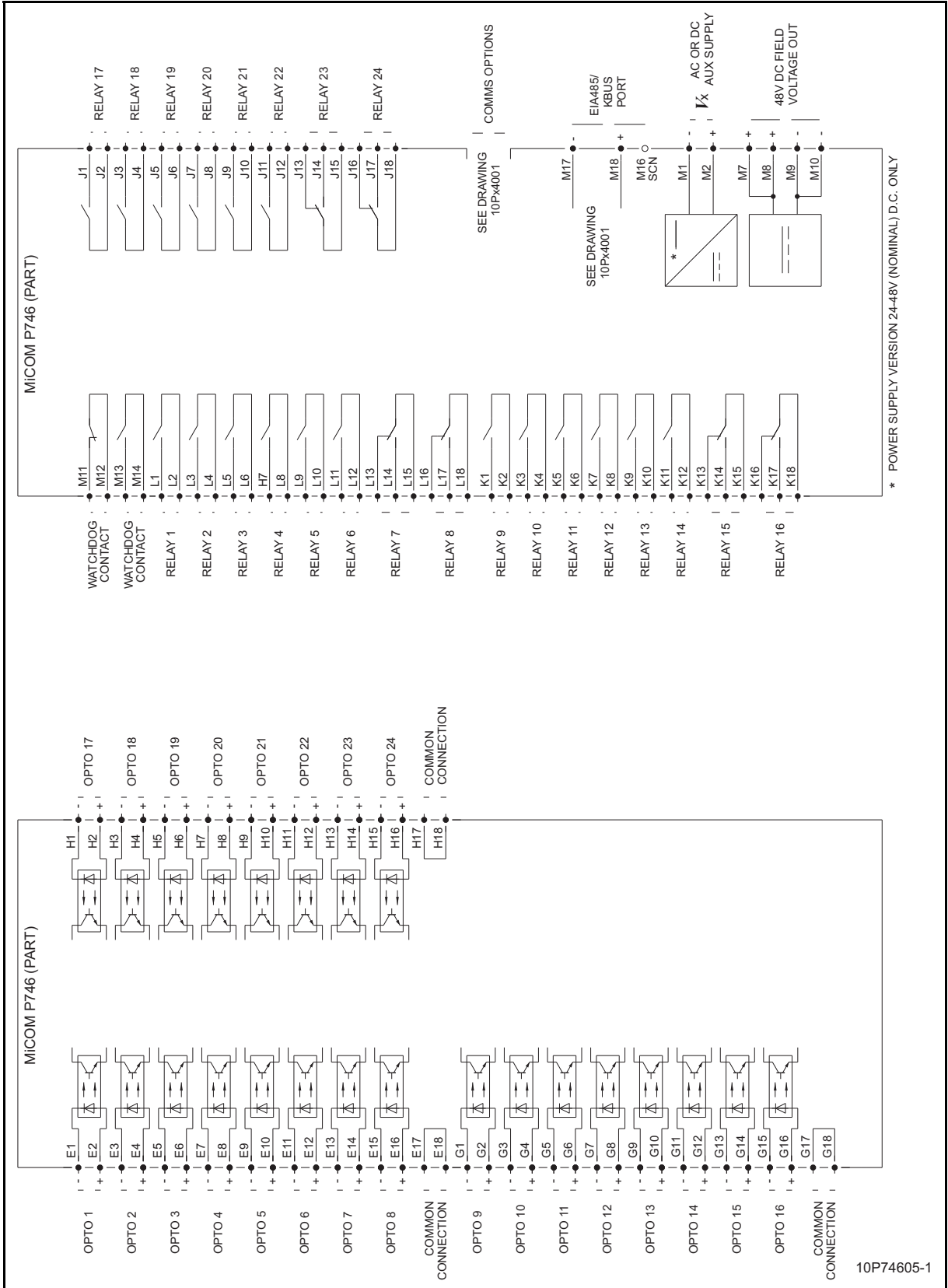
FIGURE 12: MiCOM P746 (80TE) – WIRING DESCRIPTION (P746xxxE)
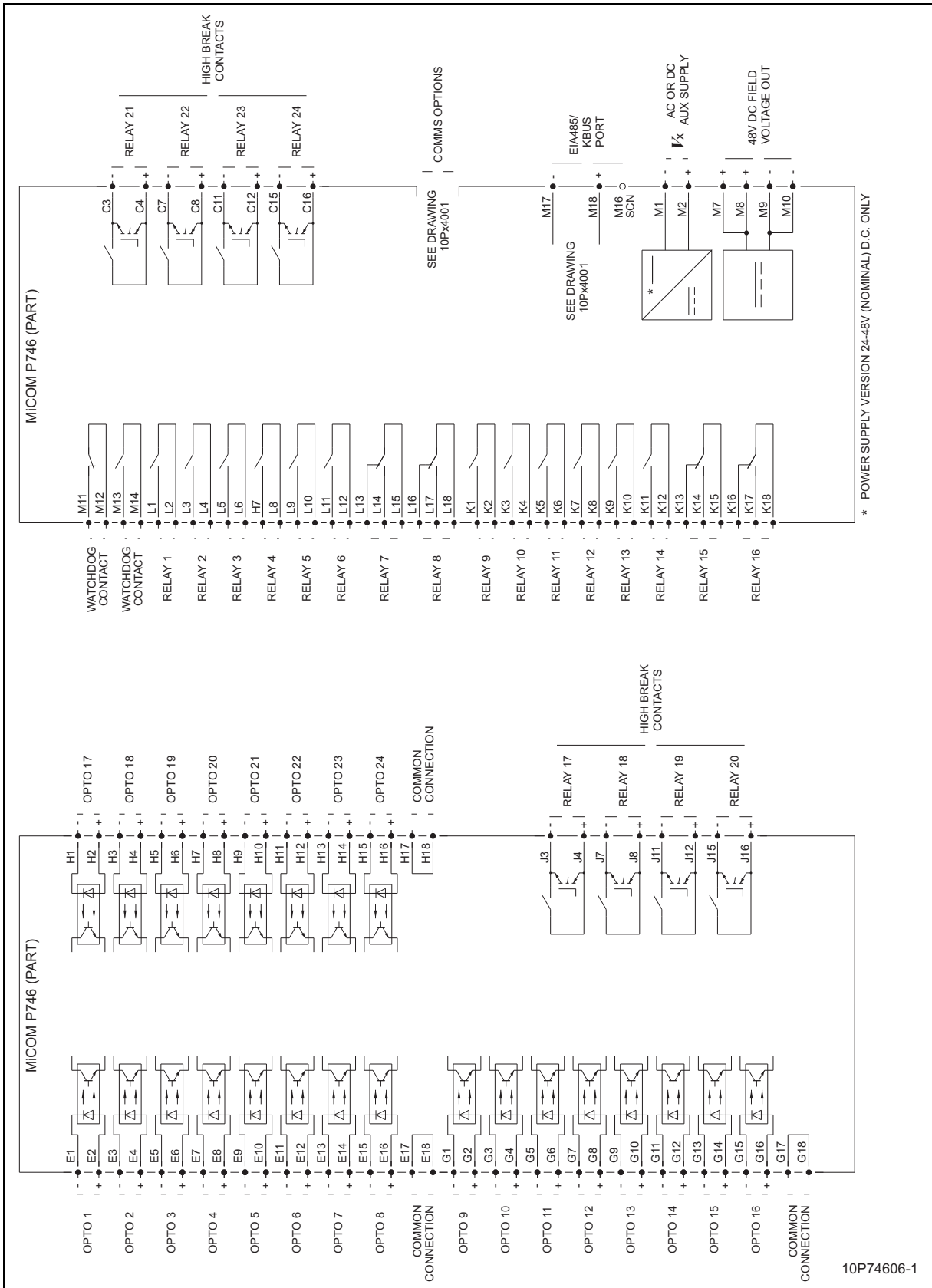
FIGURE 13: MiCOM P746 (80TE) – WIRING DESCRIPTION (P746xxxF)

