MiCOM P521

Current Differential Relay

P521/EN M/Ca4

Software Version 13
Hardware Suffix B

Technical Manual

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

Any agreements, commitments, and legal relationships and any obligations on the part of Schneider Electric including settlements of warranties, result solely from the applicable purchase contract, which is not affected by the contents of the technical manual.

This device MUST NOT be modified. If any modification is made without the express permission of Schneider Electric, it will invalidate the warranty, and may render the product unsafe.

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SAFETY INFORMATION

CHAPTER SI

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Notes:

1 INTRODUCTION

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

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

The technical data in this Safety Information section is typical only, see the technical data section of the relevant product publication(s) for data specific to a particular equipment.

WARNING **Before carrying out any work on the equipment the user should be familiar with the contents of this Safety Information 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 Information 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 that Safety Information section, or this Safety Guide.

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 Schneider Electric technical sales office and request the necessary information.

3 SYMBOLS AND LABELS ON THE EQUIPMENT

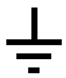
For safety reasons the following symbols and external labels, which may be used on the equipment or referred to in the equipment documentation, should be understood before the equipment is installed or commissioned.

3.1 Symbols

Caution: refer to equipment documentation

Caution: risk of electric shock

Protective Conductor (*Earth) terminal



Functional/Protective Conductor (*Earth) terminal

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

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

3.2 Labels

See Safety Guide (SFTY/4L M) for typical equipment labeling information.

4 INSTALLING, COMMISSIONING AND SERVICING

Manual Handling

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

Many injuries are caused by:

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

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

Equipment Connections

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

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

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

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

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

Any disassembly of the equipment may expose parts at hazardous voltage, also electronic parts may be damaged if suitable ElectroStatic voltage Discharge (ESD) 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. Schneider Electric strongly recommends that these contacts are hardwired into the substation's automation system, for alarm purposes.

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

The equipment must be connected in accordance with the 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.

Pre-Energization Checklist

Before energizing the equipment, the following should be checked:

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

Accidental Touching of Exposed Terminals

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

Equipment Use

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

Removal of the Equipment Front Panel/Cover

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

UL and CSA/CUL Listed or Recognized Equipment

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

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

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

Equipment Operating Conditions

The equipment should be operated within the specified electrical and environmental limits.

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.

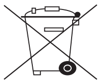
Cleaning

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. Unless otherwise stated in equipment technical manual, the following data is applicable. The protective fuse should be located as close to the unit as possible.

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

6.2 Protective Class

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

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 standards.
Altitude	Operation up to 2000m

INTRODUCTION

CHAPTER 1

Date:	January 2012
Software version:	13
Hardware Suffix:	B
Connection diagram:	10P52101

Contents

Notes:

1 INTRODUCTION

The MiCOM P521 is a numerical current differential relay designed to control, protect and monitor overhead lines and cables of low to medium voltage systems.

2 HOW TO USE THIS MANUAL

This manual provides a description of the MiCOM P521 functions and settings. It enables the user to become familiar with the application, installation, setting and commissioning of this relay.

This manual has the following format:

	Safety Information	Pxxx/EN SI
1	Introduction	P521/EN IT
	Contents of the manual and general introduction to the MiCOM P521.	
2	Installation	P521/EN IN
	Discusses the precautions to be taken when handling and installing electronic equipment.	
3	User Guide	P521/EN FT
	A detailed description of the features of the MiCOM P521 relay.	
4	Menu Content Tables	P521/EN HI
	Relay Menu Map	
5	Technical Data and Curves	P521/EN TD
	Comprehensive details of nominal values, setting ranges, specifications and characteristics	
6	Application Guide	P521/EN AP
	Introduction to the applications of the MiCOM P521 relay including setting guidelines and explanations of special features provided.	
7	MODBUS Database/IEC 60870-5-103	P521/EN GC
8	Commissioning and Maintenance Guide	P521/EN CM
	Guide to commissioning, problem solving and maintenance of MiCOM P521.	
9	Connection Diagrams	P521/EN CO
	All wiring connections to the relay.	
10	Modem Configuration	P521/EN MC
	Guide to configuration of the modem’s compatible with the MiCOM P521	
11	Accessories	P521/EN AC
	Comprehensive details of the accessories available for the P521	
12	Commissioning Test and Record Sheets	P521/EN RS
13	Version History	P521/EN VC
	Details of the Hardware / Software Version History and Compatibility	
14	Symbols and Glossary	Pxxx/EN SG

3 INTRODUCTION TO THE MICOM P521

The MiCOM protection relay range follows on from the success of the MIDOS, K and MODN ranges by incorporating the latest developments in digital technology. The MiCOM P521 relay uses the same modular box concept but provides more protection for the most demanding applications.

The relay has a large number of functions for controlling and collecting data. This can form part of a fully integrated system covering protection, control, instrumentation, data acquisition and the recording of faults, events and disturbances. The relay front panel has a Liquid Crystal Display (LCD) with 2 x 16 back-lit alphanumerical characters, a tactile 7 button keypad (to gain access to all the settings, alarms and measurements) and 8 LEDs to display the state of the MiCOM P521 relay. In addition, the use of the front EIA(RS)232 and rear EIA(RS)485 communication ports makes it possible to read, reinitialize and change the settings of the relay, if required, from a local or remote PC equipped with the MiCOM S1 software.

Its flexibility of use, reduced maintenance requirements and ease of integration allow the MiCOM P521 to provide an evolving solution for the problems of the protection of electric networks.

The MiCOM P521 relay provides comprehensive unit protection of overhead lines underground cables and ring mains. The integration of many protection features, including phase overcurrent and earth fault protection, allows application to wide range of medium and low voltage applications.

4 MAIN FUNCTIONS

The following table shows the functions available in the MiCOM P521 relay.

Functions	ANSI Code
Phase segregated current differential protection	87L
Instantaneous / time delayed overcurrent protection	50/51
Instantaneous / time delayed earth fault protection	50N/51N
Thermal overload protection	49
Broken conductor detection	46BC
Undercurrent protection	37
Negative sequence overcurrent protection	46
Direct Intertripping	
Permissive intertripping	
Programmable inter-trip	
Trip circuit supervision	
Circuit breaker monitoring and control	
Circuit breaker failure detection	50BF
Current transformer supervision	
Cold load pickup (O/C and E/F only)	
Four Setting groups	86
Instantaneous/start contact (O/C and E/F only)	
Latching output contacts	50BF
Blocking logic	
Selective relay scheme logic	
A-B-C and A-C-B phase rotation operation	
Measurements (True RMS)	
Peak and rolling values	
Event records	
Fault records	
Instantaneous records	
Disturbance records	
EIA(RS)232 front communication	
EIA(RS)485 rear communication	
Commissioning features	
Logic equations	

INSTALLATION

CHAPTER 2

Date:	January 2012
Software version:	13
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Connection diagram:	10P52101

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1 GENERAL CONSIDERATIONS

1.1 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 damage has been sustained in transit. If damage has been sustained during transit a claim should be made to the transport contractor and Schneider Electric should be promptly notified.

Relays that are supplied unmounted and not intended for immediate installation should be returned to their protective polythene bags.

1.2 ElectroStatic Discharge (ESD)

The relays use components that are sensitive to electrostatic discharges.

The electronic circuits are well protected by the metal case and the internal module should not be withdrawn unnecessarily. When handling the module outside its case, care should be taken to avoid contact with components and electrical connections. If removed from the case for storage, the module should be placed in an electrically conducting antistatic bag.

There are no setting adjustments within the module and it is advised that it is not unnecessarily disassembled. Although the printed circuit boards are plugged together, the connectors are a manufacturing aid and not intended for frequent dismantling; in fact considerable effort may be required to separate them. Touching the printed circuit board should be avoided, since Complementary Metal Oxide Semiconductors (CMOS) are used, which can be damaged by static electricity discharged from the body.

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 often may not be immediately apparent but the reliability of the circuit will have been reduced.

The electronic circuits are completely safe from electrostatic discharge when housed in the case. Do not expose them to risk of damage by withdrawing modules unnecessarily.

Each module incorporates the highest practicable protection for its semiconductor devices. However, if it becomes necessary to withdraw a module, the following precautions should be taken to preserve the high reliability and long life for which the equipment has been designed and manufactured.

1. Before removing a module, ensure that you are at the same electrostatic potential as the equipment by touching the case.
2. Handle the module by its frontplate, frame or edges of the printed circuit board. 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 helps to achieve an equal potential.
4. Place the module on an antistatic surface, or on a conducting surface which is at the same potential as yourself.
5. Store or transport the module in a conductive bag.

If you are making measurements on the internal electronic circuitry of any equipment 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 500 kΩ – 10 MΩ.

If a wrist strap is not available you should maintain regular contact with the case to prevent a build-up of static. Instrumentation which may be used for making measurements should be earthed to the case whenever possible.

More information on safe working procedures for all electronic equipment can be found in BS5783 and IEC 147-OF. 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 above-mentioned BS and IEC documents.

3 RELAY MOUNTING

Relays are dispatched either individually or as part of a panel/rack assembly.

If an MMLG test block is to be included it should be positioned at the right-hand side of the assembly (viewed from the front). Modules should remain protected by their metal case during assembly into a panel or rack.

For individually mounted relays an outline diagram is supplied in section 6 of Installation (P521/EN IN) showing the panel cut-outs and hole centers.

4 UNPACKING

Care must be taken when unpacking and installing the relays so that none of the parts are damaged or the settings altered. Relays must only be handled by skilled persons. The installation should be clean, dry and reasonably free from dust and excessive vibration. The site should be well lit to facilitate inspection. Relays that have been removed from their cases should not be left in situations where they are exposed to dust or damp. This particularly applies to installations which are being carried out at the same time as construction work.

5 STORAGE

If relays are not to be installed immediately upon receipt, they should be stored in a place free from dust and moisture in their original cartons. Where de-humidifier bags have been included in the packing they should be retained. The action of the de-humidifier crystals will be impaired if the bag has been exposed to ambient conditions and may be restored by gently heating the bag for about an hour, prior to replacing it in the carton.

Dust which collects on a carton may, on subsequent unpacking, find its way into the relay; in damp conditions the carton and packing may become impregnated with moisture and the de-humidifier will lose its efficiency.

Storage temperature: –25°C to +70°C.

6 CASE DIMENSIONS

The MiCOM P521 relay is available in a MiCOM size 30TE metal case for panel or flush mounting.

Weight:	1.7 to 2.1 Kg		
External size:	Height	case	152 mm
		front panel	177 mm
	Width	case	150 mm
		front panel	155 mm
	Depth	case	226 mm
		front panel + case	252 mm

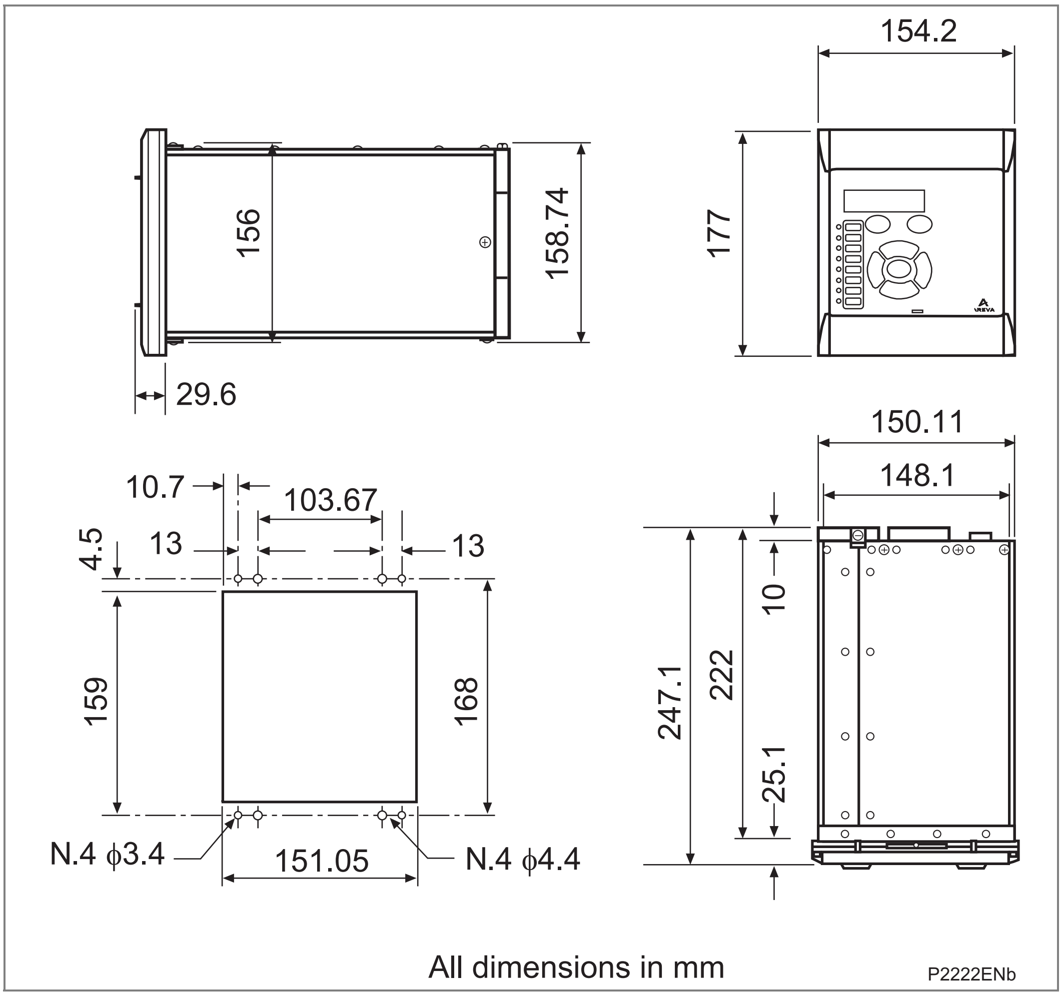

Figure 1 - MiCOM P521 relay case dimensions

USER GUIDE

CHAPTER 3

Date:	January 2012
Software version:	13
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Connection diagram:	10P52101

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FIGURES

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1 DESCRIPTION OF THE P521 RELAY

MiCOM P521 is a fully numerical relay that is designed to perform electrical protection and control functions.

3 phase and 1 earth current inputs are available at both 1 and 5 Amps ratings on the relay (4 inputs for 1 A and 4 inputs for 5 A). It is possible to use a combination of input ratings on the same relay (i.e. a mix of 1 A for earth fault and 5 A for phase connections).

All output relays can be programmed to respond to any of the available control or protection functions. Logic inputs can also be allocated to the various control functions.

The MiCOM relays are powered from either a DC or an AC auxiliary supply (2 ranges of auxiliary supply). Any short supply interruptions (< 50 ms) are filtered and regulated through the auxiliary supply.

The front panel enables the user to navigate through the menu to access data, change the settings, read the measurements, etc. Eight LEDs on the front panel allows a clear and simple indication of events. The various alarms detected are displayed on the back-lit LCD display. No password is required to read or clear these alarm messages. However, the modification of settings can only be carried out with a password.

MiCOM P521 relay continuously measures the phase and earth currents and calculates the true RMS component up to 10th harmonic.

MiCOM P521 relay has available via its rear connectors, a standard EIA(RS)485 port. Communication protocols can be chosen at the time of order, from MODBUS RTU, IEC 60870-5-103 or DNP3.0. Using the communication channel, all stored information (measurements, alarms and settings) can be read, and the settings can be modified if necessary.

Consultation and modification of this data can be carried out on site with a PC and the appropriate Schneider Electric software (e.g. MiCOM S1 Studio).

EIA(RS)485 based communication allows the MiCOM P521 relay to be directly linked to a digital control system (MiCOM S10 for example). All the available data is then placed at the disposal of the supervisor and can be processed either locally or remotely.

The MiCOM P521 relay gives the user more flexibility to adapt the relay to the desired applications. With regard to low installation costs, this relay offers an economic solution, providing integrated protection and control functions.

2 USER INTERFACE

The MiCOM P521 relay front panel serves as an interface between the user and the protection relay. It enables the user to modify and read relay settings and to display measurements and alarms.

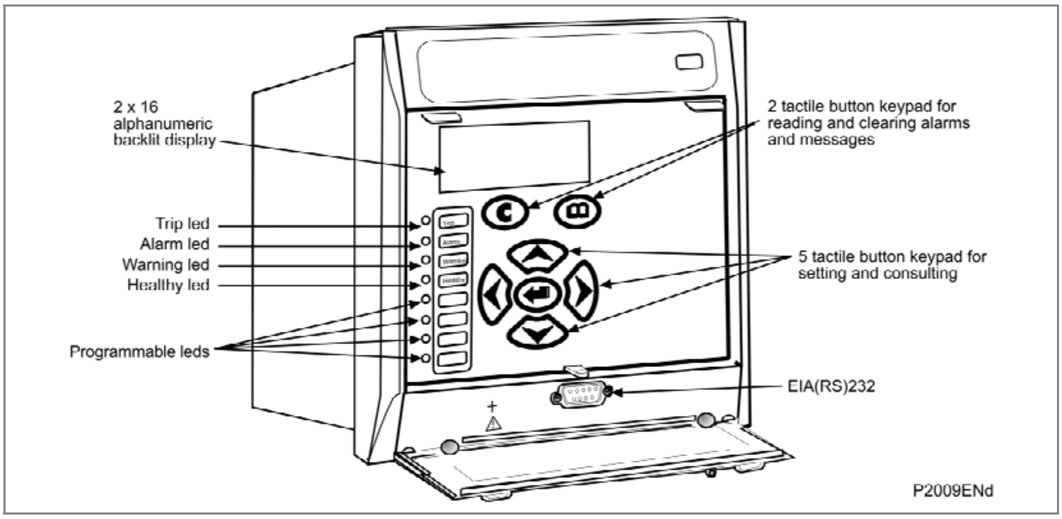

Figure 1 - MiCOM P521 front panel

The front panel of the relay consists of three separate sections:

1. The LCD display and the keypad
2. The LEDs
3. The two zones under the upper and lower flaps.

2.1 LCD Display and Keypad Description

2.1.1 LCD Display

The front panel of the MiCOM P521 relay has a Liquid Crystal Display (LCD) on which data such as settings, measured values and alarms can be viewed. The data is accessed through a menu system.

The LCD has two lines each with sixteen characters. A back-light is activated when any key is pressed and will remain lit for five minutes after the last key press. This allows the display to be read in most lighting conditions.

2.1.2 Keypad

The keypad has seven keys divided into two groups:

There are two keys situated immediately under the screen (keys Ⓒ and 🕮).

The Five main keys situated at the middle of the front face are for menu navigation.

2.1.2.1 Alarm Keys

The two keys Ⓒ and 🕮 are dedicated for reading and acknowledging the alarms. So as to display successive alarms, press on 🕮 key. The alarms are presented in reverse order for their detection (the most recent first, the oldest last). So as to acknowledge the alarms, the user can either acknowledge each alarm using ⓒ or go to the end of the ALARM menu and carry out a general acknowledgement.

Latched indications/contacts will also be reset once the ⓒ key has been pressed.

2.1.2.2 Programming Keypad

The five keys situated in the middle of the MiCOM front panel are dedicated to menu navigation and setting changes.

The keys ⌃, ⌄, ⟩ and ⟨ make it possible to move in the direction indicated to the various levels of the menus.

The key ↵ validates a choice or value (modification of settings).

2.2 LEDs

The LED labels on the front panel are by default written in English, however the user also has self-adhesive labels, available with MiCOM relays, in French. Additional blank labels are provided on which it is possible to write using a ball point pen.

The top four LEDs indicate to the status of the relay (Trip condition, alarm LED, equipment failure and auxiliary supply).

The four lower LEDs can be freely programmed by the user to correspond to operation of the various thresholds and / or the state of the logic inputs.

Eight LEDs are located in the left portion of the front plate (numbered from 1 to 8 starting from the top):

LED 1 Color : RED Label : Trip

LED 1 indicates when a trip order has been issued by the relay to the circuit breaker or contactor. This LED copies the trip order issued to the Trip output (output RELAY 1). Its normal state is unlit. It is illuminated as soon as a tripping order is issued. It goes out when the associated alarm is acknowledged, provided the initiating protection element has fully reset.

LED 2 Color : ORANGE Label : ALARM

LED 2 indicates that an alarm has been registered by MiCOM P521 relay. The alarms are either threshold crossings (instantaneous), or tripping orders (possibly time delayed, depending upon which protection element operates). In addition to threshold crossings and trips an alarm will also be given in the event of a protection comms channel failure. As soon as an alarm is registered, the LED flashes. When all the stored alarms are read (🕮), the LED is illuminated continuously.

When all the alarms are acknowledged ⓒ, the LED goes out.

Note	*The instantaneous alarms can be selected to manual or automatic reset. This can be set in CONFIGURATION/ALARMS/Inst. Self Reset? YES / NO* *Choose YES for automatic reset. The default setting is NO.*

LED 3 Color : ORANGE Label : Warning

LED 3 is dedicated to the internal alarms of the MiCOM P521. When a « non critical » internal alarm (typically a control comms fault i.e. MODBUS etc.) is detected, the LED will flash. When the fault is classed as « critical », the LED is illuminated continuously. The extinction of this LED is only possible by the disappearance of the cause that provoked it (repair of the module, disappearance of the Fault).

LED 4 Color : GREENLabel : Healthy

LED 4 indicates that the MiCOM P521 has a healthy auxiliary supply in the nominal range.

LED 5 to 8 Color : RED Label : Left Blank

These LEDs can be programmed by the user on the basis of information on available thresholds (instantaneous and time-delayed) and the state of the logic inputs. The user selects the information he wishes to see associated with each LED from the menu element. A single LED can be associated with more than one protection / control function. Each LED illuminates when the associated information is valid. The extinction of each LED occurs when the associated alarm is acknowledged.

2.3 The two Areas under the Top and Bottom Flaps

Under the upper flap, a label identifies the relay according to its model (ordering code) and serial number. This information defines the product uniquely and specifically.

In making all requests for information from Schneider Electric After Sales Department, please quote these two numbers.

Information indicated in the lower portion of this label covers the auxiliary supply voltage and the nominal earth current value.

Under the lower flap, an EIA(RS)232 port is available. This can be used to download a setting file from a PC with the MiCOM S1 setting software. Alternatively, the EIA(RS)232 port can be used to download new application software versions into the relay flash memory.

The removal of the MiCOM active part (chassis) from the case is performed by opening the two flaps, then with a 3 mm screwdriver, turn the extractor cam situated under the upper flap, and pull using the two slots situated behind these flaps.

Note:	*When re-inserting the chassis into the case, ensure that the extractor cam is pushed back flat, and that the chassis is then pushed fully back into the case as far as it can go.*

2.4 Battery Box

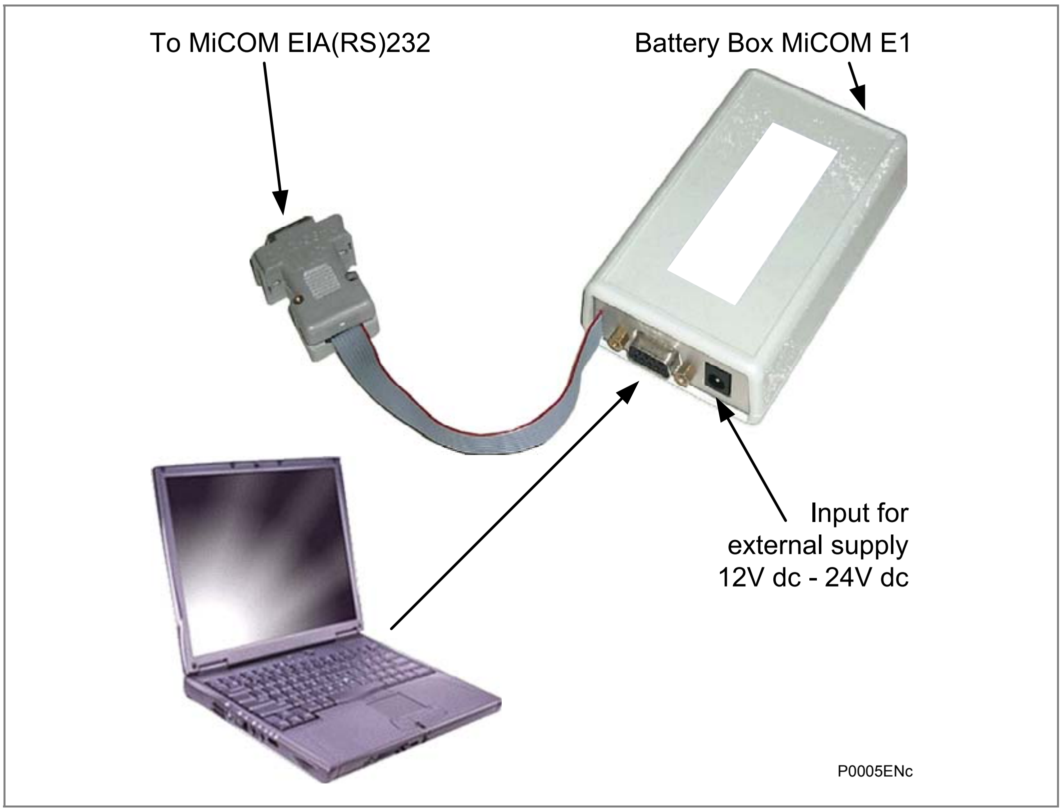

Figure 2 - Battery box MiCOM E1

The battery box performs the two following functions:

4. Temporary powering of the relay in order to allow the user to view or modify data when the auxiliary power supply has failed. The battery box uses a 6LR61 (9 V) battery, which can power the relay up to 3 hours. When the battery is flat it is possible to power the battery box with an external dc supply. The dc voltage value must be between 12 Vdc and 24 Vdc.

5. EIA(RS)232 interface between the MiCOM relay and the PC equipped with the setting software MiCOM S1 Studio.

2.5 Tripping Output

The trip output for the MiCOM P521 relay is dedicated to output relay RL1. Operation of only RL1 will result in illumination of the red trip LED.

3 MENUS

The menu of the MiCOM P521 relay is organized into main and sub menus, much like a PC directory structure.

3.1 Default Display

By default, the current value (selected phase, earth or all phases and earth) is continuously displayed.

As soon as an alarm is generated by the MiCOM relay, that information is considered as priority and replaces the default value.

The default display choice is made in the CONFIGURATION/Display menu.

3.2 Access to the Menu

Complete menu access is performed by manipulation of the keys ⇑, ⇓, ⇒ and ⇐. The general arrangement of the menus is shown in Figure 3 for P521.

Reading of parameters and measurements is possible without entering the password. However, modification of the parameters does require the password. Should an error be made in entering a parameter, press Ⓒ to cancel.

Except for reading and canceling, the keys Ⓒ and 📖 are inactive.

Note	*The letter P is displayed when the password is entered. However If no key is pressed for 5 minutes, the password mode becomes inactive.*

3.3 Password

3.3.1 Password Protection

Password protection is applicable to the relay settings, especially to the selection of the various thresholds, time delays, communication parameters, allocation of inputs and outputs relays.

The password consists of four alphabetical capital characters. When leaving the factory, the password is AAAA. If necessary the user can define their own combination of characters.

Should the password be lost or forgotten, modification of the relay settings is prohibited. In these circumstances the manufacturer or agent can supply a “master” password when given the relay serial number.

Note:	*The programming mode is indicated by a letter "P" on the lower right hand side of the display, but only when a column heading is displayed. The letter “P” is present as long as the password is active (5 minutes if no key is pressed).*

3.3.2 Entering the Password

The password is requested as soon as an attempt is made to modify a relay setting. The user must enter the password (4 characters/letters) and accept the entire password with ↵. If the password is correct “PASSWORD OK” is displayed and setting changes can then commence. If the password is incorrect “PASSWORD NOK” displayed.

After 5 seconds, the display returns to the cell prior to password entry.

If no action is taken on the keypad for 5 minutes, the password is deactivated. A new request shall be associated with any subsequent setting change. A temporary interruption in the auxiliary supply will also serve to de-activate the password.

Note: If the password has been entered via the keypad, the following remote access is possible:
Front port None
Rear port Read access only
The relay will remain in this state until the password has been deactivated.

3.3.3 Changing the Password

To change the active password, go to the OP. PARAMETERS menu and then to the point of the “Password” sub menu. Enter the old password and validate. Then press ↵ and enter the new password character by character and validate the new password using ↵.

The message “NEW PASSWORD OK” is displayed to indicate that the password has changed.

3.3.4 Deactivating the Password

To deactivate the active password, go to the OP. PARAMETERS menu and then to the point of the “Password” sub menu. Press ©**.** Password protection is deactivated, and remote access via all communication ports is reactivated.

3.4 Alarm Display

The presence of any alarm is displayed on the LCD. The display of alarm messages has priority over the default current value. As soon as an alarm is detected by the relay (threshold crossing for example), the message is displayed on the MiCOM LCD and the Alarm LED (2nd LED) lights up.

The alarm messages are classed as follows:

- Electrical system alarm message
- Hardware or software fault message from the relay.

3.4.1 Electrical System Alarms

Any crossing of a threshold (instantaneous or time delay) generates an "electrical system alarm". The threshold that has been exceeded will be displayed on the LCD together with the phase/phases (A, B or C) involved in the fault.

If several alarms are triggered, they are all stored in their order of appearance the most recent alarm first, the oldest alarm last. Each message is numbered and the total number of messages is shown.

The user can read all the alarm messages using the 🕮 key without entering the password. The user can then acknowledge the alarm using the © key. The alarms can be acknowledged one by one or all of them simultaneously by going to the end of the list and pressing the © key.

The management of the ALARM LED is directly linked to the status of the stored alarms.

- If one or several messages are NOT READ and NOT ACKNOWLEDGED, the alarm LED flashes.
- If all the messages have been READ but NOT ACKNOWLEDGED, the alarm LED remains lights up continuously.

- If all the messages have been READ and ACKNOWLEDGED, the alarm LED goes out.

Note:	*The alarms concerning the instantaneous (start indications) can be selected self reset Yes or No in the CONFIGURATION/Alarms Menu*

The different electrical system alarms are described below:

I DIFF	Differential protection trip
Ie>	1st stage earth fault pick-up
Ie>>	2nd stage earth fault pick-up
Ie>>>	3rd stage earth fault pick-up
Ie>>>>	4th stage earth fault pick-up
I>	1st stage overcurrent pick-up
I>>	2nd stage overcurrent pick-up
I>>>	3rd stage overcurrent pick-up
I>>>>	4th stage overcurrent pick-up
tIe>	1st stage earth fault time delay
tIe>>	2nd stage earth fault time delay
tIe>>>	3rd stage earth fault time delay
tIe>>>>	4th stage earth fault time delay
tI>	1st stage overcurrent time delay
tI>>	2nd stage overcurrent time delay
tI>>>	3rd stage overcurrent time delay
tI>>>>	4th stage overcurrent time delay
THERMAL ALARM	Thermal alarm threshold pick-up
THERMAL TRIP	Thermal trip threshold pick-up
I<	Undercurrent element pick-up
tI<	Undercurrent fault time delay
BRKN COND.	Broken conductor indication. I2/I1 element pick-up for longer than tBC (breaker fail timer). TBC is settable in the AUTOMAT. CTRL/Broken Cond. Menu.CTRL/Broken cond. menu.
t AUX 1	t AUX1 time delay
t AUX 2	t AUX2 time delay
CB FAILURE	Circuit breaker failure indication (the CB did not trip on tBf time delay) tBF is settable in the AUTOMAT. CTRL/CB Fail menu.
I 2>	Negative sequence current threshold pick-up (1st stage)
tI 2>	Negative sequence current threshold time delay (1st stage)
I2>>	Negative sequence current threshold pick-up (2nd stage)
tI2>>	Negative sequence current threshold time delay (2nd stage)
DIRECT I-TRIP	Indicates that the relay received and tripped on direct intertrip.
I DIFF I-TRIP	Indicates that the relay has received an intertrip signal from the remote relay that has performed a differential trip.
PERMISSIVE	Indicates that the relay has tripped due to a permissive intertrip command.
T operating CB	Operating (or tripping) time of the circuit breaker longer than the value set in the AUTOMAT. CTRL/CB Supervision menu.
CB CLOSE FAILURE	Closing time of the circuit breaker longer than the value set in the AUTOMAT. CTRL/CB Supervision menu.

CB OPEN NB	Number of circuit breaker operation higher that the value set in the AUTOMAT. CTRL/CB Supervision menu.
Sum A n	Broken current measured higher than the value set in the AUTOMAT. CTRL/CB Supervision menu.
TRIP CIRCUIT	Trip circuit failure. Failure condition present for longer than the supervision timer tSUP, settable in the AUTOMAT. CTRL/CB Supervision menu.
LATCH RELAY	A least one relay is latched.
CB CLOSE FAILURE	Circuit breaker closing time longer than the value set in the AUTOMAT. CTRL/CB Supervision menu.
COMMS ALARM	Differential protection communication channel failure. Back-up protection (e.g. overcurrent) can be enabled in the event of COMMS FAILURE.
I DIFF FAIL	Indicates that the differential protection is not functioning due to either COMMS FAIL or a hardware fault. Back-up protection may still be functioning.
REM TRIP	Indicates that the circuit breaker has been given a remote trip command. A remote trip can be initiated by the front user interface, a logic input or via the remote communications link.
CB STATUS DBI	This alarm stands for "Circuit Breaker Status Don’t Believe It". In the event when the 52a and 52b contacts are both open or both closed, this alarm will be given after 5 seconds.
LOOPBACK MODE	Indicates that the protection communications are looped back on themselves for commissioning purposes. The relay will accept messages from its own address. This mode can be enabled/disabled in the AUTOMAT. CTRL/Commissioning menu.
ISOLATED RELAYS	Output relays will not operate for fault conditions but alarms and LED’s function as usual. This mode can be used for commissioning purposes.
DISABLED I DIFF	Indicates that the current differential protection has been disabled. The current differential protection can be disabled via the relay menu or via a blocking input. Blocking/Disabling either local or remote relays will cause this alarm to be displayed at both ends simultaneously.

3.4.2 Relay Hardware or Software Alarms

Any software or hardware fault of the MiCOM relay generates a "hardware/software alarm". If several alarms are generated they are all stored in their order of appearance. The alarms are displayed in reverse order (the most recent first and the oldest last). Each message is numbered and the total number of messages is indicated below.

The user can read all the alarm messages with the aid of 🕮, without entering the password.

The acknowledgement of the relay alarm messages is IMPOSSIBLE if the fault is still present. The alarm can only be acknowledged when the cause of the alarm has disappeared.

The management of the WARNING LED is directly linked to the status of the alarms stored in the memory.

- If the fault is major (the relay cannot perform protection functions), the WARNING LED is continuously illuminated and the watchdog contact will operate.
- If the fault is minor (no influence on the protection and automation function e.g. SCADA communication failure), the WARNING LED flashes. This will not cause operation of the watchdog contact.

Possible Hardware or Software alarm messages:

Major Fault

SETTING ERROR:	Setting error occurred due to data memory fault
EEPROM ERROR CALIBR.:	Calibration memory faulty
CT ERROR:	Analogue channel faulty
PROT. COMMS FAIL:	Protections comms card faulty
DEFAULT CONFIG.:	Factory settings restored due to data memory fault. This message will also be displayed following a firmware upgrade.

Minor Fault

RAM ERROR:	RAM supplied by battery faulty
BATTERY FAIL:	Battery faulty (flat or not correctly fitted)
COMM.ERROR:	Internal communications faulty
CLOCK ERROR:	Real time clock faulty
PROT. COMMS RECOVER:	Recovering from transient comms fault (back-up protection available)

Note *The “Battery backed RAM memory” and “Battery failure” alarm messages can be configured to display or not; YES or NO in CONFIGURATION/Alarms menu. If NO is selected an alarm will not be raised in the event of a Battery Fault.*

3.5 Menu Contents Description

The menu of the MiCOM P521 relay is divided into these sections:

- OP PARAMETERS
- ORDERS
- CONFIGURATION
- MEASUREMENTS
- COMMUNICATION
- PROTECTION G1
- PROTECTION G2
- PROTECTION G3
- PROTECTION G4
- AUTOMAT. CTRL
- RECORDS

To access these menus from the default display use .

To return to the default display from these menus or sub menus press .

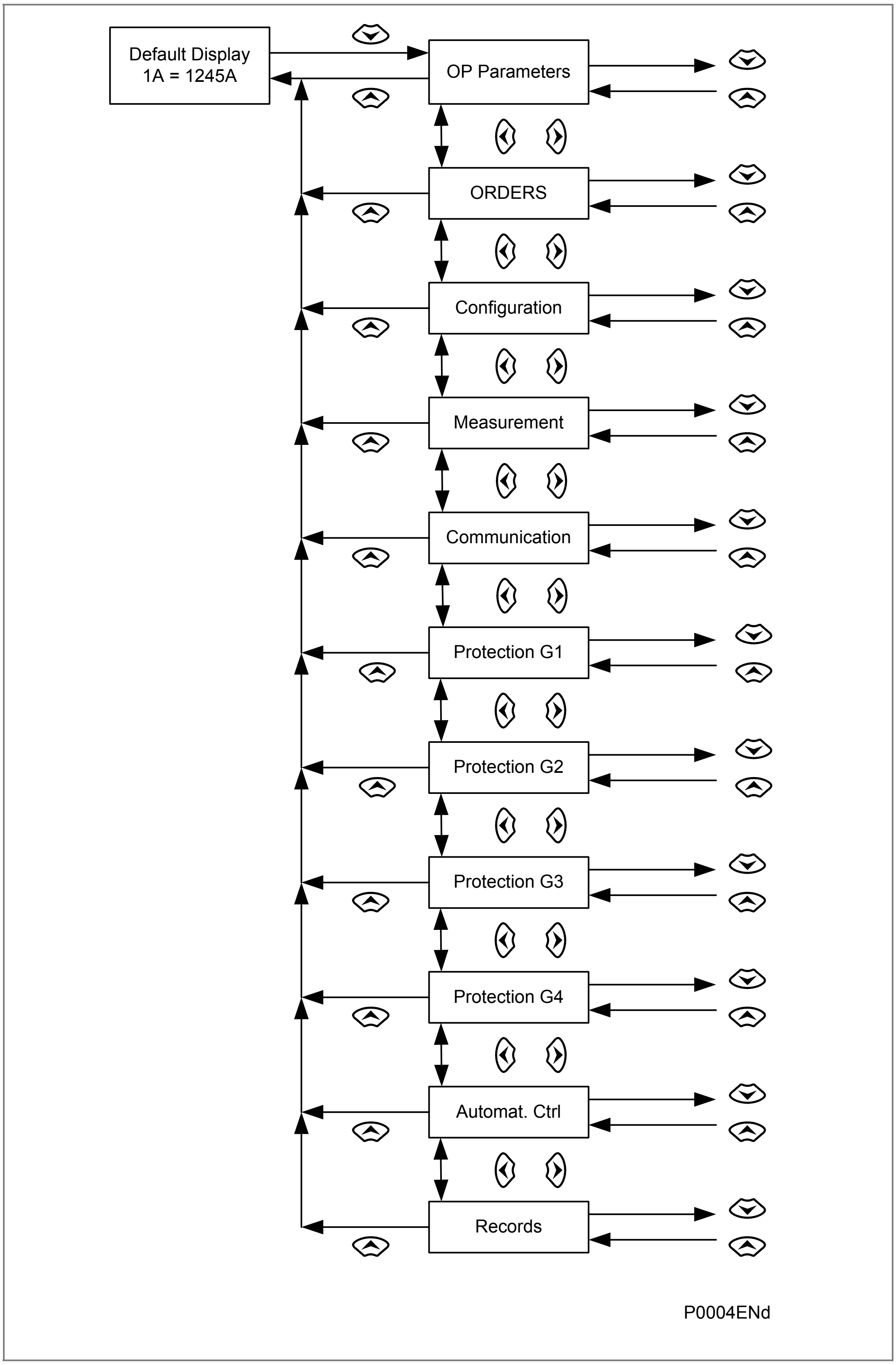

Figure 3 - Organization of MiCOM P521 main menu

Note	*The menu content tables are supplied in the Menu Content Tables section, P521/EN HI.*

3.5.1 OP Parameters Menu

To gain access to the OP PARAMETERS menu from the default display, press ⊗.

OP PARAMETERS	Heading of the OP PARAMETERS menu To gain access to the menu content, press ⊗.
Password * * * *	Entry of the password to be able to modify the MiCOM relay settings and parameters. To enter the password, press ⊕. To deactivate the active password, press ⓒ.
Password AAAA	Entry of the password is made letter by letter using ⊗ and ⊗ to go up or down the alphabet. After each letter, press ⊗, to enter the following letter. At the end, press ⊕ to validate the password. If the password is correct, the message « PASSWORD OK » is displayed on the screen. *Note The password is initially set in the factory to AAAA.*

WARNING As soon as the password has been entered, no setting change using the communication (EIA(RS)485 or EIA(RS)232) can be accepted.

LANGUAGE = ENGLISH	Choose the language for HMI. Can be selected from the following: ENGLISH, FRANCAIS, DEFAULT, CHINESE, POLSKI, RUSSIAN, ITALIANO, DEUTSCH and ESPANOL.
Description P521xxxxxxxxxx	Displays the serial number of the relay.

The model number (description) displayed in “OP Parameters” should be automatically updated when firmware is upgraded, which is upgraded by the protocol option, firmware version number. The new model number can match the option of protocol, firmware version number. When the model number has been matched, no alarm shall occur.

For example, the features of this function are as below:

- When the protocol is MODBUS, the software version is 10.A
  The Description under the OP PARAMETERS should be P521xxxx1xxAAx
- When the protocol is 103, the software version is 10.B
  The Description under the OP PARAMETERS should P521xxxx3xxABx
- When the protocol is DNP, the software version is 12.E
  The Description under the OP PARAMETERS should be P521xxxx4xxCEx

SERIAL NUM = 00000001	Displays the serial number of the relay.
Reference MiCO	Displays the name of the equipment associated with the relay. The entry of the reference is made character by character using ⊗, ⊗. After each character (letter, number or symbol), press ⊗ to move to the next character. At the end of entering, press ⊕ to accept the reference. *Note The reference is initially set in the factory to MiCO.*

Software version 13.A	Displays the version of the software.
Frequency 50 Hz	Nominal value of the network frequency. Select either 50 or 60 Hz. To modify this value, press ↵ followed by ▲, ▼ to select the desired value. Validate your choice using ↵.
Active Group 1	Display the active group (Protection G1 or G2 or G3 or G4).
Input 54321 Status 10110	Displays the state of the logic Inputs. The Logic Inputs are numbered from 1 to 5, starting from the right. The state of each input is : - state 0 : input inactive - state 1 : input active
Relay 87654321 Status 01011101	Displays the state of the logic outputs. The logic outputs are numbered from 1 to 8, starting from the right. The state of each output is : - state 0 : output relay not operated - state 1 : output relay operated Pressing the cancel key ©, in this cell, will reset any latched contacts/relays, this is with the exception of trip relay RL1. *Note The Watch-dog output (RL0) is not displayed in the output status menu.*
Date 30/01/02	Displays the date. To modify this date press ↵ then use ▲, ▼, ► to enter the required value. Accept your choice using ↵. With this example the date is : 30 January 2002.
Time 13:57:44	Displays the Time. To modify this time press ↵ then use ▲, ▼ to enter the required value. Accept your choice using ↵. With this example the time is : 13 hours, 57 minutes, 44 seconds.
Trip and Close No Operation	Enables the user to Trip or Close the circuit breaker. Select from “No Operation”, “Trip” or “Close”. To Trip or Close the circuit select either “Trip” or “Close” and then press the ↵ key. The relevant output contacts will close for the “Open Pulse” or “t Close Pulse” times found under AUTOMAT. CTRL/CB Monitoring.
Disturb Trigger No	Enables the user to create a disturbance record manually. To trigger a disturbance record, press the ↵ key and then select “Yes” using ▲, ▼.