10P74606-1

IN
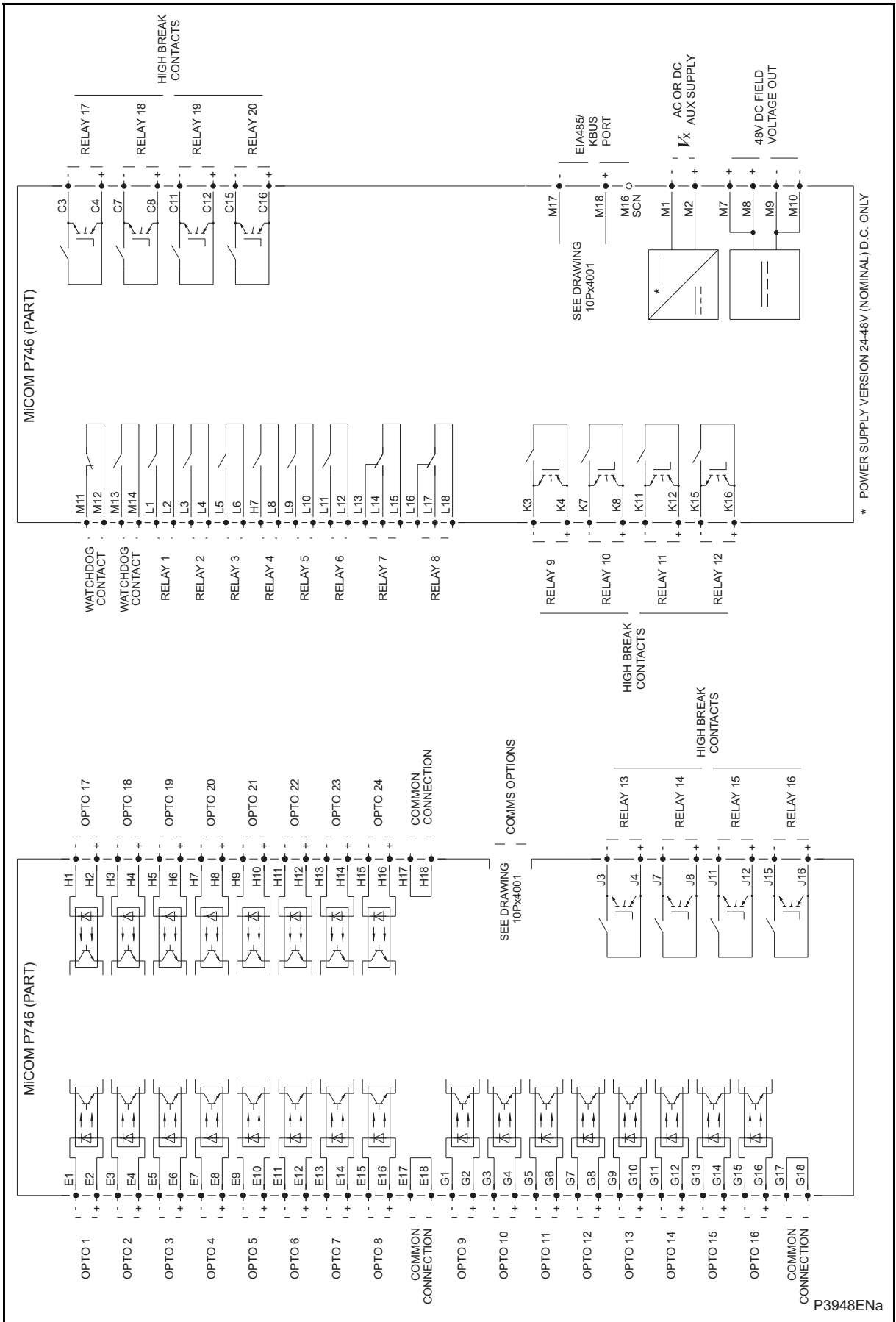
FIGURE 14: MiCOM P746 (80TE) – WIRING DESCRIPTION (P746xxxG)

FIGURE 15: MiCOM P746 (80TE) – WIRING DESCRIPTION (P746xxxH)
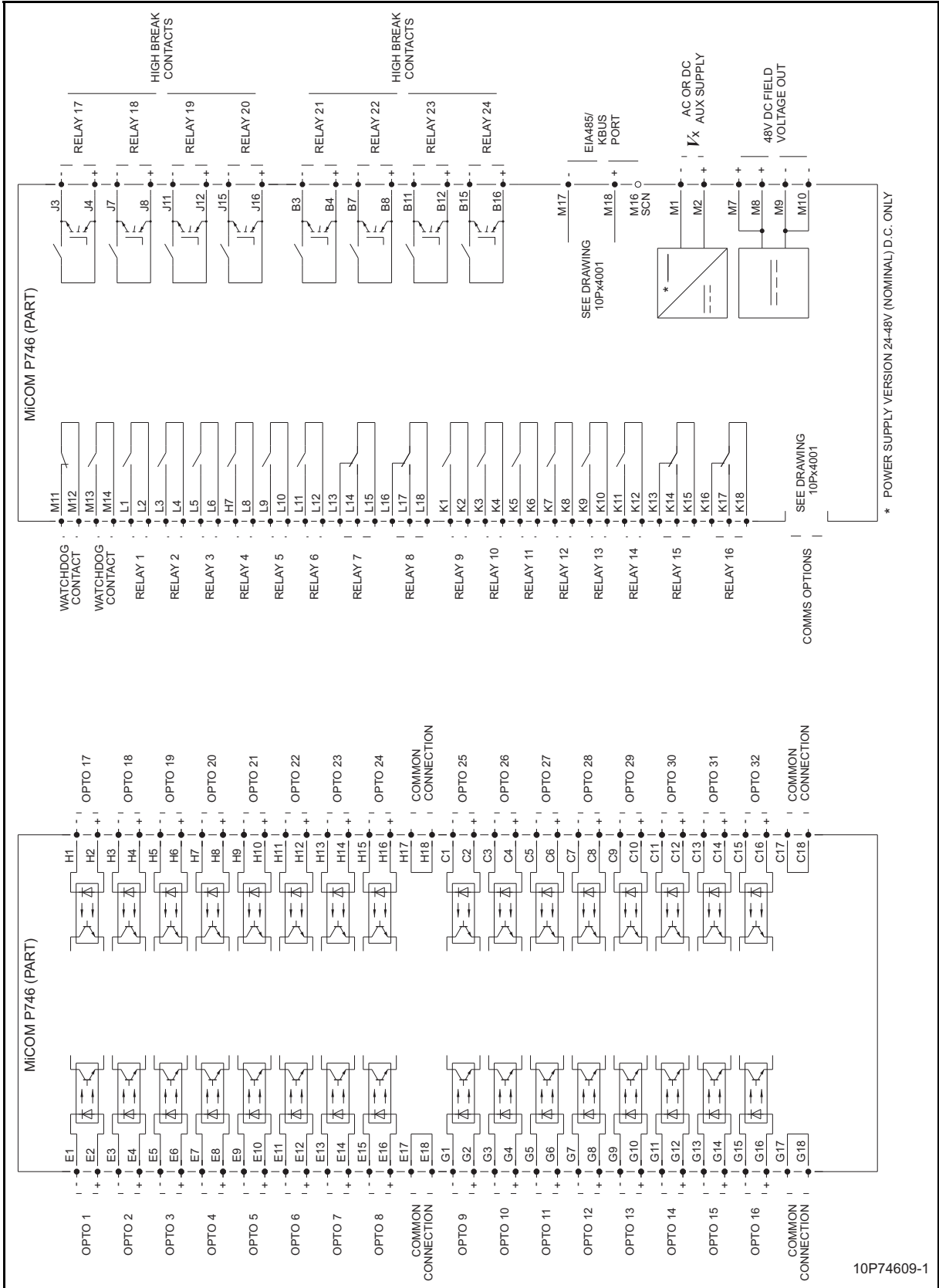
FIGURE 16: MiCOM P746 (80TE) – WIRING DESCRIPTION (P746xxxJ)

IN
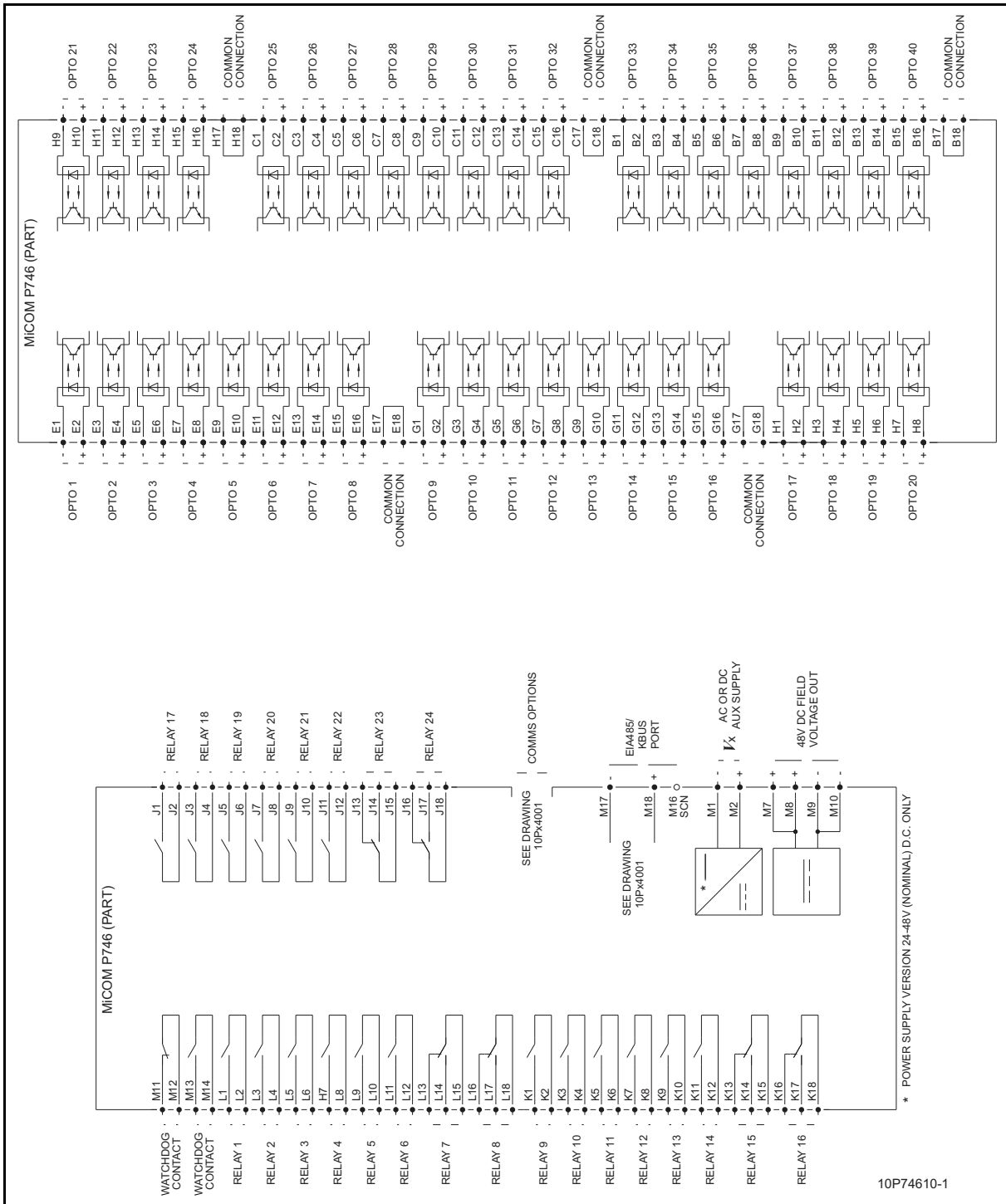
FIGURE 17: MiCOM P746 (80TE) – WIRING DESCRIPTION (P746xxxK)