3.5.2 Orders Menu

The various sub menus are:

- General Reset

To gain access to the ORDERS menu from the default display, press then .

3.5.2.1 General Reset Sub Menu

General Reset clears all the following information:

- LEDs
- All Fault records
- All Event records
- All disturbance records
- All counters
- All Measured values (Max & Average Phase current, thermal status…)
- CB monitoring records: SA2n and Nb Operation
- Latched output Relays (Under no Fault condition).
- All alarm signals

Caution	**This command should be password protected. Be aware of what information will be cleared before you run this command.**

GENERAL RESET <No> Yes	This new menu gives the user an option to run the General Reset command. The default option is No - the user needs to select Yes to run the command.
Confirmation <No> Yes	If the user selected the General Reset command, they need to confirm their choice. The default option is No - the user needs to select Yes to run the command.

Note	*The General Reset command can be run using the HMI On the device itself, or by using a remotely available protocol.*

3.5.3 Configuration Menu

The various sub menus are:

- Display
- CT Ratio
- Led 5
- Led 6
- Led 7
- Led 8
- Group Select
- Alarms
- Configuration Inputs
-
- Phase Rotation

To gain access to the CONFIGURATION menu from the default display, press then .

3.5.3.1 Display Sub Menu

CONFIGURATION	Heading of the CONFIGURATION menu. To gain access to the DISPLAY submenu, press .
Display	Heading of the DISPLAY sub menu. To gain access to the sub menu content, press .
Default Display RMS I A	Edit the default display to show either Phase A, Phase B, Phase C, Earth currents or all four simultaneously. To modify the default display, press then use either or to enter the required choice. Enable your choice using .
Phase A Text L1	Edit phase A label by selecting L1, A or R. This value can be modified after entering the password and is displayed with the corresponding measurement.
Phase B Text L2	Edit phase B label by selecting L2, B, S, Y or W. This value can be modified after entering the password and is displayed with the corresponding measurement.
Phase C Text L3	Edit phase C label by selecting L3, C, T or B. This value can be modified after entering the password and is displayed with the corresponding measurement.
E/Gnd Text E	Edit earth label by selecting N, E, or o. This value can be modified after entering the password and is displayed with the corresponding measurement.

3.5.3.2 CT Ratio Sub Menu

Display	Description
`CONFIGURATION`	Heading of the CONFIGURATION menu. To gain access to the CT RATIOS menu, press ⇓, ⇒.
`CT Ratio`	Heading of the CT RATIOS sub menu. To gain access to the sub menu content, press ⇓.
`Line CT primary` `1000`	Display of the primary rating of the phase CT. The value consists of 4 digits : Minimum 1, Maximum 9999. Press ↵ to modify this value and use ⇑, ⇓, ⇒, ⇐ to display the new primary phase CT ratio. Enable your choice by pressing ↵ at the end of selection.
`Line CT sec` `5`	Display of the secondary rating of the phase CT. This value toggles between 1 and 5.
`E/Gnd CT primary` `1000`	Display of the primary rating of the earth CT. The value consists of 4 digits : Minimum 1, Maximum 9999. Press ↵ to modify this value and use ⇑, ⇓, ⇒, ⇐ to display the new primary earth CT ratio. Enable your choice by pressing ↵ at the end of selection.
`E/Gnd CT sec` `5`	Display of the secondary rating of the earth CT. This value toggles between 1 and 5.
`CT Correct Ratio` `1000`	Displays the ratio correction factor that the local current is multiplied by. The correction factor has a setting range of 0.05 to 10. Press ↵ to modify this value and use ⇑, ⇓, ⇒, ⇐ to display the new correction factor. Enable your choice by pressing ↵ at the end of selection.
`Vectorial Comp.` `Off`	Displays the vector group that is in use.

3.5.3.3 LED 5 to 8 Configuration Sub Menus

To gain access to the LED 5 CONFIGURATION sub menu, press , , followed by twice.

To access to the others LEDs CONFIGURATION sub menus, press 3 times for LED 6, 4 times for LED 7 and 5 times for LED 8.

35 different parameters can be assigned to each LED.

These parameters are:

Text	Information
Idiff	Differential protection trip
Idiff Fail	Differential protection not functioning
B/up Prot	Back-up protection is enabled
Comms Fail	Protection comms channel failure
Direct I-Trip	Relay has received and tripped on direct intertrip
C-Diff I-Trip	Relay has tripped due to a differential intertrip
PIT	Relay has tripped due to a permissive intertrip command
I>	First instantaneous phase threshold
I>>	Second instantaneous phase threshold
I>>>	Third instantaneous phase threshold
I>>>>	Fourth instantaneous phase threshold
tI>	First time delayed phase threshold
tI>>	Second time delayed phase threshold
tI>>>	Third time delayed phase threshold
tI>>>>	Fourth time delayed phase threshold
Ie>	First instantaneous earth threshold
Ie>>	Second instantaneous earth threshold
Ie>>>	Third instantaneous earth threshold
Ie>>>>	Fourth instantaneous earth threshold
tIe>	First time delayed earth threshold
tIe>>	Second time delayed earth threshold
tIe>>>	Third time delayed earth threshold
tIe>>>>	Fourth time delayed earth threshold
Therm Trip	Thermal overload trip
Brkn Cond.	Broken conductor detected
CB Fail	Detection of a circuit breaker failure
tI2>	Time delayed negative phase sequence (1st threshold)
tI2>>	Time delayed negative phase sequence (2nd threshold)
Input 1	Status of Logic Input n° 1
Input 2	Status of Logic Input n° 2
Input 3	Status of Logic Input n° 3
Input 4	Status of Logic Input n° 4
Input 5	Status of Logic Input n° 5
t Aux 1	Aux Timer 1 operated
t Aux 2	Aux Timer 2 operated

Text	Information
CB Alarm	Circuit breaker alarm
Equation A	Equation A operated
Equation B	Equation B operated
Equation C	Equation C operated
Equation D	Equation D operated
Equation E	Equation E operated
Equation F	Equation F operated
Equation G	Equation G operated
Equation H	Equation H operated
Prgm IT 1	Programmable Inter-trip 1 operated
Prgm IT 2	Programmable Inter-trip 2 operated
Prgm IT 3	Programmable Inter-trip 3 operated
Prgm IT 4	Programmable Inter-trip 4 operated
CTS Local	Local CT failure detected
CTS Remote	Remote end CT failure detected
CTS Block	CT failure is detected and relevant protections are blocked (undercurrent, negative sequence overcurrent, broken conductor).
CTS Restrain	CT failure is detected and differential protection is in Restraint mode.
Convention Mode	Protection communication uses convention mode, i.e., not extended with the functions of CTS and Programmable Inter-trip.
CDiff Disabled	Current differential protection is disabled.

Notes ⇒ *Each parameter can be assigned to one or more LED's.*
⇒ *Each LED can be lit by one or more parameters (OR logic).*

Example of LED 5 setting:

CONFIGURATION	Heading of the CONFIGURATION menu. To gain access to the LED 5 submenu, press , followed by 2 times.
Led 5	Heading of the LED 5 sub menu. To gain access to the sub menu content, press .
Led Idiff No	Indicates that the differential protection has tripped. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led Idiff Fail No	Indicates that the differential protection is not functioning. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led B/up Prot No	Displays that the back-up protection has been enabled. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led Comms Fail No	Indicates that the protection comms channel has failed. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .

Led Direct I-Trip No	Indicates that the relay has received and tripped on a direct intertrip. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led C-Diff I-Trip No	Indicates that the relay has tripped due to a differential intertrip. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led PIT No	Indicates that the relay has tripped due to a permissive intertrip command. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led I> No	Displays the instantaneous threshold I> associated with LED 5. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led tI> No	Displays the time delay threshold tI> associated with LED 5. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led I>> No	Displays the instantaneous threshold I>> associated with LED 5. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led tI>> No	Displays the time delay threshold tI>> associated with LED 5. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led I>>> No	Displays the instantaneous threshold I>>> associated with LED 5. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led tI>>> No	Displays the time delay threshold tI>>> associated with LED 5. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led I>>>> No	Displays the instantaneous threshold I>>>> associated with LED 5. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led tI>>>> No	Displays the time delay threshold tI>>>> associated with LED 5. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led Ie> No	Displays the instantaneous threshold Ie> associated with LED 5. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led tIe> No	Displays the time delay threshold tIe> associated with LED 5. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
Led Ie>> No	Displays the instantaneous threshold Ie>> associated with LED 5. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .

`Led` `tIe>>      No`	Displays the time delay threshold tIe>> associated with LED 5. To modify this choice, press ↵ and use ▲ and ▼ to scroll through the available selections. Enable your choice using ↵.
`Led` `Ie>>>      No`	Displays the instantaneous threshold Ie>>> associated with LED 5. To modify this choice, press ↵ and use ▲ and ▼ to scroll through the available selections. Enable your choice using ↵.
`Led` `tIe>>>     No`	Displays the time delay threshold tIe>>> associated with LED 5. To modify this choice, press ↵ and use ▲ and ▼ to scroll through the available selections. Enable your choice using ↵.
`Led` `Ie>>>>     No`	Displays the instantaneous threshold Ie>>>> associated with LED 5. To modify this choice, press ↵ and use ▲ and ▼ to scroll through the available selections. Enable your choice using ↵.
`Led` `tIe>>>>    No`	Displays the time delay threshold tIe>>>> associated with LED 5. To modify this choice, press ↵ and use ▲ and ▼ to scroll through the available selections. Enable your choice using ↵.
`Led Therm` `Trip No`	Displays the thermal threshold tIθ trip order associated with LED 5. To modify this choice, press ↵ and use ▲ and ▼ to scroll through the available selections. Enable your choice using ↵.
`Led Brkn. Cond` `    No`	Displays the broken conductor information associated with LED 5. To modify this choice, press ↵ and use ▲ and ▼ to scroll through the available selections. Enable your choice using ↵.
`Led CB Fail` `    No`	Displays the circuit breaker failure information associated with LED 5. To modify this choice, press ↵ and use ▲ and ▼ to scroll through the available selections. Enable your choice using ↵.
`Led tI2>` `    No`	Displays the negative phase sequence 1st threshold tI2> associated with LED 5. To modify this choice, press ↵ and use ▲ and ▼ to scroll through the available selections. Enable your choice using ↵.
`Led tI2>>` `    No`	Displays the negative phase sequence 2nd threshold tI2> associated with LED 5. To modify this choice, press ↵ and use ▲ and ▼ to scroll through the available selections. Enable your choice using ↵.
`Led Input 1` `    No`	Displays the state of the logic input 1 associated with LED 5. To modify this choice, press ↵ and use ▲ and ▼ to scroll through the available selections. Enable your choice using ↵.
`Led Input 2` `    No`	Displays the state of the logic input 2 associated with LED 5. To modify this choice, press ↵ and use ▲ and ▼ to scroll through the available selections. Enable your choice using ↵.
`Led Input 3` `    No`	Displays the state of the logic input 3 associated with LED 5. To modify this choice, press ↵ and use ▲ and ▼ to scroll through the available selections. Enable your choice using ↵.
`Led Input 4` `    No`	Displays the state of the logic input 4 associated with LED 5. To modify this choice, press ↵ and use ▲ and ▼ to scroll through the available selections. Enable your choice using ↵.

```
Led Input 5
     No
```

Displays the state of the logic input 5 associated with LED 5. To modify this choice, press ↵ and use ↑ and ↓ to scroll through the available selections. Enable your choice using ↵.

```
Led t Aux 1
     No
```

Displays the state of the logic input delayed by t Aux 1. To modify this choice, press ↵ and use ↑ and ↓ to scroll through the available selections. Enable your choice using ↵.

```
Led t Aux 2
     No
```

Displays the state of the logic input delayed by t Aux 2. To modify this choice, press ↵ and use ↑ and ↓ to scroll through the available selections. Enable your choice using ↵.

```
Led CB Alarm
     No
```

Displays the state of the circuit breaker alarm. To modify this choice, press ↵ and use ↑ and ↓ to scroll through the available selections. Enable your choice using ↵.

```
Led Equation A
     No
```

Displays the Logic Equation A information associated with LED 5. To modify this choice, press ↵ and use ↑ and ↓ to scroll through the available selections. Enable your choice using ↵.

```
Led Equation B
     No
```

Displays the Logic Equation B information associated with LED 5. To modify this choice, press ↵ and use ↑ and ↓ to scroll through the available selections. Enable your choice using ↵.

```
Led Equation C
     No
```

Displays the Logic Equation C information associated with LED 5. To modify this choice, press ↵ and use ↑ and ↓ to scroll through the available selections. Enable your choice using ↵.

```
Led Equation D
     No
```

Displays the Logic Equation D information associated with LED 5. To modify this choice, press ↵ and use ↑ and ↓ to scroll through the available selections. Enable your choice using ↵.

```
Led Equation E
     No
```

Displays the Logic Equation E information associated with LED 5. To modify this choice, press ↵ and use ↑ and ↓ to scroll through the available selections. Enable your choice using ↵.

```
Led Equation F
     No
```

Displays the Logic Equation F information associated with LED 5. To modify this choice, press ↵ and use ↑ and ↓ to scroll through the available selections. Enable your choice using ↵.

```
Led Equation G
     No
```

Displays the Logic Equation G information associated with LED 5. To modify this choice, press ↵ and use ↑ and ↓ to scroll through the available selections. Enable your choice using ↵.

```
Led Equation H
     No
```

Displays the Logic Equation H information associated with LED 5. To modify this choice, press ↵ and use ↑ and ↓ to scroll through the available selections. Enable your choice using ↵.

```
Led Prgm IT 1
     No
```

Displays the state of Programmable Inter-tripping 1. To modify this choice, press ↵ and use ↑ and ↓ to scroll through the available selections. Enable your choice using ↵.

```
Led Prgm IT 2
     No
```

Displays the state of Programmable Inter-tripping 2. To modify this choice, press ↵ and use ↑ and ↓ to scroll through the available selections. Enable your choice using ↵.

Display	Description
`Led Prgm IT 3` `No`	Displays the state of Programmable Inter-tripping 3. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
`Led Prgm IT 4` `No`	Displays the state of Programmable Inter-tripping 4. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
`Led CTS Local` `No`	Displays the state of local CTS failure. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
`Led CTS Remote` `No`	Displays the state of remote CTS failure. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
`Led CTS Block` `No`	Displays the state of CTS block relevant protections. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
`Led CTS Restrain` `No`	Displays the state of CTS restrain current differential protection. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .
`Led Convention Mode` `No`	Displays trhe state of protection communications mode is in Convention Mode. To modify this choice, press and use and to scroll through the available selections. Enable your choice using .

3.5.3.4 Group Select Sub Menu

Display	Description
`CONFIGURATION`	Heading of the CONFIGURATION menu. To gain access to the menu, press , , , followed by ⇒ 6 times.
`Group Select`	Heading of the GROUP SELECT sub menu. To gain access to the sub menu content, press .
`Change Group` `Input = EDGE`	Displays the operation mode of the digital input associated to the change of protection setting group: "EDGE" or "LEVEL". To change the operation mode, press then use and to scroll through the available selections. Enable your choice using .

Note	*If you select Change Group=EDGE, then the following appear:* *Setting Group 1/2/3/4* *Target Group 0/1/2/3/4.*
Note	*If you select Change Group=LEVEL, then the following appear:* *"Group if low level 1/2/3/4"* *"Group if high level 1/2/3/4".*

Display	Description
`Setting Group` `1`	Displays the active setting group (1 or 2 or 3 or 4). To manually change the active setting group, press then use and to enter the required value (1 or 2 or 3 or 4). Enable your choice using . Manual changes are only possible if "EDGE" is selected in the previous cell.

3.5.3.5 Alarms Sub Menu

`CONFIGURATION`	Heading of the configuration menu. To gain access to alarms menu, press , , , followed by ⇒ 7 times.
`Alarms`	Heading of the alarms sub menu. To gain access to the sub menu content, press .
`Inst. Self-reset?` `No`	Displays the reset mode of the alarms concerning the instantaneous (protection start indications): self-reset Yes or No. If the user chooses No, the reset must be done by the push button. To change the reset mode press then use and to select either Yes or No. Enable your choice using .
`Comm.Fail-reset?` `No`	Displays the reset mode of the Communication Failure alarm: self-reset Yes or No. If the user chooses No, the reset must be done by the push button. If the user chooses Yes, the Communication Failure alarm will automatically reset when the protection communication is re-established. To change the reset mode press then use and to select either Yes or No. Enable your choice using .
`CDiff Disabled Alarm?` `No`	Select the mode of alarm displaying when the Current Differential is disabled. If Yes is chosen, Alarm will be raised when differential protection is disabled. Otherwise alarm will not ba raised. To change the setting press then use and to select either Yes or No. Enable your choice using .

3.5.3.6 Configuration Inputs Sub Menu

It is possible to configure individual digital inputs to be active from either a falling edge/low level, or on a rising edge/high level. This can be done using the “inputs” cell in the “CONFIGURATION” column A “0” means that the opto is active low, if the associated function is LEVEL dependent, or active for a falling edge if EDGE dependent. Conversely, a “1” means that the opto is active high, if the associated function is LEVEL dependent, or active for a rising edge if EDGE dependent. The choice of how the digital inputs are activated it dependent upon the application.

The table below shows which functions are LEVEL or EDGE dependent.

Example: a digital input configured "blocking logic" will operate on level, on the other hand a digital input configured "cold load pick up" will operate on edge.

ONLY a digital input configured "change of setting group" can operate either on edge or on level (selectable).

Function allocated to the Digital Input	Operation of the Digital Input
Unlatch of the output relays	On level
Position of the CB, 52a or 52b	On level
Blocking logic 1 & 2	On level
Logic selectivity 1 & 2	On level
Aux 1 & Aux 2	On level
CB fault	On level
Reset of the thermal state	On edge
Blocking of the auto-recluse	On level
Cold load pick up	On edge
Start of disturbance record	On edge
Trip circuit supervision	On level

Function allocated to the Digital Input	Operation of the Digital Input
Change of setting group	On edge or on level
CB fail start	On edge

The user has to set in the CONFIGURATION Menu the auxiliary voltage (AC or DC) for the operation of the digital inputs. This setting is necessary due to the time filtering being different if DC or AC is chosen.

```
CONFIGURATION
```

Heading of the CONFIGURATION menu. To gain access to Configuration Inputs menu, press , , , followed by 8 times.

```
Configuration
Inputs
```

Heading of the Configuration Inputs sub menu. To gain access to the sub menu content, press .

```
Inputs     5 4 3 2 1
     1 1 1 1 1
```

Displays how the digital Inputs are activated either on a falling edge/low level, or on a rising edge/high level:
0 = falling edge/low level
1 = rising edge/high level
To change the operation mode press then use , to highlight each input followed by and to toggle between 0 and 1. Enable your choice using .

```
Voltage input =
     DC
```

Displays the voltage (AC or DC) on the digital Inputs. To change the voltage press then use and to toggle between AC or DC. Enable your choice using .

3.5.3.7 Output Relays Sub Menu

```
CONFIGURATION
```

Heading of the CONFIGURATION menu. To gain access to the Phase rotation menu, press , , , followed by 9 times.

```
OUTPUT RELAYS
```

Heading of the OUTPUT RELAYS sub menu. To gain access to the Fail Safe RL1 menu, press .

```
Fail Safe RL1
Yes        <No>
```

Displays the Fail Safe RL1 setting either Yes or No (it is No by default). To change the selection use and to toggle between Yes or No. Enable your choice using

Note	*When the user set the fail safe RL1 as "YES", then The RL1 shall as invert output relays. In the maintenance mode (or if the P521 relay detects a major alarm), the fail safe RL1 is invalid.*

3.5.3.8 Phase Rotation Sub Menu

```
CONFIGURATION
```

Heading of the CONFIGURATION menu. To gain access to the Phase rotation menu, press , , , followed by 9 times.

```
Phase Rotation
```

Heading of the PHASE ROTATION sub menu. To gain access to the Phase Rotation menu, press .

```
Phase Rotation
     A-B-C
```

Displays the phase rotation either A-B-C or A-C-B. To change the phase rotation press then use and to toggle between A-B-C or A-C-B. Enable your choice using .

3.5.4 Measurements Menu

The MEASUREMENTS menu makes it possible to read the various system measurements. There are three main measurement menus, which are “Current Diff”, “Current/Frequency” and “Communications”. The “Current Diff” menu displays measurements associated with the differential protection (e.g. Differential / Bias currents), whereas the “Current/Frequency” menu displays more general measurements such as currents and demand values etc. The “Communications” measurement menu displays error statistics for the protection communications channel.

3.5.4.1 Measurements Currents Diff Sub Menu

`MEASUREMENTS`	Heading of the MEASUREMENTS menu. To gain access to the Current Diff menu, press , , , .
`Current Diff`	Heading of the Current Diff sub menu. To gain access to the Current Diff menu, press .
`Remote IA` `640.10 A`	Displays the remote A phase current (Fundamental component) taking into account the phase CT ratio (CONFIGURATION/CT RATIO sub menu). Not displayed if Vectorial Compensation is enabled.
`Remote IB` `629.00 A`	Displays the remote B phase current (Fundamental component) taking into account the phase CT ratio (CONFIGURATION/CT RATIO sub menu). Not displayed if Vectorial Compensation is enabled.
`Remote IC` `634.50 A`	Displays the remote C phase current (Fundamental component) taking into account the phase CT ratio (CONFIGURATION/CT RATIO sub menu). Not displayed if Vectorial Compensation is enabled.
`Differential IA` `0A`	Displays the A phase differential current.
`Differential IB` `0A`	Displays the B phase differential current.
`Differential IC` `0A`	Displays the C phase differential current.
`Bias IA` `640.10 A`	Displays the A phase bias current.
`Bias IB` `629.00 A`	Displays the B phase bias current.
`Bias IC` `634.50 A`	Displays the C phase bias current.
`Local Angle` `A-B    120 °`	Displays the phase angle between the currents in phases A and B at the Local end.
`Local Angle` `B-C    120 °`	Displays the phase angle between the currents in phases B and C at the Local end.
`Local Angle` `C-A    120 °`	Displays the phase angle between the currents in phases C and A at the Local end..

Diff Angle A (L-R) 0 °	Displays the differential angle between the phase A current at the Local end and the phase A current at the Remote end (time-aligned).
Diff Angle B (L-R) 0 °	Displays the differential angle between the phase B current at the Local end and the phase B current at the Remote end (time-aligned).
Diff Angle C (L-R) 0 °	Displays the differential angle between the phase C current at the Local end and the phase C current at the Remote end (time-aligned).

3.5.4.2 Measurements Current/frequency Sub Menu

MEASUREMENTS	Heading of the MEASUREMENTS menu. To gain access to the Current/Frequency menu, press , , , , .
Current/General	Heading of the Current Frequency sub menu. To gain access to the Current/Frequency menu, press .
I A 640.10 A	Displays the A phase current (True RMS value) taking into account the phase CT ratio (CONFIGURATION/CT RATIO sub menu).
I B 629.00 A	Displays the B phase current (True RMS value) taking into account the phase CT ratio (CONFIGURATION/CT RATIO sub menu).
I C 634.50 A	Displays the C phase current (True RMS value) taking into account the phase CT ratio (CONFIGURATION/CT RATIO sub menu).
I N 3.15 A	Displays the earth current (True RMS value) taking into account the earth CT ratio (CONFIGURATION/CT RATIO sub menu).
I1 = 103A	Displays the positive sequence current.
I2 = 50A	Displays the negative sequence current.
RATIO I2/I1 = 50%	Displays the ratio of I2/I1.
I N - fn RST = [C] 0.0A	Displays the earth current (True RMS value) minus the current value at the fundamental frequency (value of the harmonics). To clear the value, press (password needed).
Thermal θ RST = [C] 67%	Displays the % thermal state based on true RMS values. To clear the % values, press (password needed).
Max & Average I RST = [C]	Allows the user to clear the maximum (peak) and average (rolling) memorized values of the current. To clear these values, press (password needed).
Max IA Rms 127.36 A	Displays the maximum (peak) value for phase A. The value is the true RMS maximum value.
Max IB Rms 156.28 A	Displays the maximum (peak) value for phase B. The value is the true RMS maximum value.
Max IC Rms 139.01 A	Displays the maximum (peak) value for phase C. The value is the true RMS maximum value.

Average IA Rms 98.25 A	Displays the rolling value for phase A. The value is the true RMS average value.
Average IB Rms 97.88 A	Displays the rolling value for phase B. The value is the true RMS average value.
Average IC Rms 99.02 A	Displays the rolling value for phase C. The value is the true RMS average value.
MAX. SUBPERIOD RST = [C]	Allows the user to clear the maximum sub-period values of the 3 currents.
MAX. SUBPERIOD IA Rms = 245A	Displays the IA peak value demand. The value is the true RMS maximum value on a sub-period.
MAX. SUBPERIOD IB Rms = 240A	Displays the IB peak value demand. The value is the true RMS maximum value on a sub-period.
MAX. SUBPERIOD IC Rms = 250A	Displays the IC peak value demand. The value is the true RMS maximum value on a sub-period.
ROLLING AVERAGE RST = [C]	Allows the user to clear the rolling average values of the 3 currents.
ROLLING AVERAGE IA Rms = 0A	Displays the IA average value demand. The value is the true RMS average value on a number of sub-period set in Record menu.
ROLLING AVERAGE IB Rms = 0A	Displays the IB average value demand. The value is the true RMS average value on a number of sub-period set in Record menu.
ROLLING AVERAGE IC Rms = 0A	Displays the IC average value demand. The value is the true RMS average value on a number of sub-period set in Record menu.

3.5.4.3 Measurements Communications Sub Menu

MEASUREMENTS	Heading of the MEASUREMENTS menu. To gain access to the Communications menu, press , , , followed by 2 times.
Protection Comms	Heading of the Communications sub menu. To gain access to the Communications menu, press .
CH1 Valid Msgs 00	Displays the total number of valid messages received.
CH1 Err Msgs 00	Displays the total number of errors received.
CH1 Errored secs 0.0s	Displays the number of seconds containing 1 or more errors or lost messages.
CH1 Sev Err secs 0.0s	Displays the number of seconds containing 31 or more errors or lost messages.
CH1 Prop Delay 0.0s	Displays the propagation delay.
Elapsed Time 0.0s	Displays the time elapsed since the communications measurement statistics were last reset.

`Comms Stats RST` `RST =[C]`	Allows the user to clear the communications measurement statistics.

3.5.5 Communication Menu

There are two sub-menus under the COMMUNICATION menu: Ctrl Comms and Protection.

The Ctrl Comms sub-menu contains the configuration parameters for the rear EIA(RS)485 communication port, which depend on the protocol (order option): MODBUS, IEC 60870-5-103 or DNP3.0.

The Protection sub-menu contains the configuration parameters for the protection signaling interface to the remote P521.

3.5.5.1 MODBUS Communication Menu

`COMMUNICATION`	Heading of the COMMUNICATION menu. To gain access to the Control Comms menu, press , 3 times then . To gain access to the sub menu points, press .
`Ctrl Comms`	Heading of the Control Comms menu. To gain access to the Control Comms menu press .
`Ctrl Comms?` `Yes`	Enables / disables MODBUS RTU communication via the EIA(RS)485 port on the rear of the relay. To activate communications, press the key and use to select Yes. Enable your choice using .
`Baud Rate` `19200 bd`	Displays the speed of the MODBUS transmission. Select from: 300, 600, 1200, 2400, 4800, 9600, 19200, 38400 bauds using or and enable your choice using .
`Parity` `None`	Displays the parity in the MODBUS frame. Select Even, Odd or None using or and enable your choice using .
`Stop bits` `1`	Displays the number of stop bits in the MODBUS frame. Select 1 or 2 using or and enable your choice using .
`Relay Address` `1`	Displays the network address of the MiCOM relay in the MODBUS network. Select from 1 to 255 using or and enable your choice using .
`Date format` `PRIVATE`	Displays the format of the date. Select either PRIVATE or IEC (= IEC60870-5 Binary Time 2a format).

WARNING: A MODBUS network can only comprise 32 relay addresses on the same MODBUS sub-LAN.

3.5.5.2 IEC 60870-5-103 (VDEW) Communication Menu

`COMMUNICATION`	Heading of the COMMUNICATION menu. To gain access to the Control Comms menu, press , 3 times then . To gain access to the sub menu points, press .
`Ctrl Comms`	Heading of the Control Comms menu. To gain access to the Control Comms menu press .

Ctrl Comms? Yes	Enables / disables IEC 60870-5-103 communication via the EIA(RS)485 port on the rear of the relay. To activate communications, press the ↵ key and use ▲ to select Yes. Enable your choice using ↵.
Data Bits 9600 bd	Displays the speed of IEC 60870-5-103 transmission. Select from: 9600, 19200 bauds using ▲ or ▼ and enable your choice using ↵.
Relay Address 29	Display of the network address of the MiCOM relay in the IEC 60870-5-103 network. Select from 1 to 255 using ▲ or ▼ and enable your choice using the ↵ key.

3.5.5.3 DNP3.0 Communication Menu

COMMUNICATION	Heading of the COMMUNICATION menu. To gain access to the Control Comms menu, press ▼, ► 3 times then ▼. To gain access to the sub menu points, press ▼.
Ctrl Comms	Heading of the Control Comms menu. To gain access to the Control Comms menu press ▼.
Ctrl Comms? Yes	Enables/disables DNP3.0 communication via the EIA(RS)485 port on the rear of the relay. To activate communications, press the ↵ key and use ▲ to select Yes. Enable your choice using ↵.
Baud Rate 19200 bd	Displays the speed of the DNP3.0 transmission. Select from: 1200, 2400, 4800, 9600, 19200, 38400 bauds using ▲ or ▼ and enable your choice using ↵.
Parity None	Displays the parity in the DNP3.0 frame. Select Even, Odd or None using ▲ or ▼ and enable your choice using ↵.
Stop Bits 1	Displays the number of stop bits in the DNP3.0 frame. Select 1 or 2 using ▲ or ▼ and enable your choice using ↵.
Relay Address 1	Displays the network address of the MiCOM relay in the DNP3.0 network. Select from 1 to 59999 using ▲ or ▼ and enable your choice using ↵.

3.5.5.4 Protection Communication Menu

COMMUNICATION	Heading of the COMMUNICATION menu. To gain access to the Protection Comms menu, press ▼, ► 3 times then ▼ and ►. To gain access to the sub menu points, press ▼.
Protection	Heading of the Protection Comms menu. To gain access to the Protection Comms menu, press ▼.
Protocol SDLC	Displays the currently selected protocol for the protection comms. Select from SDLC, NRZ and Inverted_NRZ using ▲ or ▼ and enable your choice using ↵.
Data Rate 64 k	Displays the speed of protection comms transmission. Select from: 9.6 k, 19.2 k, 56 k and 64 kbits per second using ▲ or ▼ and enable your choice using ↵.
Relay Address 1A	Displays the relays protection comms address. Select from: 1A, 2A, 3A, 1B etc. through to 16 B using ▲ or ▼ and enable your choice using the ↵ key.
Clock Source Ch1 INTERNAL	Displays the source of the protection comms clock. Select from INTERNAL or EXTERNAL using ▲ or ▼ and enable your choice using ↵.

Comm Fail Timer 0 ms	Allows a settable delay for which a comms failure must be present before an alarm is issued.
Comm Delay Tol 1 ms	Displays the maximum allowable propagation time variation. Variations greater than the set value will result in a bias characteristic modification, in order to stabilize the relay.
Char Mod Time 1 s	Displays the duration the bias characteristic is modified for, following a variation in the propagation delay greater than the "Comm Delay Tol".
FRAME MODE Extension	Displays the frame structure of the protection communication. Select from Extension or Convention using or and enable your choice using .

Note	*To use the following three functions, the relay must be set in Extension mode:* *CTS,* *Programmable Inter-trip,* *Block mode for inrush option.*

While a relay of V12 communicate with earlier versions, it must be set in Convention mode.

3.5.6 Protection Menu

The PROTECTION menu (designated as PROTECTION G1, PROTECTION G2, PROTECTION G3 or PROTECTION G4 menus) enables the user to program various protection functions and settings (thresholds, time delay etc.) associated with all the protection functions.

The various sub menus are:

- [87] Current Diff
- [50/51] Phase OC
- [50N/51N] E/Gnd
- [46] Neg Seq OC
- [49] Therm OL
- [37] Under Current

To gain access to the PROTECTION G1 menu press then 4 times.

To gain access to the PROTECTION G2 menu press then 5 times.

To gain access to the PROTECTION G3 menu press then 6 times.

To gain access to the PROTECTION G4 menu press then 7 times.

3.5.6.1 [87] Current Diff Sub Menu

PROTECTION Gx	Heading of the PROTECTION Gx menu (where x = 1, 2, 3 or 4). To gain access to the [87] Current Diff menu, press , 4, 5, 6 or 7 times (as needed), then .
[87] Current Diff	Heading of the [87] Current Diff sub menu. To gain access to the sub menu points, press .

`Current Diff?` `Yes`	Enables / disables Current Differential protection. To activate the current differential protection, press the ↵ key and use ▲ to select Yes. Enable your choice using ↵.
`Is1` `0.2 In`	Displays Is1 threshold value. The Is1threshold is adjustable from 0.1 to 2 In. To modify this value, press ↵ followed by ▲ or ▼ to select the desired value. Enable your choice using the ↵ key.
`Is2` `2.0 In`	Displays Is2 threshold value. To modify this value, press ↵. The Is2 threshold is adjustable from 1 to 30 In. Press ↵ to enable your adjustment.
`k1` `30 %`	Displays the gradient of the K1 slope. To modify this value, press ↵. The k1 setting is adjustable from 0 to 150%. Press ↵ to enable your adjustment. If setting below 30%, see P521/EN AP section 2.1.5.3.
`k2` `150 %`	Displays the gradient of the k2 slope. To modify this value, press ↵. The k2 setting is adjustable from 30 to 150%. Press ↵ to enable your adjustment.
`IDiff Delay Type` `DMT`	Selects the delay type for the Current Differential protection. Select from DMT or IDMT using ▲ or ▼ and enable your choice using ↵.
`tIdiff` `0 ms`	Displays the desired operating time for the current differential protection if the delay type is DMT. Select 0 ms for instantaneous. To modify this value, press ↵ followed by ▲ or ▼. Press ↵ to enable your adjustment.
`I Diff Curve` `IEC SI`	Displays the desired operating curve for the current differential protection if the delay type is IDMT. Select from IEC SI, IEC STI, IEC VI, IEC EI, IEC LTI, CO2, IEEE MI, CO8, IEEE VI or IEEE EI using ▲ or ▼ and enable your choice using ↵.
`IDiff Tms` `1.0`	Displays the Time Multiplier Setting (TMS) associated with the I Diff Curve. TMS is visible when any of the IEC curves are selected. To modify this value, press ↵ followed by ▲ or ▼. Press ↵ to enable your adjustment.
`IDiff Time Dial` `1.0`	Displays the Time Dial associated with the I Diff Curve. TD is visible when CO2, CO8 or IEEE curves are selected. To modify this value, press ↵ followed by ▲ or ▼. Press ↵ to enable your adjustment.
`PIT Time` `200 ms`	Displays the PIT operating time. To modify this value press ↵. The PIT time is adjustable from 50ms to 20 seconds. Press ↵ to enable your adjustment.
`PIT I Disable` `No`	Enables / Disables the remote current check feature for the Permissive Intertrip (PIT) function. Choose YES to disable the current check. To choose between YES or NO, Press ↵, followed by ▲ or ▼. Press ↵ to enable your adjustment.
`PIT I Selection` `Remote`	Displays whether local or remote current will be used for the PIT current check feature. Visible if PIT I Disable is No. To choose between Local or Remote, Press ↵, followed by ▲ or ▼. Press ↵ to enable your adjustment.
`PIT I Threshold` `0.20 In`	Displays the remote current threshold for the PIT current check feature. Visible if PIT I Selection is Remote. The threshold is adjustable from 0.1 to 40 In. To modify this value, press ↵ followed by ▲ or ▼. Press ↵ to enable your adjustment.

`PIT OC Stages` `00000000   4.0 IN`	Displays which local overcurrent stage(s) start(s) will be used for the PIT current check feature. Visible if PIT I Selection is Local. The stages are I>, I>>, I>>>, I>>>>, Ie>, Ie>>, Ie>>>, Ie>>>>, starting from the right. To select press then use , to highlight each stage followed by and to toggle between 0 (not used) and 1 (used). Enable your choice using .
`DIT Rx tDwell` `     100 ms`	Displays the dwell time associated with the Direct Intertrip (DIT) commands received from the remote relay. To modify this value press . The dwell time is adjustable from 0.1 to 5 seconds. Press to enable your adjustment.
`DIT Alarm` `                  Yes`	Enables / Disables the Alarm LED illumination when a DIT signal is received. Choose YES to enable the illumination of yellow Alarm LED. To choose between YES or NO press , followed by or . Press to enable your adjustment.
`PIT Alarm` `                  Yes`	Enables / Disables the Alarm LED illumination when a PIT signal is received. Choose YES to enable the illumination of yellow Alarm LED. To choose between YES or NO press , followed by or . Press to enable your adjustment.
`CTS Is1` `     0.2 IN`	Displays the Is1 threshold value for the situation when CT failure is detected and "Restraint" mode is chosen for differential. This Is1 threshold is adjustable from 0.2 to 4 In. To modify this value, press followed by or to select the desired value. Enable your choice using the key.
`Inrush Option` `     Disabled`	Display options for the inrush restraint/block facility. Choose from Disabled, Block and Restraint. To modify the setting, press followed by or . Press to enable your adjustment.
`High Set` `     04.0 IN`	Displays the Idiff High Set setting when Inrush Option is enabled. To modify this value press . The High Set is adjustable from 4 to 32 In. Press to enable your adjustment.
`Kr` `     4`	Displays the Kr setting when Restraint mode is selected. The Kr is adjustable from 3 to 20. To modify this value press followed by or . Press to enable your adjustment.
`Harmonic Ratio` `     15%`	Displays the I2/I1 setting when Block mode is selected. It is adjustable from 5% to 50%. To modify this value press followed by or . Press to enable your adjustment.
`Transient Bias` `     No`	Enables/Disables the transient bias facility. Choose YES to enable transient bias facility. To choose between YES or NO press , followed by or . Press to enable your adjustment.

3.5.6.2 [50/51] Phase OC Sub Menu

PROTECTION Gx	Heading of the PROTECTION Gx menu (where x = 1, 2, 3 or 4). To gain access to the [50/51] Phase OC sub menu, press , 4, 5, 6 or 7 times (as needed), then and .
[50/51] Phase OC	Heading of the [50/51] Phase OC sub menu. To gain access to the sub menu press .
I>? Yes	Selection of the first phase threshold (I>). Select Yes, No or Backup. If the user enters I>(Yes or Backup), the following menu is displayed. If the user enters I> (No), go to I>> menu. If "Backup" is selected I> will only function in the event of a Protection Comms Failure.
I> 1 In	Displays the threshold current value I>. To modify this value, press . The threshold I> is adjustable from 0.1 to 25 In. Press to enable your adjustment.
Delay Type DMT	Selection of the I> threshold time delay type. Select DMT for definite time, IDMT for inverse time curves or RI for the electromechanical inverse time curve.

3.5.6.2.1 I> DMT Threshold Menu

Delay Type DMT	Displays the I> DMT time delay.
tI > 100 ms	Selection of the I> time delay. Select the time delay from 0 to 150 s using or and enable your choice using .

3.5.6.2.2 I> IDMT Threshold, IEC or IEEE/ANSI Curve Menu

Delay Type IDMT	Display the I> inverse time delay (IEC or IEEE/ANSI curves).
Curve IEC SI	Selection of the I> curve. Select from IEC SI, IEC STI, IEC VI, IEC EI, IEC LTI, CO2, IEEE MI, CO8, IEEE VI, IEEE EI using or and enable your choice using the key .
Tms 1.0	Displays the Time Multiplier Setting (TMS) associated with the IDMT Curve. TMS is visible when any of the IEC curves are selected. Select the curve TMS value. Select from 0.025 to 1.5 using or and enable your choice using .
Time Dial 1.0	Displays the Time Dial associated with the IDMT Curve. Time Dial is visible when CO2, CO8 or IEEE curves are selected. Select from 0.1 to 100 using or and enable your choice using .

3.5.6.2.3 I> DMT Reset Time, IEEE/ANSI Curves Menu

`Reset Type` `DMT`	Selection of the type of reset time delay. Select between DMT (Definite Time) and IDMT (Inverse Time) using or and enable your choice using .
`tReset 40 ms`	Selection of the tReset value associated with the DMT reset time choice. Select from 40 ms to 100 s using or and enable your choice using .

3.5.6.2.4 I> IDMT Reset Time, IEEE/ANSI Curves Menu

`Reset Type` `IDMT`	Selection of the type of reset time delay. Select between DMT (Definitive Time) and IDMT (Inverse Time) using or and enable your choice using .
`Rtms 1.0`	Selection of the Rtms value associated with the IDMT reset time choice. Select from 0.025 to 1.5 using or and enable your choice using .

3.5.6.2.5 I> IDMT Threshold, Electromechanical RI Curve Menu

`Delay Type` `RI`	Display of the I> inverse time delay (electromechanical RI curve).
`K` `1.0`	Selection of the RI curve K value. Select from 0.100 to 10 using or and enable your choice using .

3.5.6.2.6 I> DMT Reset Time, IEC / Electromechanical RI Curves Menu

`tReset` `60 ms`	Selection of the tReset value from 40 ms to 100 s using or and enable your choice using .

3.5.6.2.7 I>> Threshold Menu

`I>>?` `No`	Selection of the I>> second phase threshold. Select Yes, No or Backup. If the user enters I>>(Yes or Backup), the following menu is displayed. If the user enters I>> (No) go to I>>> menu. If "Backup" is selected I>> will only function in the event of a Protection Comms Failure.
`I>>` `10 In`	Selection of the I>> second threshold current value. To modify this value, press . The threshold I>> is adjustable from 0.5 to 40 In using or . Press to enable your adjustment.
`I>> Delay Type` `DMT`	Selection of the I>> time delay type threshold. Select DMT for definite time, IDMT for inverse time curves, RI for electromechanical inverse time curve. According to this setting, additional settings appear, as shown for I> above.
`tI >>` `100 ms`	Selection of the second threshold I>> time delay. Select the time delay from 0 to 150 s using or and enable your choice using .

3.5.6.2.8 I>>> Threshold Menu

I>>>? No	Selection of the I>>> third phase threshold. Select Yes, No or Backup. If the user enters I>>>(Yes or Backup), the following menu is displayed. If the user enters I>>> (No) go to I>>>> menu. If "Backup" is selected I>>> will only function in the event of a Protection Comms Failure.
I>>> 10 In	Selection of the I>>> third threshold current value. To modify this value, press . The threshold I>>> is adjustable from 0.5 to 40 In. Press to enable your adjustment.
tI >>> 100 ms	Selection of the third threshold I>>> time delay. Select the time delay from 0 to 150 s using or and enable your choice using .

3.5.6.2.9 I>>>> Threshold Menu

I>>>>? No	Selection of the I>>>> fourth phase threshold. Select Yes, No or Backup. If the user enters I>>>> (Yes or Backup), the following menu is displayed. If the user enters I>>>> (No), the LCD display returns to the heading of the menu [50/51] Phase OC. If "Backup" is selected I>>>> will only function in the event of a Protection Comms Failure.
I>>>> 10 In	Selection of the I>>>> fourth threshold current value. To modify this value, press . The threshold I>>>> is adjustable from 0.5 to 40 In. Press to enable your adjustment.
tI >>>> 100 ms	Selection of the fourth threshold I>>>> time delay. Select the time delay from 0 to 150 s using or and enable your choice using .

3.5.6.3 [50N/51N] Earth OC Sub Menu

PROTECTION Gx	Heading of the PROTECTION Gx menu (where x = 1, 2, 3 or 4). To gain access to the [50N/51N] E/Gnd sub menu, press , 4, 5, 6 or 7 times, and twice.
[50N/51N] E/Gnd	Heading of the [50N/51N] E/Gnd sub menu. To gain access to the sub menu content, press .
Ie>? Yes	Selection of the first earth threshold (Ie>). Select Yes, No or Backup. If the user enters Ie>(Yes or Backup), the following menu is displayed. If the user enters > (No), go to Ie>> menu. If "Backup" is selected Ie> will only function in the event of a Protection Comms Failure.
le > 0.05 Ien	Displays the current threshold value Ie>. To modify this value, press . The threshold Ie> is adjustable from: 0.002 to 1 Ien (0.002 to 1 Ien Range), 0.01 to Ien (0.01 to 8 Ien Range) and 0.1 to 25 Ien (0.1 to 40 Ien Range). Press to enable your adjustment.
Ie> Delay Type DMT	Selection of the Ie> threshold time delay type. Select from DMT for definite time, IDMT for inverse time curves, RI for the electromechanical inverse time curve or LABOR. for Laborelec inverse curves. Make your selection using or and enable your choice using .

3.5.6.3.1 Ie> DMT Threshold Menu

Display	Description
Ie> Delay Type DMT	Displays the Ie> DMT time delay.
tIe > 100 ms	Selection of the Ie> time delay. Select the time delay from 0 to 150 s using or and enable your choice using .

3.5.6.3.2 Ie> IDMT Threshold, IEC or IEEE/ANSI Curves menu

Display	Description
Ie> Delay Type IDMT	Displays the Ie> inverse time delay (IEC or IEEE/ANSI curves).
Ie> Curve IEC SI	Selection of the Ie> curve. Select from IEC SI, IEC STI, IEC VI, IEC EI, IEC LTI, CO2, IEEE MI, CO8, IEEE VI, IEEE EI using or and enable your choice using the key .
Ie> Tms 1.0	Displays the Time Multiplier Setting (TMS) associated with the IDMT Curve. TMS is visible when any of the IEC curves are selected. Select the curve TMS value. Select from 0.025 to 1.5 using or and enable your choice using .
Ie> Time Dial 1.0	Displays the Time Dial associated with the IDMT Curve. Time Dial is visible when CO2, CO8 or IEEE curves are selected. Select from 0.1 to 100 using or and enable your choice using .

3.5.6.3.3 Ie> DMT Reset Time, IEEE/ANSI Curves Menu

Display	Description
Reset Type DMT	Selection of the type of reset time delay. Select between DMT (Definitive Time) and IDMT (Inverse Time) using or and enable your choice using .
TReset 40 ms	Selection of the tReset value associated with the DMT reset time choice. Select from 40 ms to 100 s using or and enable your choice using .

3.5.6.3.4 Ie> IDMT Reset Time, ANSI Curves Menu

Display	Description
Reset Type IDMT	Selection of the type of reset time delay. Select between DMT (Definitive Time) and IDMT (Inverse Time) using or and enable your choice using .
Rtms 1.0	Selection of the Rtms value associated with the IDMT reset time choice. Select from 0.025 to 1.5 using or and enable your choice using .

3.5.6.3.5 IE> IDMT Threshold, Electromechanical RI Curve Menu

Display	Description
Ie> Delay type RI	Displays the Ie> inverse time delay (electromechanical RI curve).
K 1.0	Selection of the RI curve K value. Select from 0.100 to 10 using or and enable your choice using .

3.5.6.3.6 Ie> DMT Reset Time, IEC/RI Curves Menu

```
tReset
    60 ms
```

Selection of the tReset value from 40 ms to 100 s using or and enable your choice using .

3.5.6.3.7 Ie> IDMT Threshold, Laborelec Curve Menu

```
Ie> Delay type
    LABOR.
```

Displays the Ie> inverse time delay (Laborelec curve).

```
Ie> Curve
    1
```

Selection of the Laborelec curve. Select from Curve 1, 2 or 3 using or and enable your choice using .

```
tReset
                 40 ms
```

Selection of the tReset value from 40 ms to 100 s using or and enable your choice using .

3.5.6.3.8 Ie>> Threshold Menu

```
Ie>>?
    No
```

Selection of the Ie>> second earth threshold. Select Yes, No or Backup. If the user enters Ie>>(Yes or Backup), the following menu is displayed. If the user enters Ie>> (No) go to Ie>>> menu.

If “Backup” is selected Ie>> will only function in the event of a Protection Comms Failure.

```
Ie>> 5 Ien
```

Selection of the Ie>> second threshold current value. To modify this value, press . The threshold Ie>> is adjustable from : 0.002 to 1Ien (0.002 to 1 Ien Range) 0.01 to 8 Ien (0.01 to 8 Ien Range), and 0.5 to 40 Ien (0.1 to 40 Ion Range). Press to validate your adjustment.

```
Ie>> Delay Type
    DMT
```

Selection of the Ie>> threshold time delay type. Select DMT for definite time, IDMT for inverse time curves, RI for electromechanical inverse time curve. According to this setting, additional settings appear, as shown for I> above.

```
tIe>>
    100 ms
```

Selection of the second threshold Ie>> time delay. Select the time delay from 0 to 150 s using or and validate your choice using .

3.5.6.3.9 Ie>>> Threshold Menu

```
Ie>>>?
    No
```

Selection of the Ie>>> third earth threshold. Select Yes, No or Backup. If the user enters Ie>>> (Yes or Backup), the following menu is displayed. If the user enters Ie>>> (No) go to Ie>>> menu.

If “Backup” is selected Ie>>> will only function in the event of a Protection Comms Failure.

```
Ie>>>
    10 Ien
```

Selection of the Ie>>> third threshold current value. To modify this value, press . The threshold Ie>>> is adjustable from 0.5 to 40 Ien. Press to validate your adjustment.

```
tIe>>>
    100 ms
```

Selection of the third threshold Ie>>> time delay. Select the time delay from 0 to 150 s using or and validate your choice using .

3.5.6.3.10 Ie>>>> Threshold Menu

Ie>>>>? Yes	Selection of the Ie>>>> fourth earth threshold. Select Yes, No or Backup. If the user validates Ie>>>(Yes), the following menu is displayed. If the user enters Ie>>> (No), the LCD display returns to the heading of the menu [50N/51N] E/Gnd. If "Backup" is selected Ie>>>> will only function in the event of a Protection Comms Failure.
Ie>>>> 10 Ien	Selection of the Ie>>>> fourth threshold current value. To modify this value, press . The threshold Ie>>>> is adjustable from 0.5 to 40 Ien. Press to validate your adjustment.
tIe>>>> 100 ms	Selection of the third threshold Ie>>>> time delay. Select the time delay from 0 to 150 s using or and validate your choice using .

3.5.6.4 [46] Negative Phase Sequence I2> Sub Menu

PROTECTION Gx	Heading of the PROTECTION Gx menu (where x = 1, 2, 3 or 4). To gain access to the [46] Neg Seq OC sub menu, press , 4, 5, 6 or 7 times (as needed), then and 3 times.
[46] Neg Seq OC	Heading of the [46] NEGATIVE Phase SEQUENCE I2>sub menu. To gain access to the sub menu content, press .
I2>? No	Selection of the negative phase sequence overcurrent function. Select Yes or No. If the user validates (Yes), the following menu is displayed. If the user selects (No), the menu is deactivated.
I2> 0.1 In	Displays the negative sequence current threshold value I2>. To modify this value, press . The threshold I2> is adjustable from 0.1 to 40 In, in steps of 0.01 In. Press to validate your adjustment.
I2> Delay Type DMT	Selection of the I2> threshold time delay type. Select from DMT for definite time, IDMT for inverse time curves or RI for the electromechanical inverse time curve. To make a selection use or and validate your choice using .

3.5.6.4.1 I2> DMT Threshold Menu

I2> Delay Type DMT	Displays the I2> DMT time delay.
t I2 > 100 ms	Selection of the I2> time delay. Select the time delay from 0 to 150 s using or and validate your choice using .

3.5.6.4.2 I2> IDMT Threshold, IEC or IEEE/ANSI Curves Menu

Display	Description
I2> Delay Type IDMT	Displays the I2> inverse time delay (IEC or IEEE/ANSI curves).
I2> Curve IEC SI	Selection of the I2> curve. Select from IEC SI, IEC STI, IEC VI, IEC EI, IEC LTI, CO2, IEEE MI, CO8, IEEE VI, IEEE EI using ▲ or ▼ and validate your choice using the key ↵.
I2> Tms 0,025	Displays the Time Multiplier Setting (TMS) associated with the IDMT Curve. TMS is visible when any of the IEC curves are selected. Select from 0.025 to 1.5 using ▲ or ▼ and validate your choice using ↵.
I2> Time Dial 1.0	Displays the Time Dial associated with the IDMT Curve. Time Dial is visible when CO2, CO8 or IEEE curves are selected. Select from 0.1 to 100 using ▲ or ▼ and enable your choice using ↵.

I2> DMT reset time, IEC curves menu

Display	Description
tReset 60 ms	Selection of the tReset value from 40 ms to 100 s using ▲ or ▼ and validate your choice using ↵.

I2> DMT reset time, IEEE/ANSI curves menu

Display	Description
Reset Type DMT	Selection of the type of reset time delay. Select between DMT (Definitive Time) and IDMT (Inverse Time) using ▲ or ▼ and validate your choice using ↵.
tReset 40 ms	Selection of the tReset value associated with the DMT reset time choice. Select from 40 ms to 100 s using ▲ or ▼ and validate your choice using ↵.

I2> IDMT reset time, IEEE/ANSI curves menu

Display	Description
Reset Type IDMT	Selection of the type of reset time delay. Select between DMT (Definitive Time) and IDMT (Inverse Time) using ▲ or ▼ and validate your choice using ↵.
Rtms 0.025	Selection of the Rtms value associated with the IDMT reset time choice. Select from 0.025 to 1.5 using ▲ or ▼ and validate your choice using ↵.

3.5.6.4.3 I2> IDMT Threshold, Electromechanical RI Curve Menu

Display	Description
I2> Delay Type RI	Display of the I2> inverse time delay (electromechanical RI curve).
K 2.500	Selection of the RI curve K value. Select from 0.100 to 10 using or and validate your choice using .

I2> DMT reset time, RI curves

Display	Description
t Reset 60 ms	Selection of the t Reset value from 40 ms to 100 s using or and validate your choice using .

3.5.6.4.4 I2>> Threshold Menu

Display	Description
I2>>? Yes	Selection of the 2nd threshold of the negative phase sequence overcurrent function. Select Yes or No. If the user validates (Yes), the following menu is displayed. If the user selects (No), the menu is deactivated.
I2>> 1 In	Displays the value of the 2nd threshold of the negative phase sequence overcurrent function. To modify this value, press . The threshold I2>> is adjustable from 0.1 In to 40 In, in steps of 0.01 In. Press to validate your adjustment.
tI2>> 150 ms	Selection of the 2nd threshold I2>> time delay. Select the time delay from 0 to 150 s using or and validate your choice using .

3.5.6.5 [49] Therm OL Sub Menu

Display	Description
PROTECTION Gx	Heading of the PROTECTION Gx1 menu (where x = 1, 2, 3 or 4). To gain access to the [49] Thermal OL sub menu, press , 4, 5, 6 or 7 times as needed, then and 4 times.
[49] Therm OL	Heading of the Thermal OL menu. To gain access to the sub menu content press .
Therm OL? Yes	Selection of the thermal overload function. Select Yes or No. If the user enters Yes, the following menu is displayed. If the user enters No, the menu is deactivated.
I□ > 0.5 In	Displays the thermal current threshold value I□>. To modify this value, press . The threshold I□> is adjustable from 0.1 to 3.2 In, in steps of 0.01. Press to validate your choice.
Te 10 mn	Displays the thermal time constant (Te) associated with the thermal overload formula. To modify this value, press . The time constant Te is adjustable from 1 to 200 minutes, in steps of 1 min. Press to validate your adjustment.
K 1.05	Displays the k factor associated with the thermal overload function. To modify this value, press . The k factor is adjustable from 1 to 1.5, in steps of 0.01. Press to validate your adjustment.

Trip 110 %	Displays the percentage applicable to the thermal overload trip threshold. To modify this value, press . Trip is adjustable from 50 % to 200 % in steps of 1%. Press to validate your adjustment.
Alarm? Yes	Selection of the thermal overload alarm function. Select Yes or No. If the user validates (Yes), the following menu is displayed. If the user selects (No), the thermal overload alarm will be disabled.
Alarm 90 %	Displays the percentage applicable to the thermal overload alarm threshold. To modify this value, press . Trip is adjustable from 50 % to 200 % step of 1%. Press to validate your adjustment.

3.5.6.6 [37] Undercurrent I< Sub Menu

[37] Under Current	Heading of the [37] Under-Current sub menu. To gain access to the sub menu content, press .
I<? Yes	Selection of the undercurrent function. Select Yes or No. If the user validates (Yes), the following menu is displayed. If the user selects (no) the menu is deactivated.
I< 0.2 In	Displays the undercurrent threshold value I<. To modify this value, press . The threshold I< is adjustable from 0.02 In to 1 In, in steps of 0.01 In. Press to validate your adjustment.
tI< 200 ms	Selection of the time delay associated with the undercurrent threshold. Select the time delay from 0 s to 150 s using or and validate your choice using .

3.5.7 Automat. Ctrl Menu

The AUTOMAT. CTRL Menu makes it possible to programme the various automation functions included in the MiCOM P521.

The various sub menus are:

- Commissioning
- Trip Commands
- Latch Functions (latch of the trip output relay RL1)
- Blocking Logic 1
- Blocking Logic 2
- Logic Select. 1
- Logic Select. 2
- Outputs Relays
- Latch Output Relays (latch of the auxiliary output relays)
- Invert Output Relays
- Inputs
- Broken Conductor
- Cold Load PU
- CB Fail
- CB Supervision
- Logic Equations
- Program. I-Trip (inter-trips)
- CT Supervision

To access the AUTOMAT. CTRL Menu, press followed by six times.

3.5.7.1 Commissioning Sub Menu

This sub menu has been designed as a commissioning tool to aid testing. It makes it possible to disable output contacts and freeze circuit breaker measurements (such as number of operation etc.). In addition, this menu allows the user to perform a contact and LED test. A "Loopback" facility is also provided so that the relay can be fully tested in the absence of a remote relay (see also section 4.2.6 of the Commissioning and Maintenance chapter (P521/EN CM) for more information).

AUTOMAT.CTRL	Heading of the AUTOMAT. CTRL Menu. To gain access to the commissioning menu, press , 6 times then .
Commissioning	Heading of the Commissioning sub menu. To gain access to the sub menu points, press .
Commissioning? No	Enables / Disables of the Commissioning facilities. Select Yes or No. If the user validates (Yes), the following menu is displayed. If the user selects (No) the menu is deactivated.

Display	Description
LED Test No	Allows the user to illuminate all eight LED's on the front of the P521. To illuminate the LED's select (Yes) and Press . The LED's will remain illuminated for 5 seconds after the key is pressed. If (No) is selected the relay will not perform an LED test.
Disable Relays No	Enables / Disables all outputs contacts. To disable the output contacts select (Yes). The TRIP LED and LCD will continue to function correctly even with the contacts disabled. An "ISOLATED RELAYS" ALARM (accompanied by the alarm LED) will be generated when the contacts are disabled. The alarm can only be reset when output contacts are re-enabled by selecting (No).
Trip 87654321 Test: 00000000	Allocation of contacts to be tested. To allocate the trip test to the output relay(s), press , then select the desired output relay with the value 1 using . Repeat the operation on the other output relays if desired, then validate using .
Contact Test No	Allows the user to operate the selected contacts. To operate the selected contacts press followed by to select (Yes). The contacts will remain operated whilst (Yes) is selected. To deactivate the contacts select (No).
Disable CB Stats: No	Allows the user to "freeze" the Circuit breaker measurements in the RECORDS/CB Monitoring menu. To freeze the measurements press followed by to select (Yes). To re-activate the CB measurements, select (No) and validate your choice using .
Loopback Test OFF	Allows the user to set the Loopback Test to CHANNEL_1 (=On). In this mode the relay will only accept messages from itself and no other relay. To avoid a COMMS FAIL alarm the transmit (Tx) and receive (Rx) must be connected together on the protection comms channel. To enable the Loopback Test press followed by to select (Yes). This will be accompanied by the LOOPBACK MODE alarm. To deactivate the Loopback Test, select (No).
I Diff Trip Flags TRIP: A, B, C	Indicates which phase (A, B or C) is currently operating due to the current differential protection. Indication is given as soon as the current enters the "trip region" but will reset once the current exits this region.

3.5.7.2 Trip Commands Sub Menu

This sub menu makes it possible to assign selected thresholds to the trip output (RL1).

Display	Description
AUTOMAT. CTRL	Heading of the AUTOMAT. CTRL Menu. To gain access to the Trip Commands menu, press , 6 times, , then .
Trip Commands	Heading of the Trip ORDER sub menu. To gain access to the sub menu points, press .
Trip Idiff Yes	Allocates the current differential protection to the trip output (select Yes or No). If the user validates Yes, the trip output relay (RL1) will be activated when the current differential protection operates. If the user validates No, the trip output relay (RL1) will not be activated even when the current differential protection operates.
Trip Direct I-Trip Yes	Allocates the Direct Intertrip function to the trip output. Select Yes or No.

Trip C Diff I-Trip Yes	Allocates the Current Differential Intertrip function to the trip output relay. Select Yes or No.
Trip PIT Yes	Allocates the Permissive Intertrip function to the trip output relay. Select Yes or No.
Trip tI> Yes	Allocates the first phase time delay overcurrent threshold (tI>) to the trip output (select Yes or No). If the user validates Yes, the trip output relay (RL1) will be activated at the end of the time delay tI>. If the user validates No, the trip output relay (RL1) will never be activated, even at the end of the time delay tI>.
Trip tI>> Yes	Allocates the second phase time delay overcurrent threshold (tI>>) to the trip output. Select Yes or No.
Trip tI>>> Yes	Allocates the third phase time delay overcurrent threshold (tI>>>) to the trip output. Select Yes or No.
Trip tI>>>> Yes	Allocates the fourth phase time delay overcurrent threshold (tI>>>>) to the trip output. Select Yes or No.
Trip tIe> Yes	Allocates the first earth fault time delay threshold (tIe>) to the trip output. Select Yes or No.
Trip tIe>> Yes	Allocates the second earth fault time delay threshold (tIe>>) to the trip output. Select Yes or No.
Trip tIe>>> Yes	Allocates the third earth fault time delay threshold (tIe>>>) to the trip output. Select Yes or No.
Trip tIe>>>> Yes	Allocates the fourth earth fault time delay threshold (tIe>>>>) to the trip output. Select Yes or No.
Trip tI< Yes	Allocates of the under current threshold (tI<) to the trip output. Select Yes or No.
Trip tI2> Yes	Allocates the first time delayed negative phase sequence overcurrent threshold (tI2>) to the trip output. Select Yes or No.
Trip tI2>> Yes	Allocates the second time delayed negative phase sequence overcurrent threshold (tI2>>) to the trip output. Select Yes or No.
Trip Thermal θ Yes	Allocates the thermal overload Trip (θTrip) to the trip output. Select Yes or No.
Trip Brkn.Cond Yes	Allocates the broken conductor detection to the trip output. Select Yes or No.
Trip tAux 1 Yes	Allocates the auxiliary timer Aux 1 to the trip output. Select Yes or No.
Trip tAux 2 Yes	Allocates the auxiliary timer Aux 2 to the trip output. Select Yes or No.
TCS Block N0	Allocates the TCS Block signal to the trip output. Select Yes or No.
Trip Equ A No	Allocates the Logic Equation A operate signal to the trip output. Select Yes or No.

`Trip Equ B` `     No`	Allocates the Logic Equation B operate signal to the trip output. Select Yes or No.
`Trip Equ C` `     No`	Allocates the Logic Equation C operate signal to the trip output. Select Yes or No.
`Trip Equ D` `     No`	Allocates the Logic Equation D operate signal to the trip output. Select Yes or No.
`Trip Equ E` `     No`	Allocates the Logic Equation E operate signal to the trip output. Select Yes or No.
`Trip Equ F` `     No`	Allocates the Logic Equation F operate signal to the trip output. Select Yes or No.
`Trip Equ G` `     No`	Allocates the Logic Equation G operate signal to the trip output. Select Yes or No.
`Trip Equ H` `     No`	Allocates the Logic Equation H operate signal to the trip output. Select Yes or No.

3.5.7.3 Latch Functions Sub Menu

This sub menu makes it possible to latch the trip output relay RL1 after being operated by one or several thresholds.

`AUTOMAT. CTRL`	Heading of the AUTOMAT. CTRL Menu. To gain access to the Latch Functions menu, press ⏎, ⇩, 6 times, ⏎, then ⇩ twice.
`Latch Functions`	Heading of the Latch Functions sub menu. To gain access to the sub menu points, press ⏎.
`Latch Idiff` `     No`	Latches the trip output relay RL1 once the current differential protection (Idiff) has operated (select Yes or No). If the user validates Yes, RL1 will be latched even after Idiff has reset. If the user validates No, RL1 will “drop off” after Idiff has reset.
`Latch Direct` `I-Trip    No`	Latch the trip output RL1 once the Direct Intertrip function has operated.
`Latch C Diff` `I-Trip    No`	Latch the trip output RL1 once the Current Differential Intertrip function has operated.
`Latch PIT` `     No`	Latch the trip output RL1 once the Permissive Intertrip function has operated.
`Latch tI>` `     No`	Latches the trip output relay RL1 once the first time delayed phase overcurrent threshold (tI>) has operated. Select Yes or No.
`Latch tI>>` `     No`	Latches the trip output relay RL1 once the second time delayed phase overcurrent threshold (tI>>) has operated. Select Yes or No.
`Latch tI>>>` `     No`	Latches the trip output relay RL1 once the third time delayed phase overcurrent threshold (tI>>>) has operated. Select Yes or No.
`Latch tI>>>>` `     No`	Latches the trip output relay RL1 once the fourth time delayed phase overcurrent threshold (tI>>>>) has operated. Select Yes or No.

Latch tIe> No	Latches the trip output relay RL1 once the first time delayed earth fault threshold (tIe>) has operated. Select Yes or No.
Latch tIe>> No	Latches the trip output relay RL1 once the second time delayed earth fault threshold (tIe>>) has operated. Select Yes or No.
Latch tIe>>> No	Latches the trip output relay RL1 once the third time delayed earth fault threshold (tIe>>>) has operated. Select Yes or No.
Latch tIe>>>> No	Latches the trip output relay RL1 once the fourth time delayed earth fault threshold (tIe>>>>) has operated. Select Yes or No.
Latch tI< No	Latches the trip output relay RL1 once the time delayed under current threshold (tI<) has operated. Select Yes or No.
Latch tI2> No	Latches the trip output relay RL1 once the first time delayed negative sequence over current threshold (tI2>) has operated. Select Yes or No.
Latch tI2>> No	Latches the trip output relay RL1 once the second time delayed negative sequence over current threshold (tI2>>) has operated. Select Yes or No.
Latch Thermal θ No	Latches the trip output relay RL1 once the thermal element has operated. Select Yes or No.
Latch Brkn.Cond No	Latches the trip output relay RL1 once the broken conductor protection has operated. Select Yes or No.
Latch t Aux 1 No	Latches the trip output relay RL1 once auxiliary timer 1 has operated. Select Yes or No.
Latch t Aux 2 No	Latches the trip output relay RL1 once auxiliary timer 2 has operated. Select Yes or No.
TCS Block No	Latches the trip output relay RL1 once TCS Block has operated. Select Yes or No.
Latch Equ A No	Latches the trip output relay RL1 once Logic Equation A has operated. Select Yes or No.
Latch Equ B No	Latches the trip output relay RL1 once Logic Equation B has operated. Select Yes or No.
Latch Equ C No	Latches the trip output relay RL1 once Logic Equation C has operated. Select Yes or No.
Latch Equ D No	Latches the trip output relay RL1 once Logic Equation D has operated. Select Yes or No.
Latch Equ E No	Latches the trip output relay RL1 once Logic Equation E has operated. Select Yes or No.
Latch Equ F No	Latches the trip output relay RL1 once Logic Equation F has operated. Select Yes or No.
Latch Equ G No	Latches the trip output relay RL1 once Logic Equation G has operated. Select Yes or No.
Latch Equ H No	Latches the trip output relay RL1 once Logic Equation H has operated. Select Yes or No.

3.5.7.4 Blocking Logic Sub Menu

The Blocking Logic sub menu (designated as Blocking Logic 1 and Blocking Logic 2 menus) enables the user to block any of the time delayed thresholds by allocating to a "Blk Log" input (refer to Inputs menu).

AUTOMAT. CTRL	Heading of the AUTOMAT. CTRL Menu. To gain access to the Blocking Logic 1 menu, press , , 6 times, , followed by 4 times (5 times for Blocking Logic 2).
Blocking Logic	Heading of the Blocking Logic sub menu. To gain access to the sub menu contents, press .
Block Idiff No	Blocking of the current differential protection (Idiff) (select Yes or No). If the user validates Yes, Idiff will be blocked on the transition (logic state 1) of the "Blk log" logic input. If the user validates No, the transition of the "Blk log" logic input will not block Idiff.
Block tI> No	Blocking of the first time delayed phase overcurrent threshold (tI>) (select Yes or No). If the user validates Yes, the first threshold will be blocked on the transition (logic state 1) of the "Blk log" logic input. If the user validates No, the transition of the "Blk log" logic input will not block the first phase threshold tI>.
Block tI>> No	Blocking of the second time delayed phase overcurrent threshold (tI>>). Select Yes or No.
Block tI>>> No	Blocking of the third time delayed phase overcurrent threshold (tI>>>). Select Yes or No.
Block tI>>>> No	Blocking of the fourth time delayed phase overcurrent threshold (tI>>>>). Select Yes or No.
Block tIe> No	Blocking of the first time delayed earth fault threshold (tIe>). Select Yes or No.
Block tIe>> No	Blocking of the second time delayed earth fault threshold (tIe>>). Select Yes or No.
Block tIe>>> No	Blocking of the third time delayed earth fault threshold (tIe>>>). Select Yes or No.
Block tIe>>>> No	Blocking of the fourth time delayed earth fault threshold (tIe>>>>). Select Yes or No.
Block tI2 > No	Blocking of the first time delayed negative phase sequence overcurrent threshold (tI2>). Select Yes or No.
Block tI2 >> No	Blocking of the second time delayed negative phase sequence overcurrent threshold (tI2>>). Select Yes or No.
Block Thermal θ No	Blocking of the thermal protection. Select Yes or No.
Block Brkn.Cond No	Blocking of the broken conductor protection. Select Yes or No.
Block t Aux 1 No	Blocking of the auxiliary timer 1 (tAux1). Select Yes or No.

Block t Aux 2 No	Blocking of the auxiliary timer 2 (tAux2). Select Yes or No.
Block Equation A No	Blocking of the Logic Equation A. Select Yes or No.
Block Equation B No	Blocking of the Logic Equation B. Select Yes or No.
Block Equation C No	Blocking of the Logic Equation C. Select Yes or No.
Block Equation D No	Blocking of the Logic Equation D. Select Yes or No.
Block Equation E No	Blocking of the Logic Equation E. Select Yes or No.
Block Equation F No	Blocking of the Logic Equation F. Select Yes or No.
Block Equation G No	Blocking of the Logic Equation G. Select Yes or No.
Block Equation H No	Blocking of the Logic Equation H. Select Yes or No.

3.5.7.5 Logic Select Sub Menus

The Logic Select sub menus (designated as Logic Select. 1 and Logic Select. 2) sub menus enable the user to allocate a time delay threshold to the "Log sel" input (refer to Inputs menu). When the "Log sel" input is energized the selected overcurrent and earth fault time delays will change to the tSEL1 or tSEL2 time.

AUTOMAT. CTRL	Heading of the AUTOMAT. CTRL Menu. To gain access to the Logic Select. 1 menu, press , , 6 times, , followed by 6 times (7 times for Logic Select. 2).
Logic Select. 1	Heading of the Logic Select. 1 sub menu. To gain access to the sub menu contents, press .
Sel1 tI>> No	Logic selectivity of the second time delayed phase overcurrent threshold (tI>>) (select Yes or No). If the user validates Yes, operation of the second threshold will be delayed for tSel1 on the transition (logic state 1) of the "Log Sel 1" logic input. If the user validates No, the transition of the "Log Sel 1" logic input will not alter the second threshold tI>>.
Sel1 tI>>> No	Logic selectivity of the third time delayed phase overcurrent threshold (tI>>>). Select Yes or No.
Sel1 tI>>>> No	Logic selectivity of the fourth time delayed phase overcurrent threshold (tI>>>). Select Yes or No.
Sel1 tIe>> No	Logic selectivity of the second time delayed earth fault threshold (tIe>>). Select Yes or No.
Sel1 tIe>>> No	Logic selectivity of the third time delayed earth fault threshold (tIe>>>). Select Yes or No.

Display	Description
Sel1 tIe>>>> No	Logic selectivity of the fourth time delayed earth fault threshold (tIe>>>>). Select Yes or No.
tSel1 0 ms	Displays the selective scheme logic time delay t Sel1. To modify this value, press . The tSel1 is adjustable from 0 ms to 150 s in steps of 10 ms. Press to validate your adjustment.

3.5.7.6 Output Relays Sub Menu

This sub menu makes it possible to allocate an output relay (except Watchdog RL0) to the various thresholds (instantaneous and/or time delay). Note that the TRIP contact RL1 is allocated in the “Trip Commands” menu (under AUTOMAT. CTRL).

Output relay RL2 has change over contacts, whereas relays RL3 to RL8 have only normally open contacts.

Display	Description
AUTOMAT. CTRL	Heading of the AUTOMAT. CTRL Menu. To gain access to the Output Relays menu, press , , 6 times, , followed by 8 times.
Output Relays	Heading of the Output Relays sub menu. To gain access to the sub menu contents, press .
Trip 8765432 0000000	Allocates any trip order to the selected output relays (copies the trip contact onto one or several selected relays). To select the desired output relay(s), press , then select the desired output relay with a value 1 using .Repeat the operation on the other output relays if desired, then validate using .
Idiff 8765432 0000000	Allocates the current differential protection (Idiff) to the selected output relays. Select output relays.
Backup 8765432 Prot 0000000	Allocates the backup protection enabled function to the selected output relays. Select output relays.
Comms 8765432 Fail 0000000	Allocates the Comms Fail alarm (protection comms) to the selected output relays. Select output relays.
Direct 8765432 I-TRIP 0000000	Allocates the Direct Intertrip received to the selected output relays. Select output relays.
C DIFF 8765432 I-TRIP 0000000	Allocates the Current Differential Intertrip received to the selected output relays. Select output relays.
PIT 8765432 0000000	Allocates the Permissive Intertrip operation to the selected output relays. Select output relays.
I> 8765432 0000000	Allocates the first instantaneous phase overcurrent threshold (I>) to the selected output relays. Select output relays.
tI> 8765432 0000000	Allocates the first time delayed phase overcurrent threshold (tI>) to the output relays. Select output relays.
I>> 8765432 0000000	Allocates the second instantaneous phase overcurrent threshold (I>>) to the selected output relays. Select output relays.

Display	Description
tI>> 8765432 0000000	Allocates the second time delayed phase overcurrent threshold (tI>>) to the output relays. Select output relays.
I>>> 8765432 0000000	Allocates the third instantaneous phase overcurrent threshold (I>>>) to the selected output relays. Select output relays.
tI>>> 8765432 0000000	Allocates the third time delayed phase overcurrent threshold (tI>>>) to the selected output relays. Select output relays.
I>>>> 8765432 0000000	Allocates the fourth instantaneous phase overcurrent threshold (I>>>) to the selected output relays. Select output relays.
tI>>>> 8765432 0000000	Allocates the fourth time delayed phase overcurrent threshold (tI>>>) to the selected output relays. Select output relays.
Ie> 8765432 0000000	Allocates the first instantaneous earth fault threshold (Ie>) to the selected output relays. Select output relays.
tIe> 8765432 0000000	Allocates the first time delayed earth fault threshold (tIe>) to the selected output relays. Select output relays.
Ie>> 8765432 0000000	Allocates the second instantaneous earth fault threshold (Ie>>) to the selected output relays. Select output relays.
tIe>> 8765432 0000000	Allocates the second time delayed earth fault threshold (tIe>>) to the selected output relays. Select output relays.
Ie>>> 8765432 0000000	Allocates the third instantaneous earth fault threshold (Ie>>>) to the selected output relays. Select output relays.
tIe>>> 8765432 0000000	Allocates the third time delayed earth fault threshold (tIe>>>) to the selected output relays. Select output relays.
Ie>>>> 8765432 0000000	Allocates the fourth instantaneous earth fault threshold (Ie>>>>) to the selected output relays. Select output relays.
tIe>>>> 8765432 0000000	Allocates the fourth time delayed earth fault threshold (tIe>>>>) to the selected output relays. Select output relays.
tI< 8765432 0000000	Allocates the time delayed under current threshold (tI<) to the selected output relays. Select output relays.
tI2> 8765432 0000000	Allocates the first negative phase sequence overcurrent time delay threshold (tI2>) to the selected output relays. Select output relays.
tI2>> 8765432 0000000	Allocates of the second negative phase sequence overcurrent time delay threshold (tI2>>) to the output relays. Select output relays.
Therm 8765432 Alarm 0000000	Allocates the thermal alarm threshold to the selected output relays. Select output relays.
Therm 8765432 Trip 0000000	Allocates the thermal trip threshold to the selected output relays. Select output relays.
CB 8765432 Alarm 0000000	Allocates the circuit breaker alarm function to the selected output relays (excessive CB operations, ΣA^n, excessive tripping, closing time, CB status DBI). Select output relays.

`52 Fail    8765432` `           0000000`	Allocates the circuit breaker (52) trip circuit supervision function to the selected output relays. Select output relays.
`Brkn.      8765432` `Cond       0000000`	Allocates of the broken conductor function to the selected output relays. Select output relays.
`CB         8765432` `Fail       0000000`	Allocates the circuit breaker failure function to the selected output relays. Select output relays. CB Fail = CB not open at the end of tBF timer.
`CB         8765432` `Close      0000000`	Allocates the circuit breaker closing command to the selected output relays. Select output relays.
`tAux 1     8765432` `           0000000`	Allocates auxiliary timer 1 (Aux 1) to the selected output relays. Select output relays.
`tAux 2     8765432` `           0000000`	Allocates auxiliary timer 2 (Aux 2) to the selected output relays. Select output relays.
`Active     8765432` `Group      0000000`	Allocates setting group 2/3/4 indication to the selected output relays. Select output relays.
`TCS Block` `           N0`	Allocates the TCS Block signal to the trip output. Select Yes or No.
`Input1     8765432` `           0000000`	Allocates the Input1 signal to the selected output relays. Select Yes or No.
`Input2     8765432` `           0000000`	Allocates the Input2 signal to the selected output relays. Select Yes or No.
`Input3     8765432` `           0000000`	Allocates the Input3 signal to the selected output relays. Select Yes or No.
`Input4     8765432` `           0000000`	Allocates the Input4 signal to the selected output relays. Select Yes or No.
`Input5     8765432` `           0000000`	Allocates the Input5 signal to the selected output relays. Select Yes or No.
`Equ A      8765432` `           0000000`	Allocates the Logic Equation A operate signal to the selected output relays. Select Yes or No.
`Equ B      8765432` `           0000000`	Allocates the Logic Equation B operate signal to the selected output relays. Select Yes or No.
`Equ C      8765432` `           0000000`	Allocates the Logic Equation C operate signal to the selected output relays. Select Yes or No.
`Equ D      8765432` `           0000000`	Allocates the Logic Equation D operate signal to the selected output relays. Select Yes or No.
`Equ E      8765432` `           0000000`	Allocates the Logic Equation E operate signal to the selected output relays. Select Yes or No.
`Equ F      8765432` `           0000000`	Allocates the Logic Equation F operate signal to the selected output relays. Select Yes or No.
`Equ G      8765432` `           0000000`	Allocates the Logic Equation G operate signal to the selected output relays. Select Yes or No.

`Equ H      8765432` `           0000000`	Allocates the Logic Equation H operate signal to the selected output relays. Select Yes or No.
`Prgm       8765432` `I-Trip1    0000000`	Allocates the Programmable Inter-trip 1 signal to the selected output relays. Select Yes or No.
`Prgm       8765432` `I-Trip2    0000000`	Allocates the Programmable Inter-trip 2 signal to the selected output relays. Select Yes or No.
`Prgm       8765432` `I-Trip3    0000000`	Allocates the Programmable Inter-trip 3 signal to the selected output relays. Select Yes or No.
`Prgm       8765432` `I-Trip4    0000000`	Allocates the Programmable Inter-trip 4 signal to the selected output relays. Select Yes or No.
`CTS        8765432` `Local      0000000`	Allocates the Local CT failure signal to the selected output relays. Select Yes or No.
`CTS        8765432` `Remote     0000000`	Allocates the Remote CT failure signal to the selected output relays. Select Yes or No.
`CTS        8765432` `Block      0000000`	Allocates the signal of CTS block relevant protections to the selected output relays. Select Yes or No.
`CTS        8765432` `Res.       0000000`	Allocates the signal of CTS Restraint differential protections to the selected output relays. Select Yes or No.
`Mode       8765432` `Convent    0000000`	Allocates the signal of protection communication frame in Convention mode to the selected output relays. Select Yes or No.
`CDiff      8765432` `Disable    0000000`	Allocates the signal of current differential disabled to the selected output relays. Select Yes or No.

3.5.7.7 Latch of the Auxiliary Output Relays

This sub menu makes it possible to latch the individual output relays. The latch can be reset by key once the function that initiated the relay has reset.

`AUTOMAT. CTRL`	Heading of the AUTOMAT. CTRL Menu. To gain access to the Latch Output Relays menu, press , , 6 times, , followed by 9 times.
`Latch Output` `Relays`	Heading of the Latch Output Relays sub menu. To gain access to the sub menu content, press .
`Output 2` `     No`	Latch output relay RL2. Select Yes or No.
`Output 3` `     No`	Latch output relay RL3. Select Yes or No.
`Output 4` `     No`	Latch output relay RL4. Select Yes or No.
`Output 5` `     No`	Latch output relay RL5. Select Yes or No.
`Output 6` `     No`	Latch output relay RL6. Select Yes or No.

Display	Description
Output 7 No	Latch output relay RL7. Select Yes or No.
Output 8 No	Latch output relay RL8. Select Yes or No.

3.5.7.8 Inversion of the Auxiliary Output Relays

This sub menu makes it possible to invert the state of the individual output relays while the relay is energized.

Display	Description
AUTOMAT. CTRL	Heading of the AUTOMAT. CTRL Menu. To gain access to the Invert Output Relays menu, press , , 6 times, , followed by 10 times.
Invert Output Relays	Heading of the Invert Output Relays sub menu. To gain access to the sub menu content, press .
Output 2 No	Invert output relay RL2. Select Yes or No.
Output 3 No	Invert output relay RL3. Select Yes or No.
Output 4 No	Invert output relay RL4. Select Yes or No.
Output 5 No	Invert output relay RL5. Select Yes or No.
Output 6 No	Invert output relay RL6. Select Yes or No.
Output 7 No	Invert output relay RL7. Select Yes or No.
Output 8 No	Invert output relay RL8. Select Yes or No.

3.5.7.9 Inputs Sub Menu

This sub menu makes it possible to allocate any of the 5 logic inputs to either a label or an automation function. The available selections are shown in the following table:

Label abstract	Label signification
None	No allocation
Unlatch	Unlatches currently latched output contacts
52a	Status of 52a CB auxiliary contact
52b	Status of 52b CB auxiliary contact
CB FLT	Circuit Breaker SF6 low
Aux 1	Initiates auxiliary timer AUX 1
Aux 2	Initiates auxiliary timer AUX 2
Blk Log 1	Blocking logic 1
Blk Log 2	Blocking logic 2

Label abstract	Label signification
Strt Dist	Triggers the disturbance recorder
Cold L PU	Enables cold load pick up functionality
Log Sel 1	Logic select 1
Log Sel 2	Logic select 2
Change set	Changes setting group (default setting group = 1)
θ Reset	Resets the thermal state
Trip Circ	Assigns an input for trip circuit supervision
Strt tBF	Starts the breaker fail timer
Permis IT	Initiate a permissive intertrip
Direct IT	Initiate a direct intertrip
Comms RST	Reset protection comms statistics
Log Trip	Assigns an input to trip the circuit breaker
Log Close	Assigns an input to close trip the circuit breaker
TCS Block	Assigns an input to the External TCS Block function
GPS Sync	Time synchronization
Reset LED	Reset LED indication
Inhibit CTS	Inhibit CT supervision

In addition to the input allocation the user can specify the required operating time for auxiliary timers 1 and 2.

AUTOMAT. CTRL	Heading of the AUTOMAT. CTRL Menu. To gain access to the Inputs menu, press , , 6 times, , followed by 11 times.
Inputs	Heading of the Inputs sub menu. To gain access to the sub menu content, press .
Input 1 None	Allocation of logic input 1. To allocate a function to logic input 1, press then use or to select the desired function from the available list. Validate your choice using .
Input 2 None	Allocation of logic input 2. To allocate a function to logic input 2, press then use or to select the desired function from the available list. Validate your choice using .
Input 3 None	Allocation of logic input 3. To allocate a function to logic input 3, press then use or to select the desired function from the available list. Validate your choice using .
Input 4 None	Allocation of logic input 4. To allocate a function to logic input 4, press then use or to select the desired function from the available list. Validate your choice using .
Input 5 None	Allocation of logic input 5. To allocate a function to logic input 5, press then use or to select the desired function from the available list. Validate your choice using .
Aux1 Time tAux1 0 ms	Displays the time delay for auxiliary timer 1 (tAux1). To adjust the time, press . The tAux1 time is adjustable from 0 ms to 200 s in steps of 10 ms. Validate your choice using .

Aux2 Time tAux2 0 ms	Displays the time delay for auxiliary timer 2 (tAux2). To adjust the time, press ⊖. The tAux1 time is adjustable from 0 ms to 200 s in steps of 10 ms. Validate your choice using ⊖.

3.5.7.10 Broken Conductor Sub Menu

This menu enables the broken conductor detection and its associated settings.

AUTOMAT. CTRL	Heading of the AUTOMAT. CTRL Menu. To gain access to the Broken Conductor menu, press ⊙, ◊, 6 times, ⊙, followed by ◊ 12 times.
Broken Cond.	Heading of the Broken Conductor sub menu. To gain access to the sub menu content, press ⊙.
Brkn. Cond.? Yes	Enables the broken conductor function. Select Yes or No. If the user selects (Yes), the following menu is displayed. If the user selects (No), the broken conductor function is disabled.
Brkn. Cond Time tBC 1 ms	Displays the broken conductor time delay tBC. To modify this value, press ⊖. The tBC is adjustable from 0 to 14400 s in steps of 1 s. Press ⊖ to validate your adjustment.
Ratio I2/I1 20 %	Displays the broken conductor threshold. This threshold is a ratio between the negative phase sequence and the positive phase sequence currents. To modify this value, press ⊖. The I2/I1 ratio is adjustable from 20% to 100 % in steps of 1 %. Press ⊖ to validate your adjustment.

3.5.7.11 Cold Load Pick-Up Sub Menu

The Cold Load PU allows the user to enable the cold load pick-up function and its associated settings.