8. COMMUNICATION OPTIONS
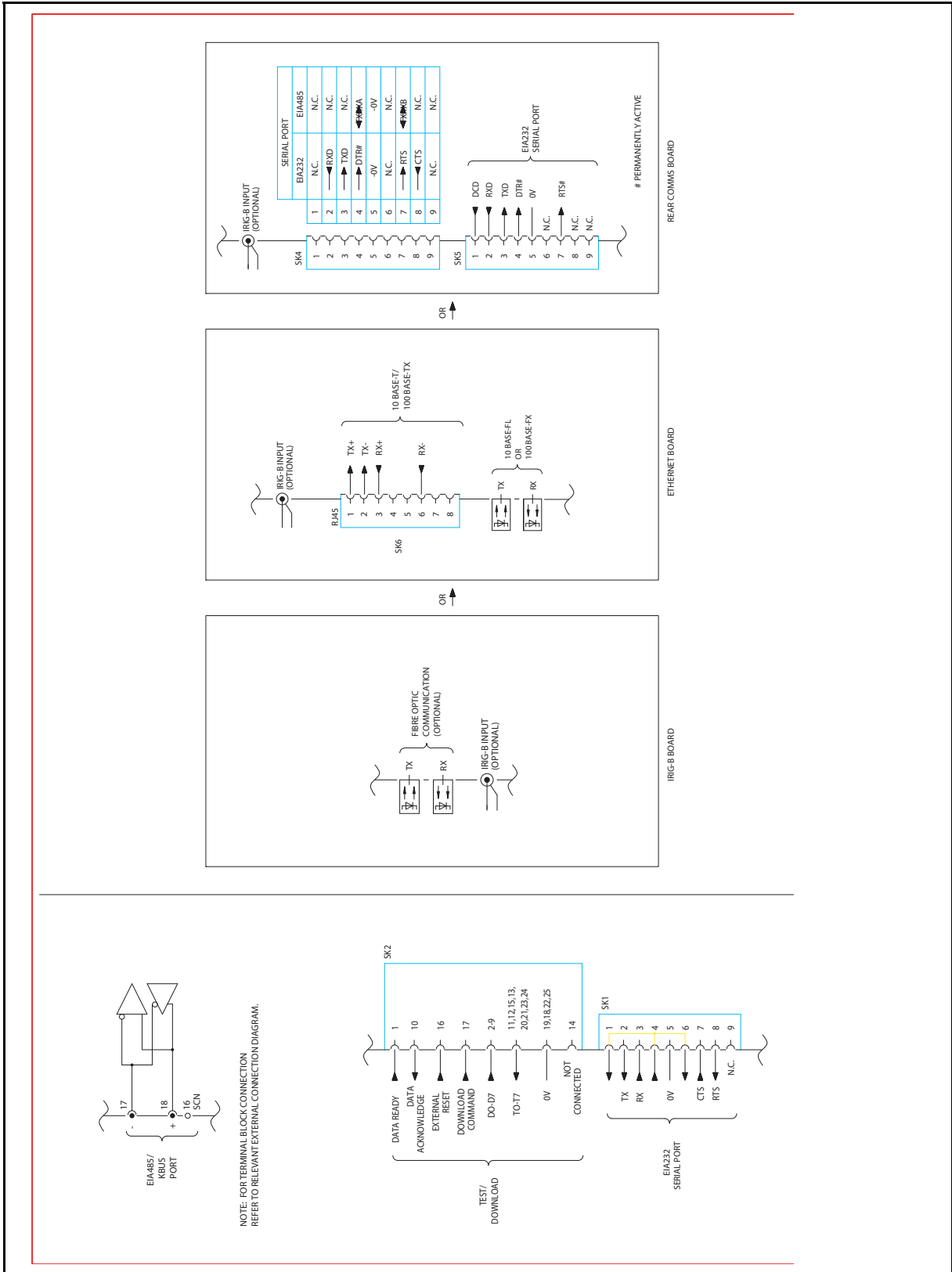
FIGURE 18: MiCOM P746 (80TE) – COMMUNICATION OPTIONS

IN

REMOTE HMI

Date:	**2008**
Hardware Suffix:	**K**
Software Version:	**01**
Connection Diagrams:	**10P746xx (xx = 01 to 07)**

HI

CONTENTS

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HI

1. INTRODUCTION

The MiCOM P746 Remote HMI is an application that is used to define/create scheme and display the P746 measured data.

The MiCOM P746 Remote HMI application operated in two modes:

− Scheme Editor: This mode allows the user to define a scheme for P746 unit with the predefined Busbars, Tie Groups and Feeder Groups.

− Dynamic Synoptic: This tool is used to display the P746 measured analogue quantities and DDB (Digital Data Bus) status information based on the scheme designed in Scheme Editor mode.

1.1 System requirements

Pre Requisite: Microsoft Dot net version 2.0 Redistribution software package or higher.

Supported Operating System: Microsoft Windows 2000, Microsoft Windows XP Professional with Service Pack 2 or Microsoft Windows XP Home with Service Pack 2 or Microsoft Windows Vista.

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2.   COMMUNICATION SETTINGS

−   MiCOM P746 Remote HMI Application supports communicating with P746 relay through SERIAL COM port and ETHERNET TUNNELING.

−   The settings for these communications can be selected before communicating with P746 in Scheme Editor or Dynamic Synoptic mode.

−   The selected communication option and their settings will be displayed in the left side of the Status Bar always.

Schemes for Communication Setup:

−   There are 3 possible schemes allowed for Communication Setup, namely FRONT SERIAL, REAR SERIAL and ETHERNET.

−   The required scheme can be selected from the list of schemes and their respective settings can be modified.

−   The "Restore Defaults" option can be used to restore the default values for the currently selected scheme.

2.1   SERIAL settings

The following settings can be set for the schemes "FRONT SERIAL" and "REAR SERIAL" to communicate with P746 through SERIAL COM port.

− COM port: The list of COM ports available in the system will be displayed. Select the port to which P746 is connected.

− Baud Rate: Select the Baud Rate to be used. The options are 19200 and 9600.

− Framing: Framing determines how many bits there are in a character and what the bits are used for. This includes the number of start bits, the number of data bits, the number and type of parity bits (none, odd or even) and the number of stop bits. A 10 bit frame contains 1 start bit, 8 data bits and 1 stop bit. An 11 bit frame contains 1 start bit, 8 data bits, 1 even parity bit and 1 stop bit. This option is not enabled for "FRONT SERIAL" scheme.

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– Transaction Values: Busy Hold-off Time, Busy Count, Reset Response Time, Response Time, Retry Count, Transmit Delay Time and Global Transmit Time.

2.2 ETHERNET settings

The following settings can be set for "ETHERNET" communication.

− IP Address (Mandatory): Set the IP address though which P746 can be connected.

− TCP Port number (Optional): Select this option if specific ETHERNET TCP port has to be used. If this option is not selected, default ETHERNET port 0 will be used.

− Bay Address (Optional): Select this option if P746 is connected though a Bay Unit and set the Bay Unit's address.

– Transaction Values: Busy Hold-off Time, Busy Count, Reset Response Time, Response Time, Retry Count, Transmit Delay Time and Global Transmit Time.

2.3 Miscellaneous

Device Address Settings:

– Set the Device Address of P746 this is to be connected.

3. SCHEME EDITOR

The Scheme Editor window is used to design the scheme for the P746 Relay using Busbar, Feeder Group and Tie Group graphical icons.

The Main Window is composed of following parts:

- The Menu Bar

- A Toolbar

- Toolbox

- Scheme Design Window
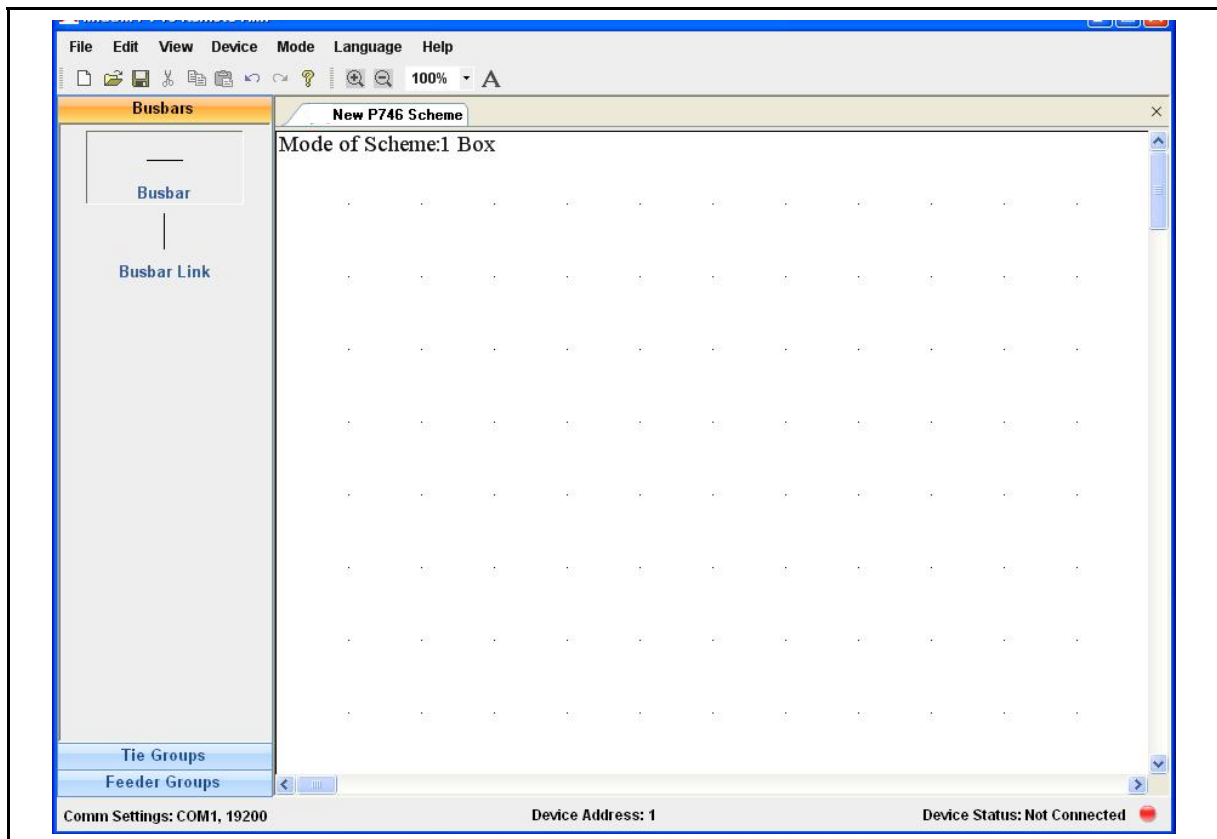
3.1   Principle of operation

A library of predefined symbols allows the scheme to be created. This library is located in the form of toolbox located in the left side of the main window. These symbols can be easily dragged and dropped into the Scheme Window.

The initial drag and drop placement of an object onto the scheme editor page will not be possible if the 'grey imaginary boundary box' of such an object is touching or overlapping with another object already placed on the page.
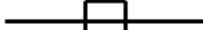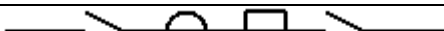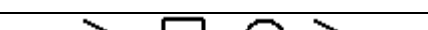
The symbols provided in the toolbox are described below:
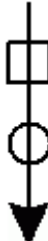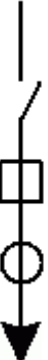
Busbar Toolbox:
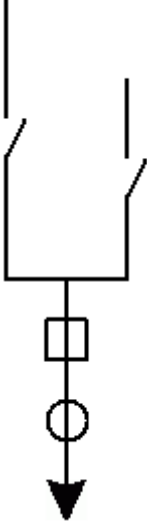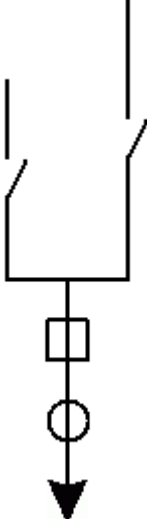
S. No	Name	Icon
1	Busbar Left	————
3	Busbar Link	│

Tie Groups Toolbox:
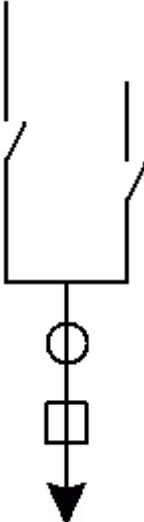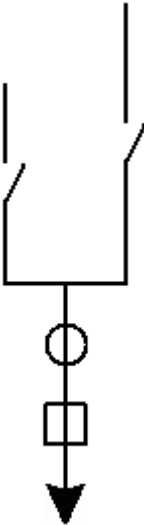
S. No	Tie Group Name	Tie Group Icon
1	Tie Group 1	
2	Tie Group 2	
3	Tie Group 3	
4	Tie Group 4	
5	Tie Group 5	
6	Tie Group 6	
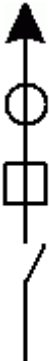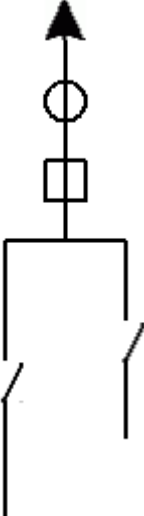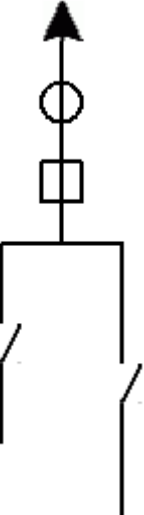
Feeder Groups Toolbox:
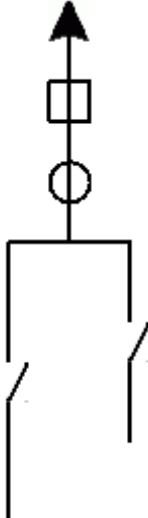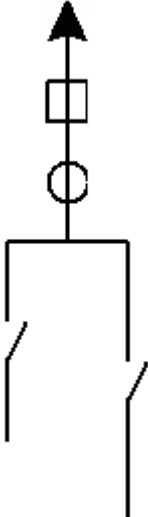
S. No	Feeder Group Name	Feeder Group Icon
1	Feeder Group 1	
2	Feeder Group 2	
3	Feeder Group 3	

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S. No	Feeder Group Name	Feeder Group Icon
4	Feeder Group 4	
5	Feeder Group 5	
6	Feeder Group 6	

S. No	Feeder Group Name	Feeder Group Icon
7	Feeder Group 7	
8	Feeder Group 8	
9	Feeder Group 9	
10	Feeder Group 10	

HI

S. No	Feeder Group Name	Feeder Group Icon
11	Feeder Group 11	
12	Feeder Group 12	
13	Feeder Group 13	
14	Feeder Group 14	

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S. No	Feeder Group Name	Feeder Group Icon
15	Feeder Group 15	
16	Feeder Group 16	

3.2 Constraints

- Number of maximum Busbars to be created in the scheme is restricted to 2.

- Only one Tie group can be created in the scheme.

- The initial drag and drop placement of an object onto the scheme editor page will not be possible if the 'grey imaginary boundary box' of such an object is touching or overlapping with another object already placed on the page.

- Feeder Group cannot be created before creating at-least one busbar in the scheme.

- The Feeder group and Tie group components can not be resized.

- Number of Feeder groups that can be created is restricted to 6 in 1 box mode and 18 in 3 box mode.

- If vertical Busbar links are used within a scheme then they must be applied to both Busbar ends, i.e. zone 1 and zone 2.

- Objects that are placed within a scheme must be placed with sufficient space to allow measurements to be displayed when in the dynamic synoptic mode.