AUTOMAT. CTRL	Heading of the AUTOMAT. CTRL Menu. To gain access to the Cold Load PU menu, press ⊙, ◊, 6 times, ⊙, followed by ◊ 13 times.
Cold Load PU	Heading of the Cold Load PU sub menu. To gain access to the sub menu points, press ⊙.
Cold Load PU? No	Enables the cold load pick-up function. Select Yes or No. If the user selects (Yes), the following menu is displayed. If the user selects (No), the cold load pick-up function is disabled.
Cold Load PU tI>? No	Associates the I> time delay threshold with the cold load pick up function. To associate tI> with the cold load pick up function, press ⊖ and select (Yes). Select (No) if the user does not wish to associate tI> with the cold load pick up function. Validate your choice using ⊖.
Cold Load PU tI>>? No	Associates the I>> time delay threshold with the cold load pick up function. To associate tI>> with the cold load pick up function, press ⊖ and select (Yes). Select (No) if the user does not wish to associate tI>> with the cold load pick up function. Validate your choice using ⊖.

Display	Description
`Cold Load PU` `tI>>>?    No`	Associates the I>>> time delay threshold with the cold load pick up function. To associate tI>>> with the cold load pick up function, press ↵ and select (Yes). Select (No) if the user does not wish to associate tI>>> with the cold load pick up function. Validate your choice using ↵.
`Cold Load PU` `tI>>>>?   No`	Associates the I>>>> time delay threshold with the cold load pick up function. To associate tI>>>> with the cold load pick up function, press ↵ and select (Yes). Select (No) if the user does not wish to associate tI>>>> with the cold load pick up function. Validate your choice using ↵.
`Cold Load PU` `tIe>?     No`	Associates the Ie> time delay threshold with the cold load pick up function. To associate tIe> with the cold load pick up function, press ↵ and select (Yes). Select (No) if the user does not wish to associate tIe> with the cold load pick up function. Validate your choice using ↵.
`Cold Load PU` `tIe>>?    No`	Associates the Ie>> time delay threshold with the cold load pick up function. To associate tIe>> with the cold load pick up function, press ↵ and select (Yes). Select (No) if the user does not wish to associate tIe>> with the cold load pick up function. Validate your choice using ↵.
`Cold Load PU` `tIe>>>?   No`	Associates the Ie>>> time delay threshold with the cold load pick up function. To associate tIe>>> with the cold load pick up function, press ↵ and select (Yes). Select (No) if the user does not wish to associate tIe>>> with the cold load pick up function. Validate your choice using ↵.
`Cold Load PU` `tIe>>>>?  No`	Associates the Ie>>>> time delay threshold with the cold load pick up function. To associate tIe>>>> with the cold load pick up function, press ↵ and select (Yes). Select (No) if the user does not wish to associate tIe>>>> with the cold load pick up function. Validate your choice using ↵.
`Cold Load PU` `tI2>?     No`	Associates the I2> time delay threshold with the cold load pick up function. To associate tI2> with the cold load pick up function, press ↵ and select (Yes). Select (No) if the user does not wish to associate tI2> with the cold load pick up function. Validate your choice using ↵.
`Cold Load PU` `tI2>>?    No`	Associates the I2>> time delay threshold with the cold load pick up function. To associate tI2>> with the cold load pick up function, press ↵ and select (Yes). Select (No) if the user does not wish to associate tI2>> with the cold load pick up function. Validate your choice using ↵.
`Cold Load PU` `t Therm.? Yes`	Associates the thermal threshold with the cold load pick up function. To associate the thermal threshold with the cold load pick up function, press ↵ and select (Yes). Select (No) if the user does not wish to associate the thermal threshold with the cold load pick up function. Validate your choice using ↵.
`Cold Load PU` `level     200 %`	Selection of the cold load pick up percentage scaling value associated with the selected thresholds. Select from 20% to 500% in steps of 1 % using ⇧ or ⇩ and validate your choice using ↵.
`Cold Load PU` `tCL =     400 ms`	Selection of the cold load pick up time delay. Select from 100 ms to 3600 s in steps of 10 ms using ⇧ or ⇩ and validate your choice using ↵.

3.5.7.12 Circuit Breaker Failure Sub Menu

The CB Fail sub menu makes it possible to enable the circuit breaker failure detection function and its associated settings.

AUTOMAT. CTRL	Heading of the AUTOMAT. CTRL Menu. To gain access to the CB Fail menu, press , , 6 times, , followed by 14 times.
CB Fail	Heading of the CB Fail sub menu. To gain access to the sub-menu points, press .
CB Fail? No	Enables / Disables the circuit breaker failure function. If the user validates (Yes), the following menu is displayed. If the user selects (No), the breaker failure function is inactive.
I<= 0.1 In	Selects the under current threshold associated with the CB failure detection function. Select from 0.02 In to 1 In in steps of 0.01 In.
CB Fail Time tBF 100 ms	Selects the circuit breaker failure time delay. Select from 30 ms to 10 s in steps of 10 ms using or and validate your choice using .
Block I>? No	Select the possibility to block the instantaneous signal I> in the event of a circuit breaker failure. Select Yes or No.
Block Ie>? No	Select the possibility to block the instantaneous signal Ie> in the event of a circuit breaker failure detection. Select Yes or No.

3.5.7.13 Circuit Breaker Supervision Sub Menu

The CB Supervision sub menu makes it possible to enable the circuit breaker supervision and monitoring function and the various settings associated with this function.

AUTOMAT. CTRL	Heading of the AUTOMAT. CTRL Menu. To gain access to the CB Supervision menu, press , , 6 times, , followed by 15 times.
CB Supervision	Heading of the CB Supervision sub menu. To gain access to the sub menu points, press .
TC Supervision Yes	Enables / Disables the trip circuit supervision function. Select Yes or No. If the user selects (Yes), the function is active. If the user selects (No) the TC supervision is disabled (go to CB Open Time menu).
t Trip Circuit t SUP 200 ms	Selects the Trip circuit supervision time. Select from 0.1 s to 10s in steps of 10 ms using or and validate your choice using .
CB Open S'vision Yes	Enables / Disables the CB operating time supervision function. Select Yes or No. If the user selects (Yes) the following menu is displayed. If the user selects (No) the CB operating time supervision function is disabled (go to CB Close menu).
CB Open Time 50 ms	Selects the maximum allowable CB operating time (tCBO). Select from 50 ms to 1.0 s in steps of 10 ms using or and validate your choice using .
CB Close S'vision Yes	Enables / Disabled the CB closing time supervision function. Select Yes or No. If the user selects (Yes), the following menu is displayed. If the user selects (No) the CB closing time supervision function is disabled (go to CB Open Alarm menu).

CB Close Time 50 ms	Selects the maximum allowable CB closing time (tCBC). Select from 50 ms to 1.0 s in steps of 10 ms using or and validate your choice using .
CB Open Alarm? Yes	Enables / Disables the maximum CB operations function. Select Yes or No. If the user selects (Yes), the following menu is displayed. If the user selects (No) the CB Operations supervision function is disabled (go to ΣAmps(n) menu).
CB Open NB = 0	Selects the maximum number of CB operations. Select from 0 to 50000 in steps of 1 using or and validate your choice using .
ΣAmps(n)? Yes	Enables / Disables the Summation Amps (or square Amps) interrupted by the CB function. Select Yes or No. If the user selects (Yes), the following menu is displayed. If the user selects (No) the CB ΣAmps(n) function is disabled (go to t Open Pulse menu).
ΣAmps(n)? 1000 E6	Selection of the summation Amps (or square Amps) alarm threshold. Select from 0 to 4000 E6 A (or A2) in steps of 1 E6 using or and validate your choice using .
n 1	Selection of the type of summation (Amps or square Amps). Select 1 for just Amps or 2 for Amps squared using or and validate your choice using .
t Open Pulse 100 ms	Selection of the tripping pulse time. Select from 100 ms to 5 s in steps of 100 ms using or and validate your choice using .
t Close Pulse 100 ms	Selection of the closing pulse time. Select from 100 ms to 5 s in steps of 100 ms using or and validate your choice using .
CB Man Trip Dly 0 ms	Selects the circuit breaker manual closing delay. Select from 0 to 60s in steps of 0.1s using or and validate your choice using .
CB Man Close Dly 0 ms	Selects the circuit breaker manual closing delay. Select from 0 to 60s in steps of 0.1s using or and validate your choice using .

3.5.7.14 Logic Equations

With the Logic Equations submenu, up to 8 complex Boolean functions can be formed using OR, OR NOT, AND, AND NOT operators. Up to 16 operands can be used in any single equation. The following logic signals are available for mapping to an equation:

TEXT	TEXT in HMI	Information
Null	Null	None
Any Trip	Trip	Any trip
CDiff Trip	I Diff	Current differential trip
Backup Enable	Backup	Backup protection is enabled
Comm. Fail	Comm. F	Protection communication failed
Direct IT	DIT	Direct inter-trip
CDiff IT	CDiffIT	Current differential inter-trip
Permissive IT	PIT	Permissive inter-trip
I> Start	I>	Phase overcurrent stage 1 starts
I> Trip	tI>	Phase overcurrent stage 1 trips
I>> Start	I>>	Phase overcurrent stage 2 starts

TEXT	TEXT in HMI	Information
I>> Trip	tI>>	Phase overcurrent stage 2 trips
I>>> Start	I>>>	Phase overcurrent stage 3 starts
I>>> Trip	tI>>>	Phase overcurrent stage 3 trips
I>>>> Start	I>>>>	Phase overcurrent stage 4 starts
I>>>> Trip	tI>>>>	Phase overcurrent stage 4 trips
Ie> Start	Ie>	Earth overcurrent stage 1 starts
Ie> Trip	tIe>	Earth overcurrent stage 1 trips
Ie>> Start	Ie>>	Earth overcurrent stage 2 starts
Ie>> Trip	tIe>>	Earth overcurrent stage 2 trips
Ie>>> Start	Ie>>>	Earth overcurrent stage 3 starts
Ie>>> Trip	tIe>>>	Earth overcurrent stage 3 trips
Ie>>>> Start	Ie>>>>	Earth overcurrent stage 4 starts
Ie>>>> Trip	tIe>>>>	Earth overcurrent stage 4 trips
I< Start	I<	Undercurrent starts
I< Trip	tI<	Undercurrent trips
I2> Start	I2>	Negative sequence overcurrent stage 1 starts
I2> Trip	tI2>	Negative sequence overcurrent stage 1 trips
I2>> Start	I2>>	Negative sequence overcurrent stage 2 starts
I2>> Trip	tI2>>	Negative sequence overcurrent stage 2 trips
Thermal Alarm	Th Alar	Thermal overload alarm
Thermal Trip	Th Trip	Thermal overload trips
CB Alarm	CB Alar	CB status discrepancy
52 Fail	52 Fail	Trip circuit alarm
Broken Cond.	Brk Co.	Broken conductor protection trips
CB Fail	CB Fail	CB failure
CB Close	CB Clos	CB Close
Aux1 Trip	tAux1	Auxiliary timer1 trips
Aux2 Trip	tAux2	Auxiliary timer2 trips
Active Group	Act Grp	=1 when active setting group is group 2
TCS Block	TCS Blk	Trip circuit supervision block operates
Input 1	Input 1	Input 1
Input 2	Input 2	Input 2
Input 3	Input 3	Input 3
Input 4	Input 4	Input 4
Input 5	Input 5	Input 5
Equ A	Equ A	Logic equation A signal
Equ B	Equ B	Logic equation B signal
Equ C	Equ C	Logic equation C signal
Equ D	Equ D	Logic equation D signal
Equ E	Equ E	Logic equation E signal
Equ F	Equ F	Logic equation F signal
Equ G	Equ G	Logic equation G signal
Equ H	Equ H	Logic equation H signal
Prgm IT 1	I-Trip1	Programmable inter-trip signal 1

TEXT	TEXT in HMI	Information
Prgm IT 2	I-Trip2	Programmable inter-trip signal 2
Prgm IT 3	I-Trip3	Programmable inter-trip signal 3
Prgm IT 4	I-Trip4	Programmable inter-trip signal 4
CTS Local Alarm	CTS L	CT fail alarm local
CTS Remote Alarm	CTS R	CT fail alarm remote
CTS Block	CTS Blk	CT fail block relevant protections
CTS Restrain	CTS Res	CT fail restraint differential protection
Convention Mode	Conv Mod	Protection communication in convention mode
CDiff Disabled	Diff Esc	Current differential protection is disabled

Example of Equation A settings for P521

```
AUTOMAT. CTRL
```

Heading of the AUTOMAT. CTRL Menu. To gain access to the Logic Equations menu, press , then scroll to reach the desired submenu.

```
Logic Equations
```

Heading of Logic Equations submenu.

To access the Logic Equations submenus, press then scroll using to reach the relevant Equation submenu.

```
Equation A.00
= Null
```

Heading of Equation A submenu

To navigate within the submenu, press . To access the relevant operand submenu, scroll using and . To modify the setting, press . Use , , , to scroll and set available selections. Press to confirm the selection.

Setting choice: =, NOT

Setting choice: as in Table

```
Equation A.01
OR         Null
```

Setting choice: OR, OR NOT, AND, AND NOT

Setting Choice: as in Table

```
Equation A.02
OR         Null
```

Setting choice: OR, OR NOT, AND, AND NOT

Setting Choice: as in Table

```
Equation A.03
OR         Null
```

Setting choice: OR, OR NOT, AND, AND NOT

Setting Choice: as in Table

```
Equation A.04
OR         Null
```

Setting choice: OR, OR NOT, AND, AND NOT

Setting Choice: as in Table

```
Equation A.05
OR         Null
```

Setting choice: OR, OR NOT, AND, AND NOT

Setting Choice: as in Table

```
Equation A.06
OR         Null
```

Setting choice: OR, OR NOT, AND, AND NOT

Setting Choice: as in Table

```
Equation A.07
OR         Null
```

Setting choice: OR, OR NOT, AND, AND NOT

Setting Choice: as in Table

```
Equation A.08
OR         Null
```

Setting choice: OR, OR NOT, AND, AND NOT

Setting Choice: as in Table

```
Equation A.09
OR         Null
```

Setting choice: OR, OR NOT, AND, AND NOT

Setting Choice: as in Table

```
Equation A.10
OR        Null
```

Setting choice: OR, OR NOT, AND, AND NOT
Setting Choice: as in Table

```
Equation A.11
OR        Null
```

Setting choice: OR, OR NOT, AND, AND NOT
Setting Choice: as in Table

```
Equation A.12
OR        Null
```

Setting choice: OR, OR NOT, AND, AND NOT
Setting Choice: as in Table

```
Equation A.13
OR        Null
```

Setting choice: OR, OR NOT, AND, AND NOT
Setting Choice: as in Table

```
Equation A.14
OR        Null
```

Setting choice: OR, OR NOT, AND, AND NOT
Setting Choice: as in Table

```
Equation A.15
OR        Null
```

Setting choice: OR, OR NOT, AND, AND NOT
Setting Choice: as in Table

3.5.7.15 Program. I-Trip Sub menu

This sub menu makes it possible to assign functions to any of the 4 inter-trip commands, to initiate an inter-trip to the remote relay without additional wiring of logic inputs or output relays.

The available selections are shown in the following table:

Label abstract	Label signification
tI>	Phase overcurrent stage 1 trips
tI>>	Phase overcurrent stage 2 trips
tI>>>	Phase overcurrent stage 3 trips
tI>>>>	Phase overcurrent stage 4 trips
tIe>	Earth overcurrent stage 1 trips
tIe>>	Earth overcurrent stage 2 trips
tIe>>>	Earth overcurrent stage 3 trips
tIe>>>>	Earth overcurrent stage 4 trips
tI<	Undercurrent trips
tI2>	Negative sequence overcurrent stage 1 trips
tI2>>	Negative sequence overcurrent stage 2 trips
CB Fail	CB fail operates
Broken Cond.	Broken conductor trips
tAux1	Auxiliary timer 1 trips
tAux2	Auxiliary timer 2 trips
Input 1	Logic input 1
Input 2	Logic input 2
Input 3	Logic input 3
Input 4	Logic input 4
Input 5	Logic input 5
Equ A	Logic equation A operates
Equ B	Logic equation B operates
Equ C	Logic equation C operates
Equ D	Logic equation D operates

Label abstract	Label signification
Equ E	Logic equation E operates
Equ F	Logic equation F operates
Equ G	Logic equation G operates
Equ H	Logic equation H operates

In addition to the input allocation the user can specify the required dwell time for programmable inter-trip command 1 to 4.

`AUTOMAT. CTRL`	Heading of the AUTOMAT. CTRL Menu. To gain access to the Program. I-Trip Functions menu, press , followed by 16 times.
`Program. I-Trip`	Heading of the Program. I-Trip sub menu. To gain access to the sub menu points, press .
`Program. I-Trip1`	Heading of the Program. I-Trip 1 sub menu. To gain access to the sub menu points, press .
`Program. I-Trip2`	Heading of the Program. I-Trip 2 sub menu. To gain access to the sub menu points, press .
`Program. I-Trip3`	Heading of the Program. I-Trip 3 sub menu. To gain access to the sub menu points, press .
`Program. I-Trip4`	Heading of the Program. I-Trip 4 sub menu. To gain access to the sub menu points, press .
`Dwell Timer` `100ms`	Set the dwell timer for the inter-trip command. To adjust the time, press . The dwell time is adjustable from 0.1s to 5s in steps of 0.05s. Validate your choice using

3.5.7.16 CT Supervision Sub Menu

The CT Supervision sub menu makes it possible to enable the current transformer supervision function and the various settings associated with this function.

`AUTOMAT. CTRL`	Heading of the AUTOMAT. CTRL Menu. To gain access to the CT Supervision menu, press , , 6 times, , followed by 18 times.
`CT Supervision`	Heading of the CB Supervision sub menu. To gain access to the sub menu points, press .
`CTS?` `No`	Enables / Disables the current transformer supervision function. Select Yes or No. If the user selects (Yes), the function is active. If the user selects (No) the CT supervision is disabled.
`CTS Reset mode` `Manual`	Selects the CTS reset mode. Select from Manual or Auto using or and validate your choice using .
`CTS Reset` `RST = [C]`	To clear the CTS alarm, press .
`CTS I1>` `0.1IN`	Selects the CTS positive current threshold for local current. Select from 0.05In to 4In in steps of 0.01In using or and validate your choice using .

CTS I2/I1> 5%	Selects the CTS low positive/negative current ratio threshold. Select from 5% to 100% in steps of 5% using or and validate your choice using .
CTS I2/I1>> 40%	Selects the CTS high positive/negative current ratio threshold. Select from 5% to 100% in steps of 5% using or and validate your choice using .
CTS TIME DLY 5.0s	Selects the time delay for raising CTS alarm. Select from 0 to 10s in steps of 0.01s using or and validate your choice using .
CTS Restrain ? No	Enables / Disables the restraint function of current differential protection when a CT failure is detected. Select Yes or No by press , followed by or and validate your choice using .

3.5.8 Records Menu

The RECORDS menu makes it possible to read the various records generated by the relay The various sub menus are:

- CB Monitoring
- Fault Record
- Instantaneous
- Disturb Record
- Time Peak Value
- Rolling Demand

To gain access to the RECORDING menu, press then 7 times.

3.5.8.1 CB Monitoring Sub Menu

The CB Monitoring sub menu makes possible to read and clear the parameters and measurements associated to this function.

RECORDS	Heading of the RECORD Menu. To gain access to the CB Monitoring menu, press , , 7 times followed by .
CB Monitoring	Heading the CB Monitoring sub menu. To gain access to the sub menu points, press .
CB Opening Time 95 ms	Displays the most recent circuit breaker opening time in ms.
CB Closing Time 115 ms	Displays the most recent circuit breaker closing time in ms.
CB Operations RST = [C] 5489	Displays the number of opening commands executed by the circuit breaker. To reset these values, press .
Σ Amps (n) RST = [C]	Allows the user to clear the memorized summation of interrupted currents. All 3 phase currents are clear simultaneously. To clear these values, press .
Σ Amps (n) IA 4 E4	Displays the summation of the Amps (or Amps squared) interrupted by the A phase circuit breaker.
Σ Amps (n) IB 2 E4	Displays the summation of the Amps (or Amps squared) interrupted by the B phase circuit breaker.
Σ Amps (n) IC 8 E3	Displays the summation of the Amps (or Amps squared) interrupted by the C phase circuit breaker.

3.5.8.2 Fault Record Sub Menu

The FAULT RECORD sub menu makes it possible to read the various parameters and measurements for each of the five faults stored in the MiCOM P521.

RECORD	Heading of the RECORD Menu. To gain access to the Fault Record menu, press , , 7 times, , followed by once.

Fault Record	Heading of the Fault Record sub menu. To gain access to the sub menu points, press .
Record Number 2	Selection of the fault record number (by selecting from 1 to 25) to be displayed. To select the fault record number, press then using or enter the required number. Validate your choice using the key .
Fault Time 12:05:23:42	Displays the time of the fault record. The format of the time is HH:MM:SS:ms. In this example the fault appeared at 12 hundred hours, 05 minutes, 23 seconds and 420 ms.
Fault Date 12/11/99	Displays the date of the fault record. The format of the date is DD/MM/YY. In this example, the fault appeared on 12 November 1999.
Active Set Group 1	Displays the active setting group (1 or 2 or 3 or 4).
Faulted Phase Phase A	Displays the faulty phase / phases for the chosen fault record. The list of possibilities are: NONE, Phase A, B, C, EARTH, AB, AC, BC, or ABC.
Fault Flags I>>	Displays the origin of the fault that has generated the trip order.
Magnitude 1200 A	Display the magnitude of the fault current. This value is the 50/60 Hz amplitude.
IA Magnitude 1200 A	Displays the magnitude of the A phase current at the time of the fault.
IB Magnitude 500 A	Displays the magnitude of the B phase current at the time of the fault.
IC Magnitude 480 A	Displays the magnitude of the C phase current at the time of the fault.
IN Magnitude 103 A	Displays the magnitude of the earth fault current at the time of the fault.
IA Differential 1200 A	Displays the magnitude of the A phase differential current at the time of the fault.
IB Differential 500 A	Displays the magnitude of the B phase differential current at the time of the fault.
IC Differential 480 A	Displays the magnitude of the C phase differential current at the time of the fault.
Max I Bias 103 A	Displays the largest bias current of the three phases at the time of the fault.
Chann 1 Status Comms OK	Displays the status of the protection comms channel. Relays display either “Comms OK” or Comms Fail”.

3.5.8.3 Instantaneous Sub Menu

The INSTANTANEOUS sub menu makes is possible to read the various parameters for each of the last five “starts”.

RECORDS	Heading of the AUTOMAT. CTRL Menu. To gain access to the CB Monitoring menu, press , , , 7 times, , followed by twice.
Instantaneous	Heading of the Instantaneous sub menu. To gain access to the sub menu points, press .
Number 5	Selection of the Instantaneous record number (by selecting either 1, 2, 3, 4 or 5) to be displayed. To select the Instantaneous record number, press then using or enter the required number. Validate your choice using .
Time 13:07:15:53	Display the time of the instantaneous record. The format is HH:MM:SS:ms. In this example the start information appeared at 13 hundred hours, 07 minutes, 15 seconds and 530 ms.
Date 09/01/01	Display the date of the instantaneous record. The format is DD/MM/YY. In this example the start information appeared on 09 January 2001.
Origin Ie>	Displays the origin of the start signal.
Length 57 ms	Displays the length of the start information.
Trip No	Displays if a trip has occurred due to the start.

3.5.8.4 Disturbance Record Sub Menu

The DISTURBANCE sub menu makes it possible to set the various parameters and thresholds associated with this recording function.

RECORD	Heading of the RECORD Menu. To gain access to the Disturbance Record menu, press , , 7 times, , followed by 3 times.
Disturb Record	Heading of the Disturb Record sub menu. To gain access to the sub menu points, press .
Record Number 5	Set the number of disturbance records that the relay can be stored (from 1 to 5). To set the number, press then using or to input the required number.
Pre-Time 100 ms	Selection of the disturbance record pre-trigger time. Select from 100 ms to 3s in steps of 100 ms using or and validate your choice using .
Post-Time 100 ms	Selection of the disturbance record post-trigger time. Select from 100ms to 3s in steps of 100 ms using or and validate your choice using .

WARNING: The Total Disturbance Recording Time is 3, 5, 7 or 9 seconds (Pre-Time + Post-Time).

Disturb Rec Trig ON INST.	Selects the start criteria for the disturbance recorder function. Select between ON INST. (start from instantaneous thresholds) or ON Trip (start from trip conditions) using or and validate your choice using .

3.5.8.5 Time Peak Value Sub Menu

The Time Peak Value sub menu makes it possible to set parameters associated with the Peak and Average values displayed in the Measurements menu.

RECORD	Heading of the RECORD Menu. To gain access to the Time Peak Value menu, press , , 7 times, , followed by 4 times.
Time Peak Value	Heading of the Time Peak Value sub menu. To gain access to the sub menu points, press .
Time Window 5 mn	Selects the length of the time window over which the peak and average values are stored. Select from either 5mn, 10mn, 15mn, 30mn, or 60mn using or and validate your choice using .

3.5.8.6 Rolling Demand Sub Menu

The Rolling Demand sub menu makes it possible to set the rolling sub-period and the number of the sub-periods for the calculation of the 3 phase Rolling Average and Peak Demand values, available in the Measurement menu.

RECORDS	Heading of the RECORD Menu. To gain access to the Rolling Demand menu, press , , 7 times, , followed by 5 times.
Rolling Demand	Heading of the Rolling Demand sub menu. To gain access to the sub menu points, press .
Sub period 5 mn	Selects the duration of the sub-period during over which the rolling average values are calculated. Select from either 5mn, 10mn, 15mn, 30mn, or 60mn using or and validate your choice using .
Num of Sub Per 1	Selects the number of sub-periods for the calculation of the average of the average values.

4 WIRING

The connection diagrams for the MiCOM P521 are provided in section P521/EN CO of this Technical Guide.

4.1 Auxiliary Supply

The auxiliary supply of the MiCOM P521 relay can be either AC or DC (the ranges are 24-250 Vdc, 48-250 Vdc or 48-240 Vac 50-60 Hz). The auxiliary voltage range is specified on the relay data plate under the upper flap on the front plate. Supply must only be connected to terminals 33 (+ve) and 34 (-ve).

4.2 Current Measurement Inputs

The MiCOM P521 relay has eight current inputs. The nominal current value of these measuring inputs is either 1 Ampere or 5 Amperes (labeled in the connection diagrams). For the same relay the user can mix the 1 and 5 Ampere inputs between phases and earth.

Note	*All phases must have the same rated current value (1 or 5 Amps).*

4.3 Logic Inputs

The MiCOM P521 relay has 5 opto-isolated logic inputs. Each input is electrically isolated from all other inputs.

Refer to the Technical Data (P521_EN_TD) for the voltage range of the inputs.

The automation operations and signaling functions to which these logic inputs respond can be selected from the AUTOMAT. CTRL Menu.

Note	*Do not forget to select in the CONFIGURATION/Configuration Inputs Menu if the voltage input is "AC" or "DC".*

4.4 Output Relays

Nine output relays are available on MiCOM P521.

The first output relay (RL0) is dedicated to indicate a relay fault (Watchdog). It is normally closed (NC) and cannot be configured.

Relay RL1 is the main trip output. The trip functions which will operate RL1 are selected in the AUTOMAT. CTRL/Trip Commands menu.

RL2 to RL8 are freely programmable. The protection and control functions to which these relays respond can be selected by means of the AUTOMAT. CTRL menu.

RL1 and RL2 have changeover contacts (1 common, 1 normally open contact, 1 normally closed contact). The other relays (RL3 to RL8) are of the normally open (NO) type.

4.5 Communication

4.5.1 EIA(RS)485 Rear Communication Port

All MiCOM relays have an EIA(RS)485 rear communication port.

The connection of communications is allocated to terminals 29-30-31-32, shown in the connection diagrams in section P521/EN CO of this Technical Guide.

4.5.2 EIA(RS)232 Front Communication Port

MiCOM P521 relay provides the user with an EIA(RS)232 communication port. This link is dedicated to the MiCOM Setting software MiCOM S1.

A standard EIA(RS)232 shielded cable should be used to connect the P521 front EIA(RS)232 port to a PC. The connecter on the P521 side must be male in gender.

The wiring of this EIA(RS)232 cable must follow the following scheme.

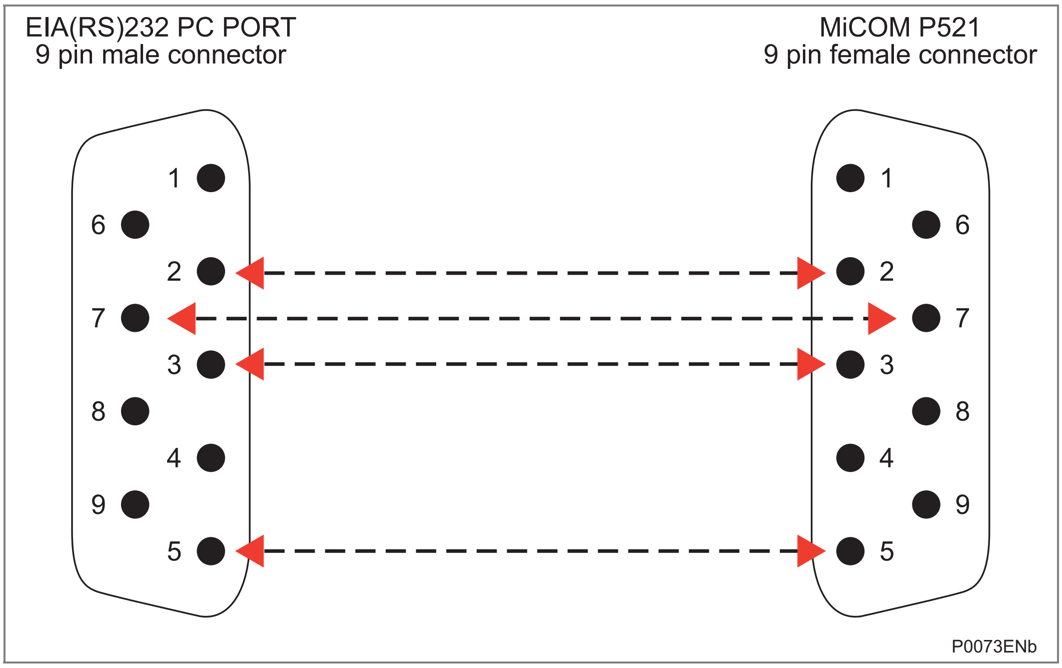

Figure 4 - EIA(RS)232 front port communication cable wiring

Notes:

MENU CONTENT TABLES

CHAPTER 4

Date:	August 2017
Software version:	13
Hardware Suffix:	B
Connection diagram:	10P52101

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FIGURES

Notes:

1 P521 – V13 Software Menu Content

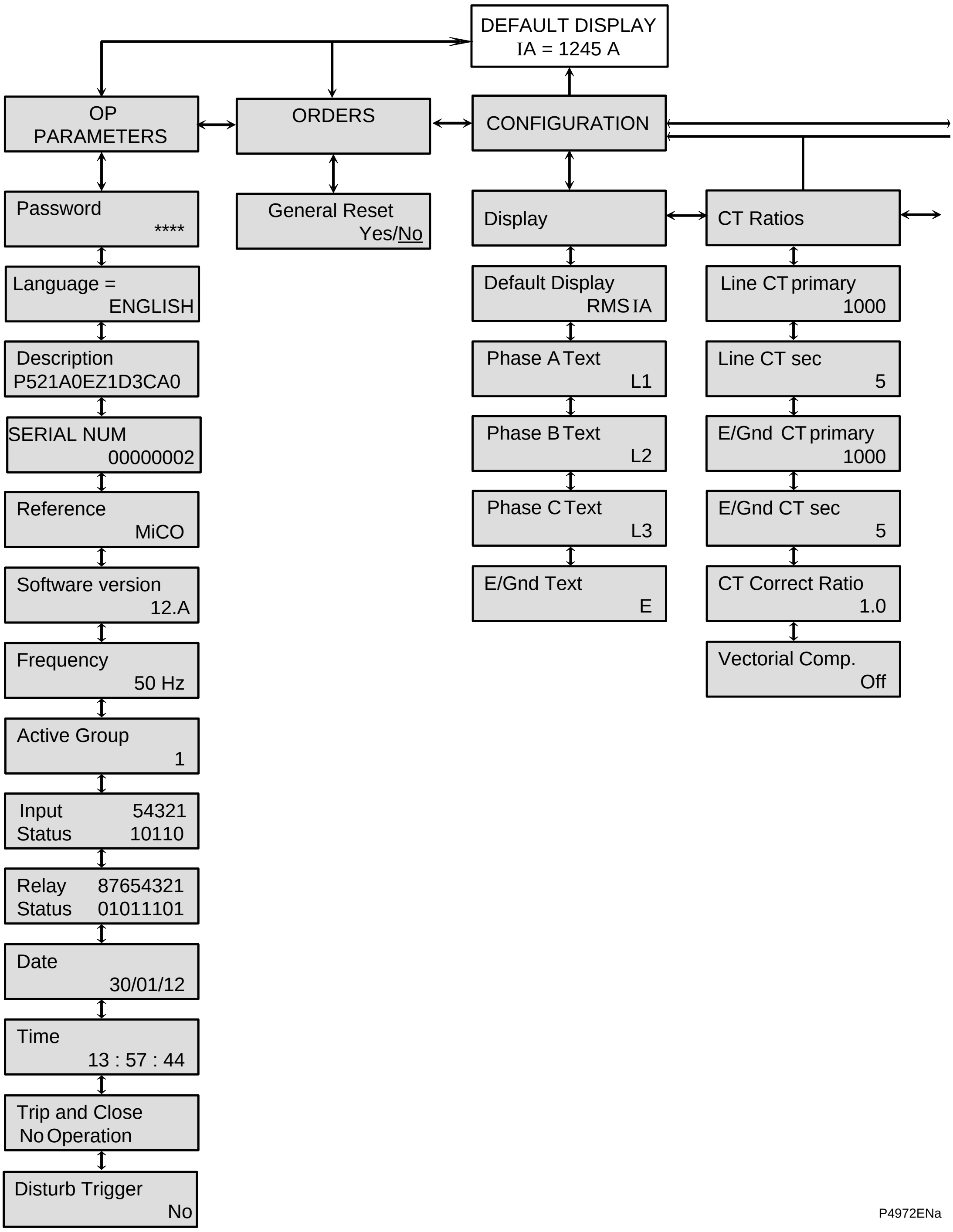

Figure 1 - OP Parameters, Orders and Configuration menu

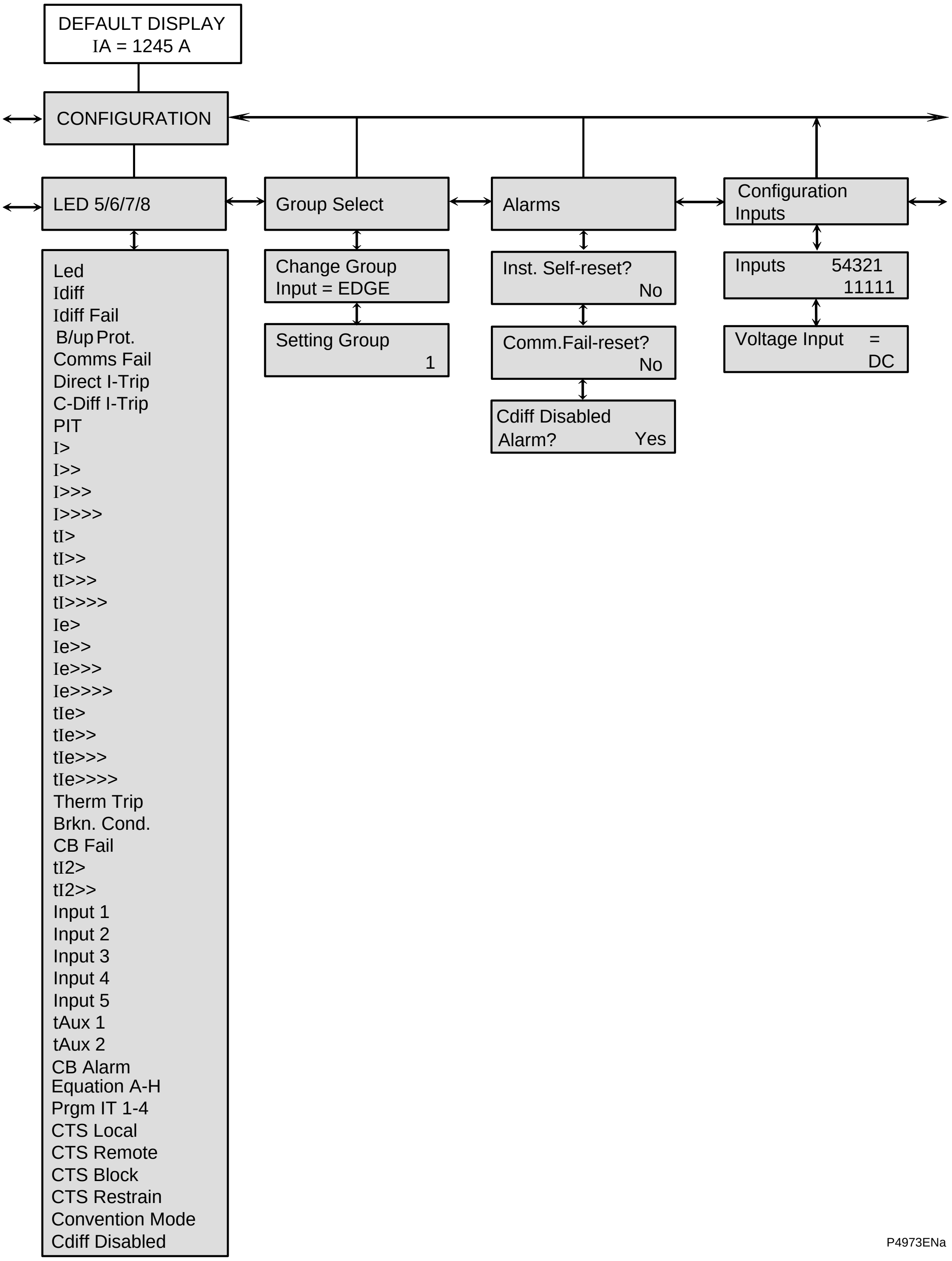

Figure 2 - Configuration menu (continued)