HI

3.3   **Designing the scheme**

3.3.1   Creating a new blank scheme

- Select File-> New menu or New icon in the toolbar. "Select Scheme Mode" window appears as shown below:
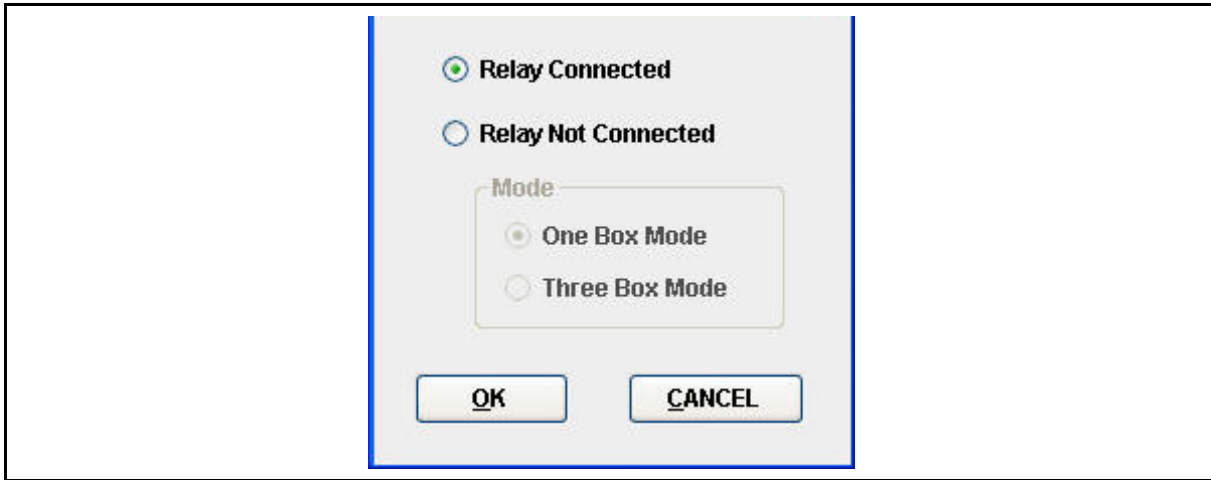
- If P746 relay is connected, select "Relay Connected" option and press "OK" button. The P746 mode will be retrieved from P746 and a new scheme will be created. Otherwise select "Relay Not connected" option, select "One Box Mode" or "3 Box Mode" and click "OK'" button to create a new scheme. In both cases the newly created scheme will be displayed as shown below:
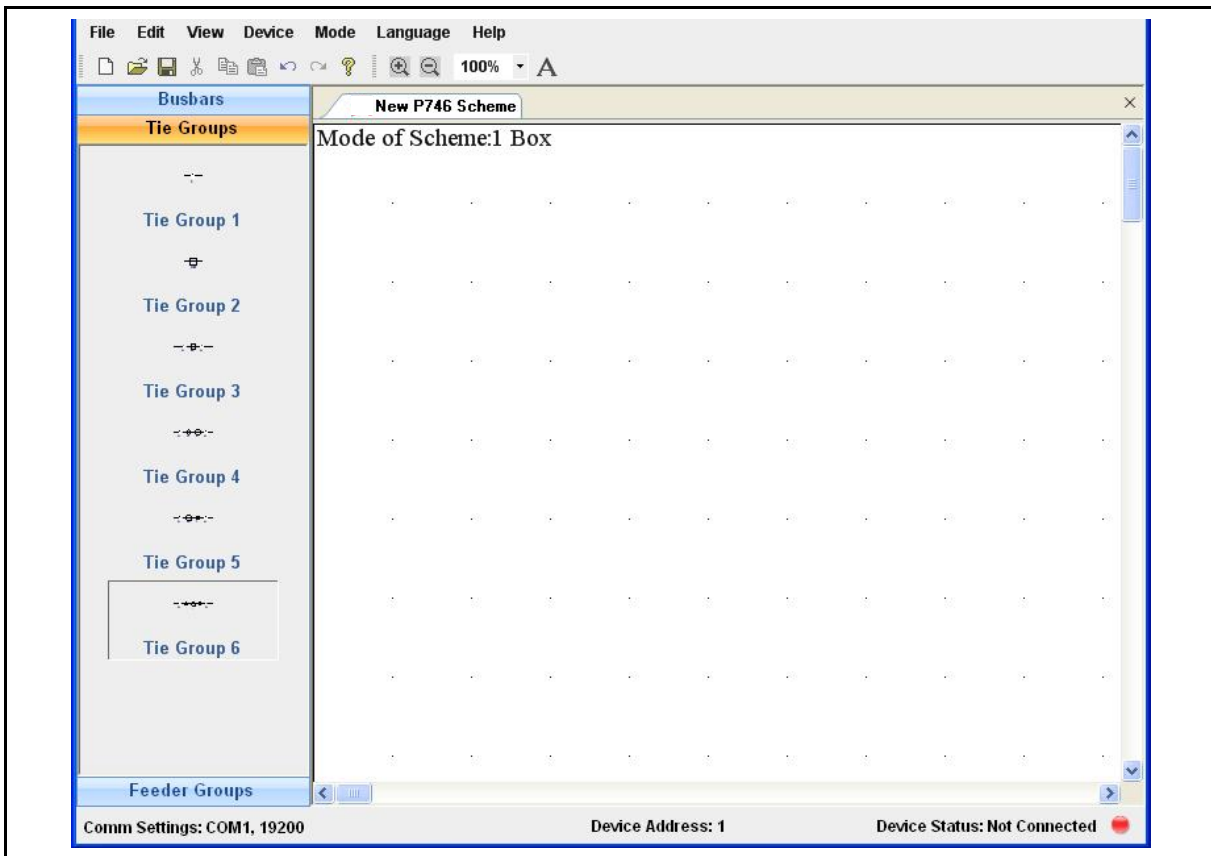
3.3.2   Creating a Busbar

The only difference between "Busbar Left" and "Busbar Right" is that the Busbar Labels on these symbols is displayed on left side and right side respectively. To create a Busbar, drag and drop "Busbar Left" or "Busbar Right" symbol from "Busbar Toolbox" into the Scheme Window. The "Set Busbar Properties" window appears as shown below:
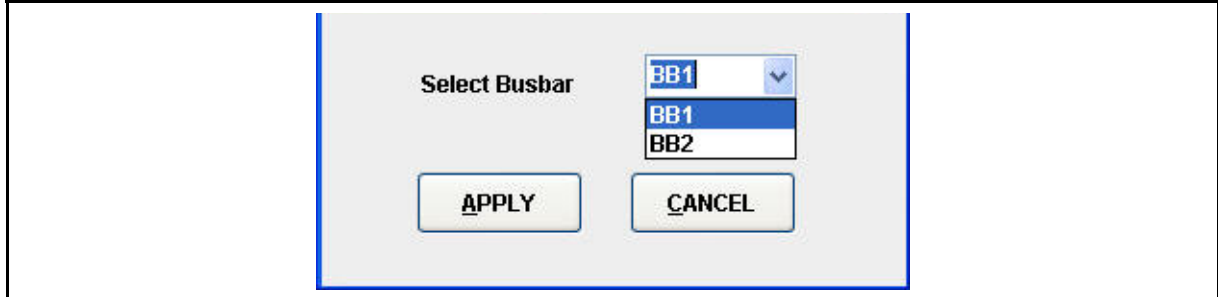
– Select "BB1" or "BB2" option and press "OK" button to create the Busbar. To increase the length of the Busbar, click on the endpoint and drag the mouse until enough Busbar length is achieved.

3.3.3   Creating a Busbar Link

Drag and drop "Busbar Link" symbol from "Busbar Toolbox" into the Scheme Window. Busbar link will be created.

Maximum of 2 Busbar Links are allowed in a scheme.

3.3.4   Creating a Tie Group

– Drag and drop Tie Group symbol from "Tie Group" toolbox into the Scheme Window.

– If the selected Tie Group does not have a CT, it will be created immediately.

– If the selected Tie Group has one CT, "Tie Group Properties" window will be displayed as shown below:

HI
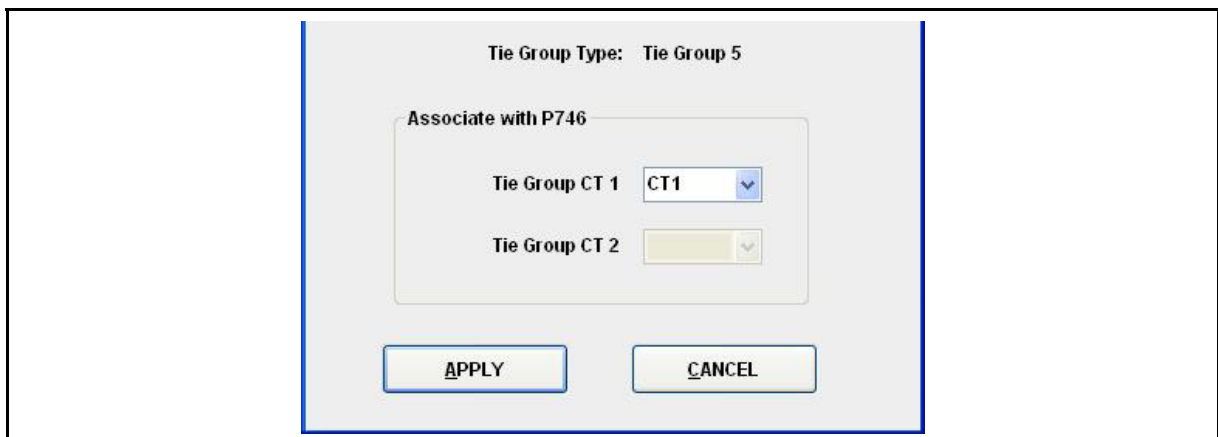
– If the selected Tie Group is having 2 CTs, "Tie Group Properties" window will be displayed as shown below:

– Select CT for CT1 and CT2 and press "APPLY" button to create the Tie Group.

Note:

– Only one Tie Group is allowed in a scheme.

– Same CTs are not allowed for CT1 and CT2 for Tie Groups with double CTs.

3.3.5   Creating a Feeder Group

– Drag and drop "Feeder Group" symbol from "Feeder Group Toolbox" into the Scheme Window. The "Feeder Group Properties" window will be displayed as shown below:
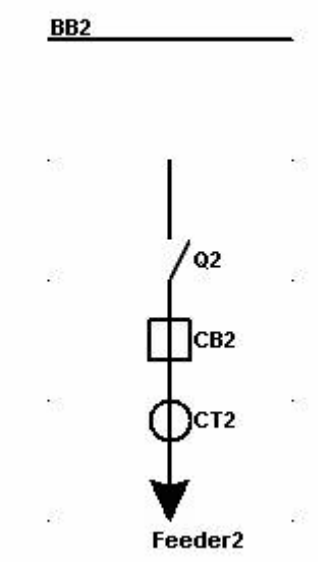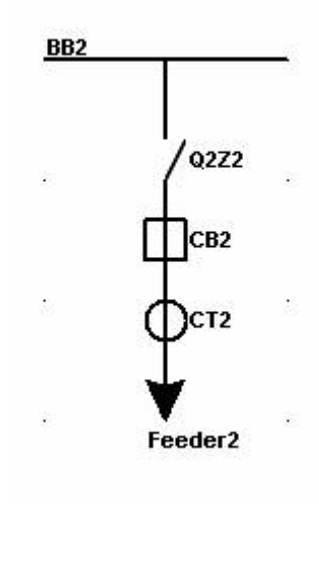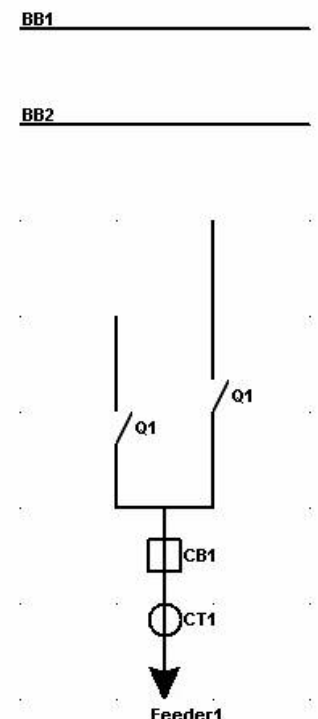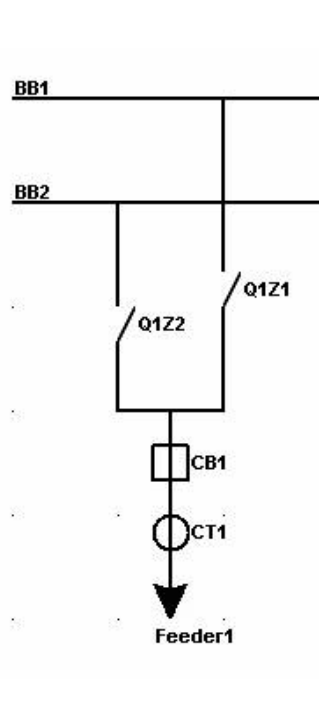
– Select the "Feeder" and press "APPLY" button to create the Feeder Group.