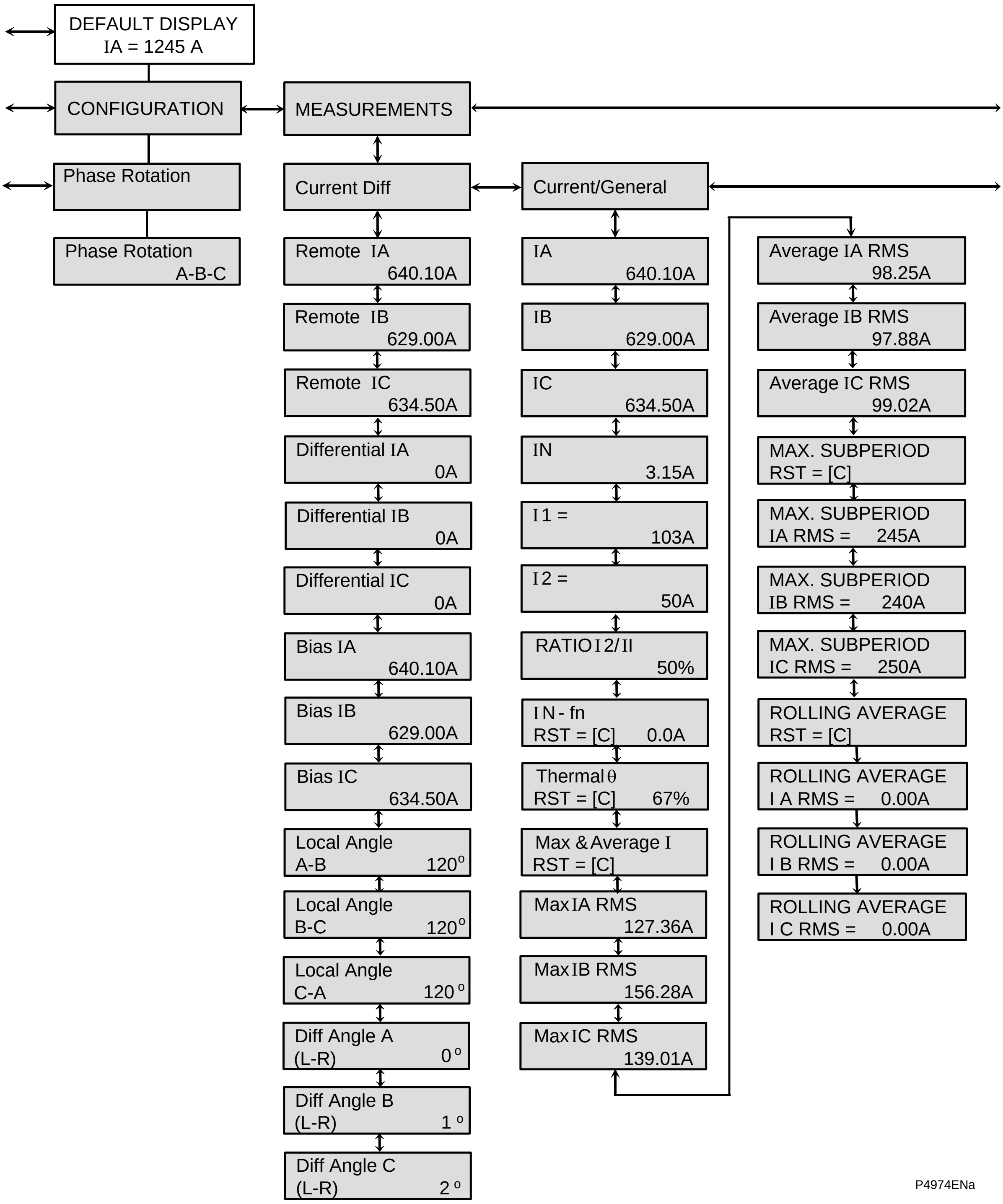

Figure 3 - Configuration menu (continued) and Measurements menu

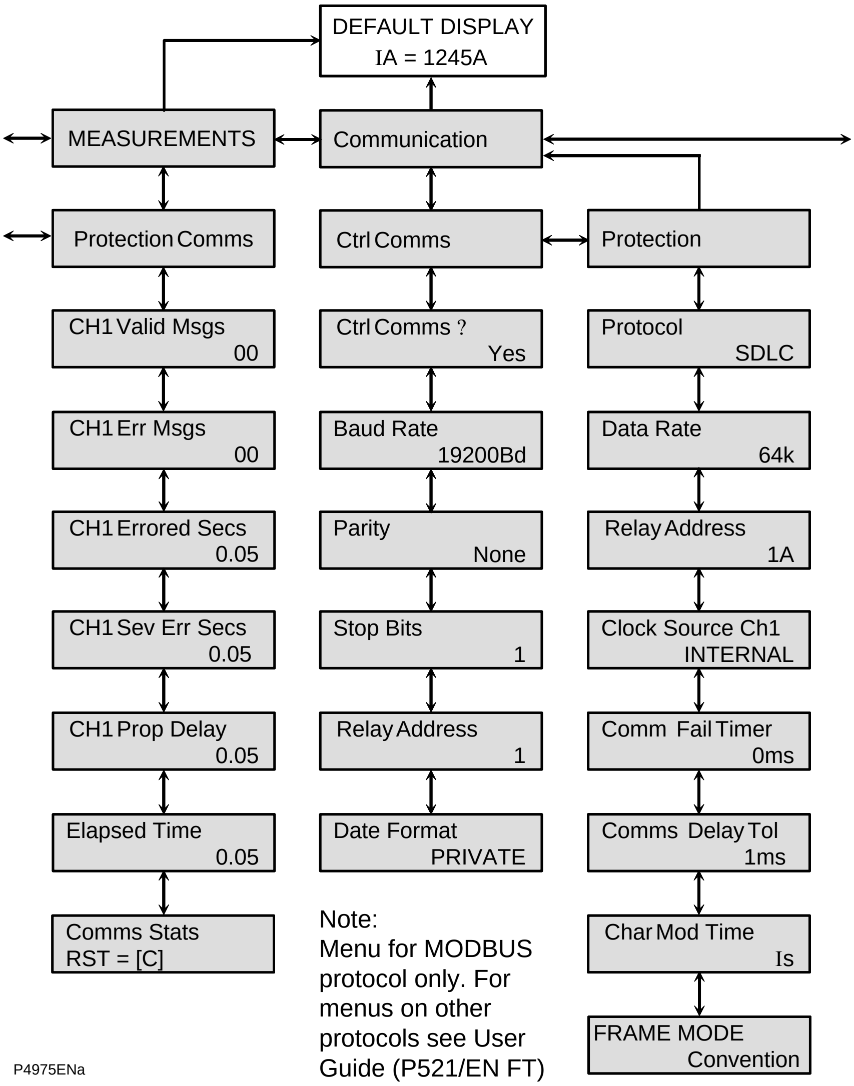

Figure 4 - Measurements menu (continued) and Communication menu

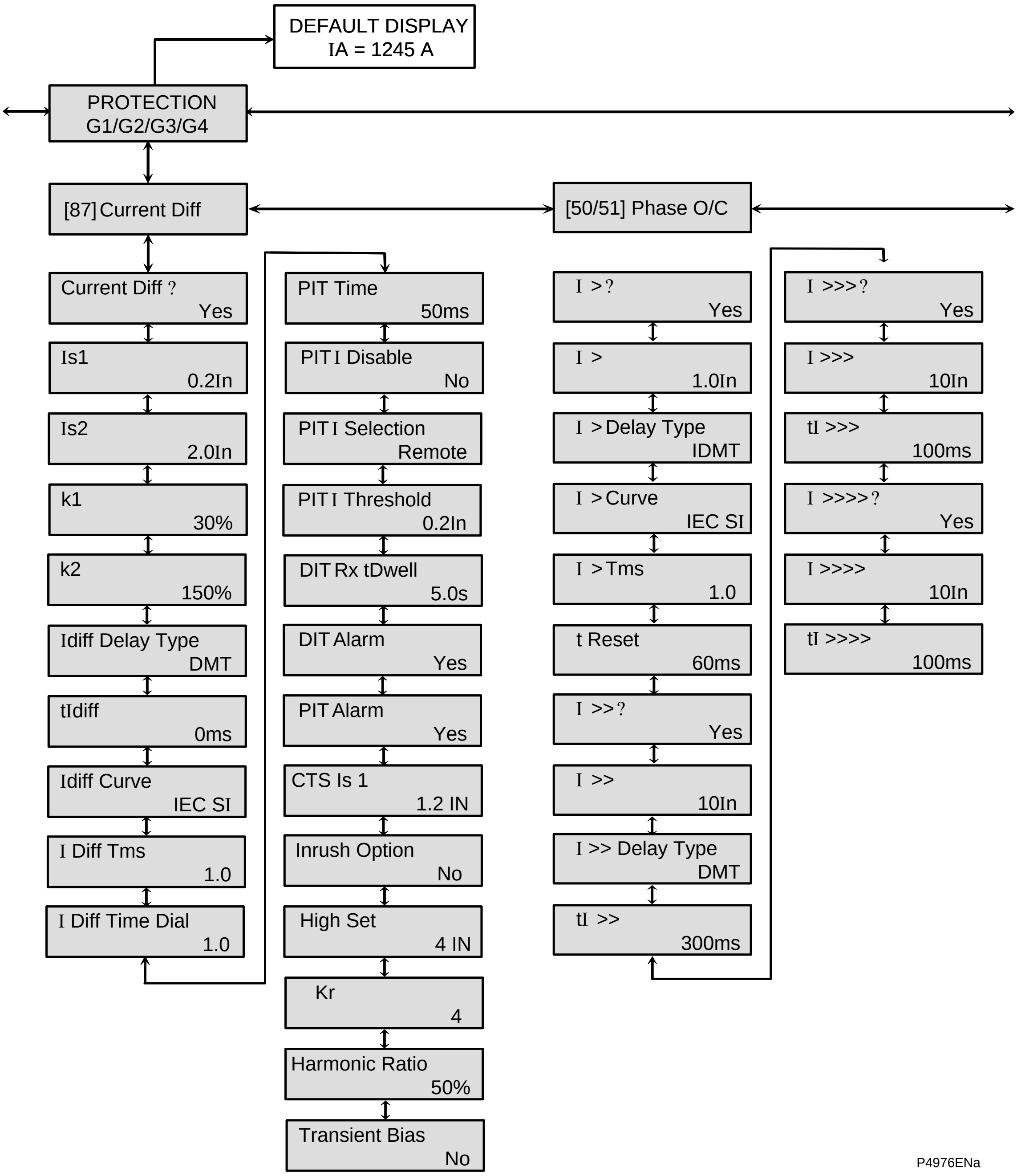

Figure 5 - Protection menu

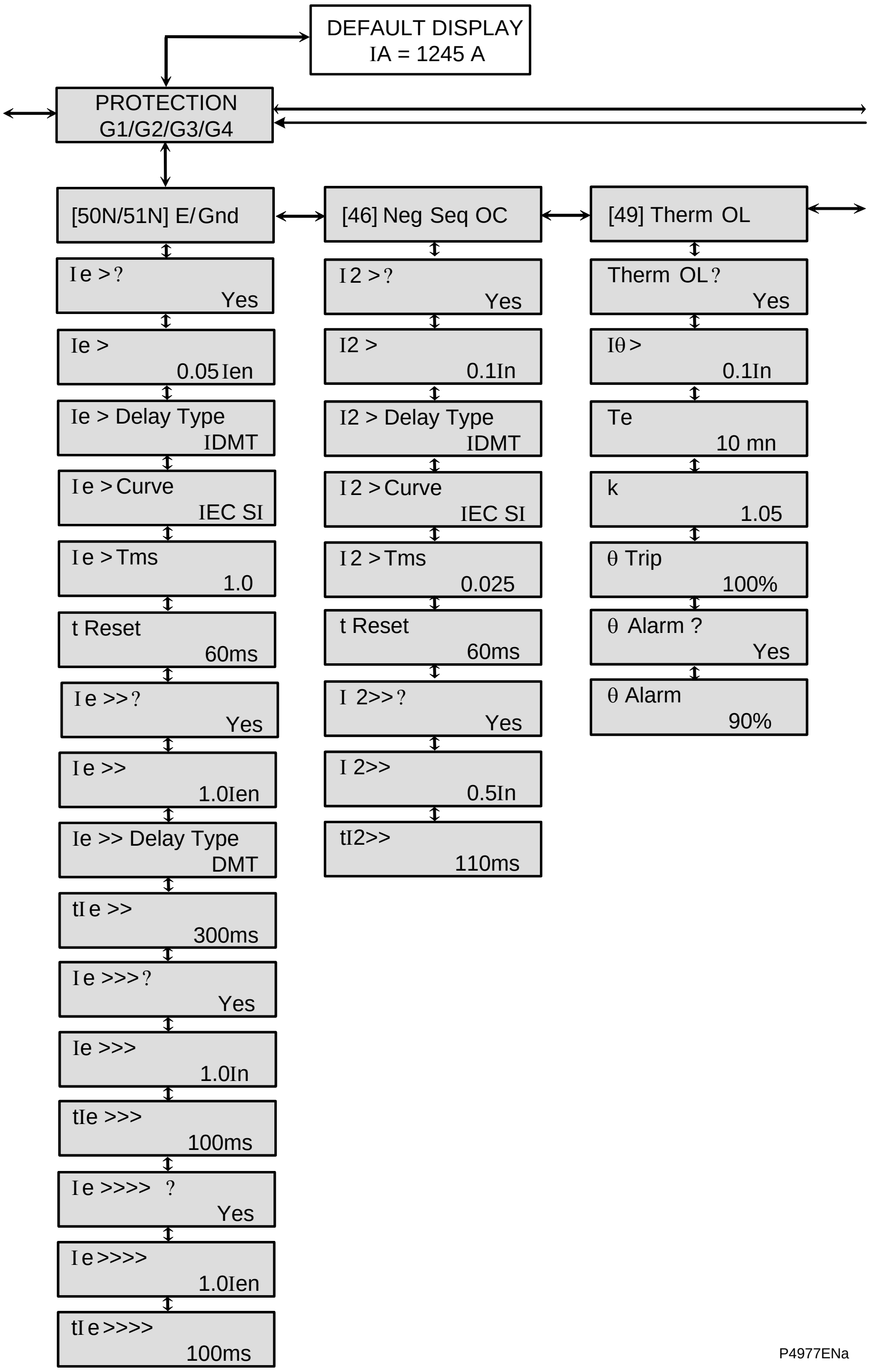

Figure 6 - Protection menu (continued)

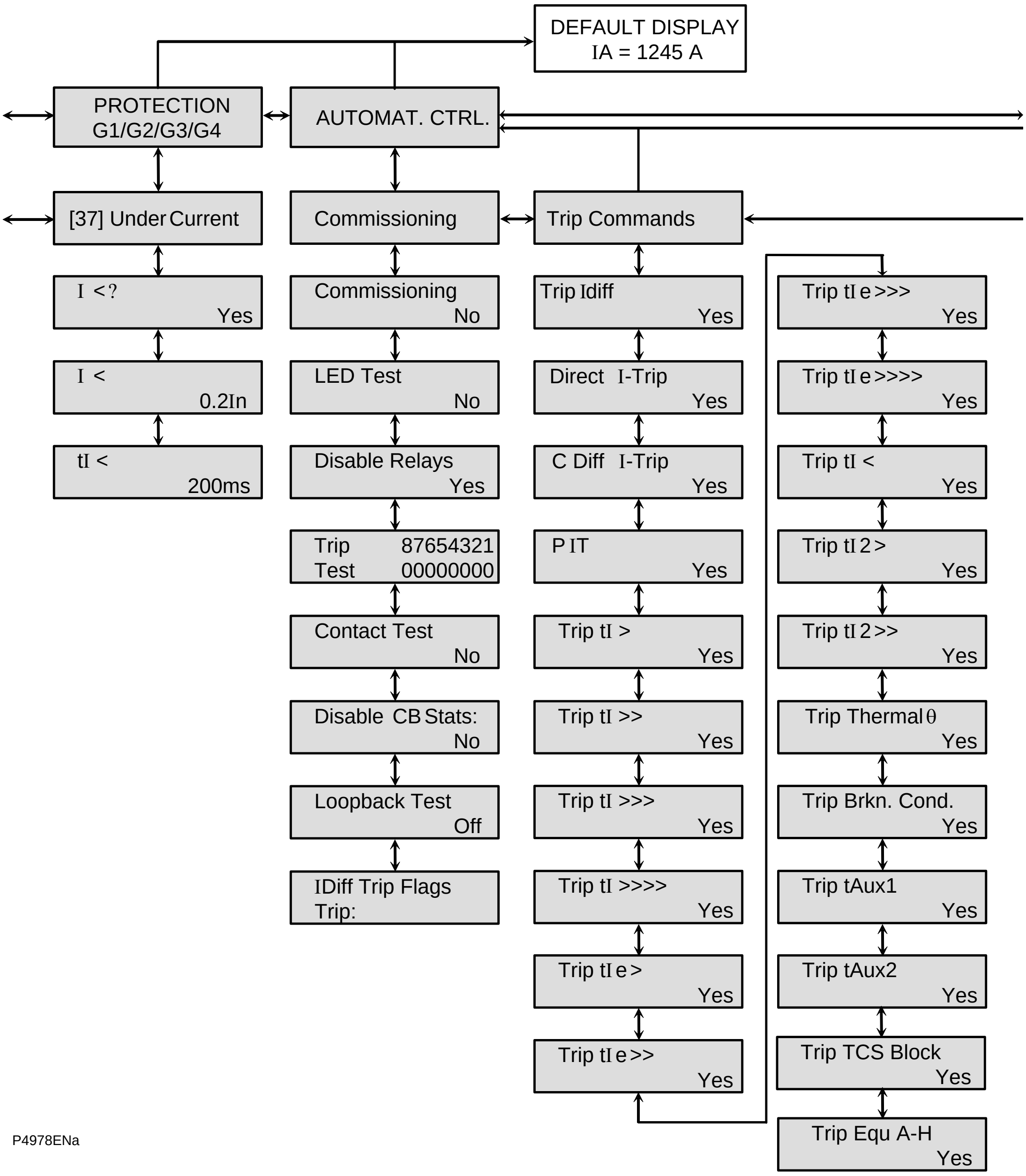

Figure 7 - Protection menu (continued) and Automatic Control menu

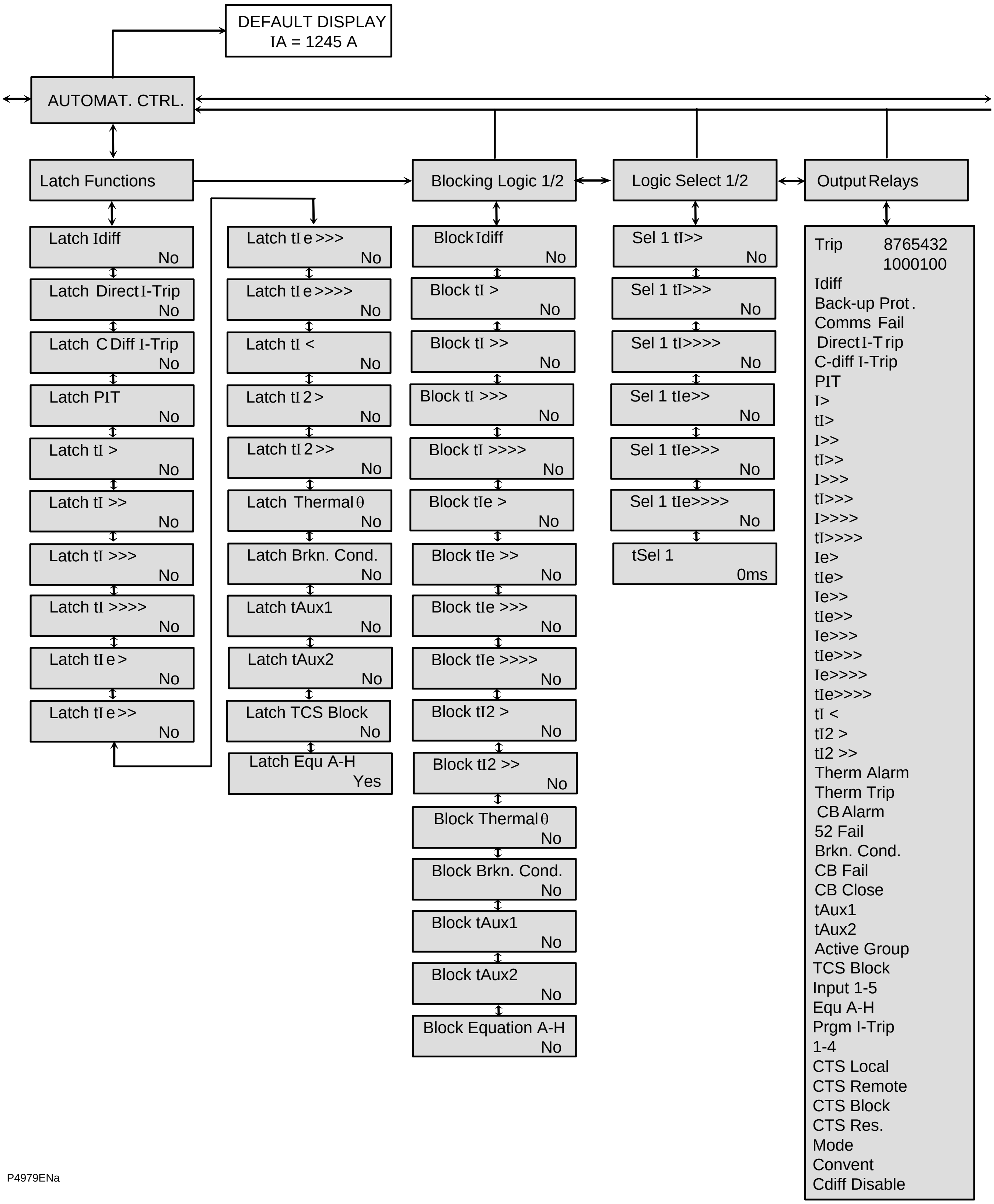

Figure 8 - Automatic Control menu (continued)

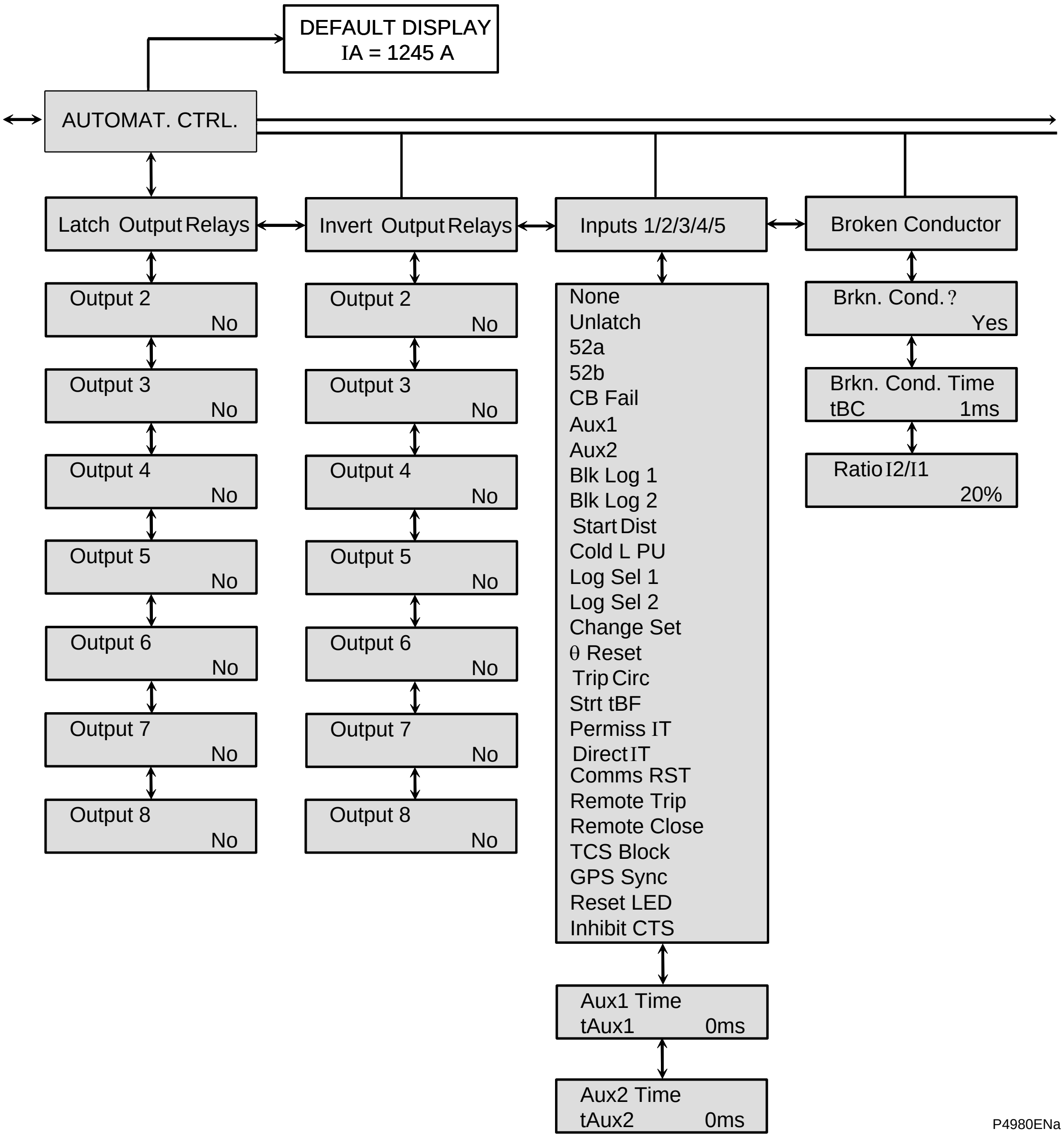

Figure 9 - Automatic Control menu (continued)

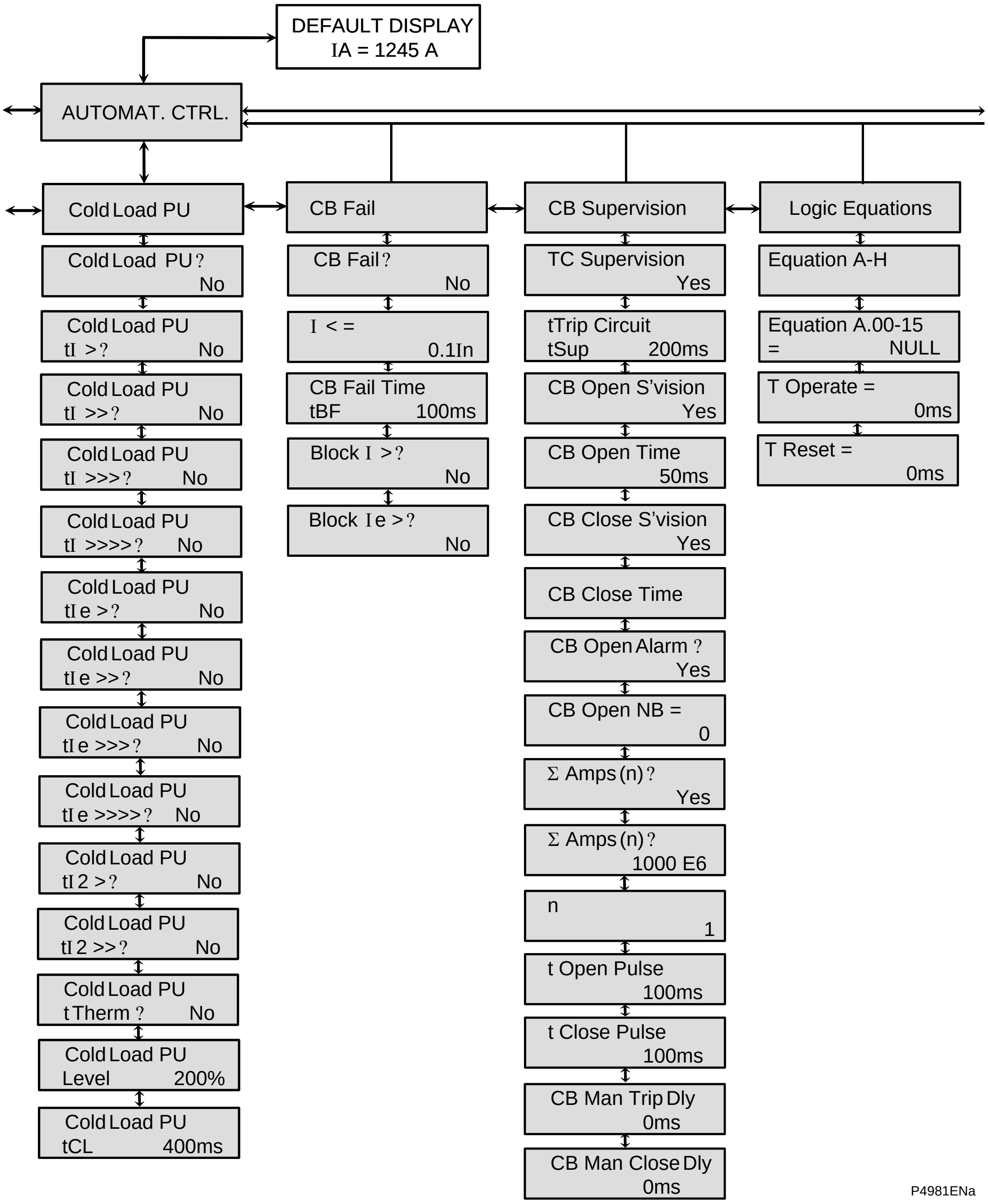

Figure 10 - Automatic Control menu (continued)

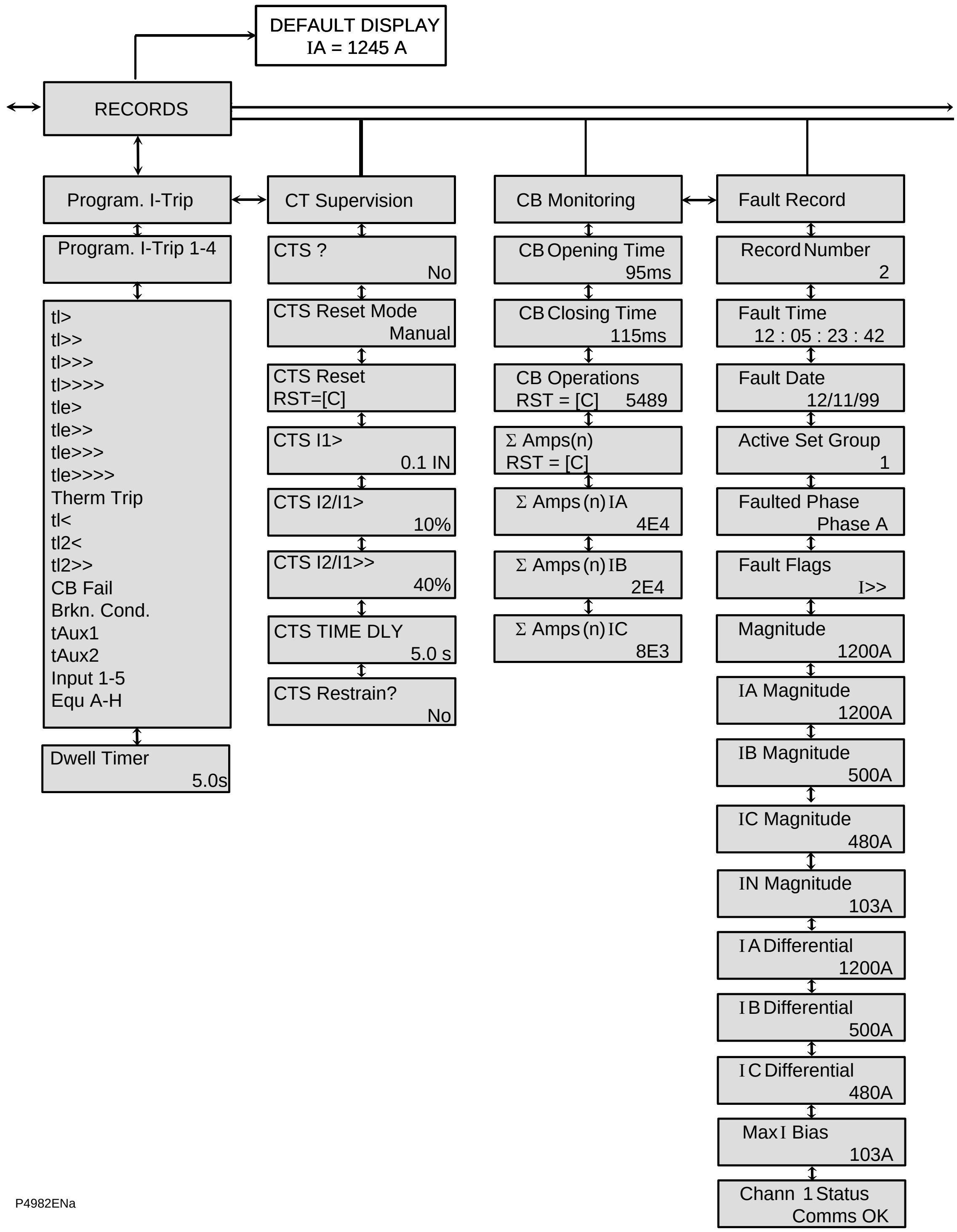

Figure 11 - Records menu

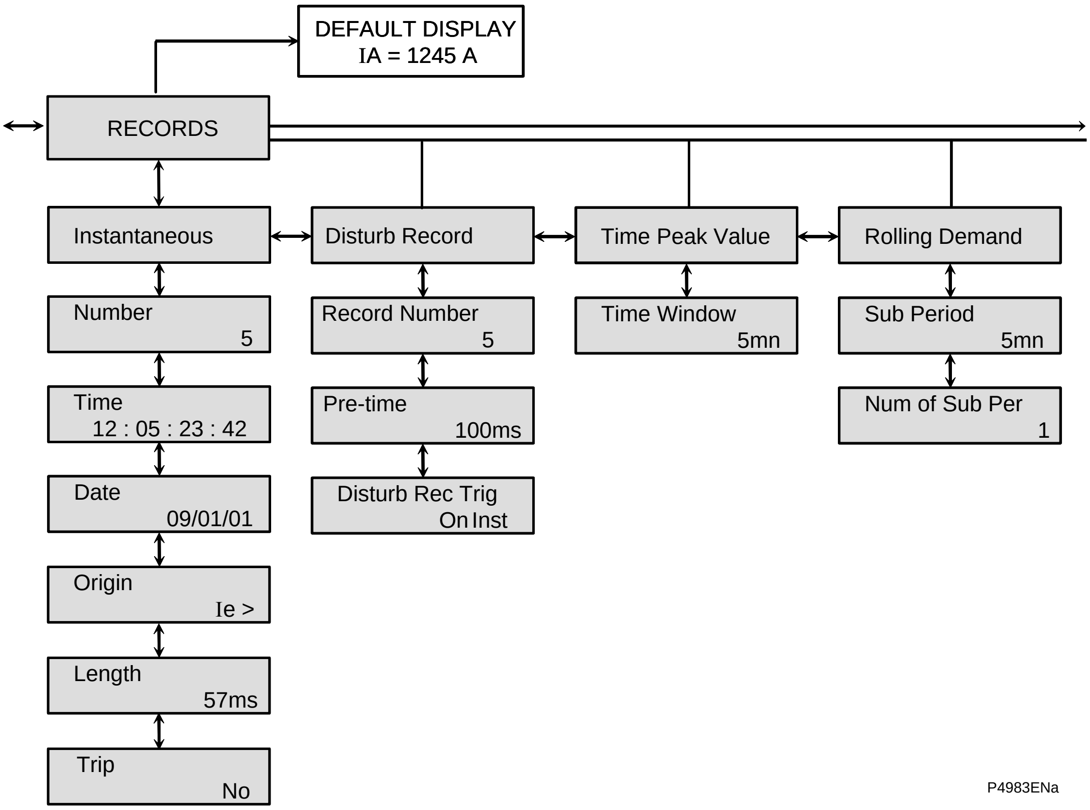

Figure 12 - Records menu (continued)

TECHNICAL DATA

CHAPTER 5

Date:	August 2017
Software version:	13
Hardware Suffix:	B
Connection diagram:	10P52101

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FIGURES

TABLES

1 PROTECTION FUNCTIONS

1.1 Current Differential Protection

- Current: Fundamental only
- Characteristic: Standard two slope

Is1	0.1 In to 2.0 In, steps of 0.05 In
Default value	0.2 In (see note)
Is2	1.0 In to 30.0 In, steps of 0.05 In
Default value	2.0 In (see note)
k1	0% to 150%, steps of 5%
Default value	30% (see note)
k2	30% to 150%, steps of 5%
Default value	150% (see note)

> *Note: Use of default setting values is recommended.*

- Hysteresis: 75%
- Instantaneous Time: < 45 ms + signaling delays *

> *Note: Valid for X/R ratios up to 120 and fault levels between 0.5 In and 25 In*

- Drop-off Time: < 60 ms + signaling delays *

> *Note: Valid for X/R ratios up to 120 and fault levels between 0.5 In and 25 In*

- Time Delays:

DMT	0 s to 150 s, steps of 0.01 s
IDMT Curves:	IEC: Short Time Inverse (IEC), Standard Inverse (IEC), Very Inverse (IEC), Extremely Inverse (IEC), Long Time Inverse (UK).
Time Multiplier Setting (TMS)	0.025 to 1.5, steps of 0.025 IEEE/ANSI: Short Time Inverse (CO2), Moderately Inverse (ANSI), Inverse (CO8), Very Inverse (ANSI), Extremely Inverse (ANSI).
Time Dial Setting (TD)	0.1 to 100, steps of 0.1
IDMT Curve Tolerance	±2% (or 50 ms whichever is greater) at greater than 2 Is1.

- Intertrip Operating Times

Permissive Intertrip Time	≤ 15 ms + PIT Time + signaling delay *
Direct Intertrip Time	≤ 15 ms + signaling delay *
Current Differential Intertrip Time	≤ 5 ms + signaling delay *

* Refer to Accuracy section for calculation of signaling delays.

1.2 Phase Overcurrent Protection

–	Current	Fundamental only
–	Current Range	0.1 to 40 x rated current, steps of 0.01 In
–	Thresholds	4 Independent (I>, I>>, I>>>, I>>>>) 0.1 In to 25 In (see note) I>> 0.5 In to 40 In (see note) I>>> 0.5 In to 40 In I>>>> 0.5 In to 40 In

> *Note:* *When I> or I>> is associated with an IDMT curve, the maximum setting recommended should be 2.0 In.*

–	Hysteresis	95%
–	Instantaneous Time	< 40 ms
–	Drop-off Time	< 30 ms
–	Time Delays:	(tI>, tI>>, tI>>>, tI>>>>)
	DMT	0 s to 150 s, steps of 0.01 s
	IDMT Curves:	IEC: Short Time Inverse (IEC), Standard Inverse (IEC), Very Inverse (IEC), Extremely Inverse (IEC), Long Time Inverse (UK).
	Time Multiplier Setting (TMS)	0.025 to 1.5, steps of 0.025
		IEEE/ANSI: Short Time Inverse (CO2), Moderately Inverse (ANSI), Inverse (CO8), Very Inverse (ANSI), Extremely Inverse (ANSI).
	Time Dial Setting (TD)	0.1 to 100, steps of 0.1
	RI:	Electromechanical Type
	K Factor Setting (K)	0.1 to 10, steps of 0.005
	IDMT Curve Tolerance	±2% (or 50 ms whichever is greater) at >2 In
	Reset Time	
–	IEEE Time Delay:	
	RTMS	0.025 to 3.2, steps of 0.025
	DMT	0.04 s to 100 s, steps of 0.01 s
	IEC Time Delay:	
	DMT	0.04 s to 100 s, steps of 0.01 s
	Transient Overreach	
–	Stages 1 & 2 (I> & I>>)	< 4% for X/R ratios up to 90
	Stages 3 & 4 (I>>> & I>>>>)	< 12% for X/R ratios up to 90

1.3 Neutral/Ground/Earth Overcurrent Protection

–	Current	Fundamental only
–	Current Ranges	0.002 to 1 x rated current, steps of 0.001 Ien 0.01 to 8 x rated current, steps of 0.005 Ien 0.1 to 40 x rated current, steps of 0.005 Ien
	Thresholds: Range:	4 Independent (Ie>, Ie>>, Ie>>>, Ie>>>>) 0.002 to 1 x Ien Ie> 0.002 Ien to 1Ien (see note 1) Ie>> 0.002 Ien to 1Ien (see note 1) Ie>>> 0.002 Ien to 1 Ien Ie>>>> 0.002 Ien to 1 Ien
–	Range:	0.01 to 8 x Ien Ie> 0.01 Ien to 1 Ien (see note 2) Ie>> 0.01 Ien to 8 Ien (see note 2) Ie>>> 0.01 Ien to 8 Ien Ie>>>> 0.01 Ien to 8 Ien
	Range:	0.1 to 40 x Ien Ie> 0.1 Ien to 25 Ien (see note 2) Ie>> 0.5 Ien to 40 Ien (see note 2) Ie>>> 0.5 Ien to 40 Ien Ie>>>> 0.5 Ien to 40 Ien

Note 1: When Ie> or Ie>> is associated with an IDMT curve the maximum setting recommended should be 0.05 Ien.

Note 2: When Ie> or Ie>> is associated with an IDMT curve, the maximum setting recommended should be the maximum of the range / 20.

–	Hysteresis	95%
–	Instantaneous Time	< 40 ms
–	Drop-off Time	< 30 ms
–	Time Delays: DMT IDMT Curves:	(tIe>, tIe>>, tIe>>>, tIe>>>>) 0 s to 150 s, steps of 0.01 s IEC: Short Time Inverse (IEC), Standard Inverse (IEC), Very Inverse (IEC), Extremely Inverse (IEC), Long Time Inverse (UK).
	Time Multiplier Setting (TMS)	0.025 to 1.5, steps of 0.025
		IEEE/ANSI: Short Time Inverse (CO2), Moderately Inverse (ANSI), Inverse (CO8), Very Inverse (ANSI), Extremely Inverse (ANSI).
	Time Dial Setting (TD)	0.1 to 100, steps of 0.1
	RI: K Factor Setting (K)	Electromechanical Type 0.1 to 10, steps of 0.005
	LABORELEC: IDMT Curve Tolerance	Curves 1, 2 and 3 (0.01 to 8 Range only) ±2% (or 50 ms whichever is greater) at >2 Ien
–	Reset Time IEEE Time Delay:	
	RTMS	0.025 to 3.2, steps of 0.025
	DMT	0.04 s to 100 s, steps of 0.01 s
	IEC Time Delay:	
	DMT	0.04 s to 100 s, steps of 0.01 s

–	Transient Over-reach Figures quoted are for X/R ratios up to 90	
	0.1 to 40 In earth fault board:	
	Stages 1 & 2 (Ie> & Ie>>)	< 4%
	Stages 3 & 4 (Ie>>> & Ie>>>>)	< 12%
	0.01 to 80 In earth fault board:	
	Stages 1 & 2 (Ie> & Ie>>)	< 3%
	Stages 3 & 4 (Ie>>> & Ie>>>>)	< 12%
	0.002 to 1 Ien earth fault board:	
	Stages 1 & 2 (Ie> & Ie>>)	< 2 %
	Stages 3 & 4 (Ie>>> & Ie>>>>)	< 5%

1.4 Thermal Overload Protection

–	Current	RMS
–	Current Threshold (Iθ>)	0.1 to 3.2 x rated current, steps of 0.01
–	Thermal State (alarm and trip)	50% to 200% x θ steps of 1%
–	Constant Time (Te)	1 min to 200 mins, steps of 1 min
–	K Factor	1 to 1.5, steps of 0.01

1.5 Undercurrent Protection

–	Current	Fundamental only
–	Phase Current Range (I<)	2% to 100% x rated current, steps of 1%
–	Time Delay (tI<)	0 s to 150 s, steps of 0.01 s
–	Hysteresis	105%

1.6 Negative Sequence Overcurrent Protection

–	Current	Fundamental only	
–	Current Range	0.1 to 40 x rated current, steps of 0.01 In	
–	Thresholds	2 Independent (I2>, I2>>)	
		I2>	0.1In to 40 In (see note)
		I2>>	0.1In to 40 In

Note: *When I2> is associated with an IDMT curve the maximum setting 6 recommended should be 2 In.*

–	Hysteresis	95%
–	Instantaneous Time	< 40 ms
–	Drop-off Time	< 30 ms

–	Time Delays:	(tI2>, tI2>>)
	DMT	0 s to 150 s, steps of 0.01 s
	IDMT Curves:	IEC: Short Time Inverse (IEC), Standard Inverse (IEC), Very Inverse (IEC), Extremely Inverse (IEC), Long Time Inverse (UK). 0.025 to 1.5, steps of 0.025
	Time Multiplier Setting (TMS)	
		IEEE/ANSI: Short Time Inverse (CO2), Moderately Inverse (ANSI), Inverse (CO8), Very Inverse (ANSI), Extremely Inverse (ANSI).
	Time Dial Setting (TD)	0.1 to 100, steps of 0.1
	RI:	
	K Factor Setting (K)	Electromechanical Type 0.1 to 10, steps of 0.005
	IDMT Curve Tolerance	±2% (or 50 ms whichever is greater) at default values.
–	Reset Time	
	IEEE Time Delay:	
	RTMS	0.025 to 3.2, steps of 0.025
	DMT	0.04 s to 100 s, steps of 0.01 s
	IEC Time Delay:	
	DMT	0.04 s to 100 s, steps of 0.01 s

2 AUTOMATION FUNCTIONS

2.1 Cold Load Pickup

– Range	20% to 500% x nominal settings, steps of 1%
– Time Delay (tCL)	0.1 s to 3600 s, steps of 0.1 s

2.2 Auxiliary Timers

– Auxiliary Timer Numbers	2 independent associated to the Logic Inputs Aux 1 and Aux2
– tAux1 & tAux2 Range	0 s to 200 s, steps of 0.01 s

2.3 Broken Conductor Detection

– Principle Used	I2/I1
– Threshold	20% to 100%, steps of 1%
– Time Delay (tBC)	0 s to 14400 s, steps of 1 s

2.4 Circuit Breaker Failure

– Undercurrent Threshold (I<)	2% to 100% x rated current, step of 1%
– Threshold Accuracy	from 0.02In to 0.1 In : 0.006 In from 0.1 In to 1 In : 2%Is
– Threshold Hysteresis	Max. 0.008 In or 0.95 Is
– CB Failure Time (tBF)	0.03 s to 10 s, steps of 0.01 s

2.5 Trip Circuit Supervision

– Time Value (tSUP)	0.1 s to 10 s, steps 0.05 s

2.6 Circuit Breaker Control and Monitoring

– CB Opening Time (tOpen)	0.05 s to 1 s, steps of 0.01 s
– CB Closing Time (tClose)	0.05 s to 1 s, steps of 0.01 s
– CB Opening Alarm Threshold	0 to 50000 Operations
– ∑Amps Alarm Threshold	0 to 4x109, steps of 106
– CB Trip Time Alarm Threshold	0.1 s to 5 s, steps of 0.1 s
– CB Close Time Alarm Threshold	0.1 s to 5 s, steps of 0.1 s

2.7 Logic Selectivity

– Timer Number	2 Independent : tSel1 and tSel2
– tSel1 & tSel2 Range	0 to 150 s, steps of 0.01 s

3 RECORDING FUNCTIONS

3.1 Event Recorder

–	Capacity	250 Events
–	Time-Tag	to 1 millisecond
–	Triggers	Any selected Protection Alarm and Threshold Logic input state change Self test events Setting changes

3.2 Fault Recorder

–	Capacity	25 Faults
–	Time-Tag	to 1 millisecond
–	Triggers	Any selected protection alarm and threshold
–	Data Stored	Fault date Protection thresholds Setting group AC inputs measurements (RMS) Fault magnitudes

3.3 Instantaneous Recorder

–	Capacity	5 Starting records (instantaneous threshold pick-up)
–	Time-Tag	1 millisecond resolution
–	Triggers	Any selected phase or earth threshold
–	Data Stored	Time and date Origin of fault (threshold) Duration of the instantaneous flag Trip (Yes or No)

3.4 Disturbance Recorder

–	Capacity		5 Records of up to 3s each
–	Sampling Rate		32 Samples per frequency cycle
–	Settings:	Pre-Time Post-Time	0.1 s to 3 s. steps of 0.1 s 0.1 s to 3 s. steps of 0.1 s
–	Triggers		Any selected protection alarm and threshold Logic input Remote command
–	Data Stored		AC Input channels Digital input/output states

4 RELAY COMMUNICATIONS

–	EIA(RS)485 Port:	Rear Port, Screened Twisted Pair
	Connectors	Screws or Snap-On
	Protocols	MODBUSTM RTU IEC 60870-5-103
	Data Rate	300 to 38400 Baud (Programmable)
–	EIA(RS)232 Port:	Front Port, Screened twisted cable
	Connector	Sub-D 9 pin female connector
	Protocol	MODBUSTM RTU
	Data Rate	19200 Baud Asynchronous

5 PROTECTION COMMUNICATIONS

–	EIA(RS)485 Port:	Rear Port, Screened twisted pair Full Duplex Connection
	Connectors	Phoenix Contact model KGG-MC 1,5/ 7
	Transmission Mode	NRZ (recommended) SDLC
	Data Rate	9600 to 64000 Baud (Programmable)
–	EIA(RS)232 Port:	Rear Port, Screened twisted cable
	Connector	Phoenix Contact Model KGG-MC 1,5/ 7
	Transmission Mode	NRZ (recommended) SDLC
	Data Rate	9600 to 64000 Baud (Programmable)
–	Fiber Port:	850 nm Multi-Mode 1300 nm Multi-Mode 1300 nm Single-Mode
	Connector:	ST Type Fiber Connector
	Transmission Mode	NRZ SDLC (recommended)
	Data Rate	9600 to 64000 Baud (Programmable)
–	$\frac{\text{Errored Secs}}{\text{Time Available}}$	<0.02 ITU-T G.821
–	$\frac{\text{Severe Error Secs}}{\text{Time Available}}$	<0.008 ITU-T G.821

5.1 Propagation Delays

5.1.1 Maximum Allowable Propagation Delay

System Frequency	Data Rate			
	9.6 kB/s	**19.2 kB/s**	**56 kB/s**	**64 kB/s**
50 Hz	162 ms	94 ms	29 ms	29 ms
60 Hz	158 ms	80 ms	24 ms	24 ms

5.1.2 Maximum Propagation Delay Difference between Send and Receive Communications Paths

System Frequency	Data Rate			
	9.6 kB/s	**19.2 kB/s**	**56 kB/s**	**64 kB/s**
50 Hz	2 ms	2 ms	2 ms	1 ms
60 Hz	1 ms	1 ms	1 ms	1 ms

6 INPUTS AND OUTPUTS

6.1 AC Inputs

–	Phase Current Inputs	1 and 5 Amps by connection
–	Earth Current Inputs	1 and 5 Amps by connection
–	Frequency: Nominal Range	 50 or 60 Hz by setting selection Nominal ±5 Hz
–	Current Inputs Burden: Phase Earth	 <0.025 VA (1 A) <0.3 VA (5 A) <0.008 VA at 0.1Ie (1 A) <0.01 VA for 0.1Ie (5 A)
–	Thermal Withstand	1s @ 100 x Rated Current with 400 A Maximum 2s @ 40 x Rated Current Continuous @ 4 x Rated Current

6.2 Logic Inputs and Outputs

6.2.1 Logic Input

The logic inputs should be powered with a DC voltage, except for the A, F, T auxiliary voltage range which accepts both DC and AC voltage.