Note: The number of Feeder Groups that can be created is restricted to 6 in 1 Box mode and 18 in 3 Box mode.

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3.3.6   Association of Zone for Isolators

−   The Zone information for isolators in Feeder Groups and Tie Groups will be associated dynamically when they are moved nearer to the Busbar.

The following are the examples of association of Zone for Isolators in Feeder Groups:

S. No	Description	Before Association	After Association
1	Association of Feeder Group with Single Isolator Group.		
2	Association of Feeder Group with Double Isolator Group.		

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The following are the examples of association of Zone for Isolators in Tie Groups:

S. No	Description	Before Association	After Association
1	Association of Tie Group with Busbar Links.		
2	Association of Tie Group without Busbar Links.		

3.3.7   Edit Options

To Move an object:

All objects in the scheme shall be moved anywhere in the scheme by following simple steps given below:

- Select the objects to be moved.

- Click the object using mouse and drag it to the new position where the object to be moved.

- Use the arrow keys ("UP", "DOWN", "LEFT" and "RIGHT" keys) to move in any direction.

- If the new position of the object overlaps with any other object, then object won't be moved.

To Copy and Paste object:

- Only one object can be copied at a time.

- Select the object to be copied.

- Copy the object by selecting Edit->Copy menu or right click the mouse on the selected object and choose "Copy Selection" from the submenu that appears.

- Select Edit->Paste menu or right click the mouse and choose "Paste Selection" from the submenu that appears.

- Left click the mouse on the point where the object is to be pasted.

- If the new position of the object overlaps with any other object, the object will not be pasted and a "beep" will sound.

To Add New Text:

- Select the 'Alphabet' character from the tool bar menu and then select the location in the scheme for new text to be placed. The "Insert Text" dialog box will then appear making it possible to insert the new text.

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To Modify Text in the Text object:

– Select the text object whose text to be modified.

– Right click the mouse on the selected text object and choose "Edit Text" option from the submenu that appears.

– "Insert Text" dialog box appears, making it possible to modify the text.

To Remove an object:

– Select a single object or multiple objects to be removed.

– Press "Del" button or select "Edit->Clear" menu to remove the selected objects.

– To remove all objects at a time, select "Edit->Clear All" menu.

To Cancel last operation:

– Press "Ctrl +Z" or select "Edit->Undo" menu to cancel the last operation.

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4. DYNAMIC SYNOPTIC

This tool allows monitoring the electrical components present in the scheme and analogue values in real time.

In Dynamic Synoptic mode, the main window consists of following parts:

– The Menu Bar

– The Toolbar

– Scheme Window

– Measurements Window

– Status Bar

On switching from Scheme Editor mode to Dynamic Synoptic Mode, the Main Window looks like this:

4.1   Animation of Scheme

The Dynamic Synoptic polls states of CBs (Circuit Breaker), CTs (Current Transformer) with their Primary ratios and load currents, CB Bus Coupler and Isolators present in the scheme. The respective icons are animated based on the states polled from P746 and the load currents are displayed near each CT. These values are updated periodically with the information polled from P746 unit connected.
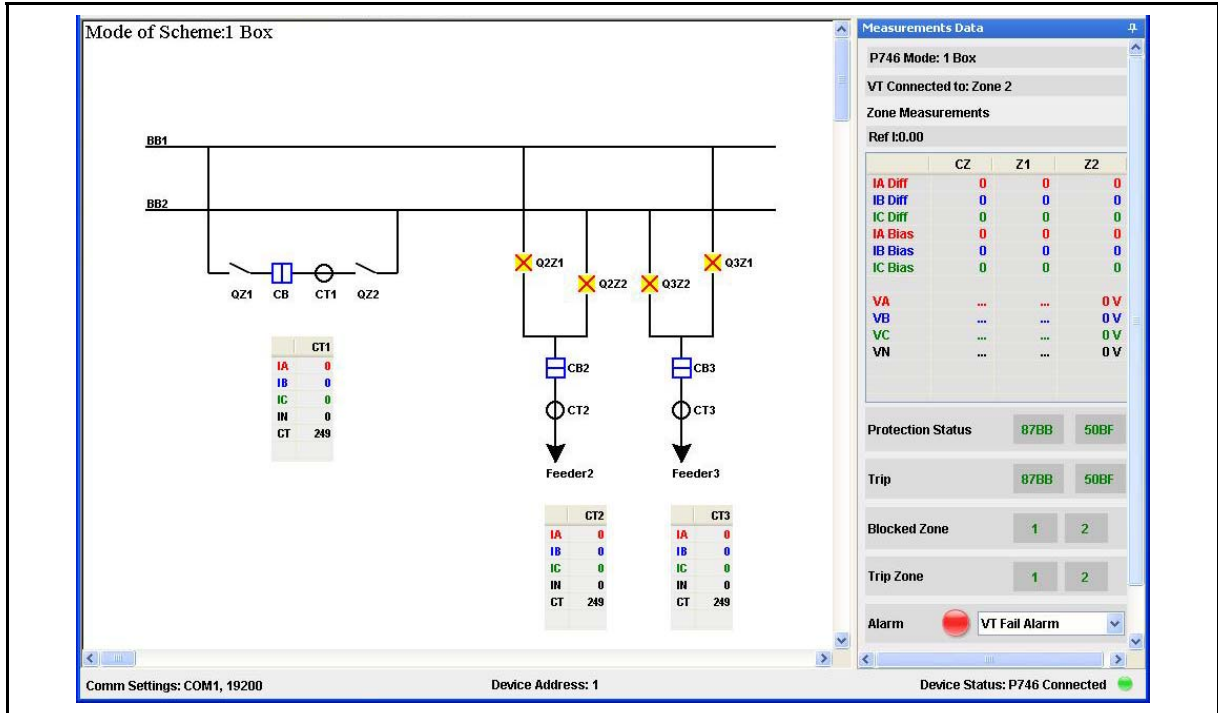
Animation of Current Transformer:

CTS HEALTHY	CTS FAIL

Animation of Circuit Breaker:

CB OPEN	CB CLOSED	CB OPEN AND NOT READY	CB CLOSED AND NOT READY	CB ALARM

Animation of Isolators:

Q OPEN	Q CLOSED	Q ALARM

HI

4.2   Measurements Data

Dynamic Synoptic polls P746 relay and displays P746 Mode Configuration, differential ad bias currents per phase, neutral values of each zone and CZ (Check Zone), voltages for connected zone, DDB Status information for Protection Status, Trip Status, Blocked Zone, Trip Zone and Alarm DDB Signals.

Zone Measurements:

− In 1 Box mode, Differential and Bias Currents per phase and neutral values of Zone1, Zone2 and Check Zone are displayed.

− In 3 Box mode, Differential and Bias Currents for the Protected phase of Zone1, Zone2 and Check Zone are displayed.

− The voltage values for connected zone are displayed.

Protection Status:

- This indicates the blocked state of 87BB and 50BF signals.

- The colors used are GREEN for "OK" and RED for "BLOCKED" state.

Trip Status:

- This indicates the trip state of 87BB and 50BF signals.

- The colors used are GREEN for "NO TRIP" and "RED" for "TRIPPED" state.

Blocked Zone:

- This indicates which zone is blocked.

- The colors used are GREEN for "OK" and RED for "BLOCKED" state.

Trip Zone:

- This indicates which zone is tripped.

- The colors used are GREEN for "NO TRIP" and "RED" for "TRIPPED" state.

Alarm Signals:

- The active alarms are displayed in the "ALARMS LIST BOX".

- On clicking the button next to this list box, the list of active alarms will be displayed.

- The ALARM icon will be in GREEN color if no alarm is active. If at least 1 alarm is active, ALARM icon will be displayed in RED in color.

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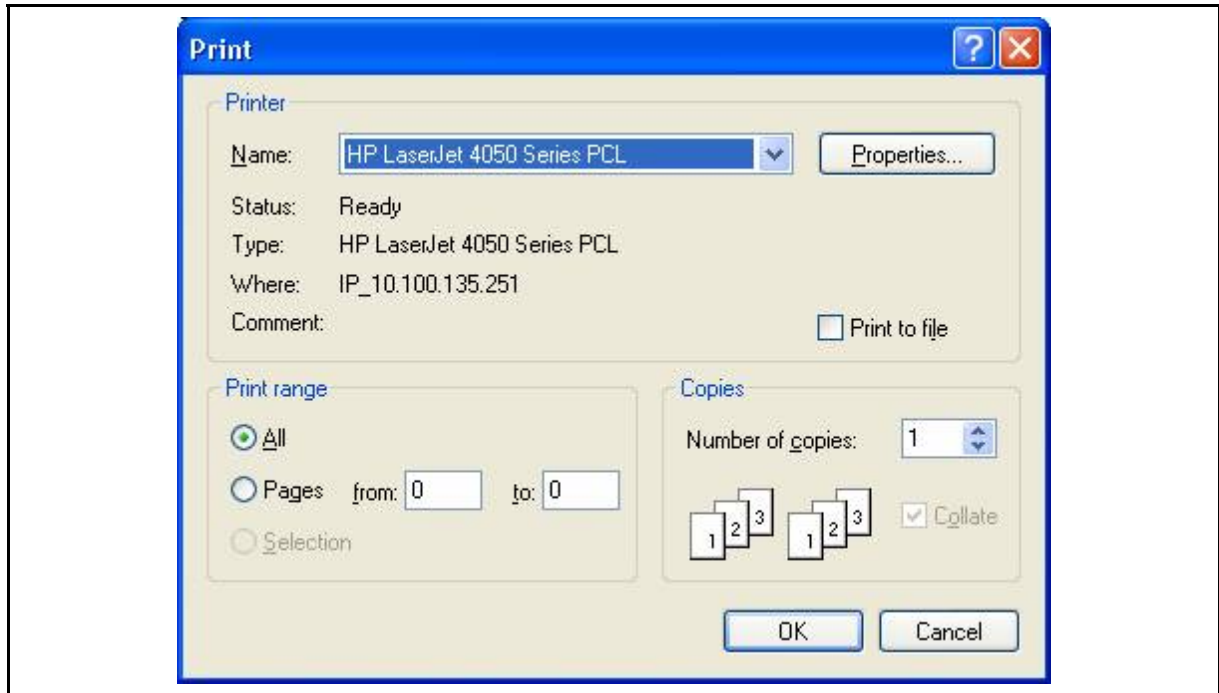## 5.   MENUS

The Main Menu Bar composed of following sub-menus:

  − File

  − Edit

  − View

  − Device

  − Mode

 − Language

  − Help

5.1   File
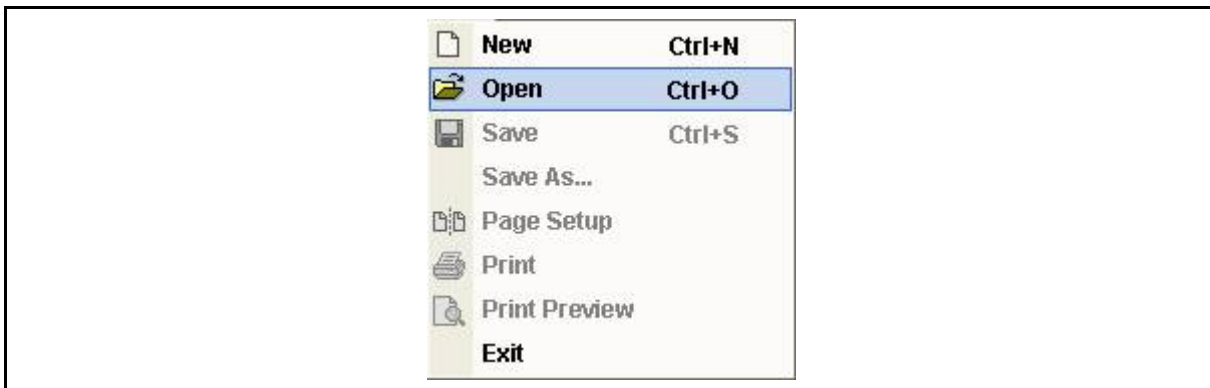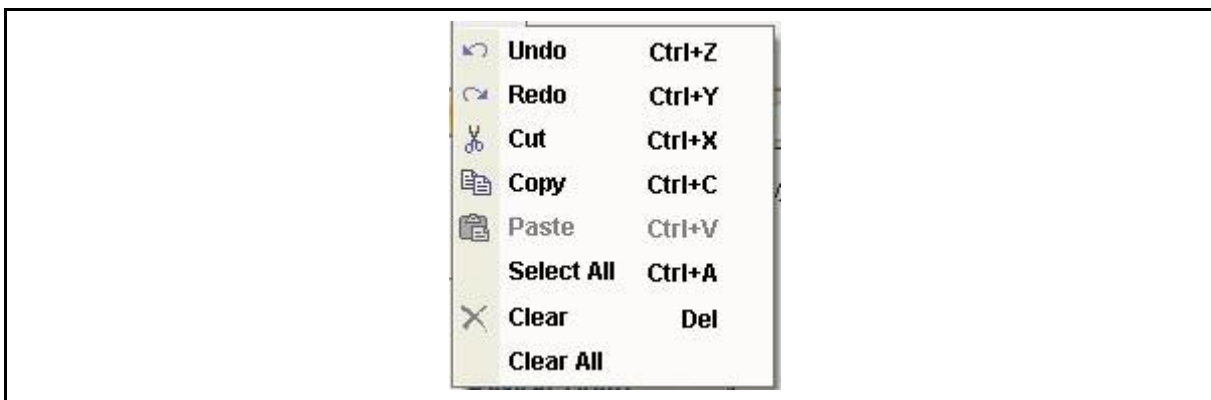

The FILE menu proposes the following actions:

  − New: Click File -> New menu or Click New icon in the Toolbar to create a new Scheme in the Scheme Editor mode. No actions except open and exit is available before creating a new scheme.

  − Open: Click File -> Open menu or Click Open icon in the Toolbar to open the saved scheme. No actions except new and exit is available before opening a scheme.

  − Save: If the scheme is kept opened and clicks the File -> Save menu or Save icon in the Toolbar, the active scheme will be saved permanently.

  − Save As…: If the scheme is kept opened and clicks the File -> Save As… menu, the active scheme can be saved with different names.

  − Close: If the scheme is kept Opened and Clicks the File -> Close menu, the scheme will be closed.

  − Page Setup: If the scheme is kept opened, Clicks the File -> Page Setup menu, the Page Setup window opens as shown below. This allows to setup the page settings for printing.

  − Print: Select File->Print to display a dialog box as shown below, that allows to select the printer though which the scheme is to be printed.

HI

− Print Preview: Select File->Print Preview to preview the scheme in Print Preview dialog box as shown below:
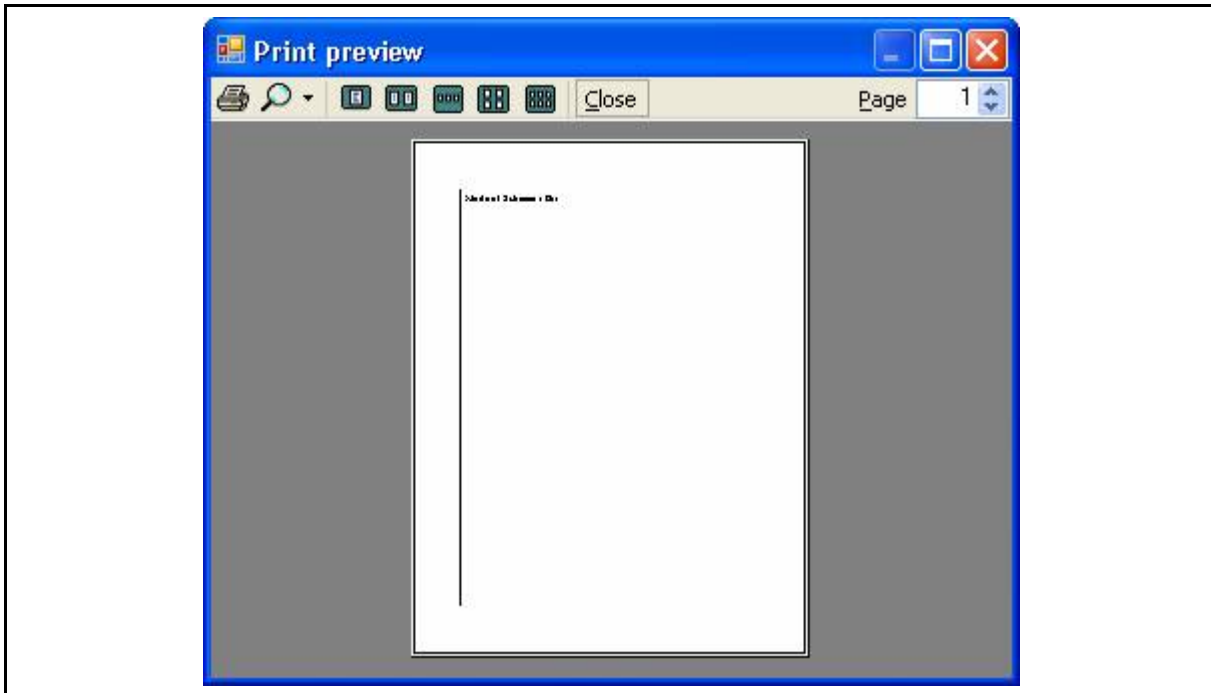
5.2   Edit

The EDIT will be enabled in the Scheme Editor mode. All submenus under this menu will be disabled in Dynamic Synoptic mode.
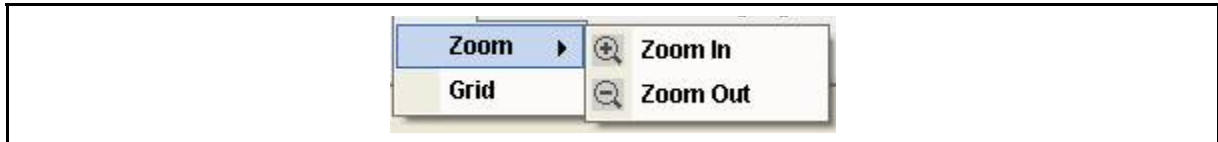
This menu proposes following actions:

− Undo: Select Edit -> Undo menu or Type "CTRL + Z" or Undo icon in the Toolbar to cancel the last action.