	RELAY AUXILIARY POWER SUPPLY		LOGIC INPUT VOLTAGES				
Ordering Code (Cortec)	**Nominal voltage range Vx**	**Operating range**	**Nominal voltage range**	**Minimal polarization voltage**	**Maximum polarization current**	**Holding current after 2ms**	**Maximum continuous withstand**
A	24 - 60 Vdc	19.2 - 76 Vdc	24 - 250 Vdc 24 - 240 Vac	19.2 Vdc 19.2 Vac	35 mA	2.3 mA	300 Vdc 264 Vac
F	48 - 250 Vdc 48 - 240 Vac	38.4 - 300 Vdc 38.4 - 264 Vac	24 - 250 Vdc 24 - 240 Vac	19.2 Vdc 19.2 Vac	35 mA	2.3 mA	300 Vdc 264 Vac
T	48 - 250 Vdc 48 - 240 Vac Special EA (**)	38.4 - 300 Vdc 38.4 - 264 Vac	24 - 250 Vdc 24 - 240 Vac	19.2 Vdc 19.2 Vac	35 mA	2.3 mA	300 Vdc 264 Vac
H	48 - 250 Vdc 48 - 240 Vac	38.4 - 300 Vdc 38.4 - 264 Vac	129 Vdc	105 Vdc	3.0 mA @ 129 Vdc		145 Vdc
V	48 - 250 Vdc 48 - 240 Vac	38.4 - 300 Vdc 38.4 - 264 Vac	110 Vdc	77 Vdc	7.3 mA @ 110 Vdc		132 Vdc
W	48 - 250 Vdc 48 - 240 Vac	38.4 - 300 Vdc 38.4 - 264 Vac	220 Vdc	154 Vdc	3.4 mA @ 220 Vdc		262 Vdc
Z	24 - 250 Vdc 48 - 240 Vac	19.2 - 300 Vdc 38.4 - 264 Vac	24 - 250 Vdc 24 - 240 Vac	19.2 Vdc 19.2 Vac	35 mA	2.3 mA	300 Vdc 264 Vac

Note	*The Ordering options A and F (Cortec) cannot be provided for any versions of the P521 product which are later than Phase I software.*
Note	*(**) Logic input recognition time for EA approval. Dedicated filtering on 24 samples (15 ms at 50 Hz).*

6.2.2 Logic Output

–	Type	Dry Contact Ag CdO
–	Rating: Make Carry Break	 30 Amps and carry for 3 s 5 Amps continuous 135 Vdc, 0.3 Amps (L/R=30 ms) 250 Vdc, 50 W resistive or 25 W inductive (L/R=40 ms) 220 Vac, 5 Amps (cos φ =0.6)
–	Operation Time	<7 ms
–	Mechanical Durability	>100 000 Operations

6.3 Power Supply

–	Auxiliary Voltages, Vaux	24 – 60 Vdc 24 – 250 Vdc 48 - 250 Vdc 48 – 240 Vac, 50/60 Hz
–	Power Supply Variations	dc ±20% ac –20%, +10%
–	Ripple	12%
–	DC Interruption	50 ms
–	Burden	3 W Standby + 0.4 W per Energized Relay + 10 mA per logic input 6 VA Standby + 0.4 VA per Energized Relay + 10 mA per logic input

7 ACCURACY

–	Protection Thresholds	±2% (5% - current differential)
–	Time Delay	±2 % with a minimum of 0.05 s
–	Measurements	Typical ±0.5% at In
–	Additional Error Due to Frequency Variation	$\pm \frac{f - fn}{fn}$ % between 45 and 65 Hz where f = actual frequency fn = nominal frequency (e.g. 50/60 Hz)
–	Calculation of Signaling Delay	

$$\text{Signaling Delay (in seconds)} = \left\{ 2 \left[\text{Integer} \left(\frac{N_B/B_R}{K_F} + 1 \right) . K_F \right] \right\} + Dp$$

Where:

BR = Baud rate setting (e.g. 9600, 19200, 56000, 64000)

NB = Number of bits in the message (NRZ = 210 bits, SDLC = 204 bits)

Dp = Propagation delay of system (select zero seconds for direct fiber connected systems, or refer to modem configuration section for typical modem propagation delays)

Integer = Nearest whole number (rounded up)

KF = $\frac{1}{4 . FS}$

FS = System frequency setting (50 Hz or 60 Hz)

8 CT DATA

–	Phase CT Primary	1 to 9999, steps of 1
–	Earth CT Primary	1 to 9999, steps of 1
–	Phase CT Secondary	1 or 5
–	Earth CT Secondary	1 or 5
–	CT Correction Factor	0.05 to 10.0, steps of 0.01
–	Earth Current	Residual Connection or Core Balanced CT (preferred in isolated and compensated neutral systems)

9 HIGH VOLTAGE WITHSTAND

9.1 Dielectric Withstand

IEC 60255-5: 2000

2.0 kVrms for one minute between all terminals and case earth (including EIA(RS)485/EIA(RS)232 socket SK1).

2.0 kVrms for one minute between all terminals of each independent circuit grouped together, and all other terminals (including EIA(RS)485/EIA(RS)232 socket SK1).

1.0 kVrms for one minute across dedicated normally open contacts of output relays.

1.0 kVrms for 1 minute across normally open contacts of changeover and watchdog output relays.

9.2 Impulse

IEC 60255-5: 2000

The product will withstand without damage impulses of 5 kV peak, 1.2/50 µs, 0.5J across:

Each independent circuit and the case with the terminals of each independent circuit connected together.

Independent circuits with the terminals of each independent circuit connected together.

Terminals of the same circuit except normally open metallic contacts.

9.3 Insulation Resistance

IEC 60255-5: 2000

The insulation resistance is greater than 100 MΩ at 500 Vdc.

10 ELECTRICAL ENVIRONMENT

10.1 Performance Criteria

The following three classes of performance criteria are used to specify the performance of the MiCOM relay when subjected to the electrical interference. The performance criteria are based on the performance criteria specified in EN 50082-2:1995.

10.1.1 Class A

During the testing, the relay will not mal-operate and upon completion of testing the relay will function as specified. A mal-operation will include a transient operation of the output contacts, operation of the watchdog contacts, reset of any of the relay's microprocessors or an alarm indication.

The relay communications must continue uncorrupted via the communications ports during the test, however, relay communications may be momentarily interrupted, provided they recover with no external intervention.

10.1.2 Class B

During the testing, the relay will not mal-operate and upon completion of the testing, the relay will function as specified. A mal-operation will include a transient operation of the output contacts, operation of the watchdog contacts, reset of any of the relay's microprocessors or an alarm indication. Transitory operation of the output LEDs is acceptable, provided no permanent false indications are recorded.

The relay communications must continue uncorrupted via the communications ports during the test. However, relay communications may be momentarily interrupted, provided they recover with no external intervention.

10.1.3 Class C

The relay will power down and power up again in a controlled manner within 5 seconds. The output relays are permitted to change state during the test as long as they reset once the relay powers up.

Communications to the relay may be suspended during the testing, as long as communication recovers with no external intervention after the testing.

10.2 Auxiliary Supply Tests, DC Interruption, etc.

10.2.1 DC Voltage Interruptions

IEC 60255-11: 1979.

DC Auxiliary Supply Interruptions 2, 5, 10, 20, 50 ms.

Performance criteria - Class A.

DC Auxiliary Supply Interruptions 100, 200 ms, 40 s.

Performance criteria - Class C.

10.2.2 DC Voltage Fluctuations

IEC 60255-11: 1979.

AC 100 Hz ripple superimposed on the DC max. and min. auxiliary supply at 12% of highest rated DC.

Performance criteria - Class A.

10.3 AC Voltage Dips and Short Interruptions

10.3.1 AC Voltage Short Interruptions

IEC 61000-4-11: 1994.

AC Auxiliary Supply Interruptions 2, 5, 10, 20, 50 ms.

Performance criteria - Class A.

AC Auxiliary Supply Interruptions 100, 200 ms, 1 s, 40 s.

Performance criteria - Class C.

10.3.2 AC Voltage Dips

IEC 61000-4-11: 1994

AC Auxiliary Supply 100% Voltage Dips 2, 5, 10, 20, 50 ms.

Performance criteria - Class A.

AC Auxiliary Supply 100% Voltage Dips 100, 200 ms, 1 s, 40 s.

Performance criteria - Class C.

10.4 High Frequency Disturbance

IEC 60255-22-1: 1988 Class III.

1 MHz burst disturbance test.

IEC 61000-4-12: 1995 Class III.

100 kHz burst disturbance test.

2.5 kV common mode.

Power supply, CTs, opto inputs, output contacts, rear EIA(RS)485 protection communications port.

1 kV differential mode.

Power supply, CTs, opto inputs and output contacts.

Performance criteria Class A.

10.5 Fast Transients

IEC 60255-22-4: 2002 (EN 61000-4-4: 1995), Class III and Class IV.

2 kV 5 kHz (Class III) and 4 kV 2.5 kHz (Class IV) direct coupling.

Power supply, opto inputs, output contacts, CTs.

2 kV 5 kHz (Class III) and 4 kV 2.5 kHz (Class IV) capacitive clamp.

EIA(RS)485 / EIA(RS)232 protection communications port.

Performance criteria Class A.

10.6 Conducted/Radiated Emissions

10.6.1 Conducted Emissions

EN 55022: 1995 Class A, IEC 60255-25: 2000 Class A.

0.15 - 0.5 MHz, 79 dBμV (quasi peak) 66 dBμV (average).

0.5 – 30 MHz, 73 dBμV (quasi peak) 60 dBμV (average).

10.6.2 Radiated Emissions

EN 55022: 1995 Class A, IEC 60255-25: 2000 Class A.

30 – 230 MHz, 40 dBμV/m at 10 m measurement distance.

230 – 1000 MHz, 47 dBμV/m at 10 m measurement distance.

10.7 Conducted/Radiated Immunity

10.7.1 Conducted Immunity

IEC 60255-22-6: 1996/A1 2001, IEC 61000-4-6: 2002 Level 3.

10 V emf @ 1 kHz 80% AM, 150 kHz to 80 MHz. Spot tests at 27 MHz, 68 MHz.

Performance criteria Class A.

10.7.2 Radiated Immunity

IEC 60255-22-3: 2000 Class III, IEC 61000-4-3: 1995 Level 3.

10 V/m 80 MHz - 1GHz @ 1 kHz 80% AM.

Spot tests at 80 MHz, 160 MHz, 450 MHz, 900 MHz (10 V/m).

Performance criteria Class A.

10.7.3 Radiated Immunity from Digital Radio Telephones

IEC 60255-22-3: 2000 Class III, IEC 61000-4-3: 2002 Class 4.

30 V/m 800 MHz – 960 MHz @ 1 kHz 80% AM.

30 V/m 1.4 GHz - 2.0 GHz @ 1 kHz 80% AM.

10 V/m 900 MHz ± 5 MHz and 1.89 GHz ± 5 MHz, 200 Hz rep. Freq., 50% duty cycle pulse modulated.

Performance criteria Class A.

10.8 Electrostatic Discharge

IEC 60255-22-2: 1996 Class 3 & Class 4, IEC 61000-4-2: 1995.

Class 4: 15 kV air discharge (front panel excluding front comms.).

Class 3: 8 kV air discharge (communications port).

Class 3: 6 kV contact discharge (front panel).

Performance criteria Class A.

10.9 Surge Immunity

IEC 60255-22-5: 2002, IEC 61000-4-5: 1995 Levels 3 and 4.

Level 4 - AC/DC PSU, CTs, optos, output contacts.

Level 3 - DC PSU, EIA(RS)485 rear protection communications channel.

Performance criteria Class A under reference conditions.

10.10 Power Frequency Magnetic Field

IEC 61000-4-8: 1993 Level 5.

100 A/m field applied continuously in all planes with the EUT configured in its quiescent and tripping states.

1000 A/m field applied for 3 s in all planes with the EUT configured in its quiescent and tripping states.

Performance criteria Class A.

10.11 Pulse Magnetic Field Immunity

IEC 61000-4-9: 1993 Level 5.

6.4 μs/16 μs magnetic pulse, 1000 A/m, applied in both polarities in each plane with the EUT configured in its quiescent state.

Performance criteria Class A.

10.12 Damped Oscillatory Magnetic Field Immunity

IEC 61000-4-10: 1993 Level 5.

0.1 MHz and 1 MHz damped oscillatory pulses, 100 A/m, applied in both polarities in each plane with the EUT configured in its quiescent state.

Performance criteria Class A.

10.13 Power Frequency Interference

IEC 60255-22-7: 2003

NGTS* 2.13 Issue 1 Dec 2000, section 7.55

EATS 48-5, Issue 2: 2000.

300 Vrms common mode.

250 Vrms differential mode.

Voltage applied to all non-mains frequency inputs. Permanently connected communications circuits tested to Class 3 (100-1000 m) test level 50 mV.

Performance criteria Class A.

* National Grid Technical Specification

10.14 Surge Withstand Capability (SWC)

ANSI/IEEE C37.90.1 (2002)

Oscillatory SWC Test

> 2.5 kV – 3 kV, 1 - 1.5 MHz - common and differential mode - applied to all circuits except for terminal block communications, which are tested common mode only via the cable screen.

Fast Transient SWC Tests

> 4 – 5 kV crest voltage - common and differential mode - applied to all circuits except for terminal block communications, which are tested common mode only via the cable screen.

Performance criteria Class A

10.15 Radiated Immunity

ANSI/IEEE C37.90.2 1995

35 V/m 25 MHz – 1 GHz, no modulation, applied to all sides.

35 V/m 25 MHz – 1 GHz, 100% pulse modulated, to front only.

Performance criteria Class A.

11 ATMOSPHERIC ENVIRONMENT

11.1 Temperature

IEC 60068-2-1: 2007

-25°C storage (96 hours)

-40°C operation (96 hours)

IEC 60068-2-2: 2007

+70°C storage (96 hours)

+85°C operation (96 hours)

11.2 Humidity

IEC 60068-2-3: 1969

Damp heat, steady state, 40° C ± 2° C and 93% relative humidity (RH) +2% –3%, duration 56 days.

IEC 60068-2-30: 1980

Damp heat cyclic, six (12 + 12 hour cycles) of 55°C ±2°C 93% ±3% RH and 25°C ±3°C 93% ±3% RH.

11.3 Enclosure Protection

IEC 60529: 2001

IP52 Category 2

IP5x – Protected against dust, limited ingress permitted.

IPx2 – Protected against vertically falling drops of water with the product in 4 fixed positions of 15° tilt with a flow rate of 3 mm/minute for 2.5 minutes.

12 MECHANICAL ENVIRONMENT

12.1 Performance Criteria

The following two classes of performance criteria are used within sections to (where applicable) to specify the performance of the MiCOM relay when subjected to mechanical testing.

12.1.1 Severity Classes

The following table details the Class and Typical Applications of the vibration, shock bump and seismic tests detailed previously

Class	Typical Application
1	Measuring relays and protection equipment for normal use in power plants, substations and industrial plants and for normal transportation conditions
2	Measuring relays and protection equipment for which a very high security margin is required or where the vibration (shock and bump) (seismic shock) levels are very high, e.g. shipboard application and for severe transportation conditions.

12.1.2 Vibration (Sinusoidal)

IEC 60255-21-1: 1988

Cross over frequency - 58 to 60 Hz

Vibration response

Severity Class	Peak Displacement Below Cross Over Frequency (mm)	Peak Acceleration Above Cross Over Frequency (gn)	Number of Sweeps in Each Axis	Frequency Range (Hz)
2	0.075	1	1	10 – 150

Vibration endurance

Severity Class	Peak Acceleration (gn)	Number of Sweeps in Each Axis	Frequency Range (Hz)
2	2.0	20	10 – 150

12.1.3 Shock and Bump

IEC 60255-21-2: 1988

Type of Test	Severity Class	Peak Acceleration (gn)	Duration of Pulse (ms)	Number of Pulses in Each Direction
Shock Response	2	10	11	3
Shock Withstand	1	15	11	3
Bump	1	10	16	1000

12.1.4 Seismic

IEC 60255-21-3: 1993

Cross over frequency - 8 to 9 Hz

x = horizontal axis, y = vertical axis

Severity Class	Peak Displacement Below Cross Over Frequency (mm)		Peak Acceleration Above Cross Over Frequency (gn)		Number Of Sweep Cycles In Each Axis	Frequency Range (Hz)
	x	y	x	y		
2	7.5	3.5	2.0	1.0	1	1- 35

13 EC EMC COMPLIANCE

Compliance to the European Community Directive 89/336/EEC amended by 93/68/EEC is claimed via the Standards route.

The following Product Specific Standard was used to establish conformity:

EN 50263: 2000

14 EC LVD COMPLIANCE

Compliance with European Community Directive on Low Voltage 73/23/EEC is demonstrated by reference to generic safety standards:

EN 61010-1: 2001

EN 60950-1: 2001

15 BATTERY LIFE

Battery life (assuming relay energized for >90% of time) > 10 years.

16 FREQUENCY RESPONSE

With exception of the RMS measurements and thermal overload protection all other measurements are based upon the Fourier derived fundamental component. The fundamental component is extracted by using a 16 sample Discrete Fourier Transform (DFT). This gives good harmonic rejection for frequencies up to the 15th harmonic. The 15th is the first predominant harmonic that is not attenuated by the Fourier filter and is known as an 'Alias'. The Alias, however, is attenuated by approximately 70% by an additional analogue, 'anti-aliasing' filter (low pass filter). The combined affect of the anti-aliasing and Fourier filters is shown in Figure 1.

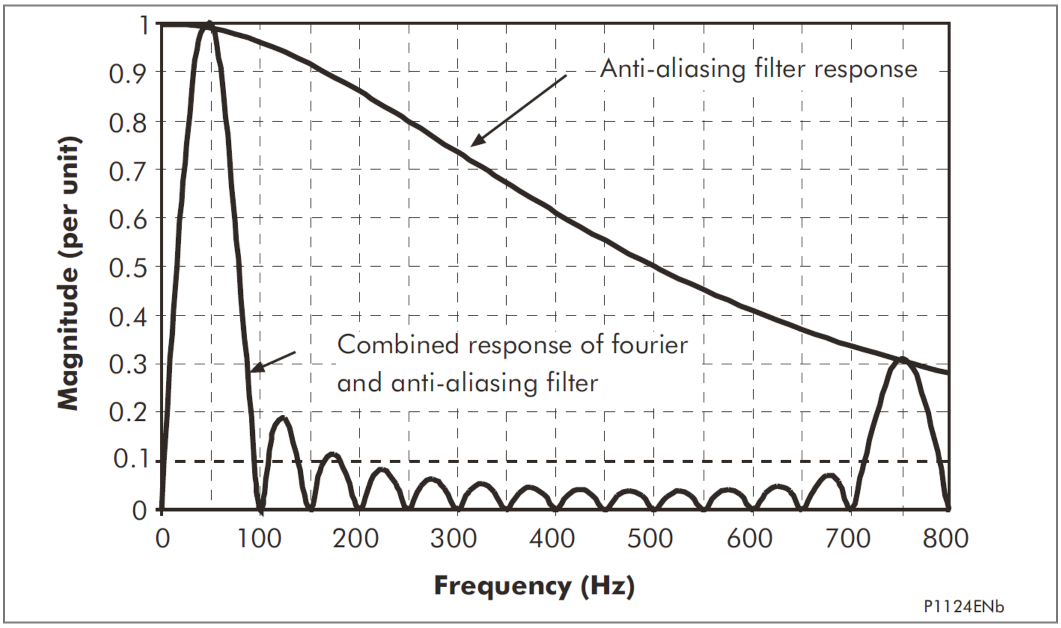

Figure 1 - Frequency Response

17 CURVES

17.1 IDMT Curves

17.1.1 Pick-up IDMT Mathematical Formula

Inverse Time Curves Formulae:

The first and second stage phase and earth overcurrent threshold can be selected with a dependent time characteristic. The time delay is calculated with a mathematical formula. There are eleven inverse time characteristics available.

The mathematical formula applicable to the first ten curves is:

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

Where:

t = Operating time (secs)

K = Coefficient (see table)

I = Value of measured current

IS = Value of the programmed threshold (Pick-up value)

α = Coefficient (see table)

L = ANSI/IEEE coefficient (zero for IEC curves)

T = Time Multiplier Setting (TMS) for IEC curves or Time Dial (TD) for ANSI/IEEE curves.

Type of curve	Standard	K Factor	α Factor	L Factor
Short Time Inverse	IEC	0.05	0.04	0
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
Short Time Inverse	CO2	0.02394	0.02	0.01694
Moderately Inverse	ANSI/IEEE	0.0515	0.02	0.114
Inverse	CO8	5.95	2	0.18
Very Inverse	ANSI/IEEE	19.61	2	0.491
Extremely Inverse	ANSI/IEEE	28.2	2	0.1215

Table 1 - Inverse curve factors

The RI curve (electromechanical) is given by the following formula:

$$t = K \times \left(\frac{1}{0.339 - 0.236 / (I/Is)} \right) \text{ when } 1.1 <= (I/Is) <= 20$$

Although the curves tend towards infinity when the current approaches Is, the minimum guaranteed value of the operating current for all the curves with the inverse time characteristic is 1.1 Is (with a tolerance of ±0.05 Is).

Laborelec Curves:

The first and second earth thresholds can be selected with dedicated Laborelec curves. There are 3 curves available with the following formula:

$t = \alpha I + b$

Where:

t = Tripping time

α = Coefficient (see table)

b = Coefficient (see table)

I = Primary residual current (between 1 and 40A)

Type of Curve	α	b
LABORELEC 1	– 0.0897	4.0897
LABORELEC 2	– 0.0897	4.5897
LABORELEC 3	– 0.0897	5.0897

Table 2 - Laborelec curve factors

In order to be compliant with the Laborelec specifications the relay must be used with:

- An earth current range 0.01 Ien to 8 Ien
- A rated current wiring 1 A
- A core balanced CT with a ratio 20/1.

For a complete operating of the curve, the relay must be set to 0.05Ien (secondary residual current).

17.1.2 Reset Timer IDMT Mathematical Formula

Reset Timer Description:

The first and second phase and earth overcurrent stages are provided with a timer hold facility 'tReset', which may be set to a definite time value or to an inverse time characteristic (IEEE/ANSI curves only). This may be useful in certain applications, for example when grading with upstream electromechanical overcurrent relays which have inherent reset time delays.

Another possible situation where the timer hold facility may be used to reduce fault clearance times is where intermittent faults occur. An example of this may occur in a plastic insulated cable. In this application, it is possible that the fault energy melts and reseals the cable insulation, thereby extinguishing the fault. This process repeats to give a succession of fault current pulses, each of increasing duration with reducing intervals between the pulses, until the fault becomes permanent.

When the reset time of the overcurrent relay is minimum the relay will be repeatedly reset and not be able to trip until the fault becomes permanent. By using the Timer Hold facility the relay will integrate the fault current pulses, thereby reducing fault clearance time.

The reset timer 'tReset' facility can be found in the following menu configurations:

If the threshold is selected with an IDMT IEC or RI curve, the reset timer 'tReset' with DMT characteristic is settable in the menu and can be found at the following locations:

Phase fault reset timer setting:

Protection → [50/51] Phase OC → tReset

Earth fault reset timer setting:

Protection → [50N/51N] E/Gnd → tReset

If the threshold is selected with an IDMT IEEE or CO curve, the reset timer 'tReset' with a DMT or IDMT characteristic is settable in the menu at the following locations:

Phase fault reset timer setting:

Protection → [50/51] Phase OC → Reset Type

Earth fault reset timer setting:

Protection → [50N/51N] E/Gnd → Reset Type

Inverse Time Curves Formulae:

The mathematical formula applicable to the five curves is:

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

Where:

t	=	Reset time
K	=	Coefficient (see table)
I	=	Value of the measured current
IS	=	Value of the programmed threshold (pick-up value)
α	=	Coefficient (see table)
T	=	Reset Time Multiplier (Rtms) between 0.025 and 3.2

Type of Curves	Standard	K Factor	α Factor
Short Time Inverse	CO2	2.261	2
Moderately Inverse	ANSI/IEEE	4.85	2

Type of Curves	Standard	K Factor	α Factor
Inverse	CO8	5.95	2
Very Inverse	ANSI/IEEE	21.6	2
Extremely Inverse	ANSI/IEEE	29.1	2

Table 3 - Inverse curve factors

17.1.3 IEC Curves

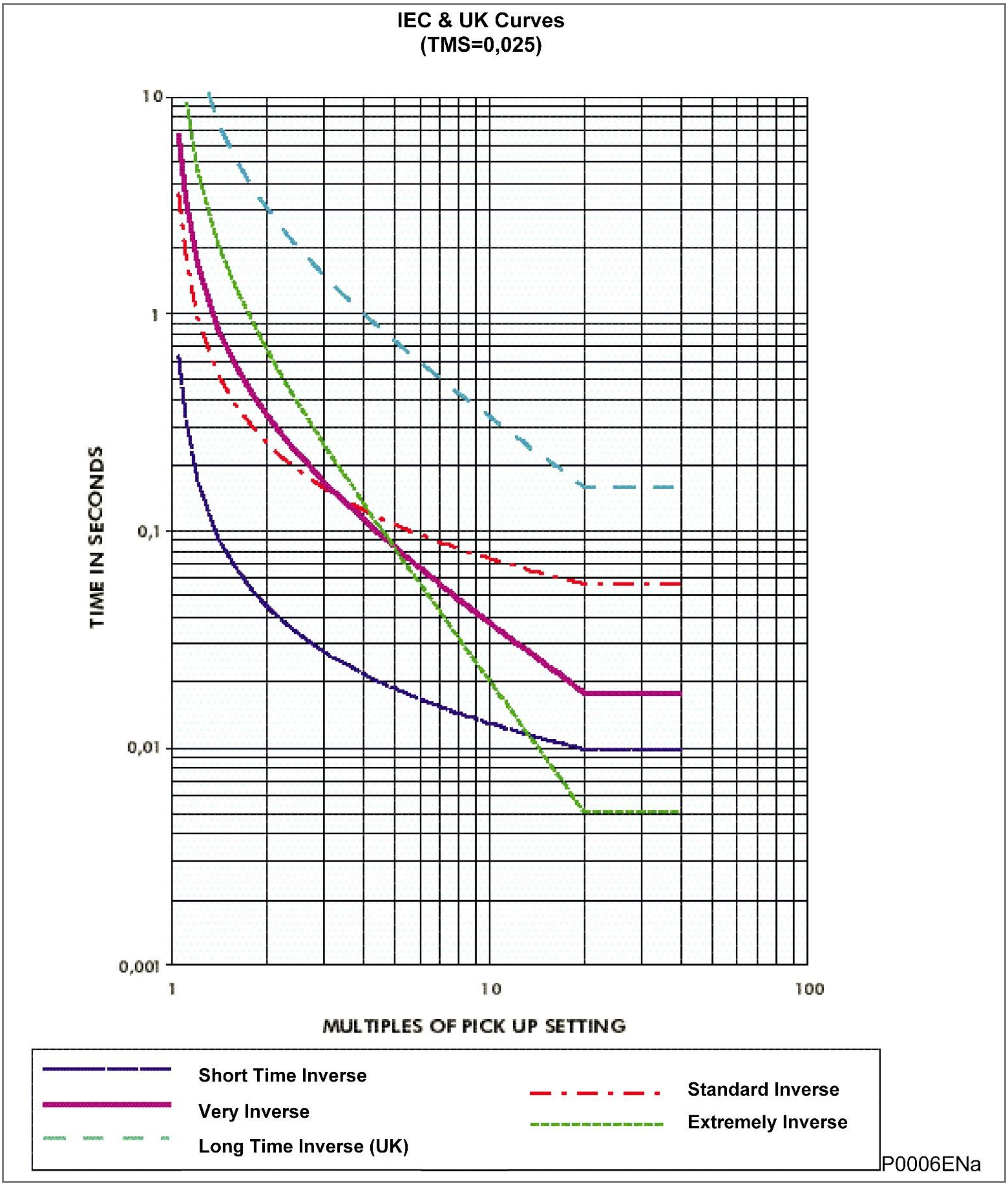

Figure 2 - IEC & UK curves

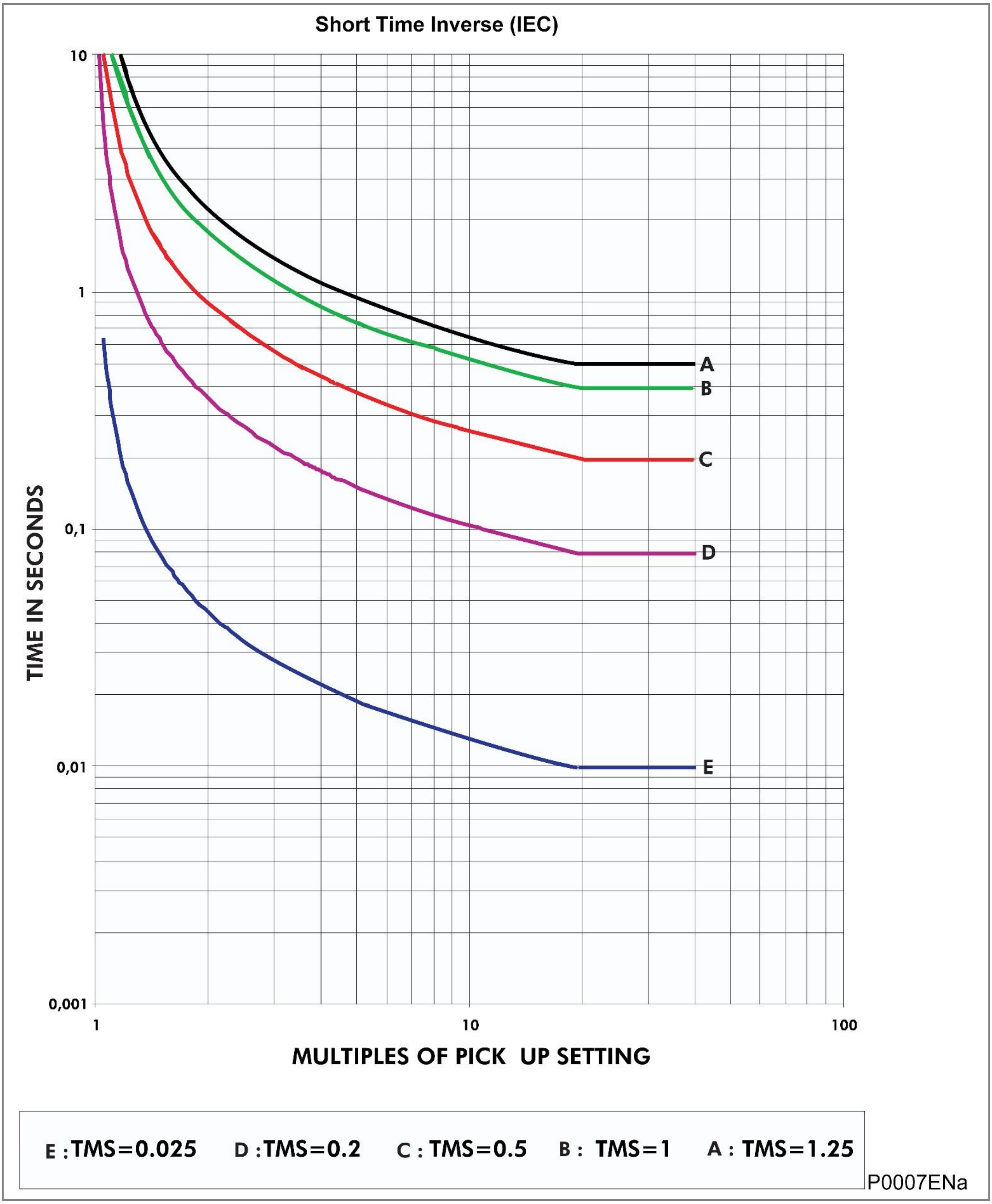

Figure 3 - Short Time Inverse (IEC)

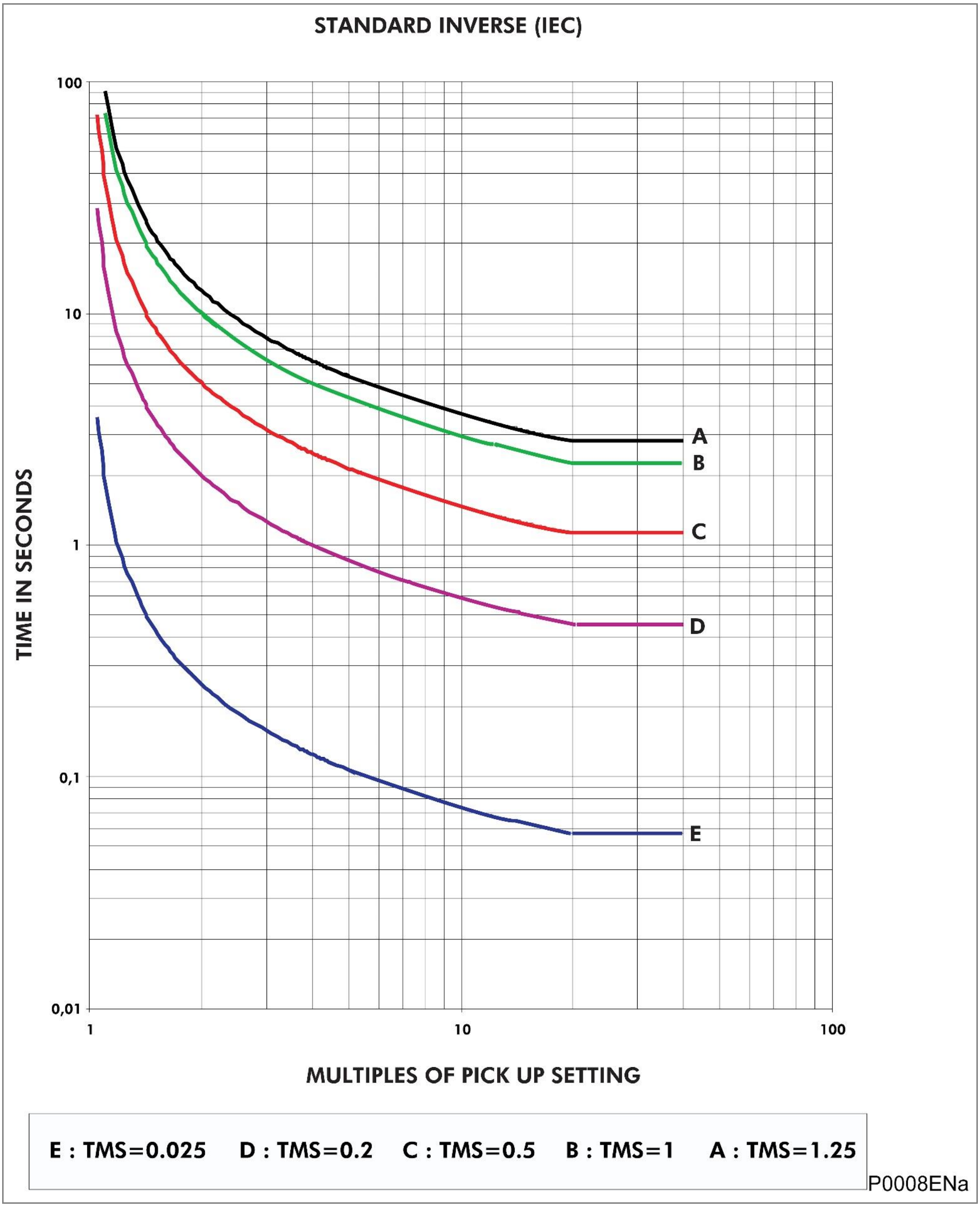

Figure 4 - Standard Inverse (IEC)

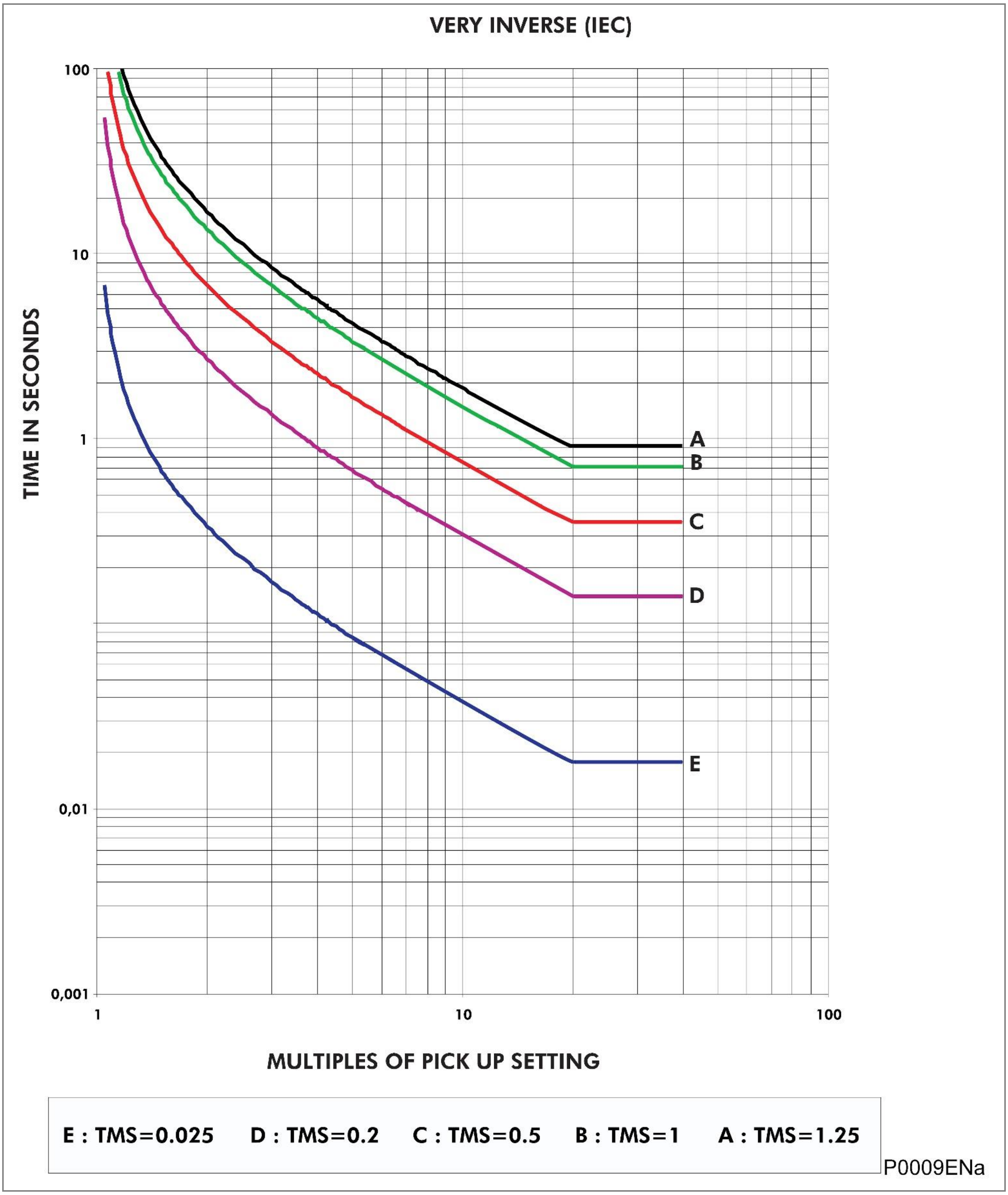

Figure 5 - Very Inverse (IEC)

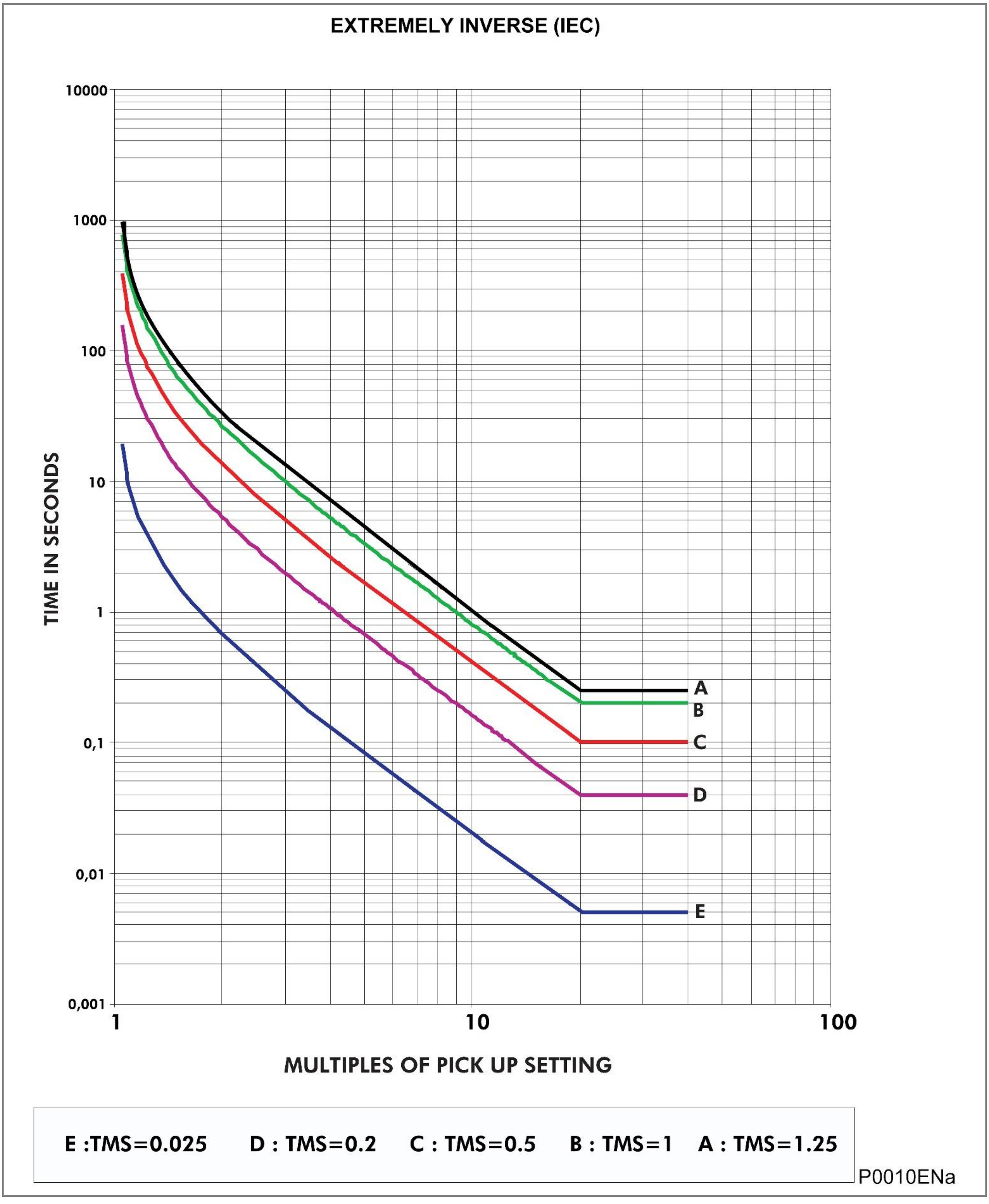

Figure 6 - Extremely Inverse (IEC)

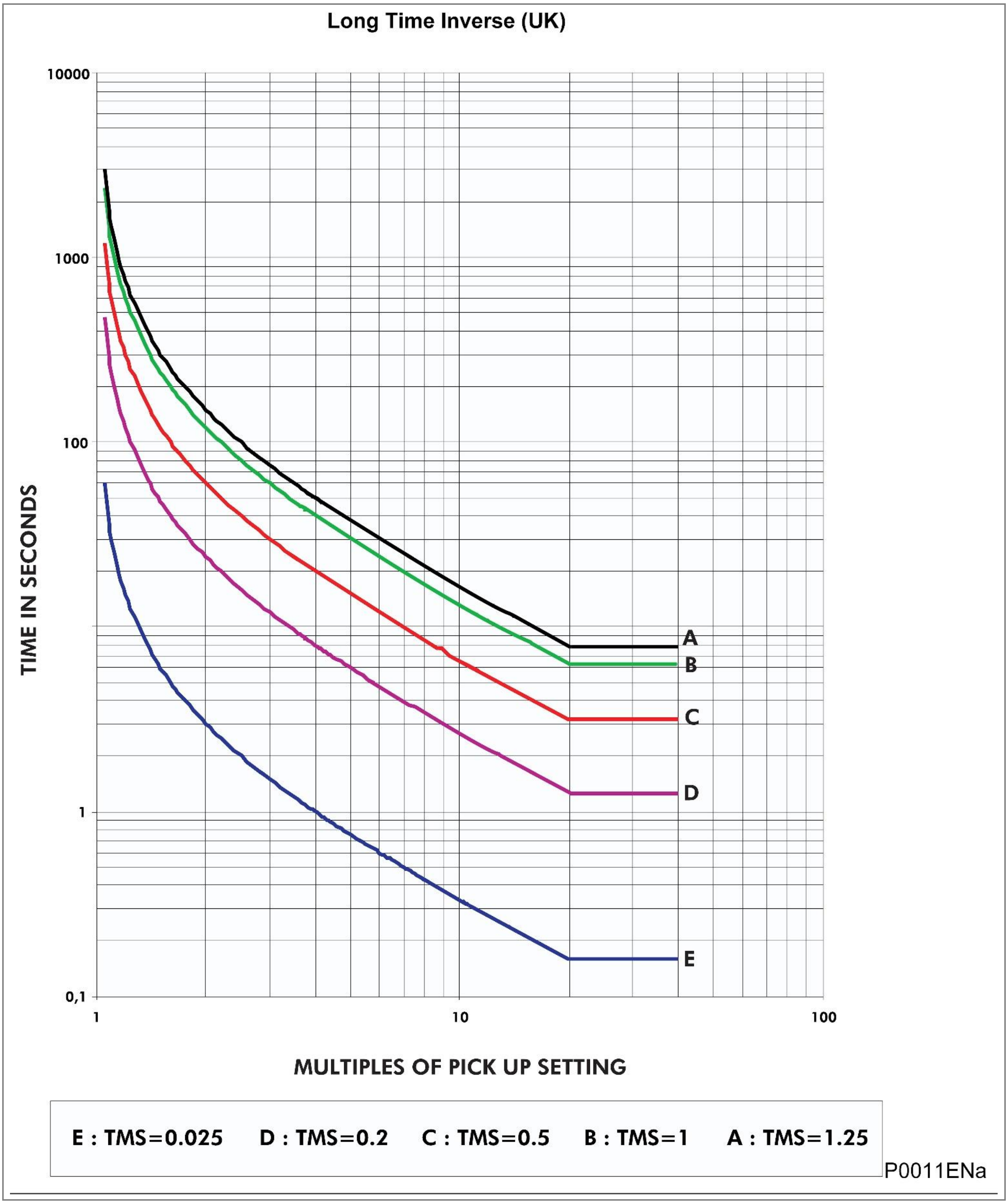

Figure 7 - Long Time Inverse (UK)

17.1.4 RI Curves

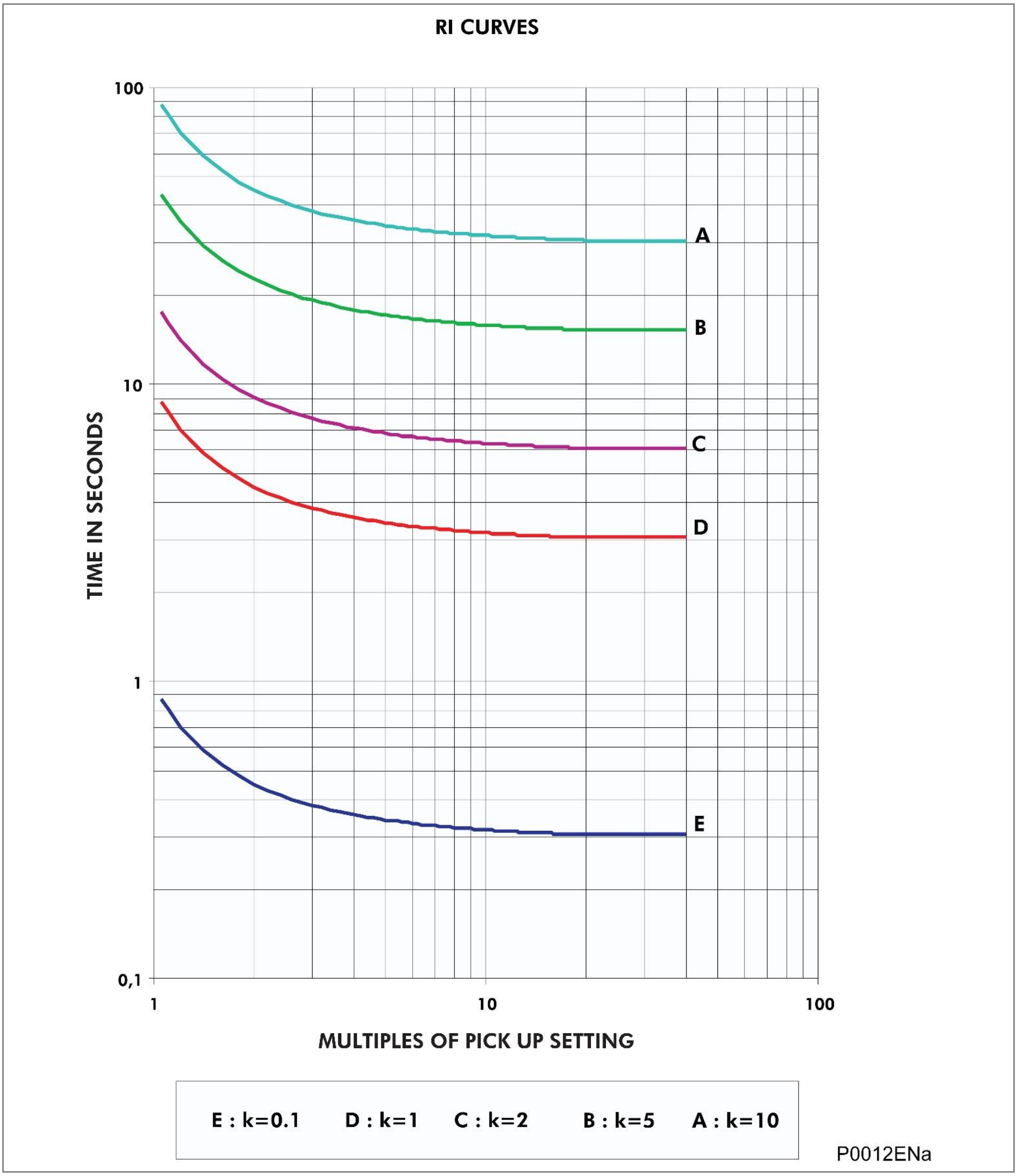

Figure 8 - RI Curves

17.1.5 IEEE/ANSI & CO Curves

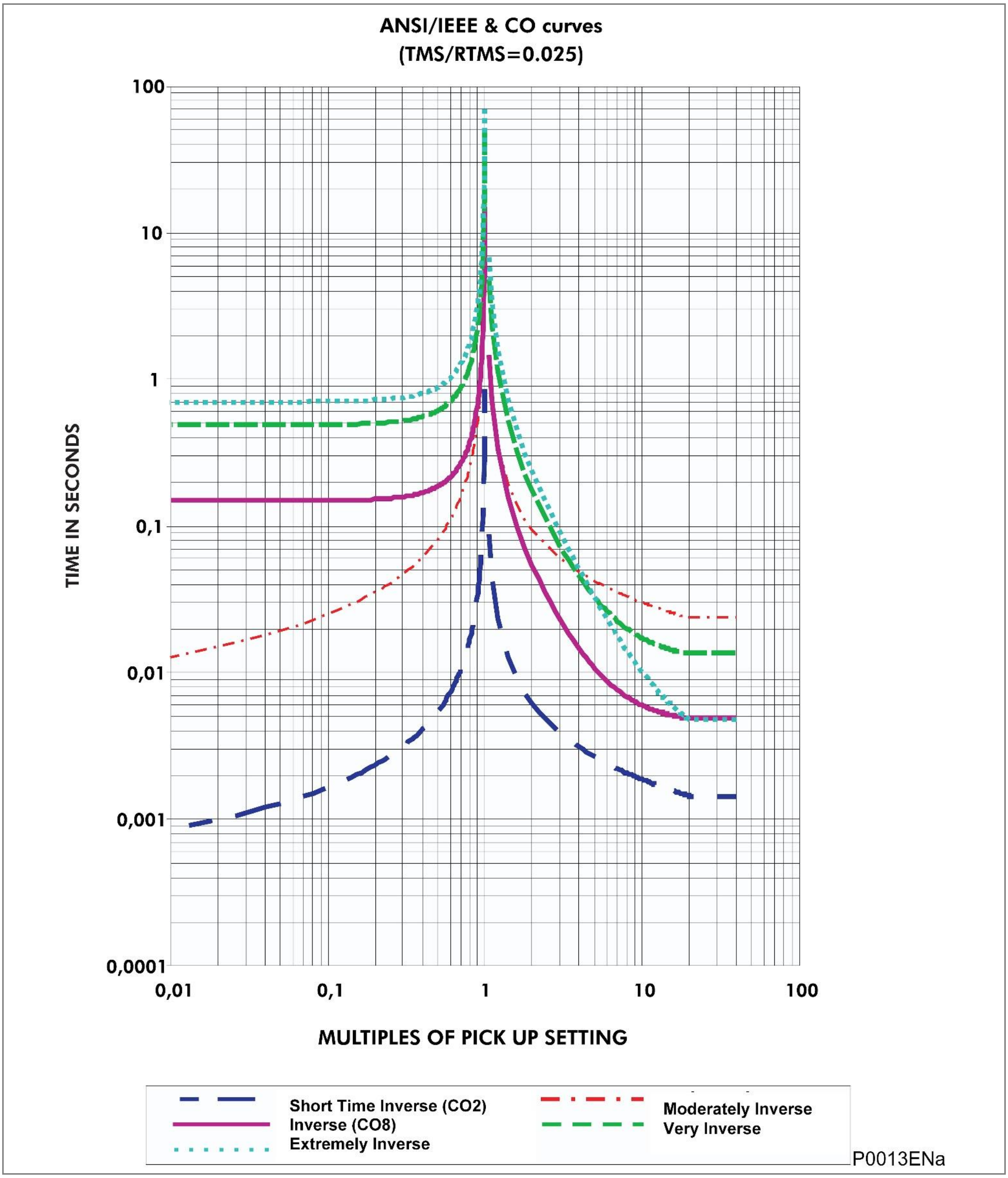

Figure 9 - ANSI/IEEE & CO curves

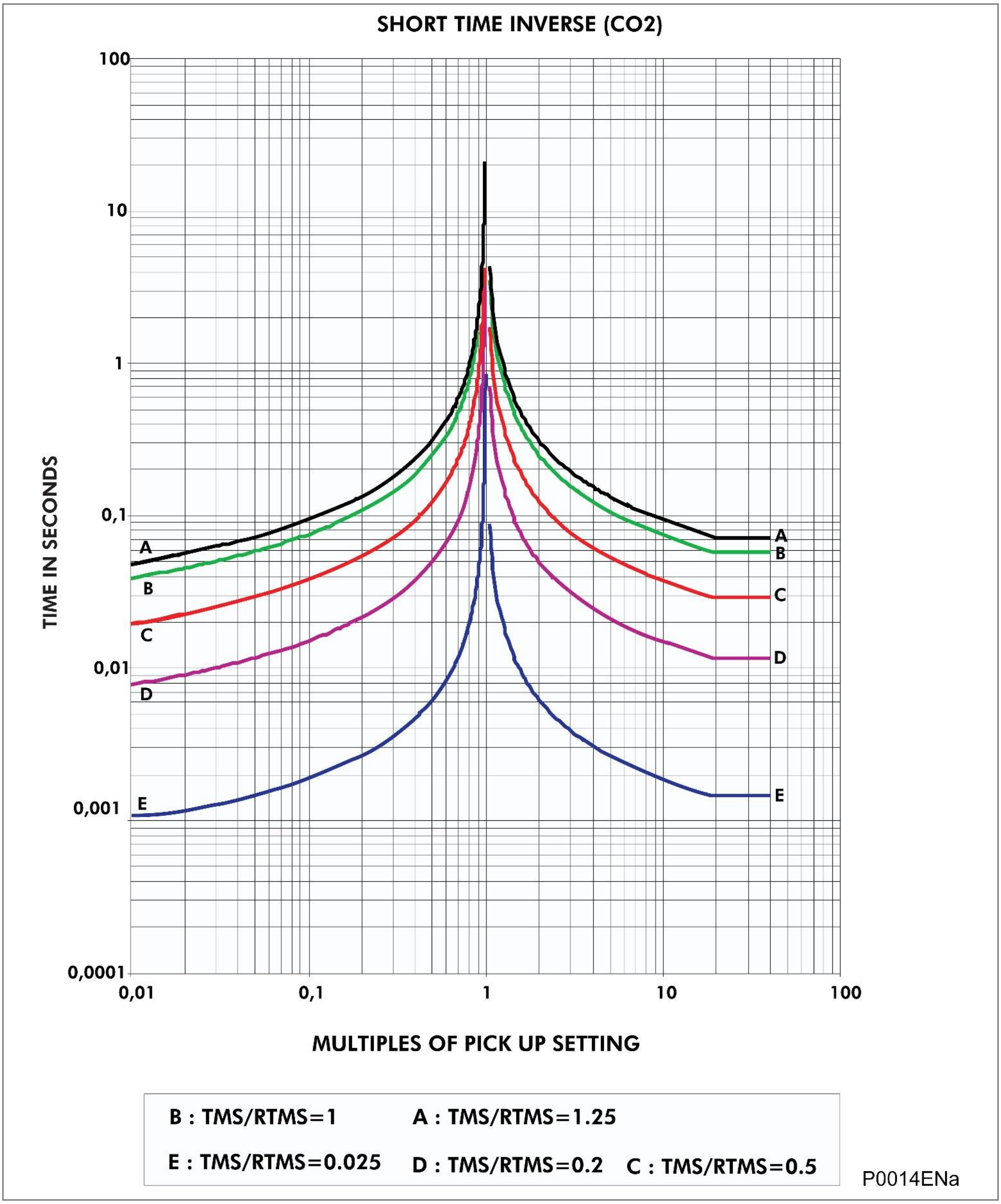

Figure 10 - Short Time Inverse (CO2)

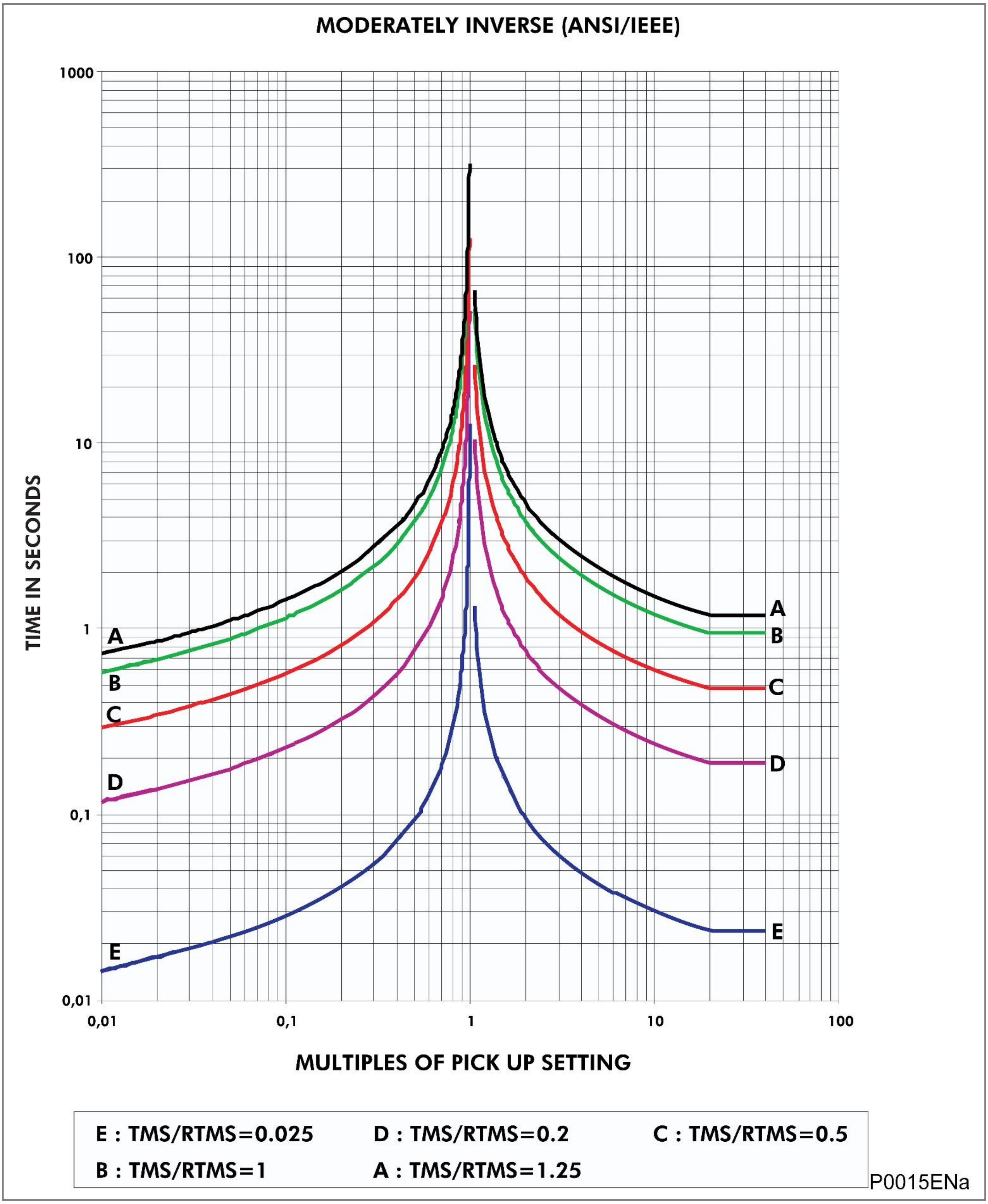

Figure 11 - Moderately Inverse (ANSI/IEEE)

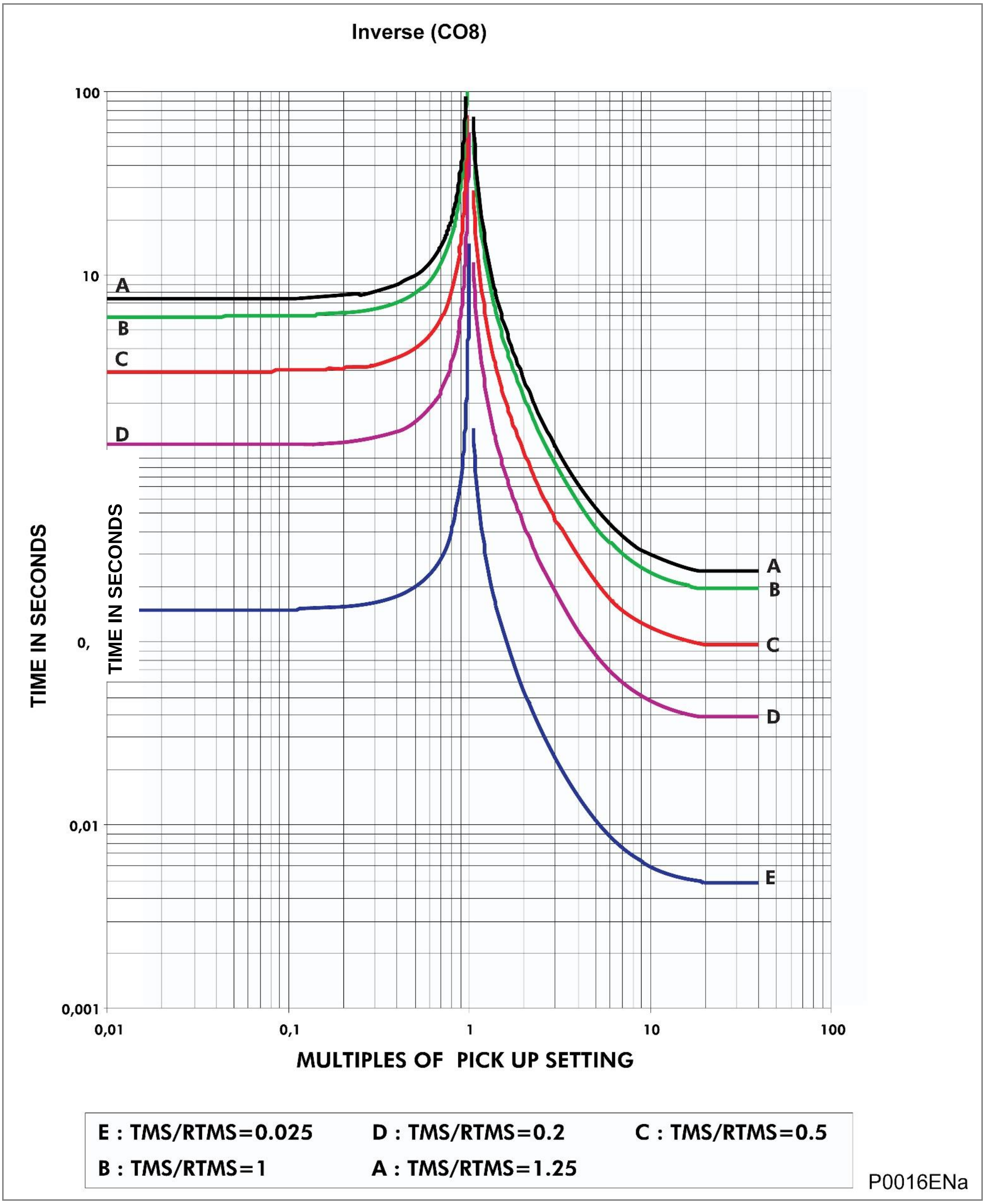

Figure 12 - Inverse (CO8)

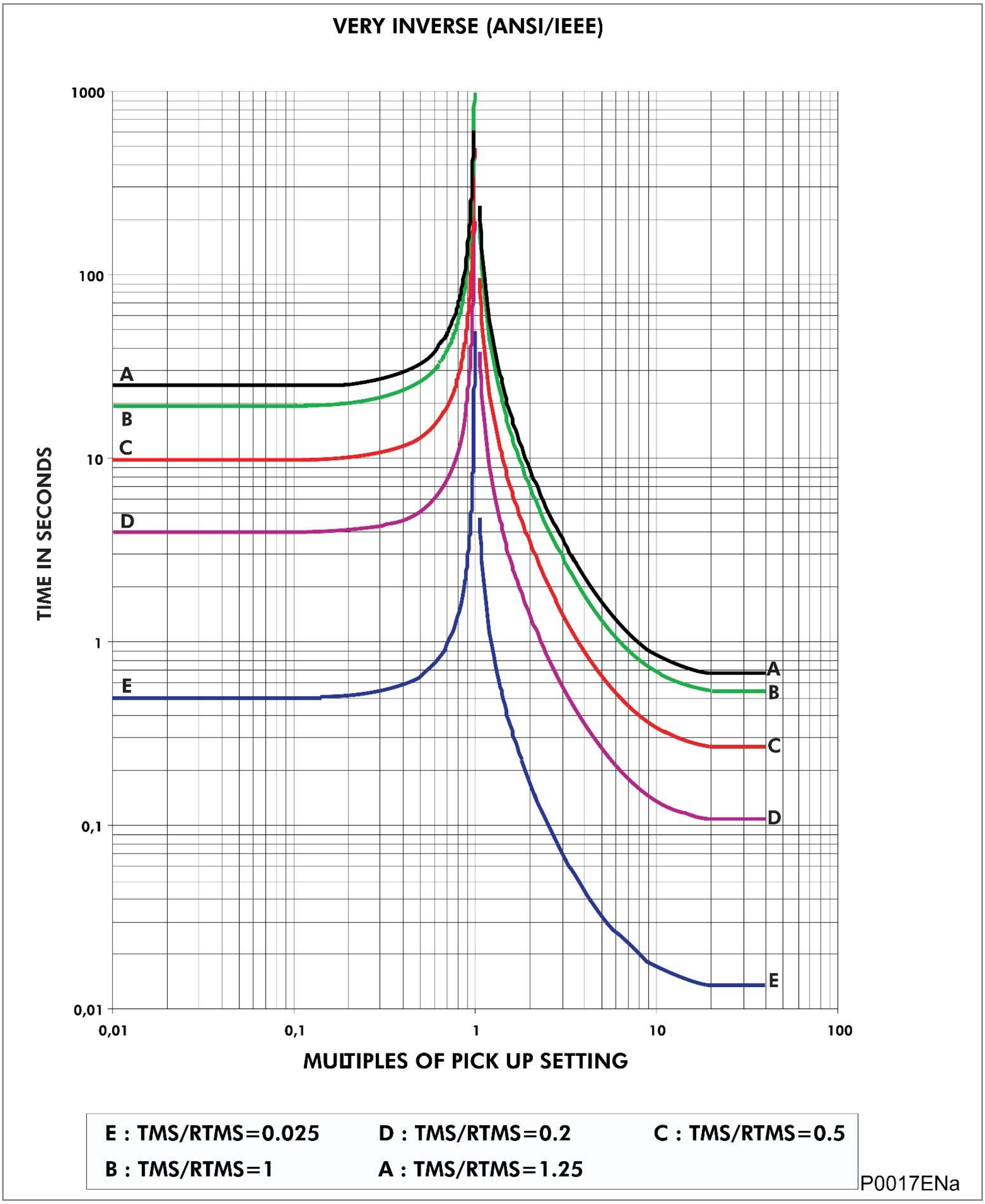

Figure 13 - Very Inverse (ANSI/IEEE)

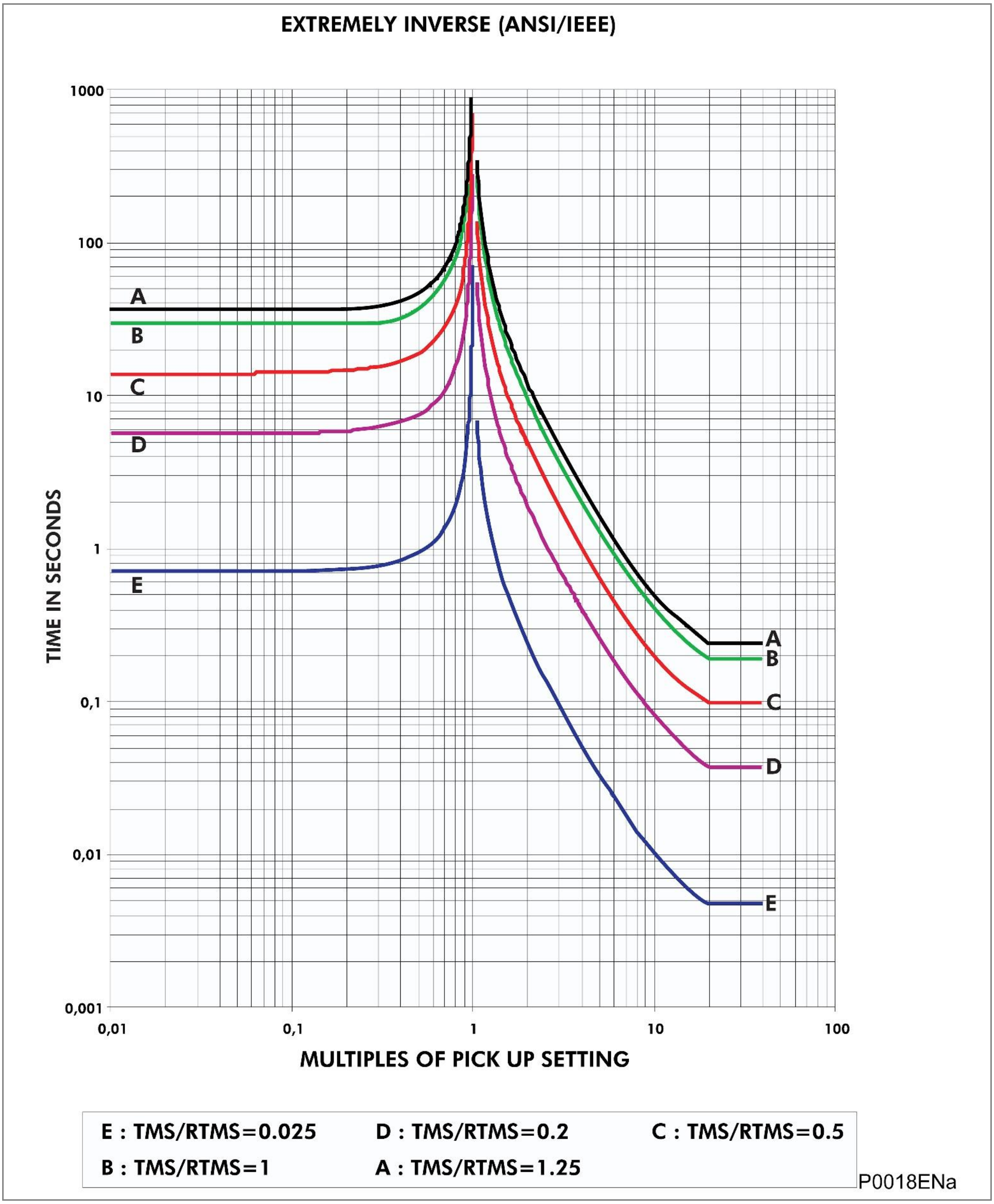

Figure 14 - Extremely Inverse (ANSI/IEEE)

17.1.6 Laborelec Curve

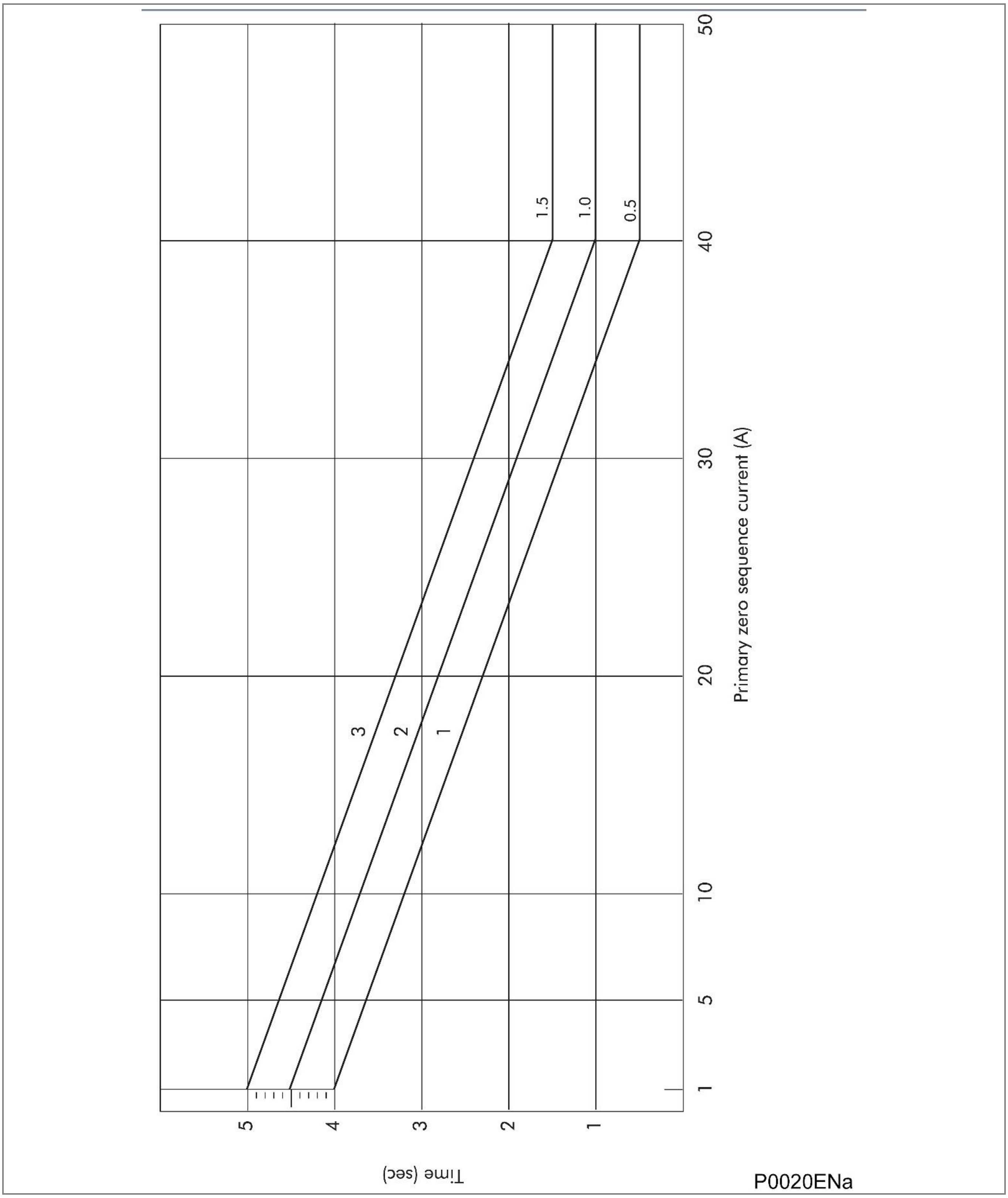

Figure 15 - Laborele Curve

17.2 Thermal Overload Curves

17.2.1 Mathematical Formula

The thermal time characteristic is given by:

$$\log_e\left(\frac{-t}{\tau}\right)=\left(\frac{I^2-\left(k\times I_{FLC}\right)^2}{\left(I^2-I_P{}^2\right)}\right)$$

Where:

t = Time to trip, following application of the overload current, I

τ = Heating and cooling time constant of the protected plant

I = Largest phase current (RMS value)

IFLC = Full load current rating (relay setting 'Thermal Trip')

k = 1.05 constant, allows continuous operation up to < 1.05 IFLC

IP = Steady state pre-loading before application of the overload

The time to trip varies depending on the load current carried before application of the overload, i.e. whether the overload was applied from "hot" or "cold".

Mathematical formula applicable to the MiCOM Relays:

The calculation of the time to trip is given by:

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Where:

Ttrip = Time to trip (in seconds)

Te = Thermal time constant of the protected element (in seconds)

Ix = Thermal overload equal to $\frac{Ieq}{k \cdot I\theta >}$

Ieq = Equivalent current corresponding to the RMS value of the largest phase current

Iθ> = Full load current rating (IFLC) given by the national standard or by the supplier

k = Factor associated to the thermal state formula

θ2 = Initial thermal state. If the initial thermal state = 30% then θ2 = 0.3

θtrip = Trip thermal state. If the trip thermal state is set at 100%, then θtrip = 1

The calculation of the thermal state is given by the following formula:

$$\theta_{\iota+1} = \left(\frac{Ieq}{(k \cdot I\theta >)}\right)^2 \cdot \left[1 - \log e\left(\frac{-t}{Te}\right)\right] + \theta_\iota \cdot \log e\left(\frac{-t}{Te}\right)$$

where θ is being calculated every 0.1 s.

17.2.2 Tripping Curve

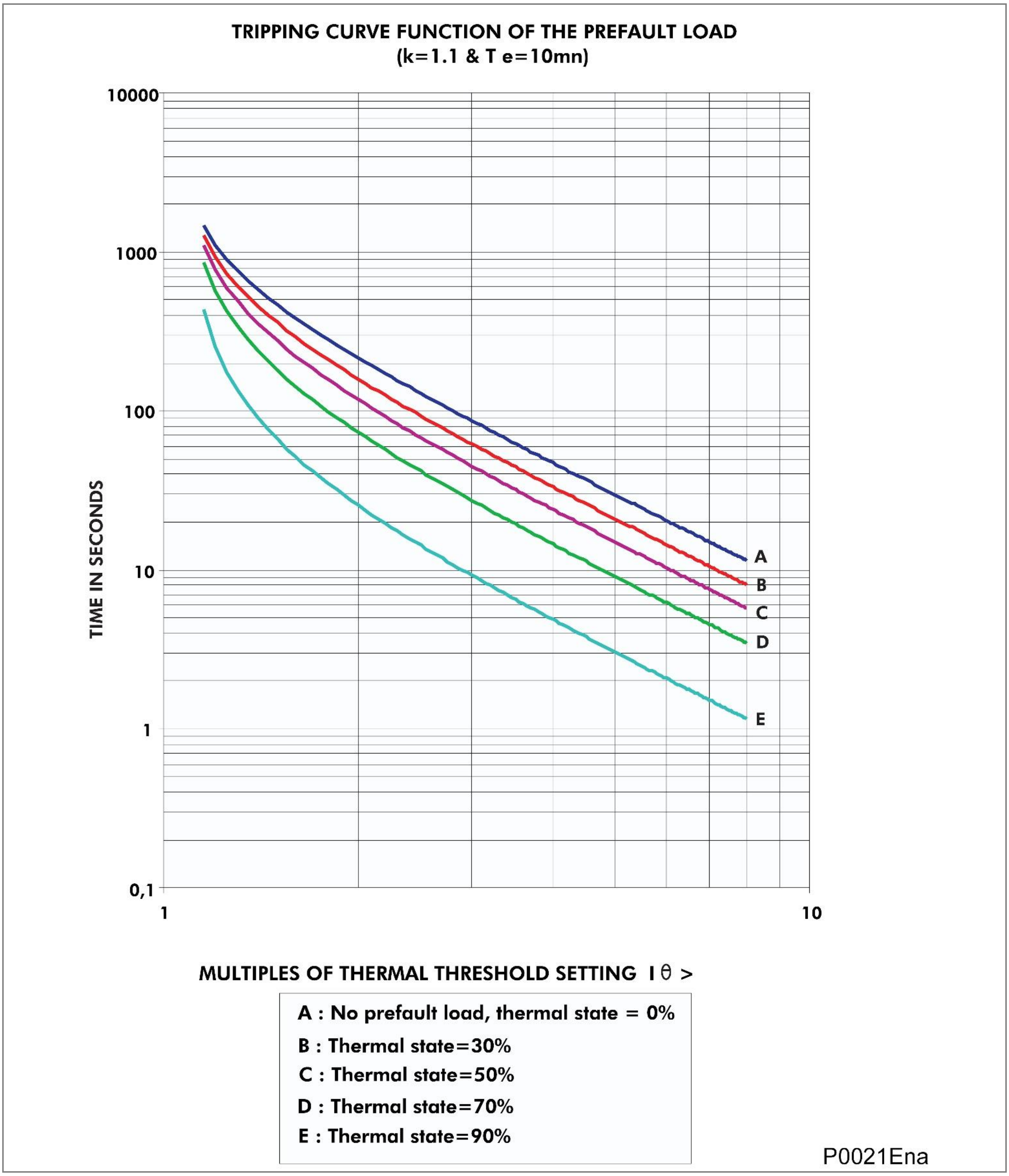


Figure 16 - Thermal Overload Tripping curve

APPLICATION GUIDE

CHAPTER 6

Date:	August 2017
Software version:	13
Hardware Suffix:	B
Connection diagram:	10P52101

CONTENTS

TABLES

FIGURES

Notes:

1 INTRODUCTION

The MiCOM P521 relay has been designed to provide more functionality in terms of protection, measuring, automatic operation and control in any low/medium voltage electrical network.

These relays can be used at industrial and distribution levels to overcome grading difficulties in complex networks. For distribution systems, continuity of supply is of paramount importance. Faults within the protected zone will be cleared very quickly by the MiCOM P521, therefore minimizing damage and disruption to the rest of the system. The majority of overhead line faults are semi-permanent in nature. Multi-shot auto-reclose can therefore be used in conjunction with the P521 once again minimizing disruption to the system. The relay also has various other protection features such as overcurrent and earth fault protection. These features can be either permanently enabled or enabled when the differential communication channel fails. The phase and earth fault protection have four stages that can be set either instantaneous or IDMT (stages 1 and 2 only). There is also a wide choice of operating time curves (IEC, UK, ANSI/IEEE, C0, LABORELEC and Rectifier) which makes it possible to adapt these relays to an existing protection scheme, irrespective of the other relays already installed on the network.

A choice of protection communications mediums are also available; these include electrical (i.e. pilot wires etc.), modem communications, multiplexed networks and direct fiber optic links.

The P521 also offers the ability to change the protection communications interface from electrical to fiber optic without the need for a software/firmware upgrade. This allows the P521 to be applied to networks that are to have their protection communication upgraded in the future.