− Redo: Select Edit -> Redo menu or Type "CTRL + Y" or Redo icon in the Toolbar to bring again the cancelled last action.

− Cut: Select Edit -> Copy menu or Copy icon in the Toolbar to copy the selected symbol the scheme.

− Copy: Select Edit -> Copy menu or Copy icon in the Toolbar to copy the selected symbol in the scheme.

− Paste: Select Edit -> Paste menu or Paste icon in the toolbar to paste the cut or copied symbol in the scheme.

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– Select All: Select Edit -> Select All menu or type "CTRL + A" to select all the symbols in the scheme.

– Clear: Select Edit -> Clear menu or press Delete key to delete the selected symbol in the scheme.

– Clear All: Select Edit -> Clear All to delete the all the symbols in the scheme.

5.3 View

The view menu proposes the following actions:

– **Zoom In:** Click View -> Zoom -> Zoom In or "Zoom In" icon in the Toolbar to enlarge the scheme from 25% to 200%.

– **Zoom Out:** Click View -> Zoom -> Zoom Out menu or "Zoom Out" icon in the Toolbar to minimize the scheme from 200% to 25%.

– **Grid:** Click View -> Grid menu to view and hide the grid in the scheme.
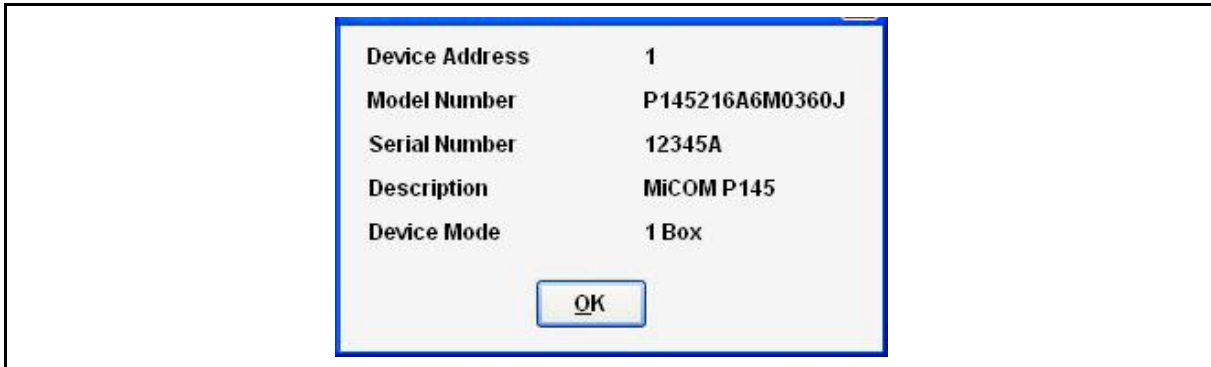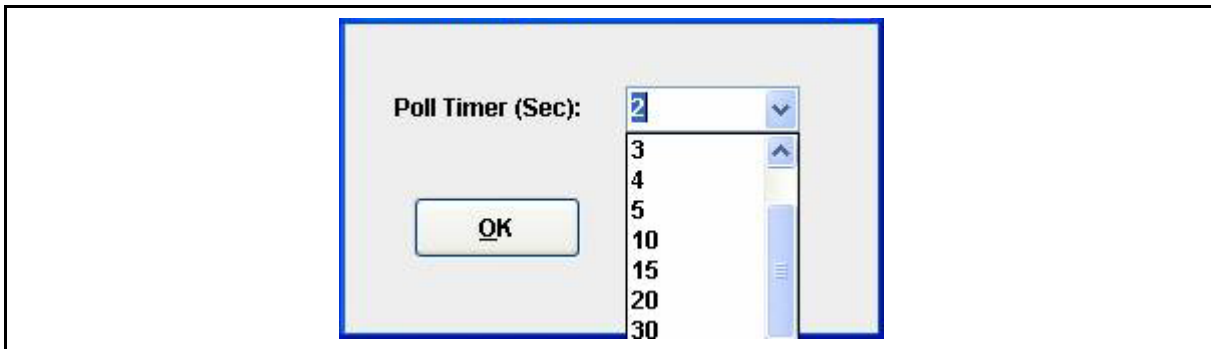
5.4 Device
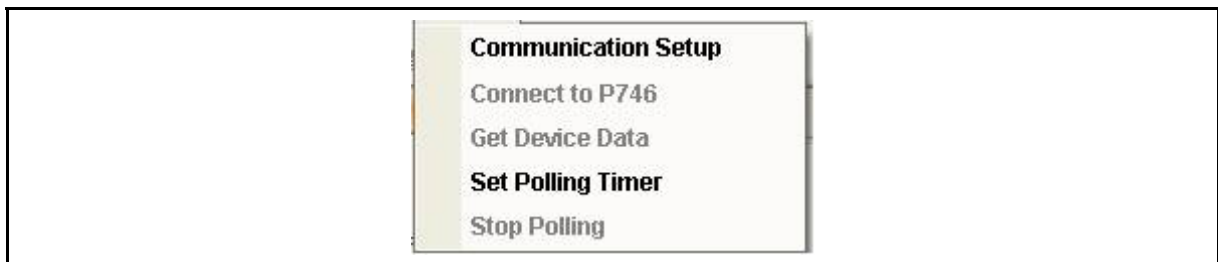
The Device menu proposes the following actions:

– Communication Setup: Select Device -> Communication Setup menu to display "Communication Setup" dialog box to set the communication settings in Scheme Editor and Dynamic Synoptic mode.

– Connect to P746: Select Device -> Connect to P746 to connect to P746 relay through the selected communication option. After connecting to P746 relay, it starts to poll the data from the P746 relay, animates the scheme and displays the measurement data received from P746 unit.

HI

− Get Device Data: This menu will be enabled only when the data is being polled from P746. Select Device -> Get Device Data to display the device information in a dialog box as shown below:

− Set Polling Timer: Select Device -> Set Polling Timer menu to set the polling frequency using "Set Polling Timer" dialog box as shown below:


− Stop polling: This menu will be enabled only when the data is being polled from P746. Select Device-> Stop Polling menu to stop polling in the Dynamic Synaptic mode.

5.5 Mode

The MODE menu contains only one sub-menu whose functionality differs in idle condition, Scheme Editor Mode and Dynamic Synoptic Mode.

− If there is no scheme present, the submenu will be disabled.

− If Scheme Editor Mode is active, "Switch to Dynamic Synoptic Mode" will be displayed. Select this menu item to switch from Scheme Editor mode to Dynamic Synaptic mode.
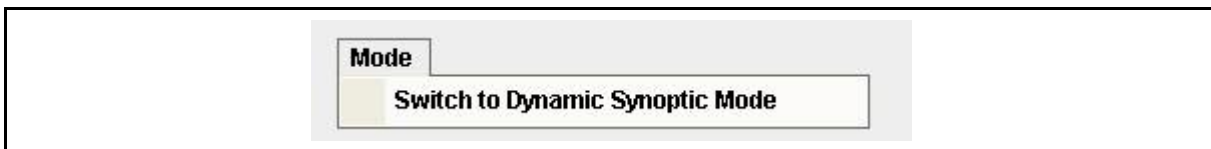
− If Dynamic Synaptic Mode is active, "Switch to Scheme Editor Mode" will be displayed. Select this menu item to switch from Dynamic Synaptic Mode to Scheme Editor mode.

HI
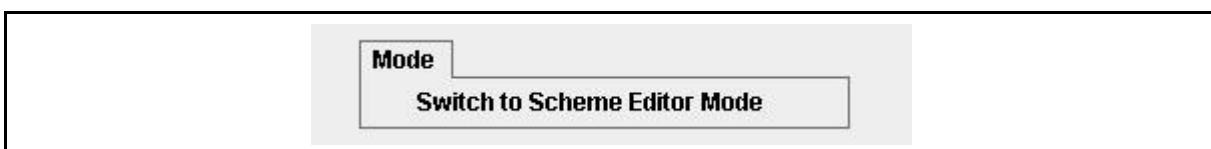
5.6   Language

The Language menu proposes the following actions:

− English: Select Language -> English menu to choose English language.

− French: Select Language -> Français menu to choose French language.

− Spanish: Select Language-> Español menu to choose Spanish language.

− German: Select Language -> Deutsch menu to choose German language.

− Russian: Select Language -> Русский menu to choose Russian language.

− Chinese: Select Language -> 简体中文 menu to choose Chinese language.

HI

FIRMWARE AND SERVICE MANUAL
VERSION HISTORY

Date: **2009**

Hardware Suffix: **K**

Software Version: **01**

Connection Diagrams: **10P746xx (xx = 01 to 07)**

VH

Relay type: P746 …						
Software Version		Hardware Suffix	Original Date of Issue	Description of Changes	S1 Compatibility	Technical Documentation
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 boards	V2.14	P746/EN xx/C11
01	E	K	May 2009	✓ Improvement of internal fault tripping	V2.14	P746/EN xx/E11
01			October 2011	Rebranded to Alstom		P746/EN M/F11

VH

		Relay Software Version																																
		01																																	
Setting File Software Version	01	✓																																	

		Relay Software Version				
		01				
	01	✓				

PSL File Software Version

*: P742 & P743

VH

Relay Software Version																									
	01																								
01	✔																								

GRID **ALSTOM**