1.1 P521 Protection Features

The P521 has the following protection features:

- Phase current differential protection [87] - Phase segregated biased differential protection provides the main protection element for the relay. Provides high speed, discriminative protection for all fault types.
- Phase fault overcurrent protection [50/51] - Four stage time delayed or instantaneous backup protection.
- Earth fault protection [50N/51N] - Four stage backup time delayed or instantaneous protection. (Normal, sensitive and very sensitive earth fault ranges are available at the ordering stage).
- True RMS thermal protection [49] - Thermal protection for overhead lines and cables.
- Undercurrent protection [37] - To detect loss of load conditions.
- Broken conductor protection - To detect open circuit faults
- Negative sequence overcurrent protection [46] - This can be selected to provide remote backup protection for phase to phase or phase to earth faults.
- Circuit breaker fail protection - To take remedial action in the event of slow or inoperable circuit breaker.
- Trip circuit supervision - Checks the integrity of the trip circuit and the trip circuit supply voltage. In the event that the trip circuit becomes open circuit, or the trip circuit supply voltage is lost, the relay will issue a trip circuit fail alarm.
- Direct/permissive intertrip - Independent intertripping facility using the relay's protection communications channels.

- Programmable inter-trip commands – Four independent inter-trip commands are provided in addition to the Direct/permissive inter-trips. Protection, binary input and logic equation signals can be assigned to initiate an inter-trip.
- Protection communications supervision - To detect failure of protection communications and enable remedial action to be taken, i.e. switch in communication independent backup protections (e.g. overcurrent and earth fault protection).
- Cold load pick-up logic - May be used to transiently raise the setting for both the phase and the earth fault protection.
- Selective overcurrent logic - Provides the capability of temporarily altering the time settings of stages 2, 3 and 4 of the phase overcurrent and earth fault elements.
- CTS – Current transformer supervision can detect CT failures and prevent differential, negative sequence overcurrent and undercurrent protection from mal-operation.

1.2 Non-Protection Features

Below is a summary of the P521 relay non-protection features.

- Local/remote measurements - Various measurement values from the local and remote line ends available for display on the relay or accessed from the serial communications.
- Front EIA(RS)232 communication port (MODBUS only).
- Rear EIA(RS)485 communication port - Provides remote serial communications. The following communications protocols are supported: MODBUS, IEC 60870-5-103, DNP3.0.
- Fault/event/disturbance records - Available from the serial communications or on the relay LCD (fault and event records only).
- Four setting groups - Independent setting groups to cater for switched feeding or customer specific applications.
- Selectable phase rotation.
- Circuit breaker control - Control of the circuit breaker can be achieved either locally via the user interface or remotely.
- Circuit breaker condition monitoring - Provides records/alarm outputs regarding the number of CB operations, cumulative interruption duty, and the breaker operating**/**closing time.
- Commissioning test facilities - Allows the user to test the LEDs, energize selected output relays, freeze circuit breaker measurements and enable LOOPBACK mode.
- Continuous self-monitoring - Power on diagnostics and self checking routines to provide maximum relay reliability and availability.
- Logic equations – Eight Boolean logic equations are available, each with maximum 16 variants, which can be chosen from signals of protection, binary input, alarm and output of other logic equations.

2 APPLICATION OF INDIVIDUAL PROTECTION FUNCTIONS

The following sections detail the individual protection functions in addition to where and how they may be applied. Each section also gives an extract from the respective menu columns to demonstrate how the settings are actually applied to the relay.

2.1 Current Differential Protection

The primary protection element of the P521 relay is the current differential protection. This technique involves the comparison of the currents at each end of the line. A communications path is therefore an essential requirement of any such scheme. The P521 relay utilizes a 9.6/19.2/56/64 kbits/s digital communications system either for direct optical fiber between ends, direct EIA(RS)485 link, modem connections, or via a multiplexed link.

2.1.1 Current Differential Characteristics

The basic operating principle of differential protection is to calculate the difference between the currents entering and leaving a protected zone. The protection operates when this difference exceeds a set threshold.

Differential currents may also be generated during external fault conditions due to CT saturation. To provide stability for through fault conditions, the relay adopts a biasing technique. This method effectively raises the setting of the relay in proportion to the value of through fault current to prevent relay maloperation. Figure 1 shows the operating characteristics of the P521 phase differential element.

The differential current is calculated as the vector summation of the currents entering the protected zone. The bias current is the average of the measured current at each line end. It is found by the scalar sum of the current at each terminal, divided by two. Both of these calculations are based upon the fundamental component of the line currents only.

Each of these calculations is done on a phase by phase basis. The level of bias used for each element is the highest of the three calculated for optimum stability.

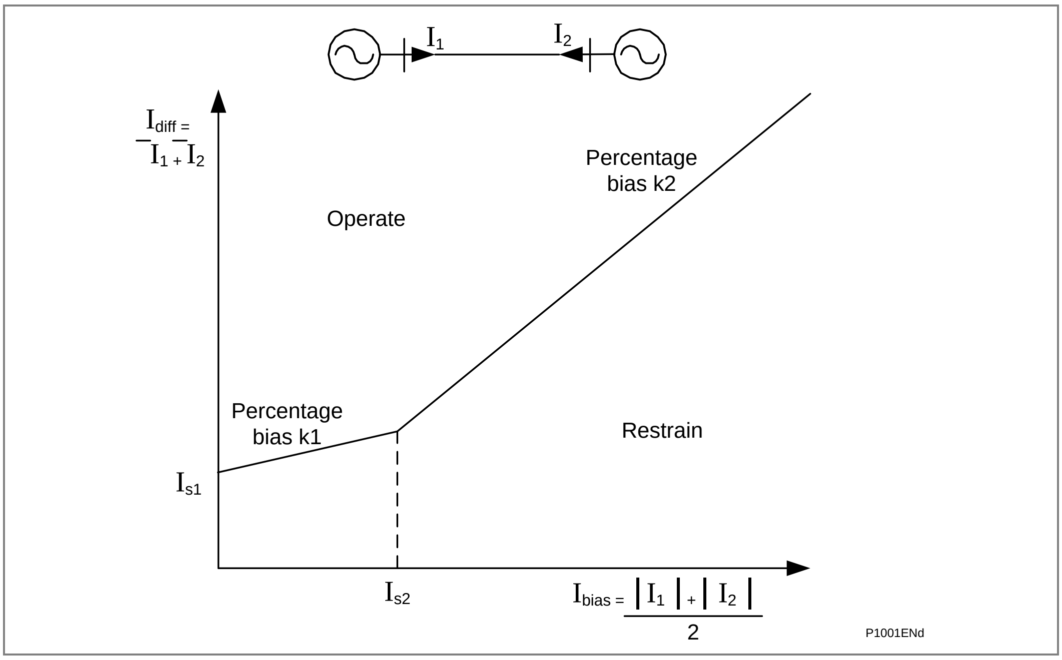


Figure 1 - Relay bias characteristic

The characteristic is determined by four protection settings:

Is1 The basic differential current setting which determines the minimum pick-up level of the relay.

k1 The lower percentage bias setting used when the bias current is below

Is2. This provides stability for small CT mismatches, whilst ensuring good sensitivity to resistive faults under heavy load conditions.

Is2 A bias current threshold setting, above which the higher percentage bias k2 is used.

k2 The higher percentage bias setting used to improve relay stability under heavy through fault current conditions.

The tripping criteria can be formulated as:

1. for |Ibias| < Is2,

   |Idiff| > k1.| Ibias| + Is1

2. for |Ibias| > Is2,

   |Idiff| > k2.| Ibias| - (k2 - k1). Is2 + Is1

When a trip is issued by the differential element, in addition to tripping the local breaker, the relay will send a differential intertrip signal to the remote relay. This will ensure tripping of both ends of the protected line, even for marginal fault conditions. The relay receiving the intertrip signal will indicate that it has operated due to a differential intertrip by displaying "I DIFF I-TRIP".

The differential protection can be time delayed using either a definite or inverse time characteristic by selecting either DMT or IDMT in the delay type cell. Table 1 details the settings available for the Current Differential protection element. The following settings can be found in the ***PROTECTION G1 (G2 (G3) (G4))/[87] Current Diff*** menu.

It is possible to block operation of the current differential element by energizing a chosen digital input (see Blocking functions section). If the "Block Idiff" input is energized, the current differential element is prevented from operating. Furthermore, the relay will ignore any current differential intertrip signals (I DIFF I-TRIP) sent by the remote relay. The direct and permissive intertrip functions, however, will continue to function even if the current differential protection is blocked by the digital input.

[87] Current Diff	Default Setting	Min	Max	Step
Current Diff ?	Yes	No	Yes	N/A
Is1	0.2 In	0.1 In	2 In	0.05 In
Is2	2 In	1In	30 In	0.05 In
k1	30%	0%	150%	5%
k2	150%	30%	150%	5%
IDiff Delay Type	DMT	DMT	IDMT	N/A
tIdiff	0s	0s	150s	0.01s
I Diff Curve	IEC SI	IEC STI, IEC SI, IEC VI, IEC EI, IEC LTI, CO2, IEEE MI, CO8, IEEE VI		
IDiff Tms	1	0.025	1.5	0.025
IDiff Time Dial	1	0.1	100	0.1
PIT Time	0.2s	0.05s	2s	0.01s
PIT I Disable	No	No	Yes	N/A
PIT I Selection	Remote	Local	Remote	N/A
DIT Rx tDwell	0.1 s	0.1 s	5 s	0.05 s
DIT Alarm	No	No	Yes	N/A
PIT Alarm	No	No	Yes	N/A

[87] Current Diff	Default Setting	Min	Max	Step
Inrush Restraint	No	No	Yes	N/A
High Set	4 In	4 In	32 In	0.01 In
Kr	4	3	20	1
Harmonic Ratio	15%	5%	50%	1%
Transient Bias	No	No	Yes	N/A

Table 1 - Current differential settings

The High Set element is an unrestrained element designed to provide high speed operation in the event of CT saturation or where a fault occurs during an inrush condition in a transformer feeder application. Where transformer inrush restraint is used, the resultant second harmonic current produced from transformer inrush or CT saturation may cause slow relay operation.

The High Set element is only visible and activated when Inrush Restraint is enabled, to overcome this condition. The High Set element should be set in excess of 40% of the peak magnetizing inrush current.

Transient Bias is a new feature that increases relay stability during local-end primary CT saturation under external fault conditions.

When CT saturation occurs, the waveforms sampled by the relay can become distorted, leading to unwanted differential currents. The CT saturation will normally dissipate over time, so it is transient in nature.

It is not necessary for differential protection to be blocked when CT saturation is detected - the P521 ensures stability under this condition by temporarily raising the differential current characteristic threshold by applying an additional bias component.

This additional bias component is allowed to decay to ensure it is transient in nature and mimics the behavior of the CT saturation. As a result the relay is able to withstand larger amounts of CT saturation without tripping. The Transient Bias function can be used to mitigate transient CT saturation only, as sustained saturation will remain after the decay has elapsed.

2.1.2 Time Alignment of Current Vectors

To calculate differential current between line ends it is necessary that the current samples from each end are taken at the same moment in time. This can be achieved by time synchronizing the sampling, or alternatively, by the continuous calculation of the propagation delay between line ends. The P521 relay has adopted this second technique.

Consider the two-ended system as shown in Figure 2.

Two identical relays, A and B are placed at the two ends of the line. Relay A samples its current signals at time tA1, tA2 etc., and relay B at time tB1, tB2 etc.

Note	*The sampling instants at the two ends will not, in general, be coincidental or of a fixed relationship, due to slight drifts in sampling frequencies.*

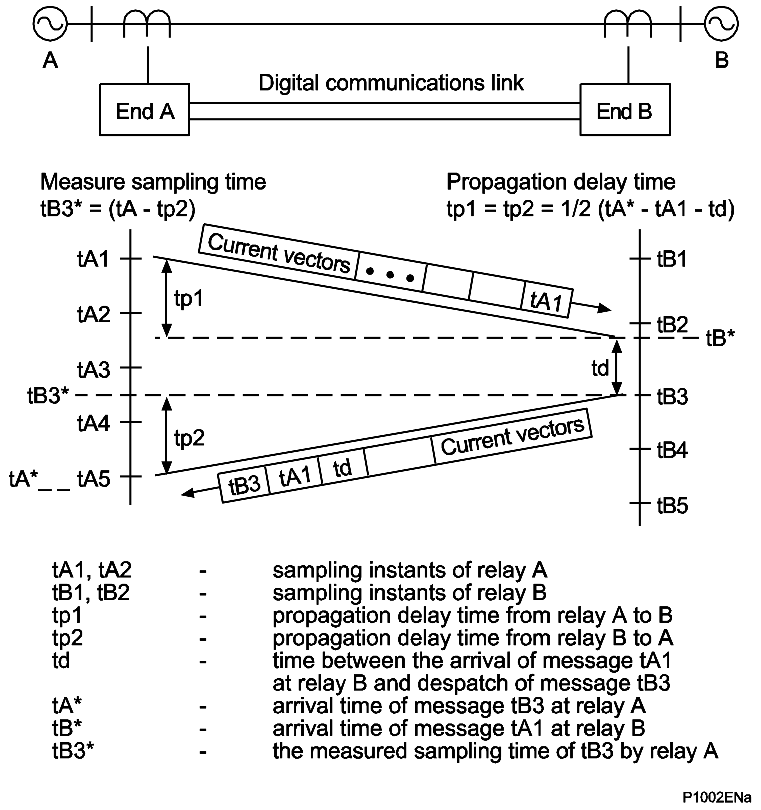


Figure 2 - Propagation delay measurement

Assume that at time tA1, relay A sends a data message to relay B. The message contains a time tag, tA1, together with other timing and status information and the current vector values calculated at tA1. The message arrives at end B after a channel propagation delay time, tp1. Relay B registers the arrival time of the message as tB*.

Since relays A and B are identical, relay B also sends out data messages to end A. Assume relay B sends out a data message at tB3. The message therefore contains the time tag tB3. It also returns the last received time tag from relay A (i.e. tA1) and the delay time, td, between the arrival time of the received message, tB*, and the sampling time, tB3, i.e. td = (tB3 - tB*).

The message arrives at end A after a channel propagation delay time, tp2. Its arrival time is registered by relay A as tA*. From the returned time tag, tA1, relay A can measure the total elapsed time as (tA* - tA1). This equals the sum of the propagation delay times tp1, tp2 and the delay time td at end B.

Hence,

(tA* - tA1) = (td + tp1 + tp2)

The relay assumes the transmit and receive channels follow the same path so they have the same propagation delay time. This time is calculated as follows:

tp1 = tp2 = ½ (tA* - tA1 - td)

Note	*The propagation delay time is measured for each received sample and this can be used to monitor any change on the communication link.*

As the propagation delay time has now been deduced, the sampling instant of the received data from relay B (tB3*) can be calculated. As shown in Figure 2, the sampling time tB3* is measured by relay A as:

tB3* = (tA* - tp2)

In Figure 2, tB3* is between tA3 and tA4. To calculate the differential and bias currents, the vector samples at each line end must correspond to the same point in time. It is necessary therefore to time align the received tB3* data to tA3 and tA4. This can be achieved by rotating the received current vector by an angle corresponding to the time difference between tB3* and tA3 (and tA4). For example a time difference of 1ms would require a vector rotation of $^{1}/_{20}$ * 360° = 18° for a 50Hz system.

As two data samples can be compared with each data message, this process will have the effect of increasing the operating speed for any given bandwidth.

Note	*The current vectors of the three phases need to be time aligned separately.*

2.1.3 Capacitive Charging Current

The charging current of a line or cable will be seen as differential current. If this current is of a sufficiently high magnitude, as is the case for cables and long feeders, then relay maloperation could occur. Two issues are apparent with charging current; the first being inrush during line energization and the second being steady state charging current.

Inrush charging current is normally a high order harmonic (9th or 11th for example). The Fourier filtering used by the P521 relay will remove these frequency components and hence provide stability.

Steady state charging current is nominally at fundamental frequency and hence may cause relay maloperation.

To overcome this problem it must be ensured that the base current setting on the relay (Is1) is set to at least 2.5x the steady state line charging current to avoid possible maloperation.

Table 2 shows some typical steady state charging currents for various lines and cables.

Voltage (kV)	Core Formation and Spacing	Conductor Size in mm^2	Charging Current A/km
11 kV Cable	Three-core	120	1.2
33 kV Cable	Three-core	120	1.8
33 kV Cable	Close-trefoil	300	2.5
66 kV Cable	Flat, 127 mm	630	10
132 kV Overhead Line	-	175	0.22
132 kV Overhead Line	-	400	0.44
132 kV Cable	Three-core	500	10
132 kV Cable	Flat, 520 mm	600	20
275 kV Overhead Line	-	2 x 175	0.58
275 kV Overhead Line	-	2 x 400	0.58
275 kV Cable	Flat, 205 mm	1150	19
275 kV Cable	Flat, 260 mm	2000	24
400 kV Overhead Line	-	2 x 400	0.85
400 kV Overhead Line	-	4 x 400	0.98
400 kV Cable	Flat, 145 mm	2000	28
400 kV Cable	Tref., 585 mm	3000	33

Table 2 - Typical cable/line charging currents (UK, 50 Hz)

2.1.4 Ratio Compensation

To ensure correct operation of the differential element, it is important that under load and through fault conditions, the currents into the differential element of the relay are balanced. In some cases, the current transformer primary ratings at each end of the line will not exactly match. A ratio correction factor ***(CONFIGURATION/CT Ratio/CT Correct Ratio)*** is therefore provided which is adjustable from 0.05 to 10 in steps of 0.01. The CT ratio correction factor is applied to ensure that the signals to the differential algorithm are correct.

Ideally, the compensated current values should be arranged to be as close as possible to the relay rated current to provide optimum relay sensitivity. The corrected currents should not, however, be arranged to exceed relay rated current under through load conditions.

In general, CT Correction Ration can be calculated as below.

For end each end a and b, their Correction Ration k_a and k_b can be defined as:

$$k_a = \frac{I_{n,a}}{I_{ref,a}}$$

$$k_b = \frac{I_{n,b}}{I_{ref,b}}$$

Where,

$I_{n,a}$ Rated current of CT primary at end a

$I_{n,b}$ Rated current of CT primary at end b

$I_{ref,a}$ Reference current of end a

$I_{ref,b}$ Reference current of end b

Reference currents are determined as follows:

$$I_{ref,a} = \frac{S_{ref}}{\sqrt{3}V_{n,a}}$$

$$I_{ref,b} = \frac{S_{ref}}{\sqrt{3}V_{n,b}}$$

Where

S_{ref} Reference power. For feeder application, it can be determined by rated current multiplying rated voltage. Alternatively, use the rated current of the feeder as I_{ref}. For transformer application, the rated power of the transformer can be used.

Note	*CT rated current I_n and reference current I_{ref} in above calculation are all in primary values. Secondary values can also be used in calculation, see section 2.1.6.2 as an example.*

2.1.5 Additional Protection Considerations

2.1.5.1 Minimum Operating Current

Note	*The minimum operating current is related, but not equal to, the $Is1$ setting.*

Consider a single end fed fault with no load but fault current, I:

$|I_{diff}| = I$
$|I_{bias}| = ½I$

Assuming $|I_{bias}| < I_{s2}$, then, using the equation 1 from section 2.1.1, the relay will operate if:

$|I_{diff}| > k1.|I_{bias}| + I_{s1}$ or
$I > k1.½I + I_{s1}$ or
$I > I_{s1} / (1 - 0.5\ k1)$

The minimum operating current is therefore a function of the Is1 and k1 settings. Since k1 is recommended to be set to 30%, the minimum operating current will be:

$I_{min} = 1.176\ I_{s1}$

For most applications a minimum setting of 0.2 pu is recommended. This will give the relay a sensitivity of 0.235 pu.

2.1.5.2 Relay Sensitivity under Heavy Load Conditions

The sensitivity of the relay is governed by its settings and also the magnitude of load current in the system. For a two-ended system, with relays X and Y, the following applies:

$|I_{diff}| = |(I_X + I_Y)|$

$|I_{bias}| = 0.5\ (|I_X| + |I_Y|)$

Assume a load current of I_L flowing from end X to Y. Assume also a high resistance fault of current I_F being singly fed from end X. For worst case analysis, we can assume also I_F to be in phase with I_L:

$I_X = I_L + I_F$

$I_Y = I_L$

$|I_{diff}| = |I_F|$

$|I_{bias}| = |I_L| + 0.5\ |I_F|$

Relay sensitivity when $|I_{bias}| < I_{s2}$:

For $|I_{bias}| < I_{s2}$, the relay would operate if $|I_{diff}| > k1\ |I_{bias}| + I_{s1}$

or $|I_F| > k1\ (|I_L| + 0.5\ |I_F|) + I_{s1}$

or $(1 - 0.5\ k1)\ |I_F| > (k1\ |I_L| + I_{s1})$

or $|I_F| > (k1\ |I_L| + I_{s1}) / (1 - 0.5\ k1)$

For Is1 = 0.2 pu, k1 = 30% and Is2 =2.0 pu, then

For $|I_L| = 1.0$ pu, the relay would operate if $|I_F| > 0.59$ pu

For $|I_L| = 1.59$ pu, the relay would operate if $|I_F| > 0.80$ pu

If $|I_F| = 0.80$ pu and $|I_L| = 1.59$ pu, then $|I_{bias}| = 1.99$ pu which reaches the limit of the low percentage bias curve.

Relay sensitivity when $|I_{bias}| > I_{s2}$:

For $|I_{bias}| > I_{s2}$, the relay would operate if

$|I_{diff}| > k2\ |I_{bias}| - (k2 - k1)\ I_{s2} + I_{s1}$

or $|I_F| > k2\ (|I_L| + 0.5\ |I_F|) - (k2 - k1)\ I_{s2} + I_{s1}$

or $(1 - 0.5\ k2)\ |I_F| > (k2\ |I_L| - (k2 - k1)\ I_{s2} + I_{s1})$

or $|I_F| > (k2\ |I_L| - (k2 - k1)\ I_{s2} + I_{s1}) / (1 - 0.5\ k2)$

For $Is1 = 0.2$ pu, $k1 = 30\%$, $Is2 = 2.0$ pu and $k2 = 100\%$, then,

for $|I_L| = 2.0$ pu, the relay would operate if $|I_F| > 1.6$ pu

for $|I_L| = 2.5$ pu, the relay would operate if $|I_F| > 2.6$ pu

Fault Resistance Coverage:

Assuming the fault resistance, R_F, is much higher than the line impedance and source impedance, then for a 33kV system and 400/1 CT:

$$|I_F| = (V_{ph-n} / R_F) * (1/\text{CT ratio})\ \text{pu}$$

$$= ((33000 / \sqrt{3}) / R_F) / 400\ \text{pu}$$

$$= 47.63/R_F\ \text{pu}$$

Based on the above analysis, the relay will detect a fault current in excess of 0.59 pu with a load current of 1 pu flowing. The fault resistance would have to be less than 47.63/0.59 = 81Ω in this case.

With a short time overload current of 2.0 pu, the relay will be able to detect a fault resistance of 47.63/1.6 = 30 Ω or lower.

2.1.5.3 Setting k1 Less than 30%

If desired, k1 can be set to less than the recommended setting of 30%, down to a minimum of 0%, to increase relay sensitivity. However, if doing so the user should consult Schneider Electric concerning the CT requirements. This is because under certain conditions on systems with high X/R ratio and low fault currents there may be stability issues with a very low k1 setting.

2.1.6 Example Settings

2.1.6.1 Differential Element (Is1)

All four settings are user adjustable. This flexibility in settings allows the relay characteristic to be tailored to suit a particular sensitivity and CT requirements. To simplify the protection engineer's task, we strongly recommend three of the settings be fixed to:

Is2	=	2.0 pu
k1	=	30%
k2	=	150%

These settings will give a relay characteristic suitable for most applications. It leaves only the Is1 setting to be decided by the user. The value of this setting should be in excess of any mismatch between line ends although the CT ratio correction factor can be used to alleviate this problem. The effects of capacitive line charging current, if any, must also be considered when deciding the Is1 setting.

By considering the circuit shown in Figure 3, the settings for the current differential element can be established.

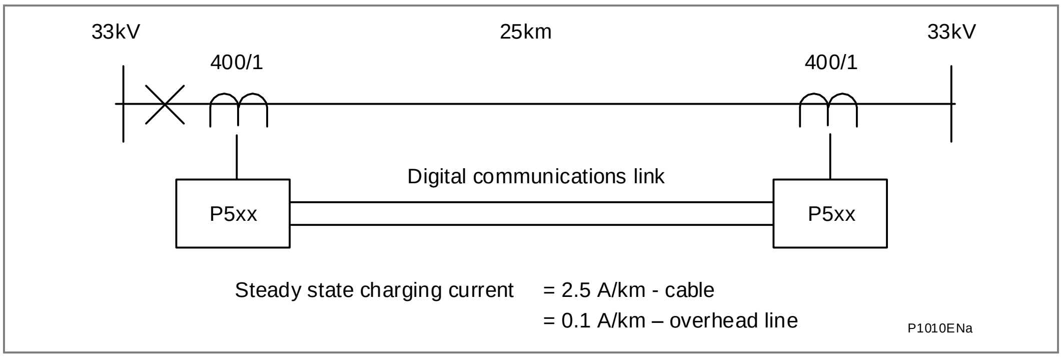


Figure 3 - Typical plain feeder circuit

The following settings should be set as follows:

Is2 = 2.0 pu

k1 = 30 %

k2 = 150 % (for a two terminal application)

This leaves the setting of Is1 to be established.

The Is1 setting for the P521 relay must be set above 2.5 times the steady state line charging current value. In this example, assume a cable is used:

Is1 > 2.5 x Ich

Is1 > 2.5 x (25 km x 2.5 A/km)

Is1 > 156.25 A

The line CTs are rated at 400 amps primary. The setting of Is1 must therefore exceed 156.25/400 = 0.391 pu.

Therefore select:

Is1 = 0.4 pu

2.1.6.2 CT Ratio Correction

In cases where different CT ratios are used at each line end the relay can be set with a CT ratio correction factor “CT Correct Ratio” ***(CONFIGURATION/CT Ratio)***. Assuming the relay is applied to the system shown in Figure 4 and the maximum full load current was 375 Amps the relay can be set as follows.

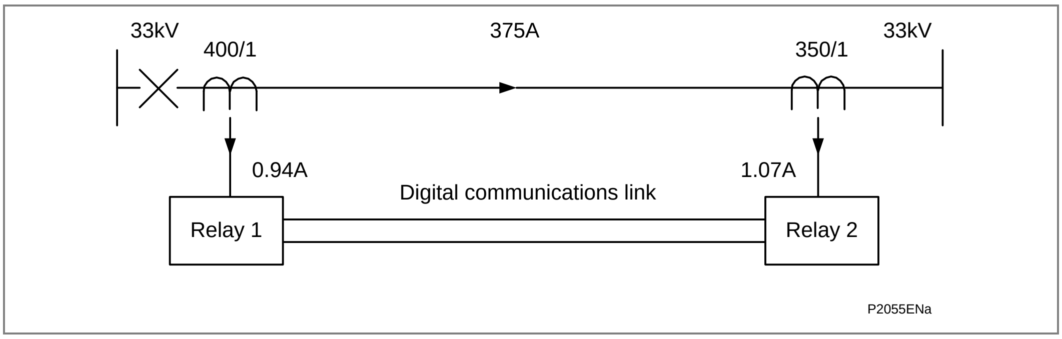


Figure 4 - Plain feeder with unmatched CTs

It is good practice to correct the mismatched current to rated current to maintain good sensitivity for high resistance faults. In this example the current entering relay 1 must be scaled upwards, whereas the current entering relay 2 must be scaled down.

To calculate the correction factor for relay 1:

Current entering relay 1 = 375 / 400 = 0.938 A

To correct to rated current our correction factor must be 1/0.938 = <u>1.071</u>

The same can be done for relay 2.

To calculate the correction factor for relay 2:

Current entering relay 1 = 375 / 350 = 1.071 A

To correct to rated current our correction factor must be 1/1.071 = <u>0.938</u>

The differential spill current will now be reduced to practically zero instead of 0.133 A (1.071-0.938) which was the current before the any correction.

2.1.7 Protection of Transformer Feeders

In applying the well-established principles of differential protection to transformers, a variety of considerations have to be taken into account. These include compensation for any phase shift across the transformer, possible unbalance of signals from current transformers either side of windings, and the effects of the variety of earthing and winding arrangements. In addition to these factors, which can be compensated for by correct application of the relay, the effects of normal system conditions on relay operation must also be considered. The differential element must restrain for system conditions which could result in maloperation of the relay, such as high levels of magnetizing current during inrush conditions.

In traditional transformer feeder differential schemes, the requirements for phase and ratio compensation were met by correct selection of the line current transformers. The P521 (from software version 2.A) provides software Interposing Current Transformers (ICTs) to give the required vector compensation. The advantage of having replica ICTs is that they give the P521 relays the flexibility to cater for line CTs connected in either star or delta, as well as being able to compensate for a variety of system earthing arrangements.

A further consideration is the operation of differential protection for faults during transformer inrush conditions. An unrestrained differential High Set element is provided to ensure high speed operation under these conditions, as well as in the event of CT saturation, which produces second harmonics.

Ratio compensation, however, is provided by adjusting a software CT ratio correction factor (see section 2.1.6.2).

2.1.7.1 Transformer Magnetizing Inrush

The magnetizing inrush current to a transformer appears as a large operating signal to the differential protection. Special measures are taken with the relay design to ensure that no maloperation occurs during inrush.

Under normal steady state conditions, the magnetizing current associated with the operating flux level is relatively small (usually less than 1% of rated current). However, if a transformer winding is energized at a voltage zero, with no remnant flux, the flux level during the first voltage cycle (2 x nominal flux maximum) will result in core saturation and in a high, non-sinusoidal magnetizing current waveform. This current is commonly referred to as magnetizing inrush current and may persist for several cycles. The magnitude and duration of magnetizing inrush current waveforms are dependent upon a number of factors, such as transformer design, size, system fault level, point on wave of switching, number of banked transformers, etc. Figure 5 shows typical transformer magnetizing currents for steady state and inrush conditions.

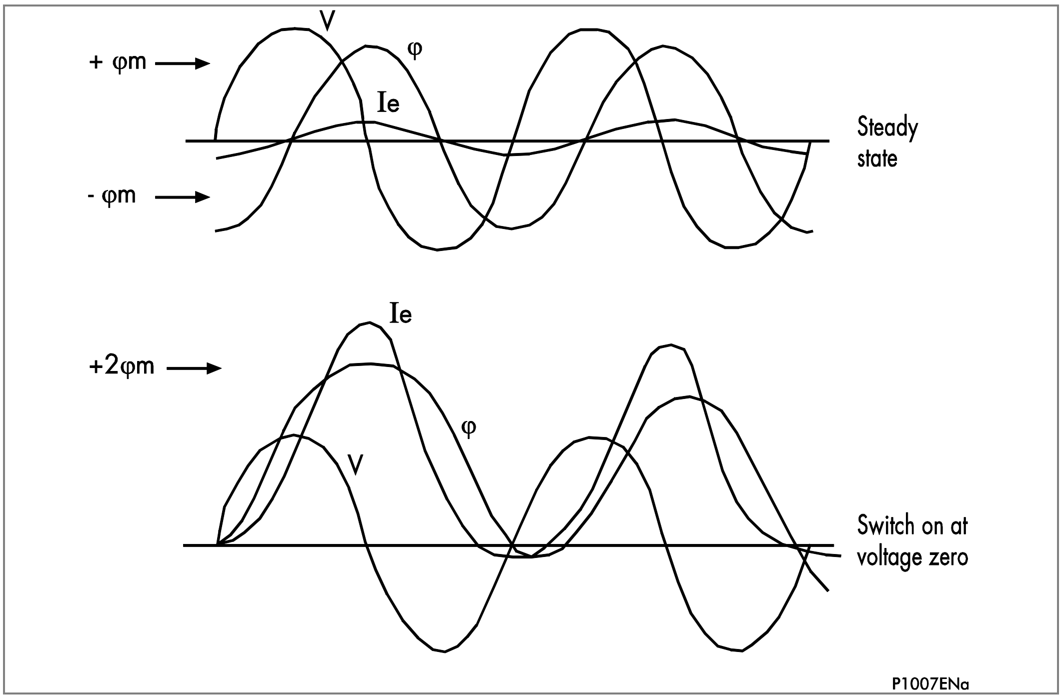


Figure 5 - Magnetizing inrush waveforms

The magnetizing inrush current contains a high percentage of second harmonic. The MiCOM P521 relay filters out this component of the waveform and makes use of it to achieve stability. There are two options available, Restrain and Block. To enable the inrush option facility the user can select from the menu cell ***PROTECTION G1 (G2 (G3) (G4))/[87] Current Diff/ Inrush Option.***

Restrain mode:

In this mode, the relay uses the second harmonic component as an additional bias quantity. The multiplying factor used to ensure stability is set by Kr.

When set correctly it will ensure stability under magnetizing inrush conditions. Kr is described by the following equations, and it is our recommendation that it is set taking into account the level of 2nd harmonic likely to be generated by the transformer under typical inrush conditions. Section 2.1.7.4 gives an example of calculation of Kr.

The additional bias is calculated by:

$$I_{additional\ bias} = Kr \times Ih2$$

$$I_{bias'} = I_{bias} + I_{additional\ bias}$$

Now the tripping criteria can be formulated as:

When $I_{bias'} \leq Is2$

$$Idiff > Is1 + k1 \times I_{bias'}$$

When $I_{bias'} > Is2$

$$Idiff > Is1 + k2 \times I_{bias'} - (k2 - k1) \times Is2$$

The value of Ih2 used above is the maximum second harmonic in three phases, obtained from both local and remote ends.

As Kr directly affects the bias curve, it should be noted that it operates as a restrain function, and in the absence of any information on 2nd harmonic content, setting Kr too high to ensure stability may result in longer operating times for internal faults currents below the high set value.

Block mode:

For any of the three phases, if the level of phase current is above 5% In, and if the ratio of Ih2 to fundamental in the line is above the **Harmonic Ratio** setting, the differential protection will be blocked at both local and remote end, unless the differential current is larger than the high set value.

Note 1	*If block mode is required, it should be set at both ends. If block mode is set at only one end, an alarm "Conf. Alarm Inrush" will be generated on the front panel LCD at both end relays. The relay that is not set in block mode will not be blocked by the local nor remote end inrush current.*
Note 2	*To work in Block mode, the relays must be set in Extension communication mode in the menu COMMUNICATION/Protection/FRAME MODE.*

2.1.7.2 Ratio Correction

To ensure correct operation of the differential element, it is important that under load and through fault conditions, the currents into the differential element of the relay balance. In many cases, the HV and LV current transformer primary ratings will not exactly match the transformer winding rated currents. Ratio correction factors are therefore provided to ensure that the signals to the differential algorithm are correct. Section 2.1.6.2 explains how this feature can be applied to a plain feeder with different CT ratios at each end of the line. The same method can be used when applying the relay to a transformer feeder, although extra attention must be paid to transformers with tap changers. To minimize unbalance due to tap changer operation, current inputs to the differential element should be matched for the mid-tap position. Ideally, the compensated current values should be arranged to be as close as possible to relay rated current to provide optimum relay sensitivity. The corrected currents should not, however, be arranged to exceed relay rated current under through load conditions.

2.1.7.3 Phase Correction and Zero Sequence Current Filtering

To compensate for any phase shift between two windings of a transformer, it is necessary to provide phase correction. This was traditionally provided by the appropriate delta connection of main line CTs.

Phase correction is provided in the P521 relay via software interposing CTs. The phase correction (vector compensation) settings available in the P521 relay ***(CONFIGURATION/CT Ratio/Vector Comp)*** are given in Table 3:

Setting	Phase Shift	Action
Off	-	None
Yy0	0°	None
Yd1	30° lag	Ia = (IA - IC) / √3 Ib = (IB - IA) / √3 Ic = (IC - IB) / √3
Yy2	60° lag	Yy8 and Invert
Yd3	90° lag	Ia = (IB - IC) / √3 Ib = (IC - IA) / √3 Ic = (IA - IB) / √3

Setting	Phase Shift	Action
Yy4	120° lag	Ia = IB Ib = IC Ic = IA
Yd5	150° lag	Yd11 and Invert
Yy6	180° lag	Invert currents
Yd7	150° lead	Yd1 and Invert
Yy8	120° lead	Ia = IC Ib = IA Ic = IB
Yd9	90° lead	Yd3 and Invert
Yy10	60° lead	Yy4 and Invert
Yd11	30° lead	Ia = (IA - IB) / √3 Ib = (IB - IC) / √3 Ic = (IC - IA) / √3
Ydy0	0°	Ia = IA - (IA + IB + IC) / 3 Ib = IB - (IA + IB + IC) / 3 Ic = IC - (IA + IB + IC) / 3
Ydy6	180° lag	Ydy0 and Invert

Table 3 - Vector compensation settings

Note 1 *Ia, Ib and Ic are the corrected currents and IA, IB and IC are the uncorrected phase currents.*

Note 2 *Any setting other than “OFF” will disable the remote current measurements and they will become invisible.*

In addition to compensating for the phase shift of the protected transformer, it is also necessary to mimic the distribution of primary zero sequence current in the protection scheme.

Figure 6 shows the need for zero sequence current filtering for differential protection across a transformer. The power transformer delta winding acts as a ‘trap’ to zero sequence current. This current is therefore only seen on the star connection side of the transformer and hence as differential current.

The filtering of zero sequence current has traditionally been provided by appropriate delta connection of main line CT secondary windings. In the P521 relay, zero sequence current filtering is automatically implemented in software when a delta connection is set for a software interposing CT. Where a transformer winding can pass zero sequence current to an external earth fault, it is essential that some form of zero sequence current filtering is employed. This would also be applicable where in-zone earthing transformers are used.

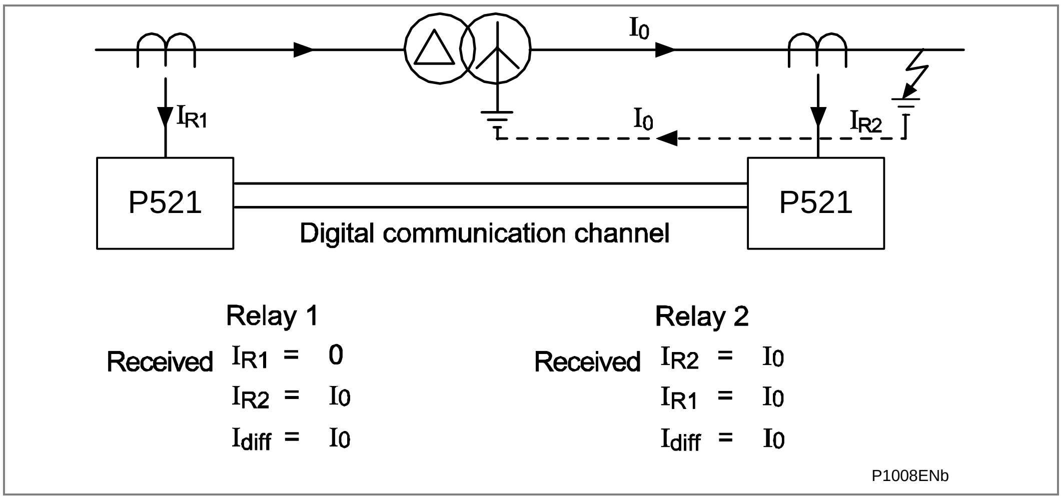


Figure 6 - Need for zero-sequence current filtering

Some examples of selection of phase compensation factors are shown in Table 4.

Transformer Connection	Transformer PHASE Shift	Vectorial Compensation (Relay Setting)	
		HV	LV
Dy1	- 30º	Yy0 (0 deg)	Yd11 (+30 deg)
Yd1	- 30º	Yd1 (-30 deg)	Yy0 (0 deg)
Dy5	- 150º	Yy0 (0 deg)	Yd7 (+150 deg)
Yd5	- 150º	Yd5 (-150 deg)	Yy0 (0 deg)
Dy7	+ 150º	Yy0 (0 deg)	Yd5 (-150 deg)
Yd7	+ 150º	Yd7 (+150 deg)	Yy0 (0 deg)
Dy11	+ 30º	Yy0 (0 deg)	Yd1 (-30 deg)
Yd11	+ 30º	Yd11 (+30 deg)	Yy0 (0 deg)

Table 4 - Examples of selection of phase compensation factors

2.1.7.4 Setting example of transformer feeders

If we consider a transformer feeder with the following parameters of the transformer to be protected by P521 (as in Figure 6):

Rated capacity: 7.5MVA

Connection type: Dyn11

Rated voltage and CT ratio:

HV side: 22kV, 1200:1

LV side: 6.3kV, 1250:1

Additionally, the maximum inrush current will reach up to 5In, with 2nd harmonic component in the rage of 20~60% with respect to the fundamental.

The CT correction factors are calculated as:

HV side: $$\frac{1200}{7.5\times10^6/\sqrt{3}\times22\times10^3}=6.10$$

LV side: $$\frac{1250}{7.5\times10^6/\sqrt{3}\times6.3\times10^3}=1.82$$

The vector compensation can be set as per Table 4:

HV side: Yy0 (0 deg)

LV side: Yd1 (-30 deg)

There are two options regarding inrush: Restrain and Block.

If Block mode is selected, the default setting of Harmonic Ratio (15%) is appropriate.

If Restrain mode is selected, the multiplying factor Kr should be calculated based on the setting, inrush current and 2nd harmonic component.

It can be derived from the equations in 2.1.7.1 that to keep relay stable during transformer inrush, Kr should satisfy:

$$Kr > \frac{Is2/\left(Is1 + k1Is2\right) - 0.5}{\%Ih2}$$

For the default P521 settings this gives the following Kr factors for different inrush levels.

% Ih2	Kr
12%	17
15%	14
20%	10
25%	8

In summary, the relay could be set as below:

Setting parameter	HV side	LV side
Is 1	0.2 In	0.2 In
Is 2	2.00 In	2.00 In
K1	30 %	30 %
K2	150 %	150 %
Inrush Option	Restrain/Block	Restrain/Block
High Set	7	7
Kr (for Inrush Option = Restrain)	10	10
Harmonic Ratio (for Inrush Option = Block)	15%	15%
Transient Bias	Yes	Yes
CT Correction factor	6.10	1.82
Vector compensation	Yy0 (0 deg)	Yd1 (-30 deg)

2.1.8 In Zone ‘Teed’ Loads

Many rural feeders have small fuse protected loads tapped off the line within the zone of protection. In most cases the load is small enough to be ignored when setting the Is1 threshold. The problem, however, is when a fault occurs downstream of the fuse. The current differential protection would assume the fault was on the feeder, instead of at the load, and may trip before the fuse has a chance to blow. This could cause considerable and unnecessary disruption to rest of the system.

To prevent this from occurring the operating time of the current differential element can be time delayed to grade with the fuse. The time delay can be either definite time (DMT) or Inverse time (IDMT), selectable in the “IDiff Delay Type” cell under ***PROTECTION G1 (G2) (G3) (G4)/ [87] Current Diff***. If DMT is chosen, the relay can be set with a definite time delay setting. If, however, IDMT is chosen a curve and its associated TMS/Time dial can be selected to grade with the fuse. To reduce fault clearance times for heavy internal faults the IDMT delay type is preferable as the operating time reduces for larger fault currents.

2.2 Overcurrent and Earth Fault Protection

The overcurrent and earth fault protection is provided as an alternative form of back-up protection. The P521 relay has four stages overcurrent and four stages of earth fault. The first two stages have a selectable IDMT or DMT characteristic. The third and fourth stages have a DMT characteristic only. The overcurrent and earth fault protection can be selectively enabled or disabled in the "I> ?" cell (Yes = enabled, No = disabled). A feature also exists whereby the protection can be enabled upon failure of the differential protection communication channel (select "backup" in the "I> ?" cell).

The overcurrent protection stages are labeled I>/tI>, I>>/tI>>, I>>>/tI>>> and I>>>>/tI>>>>. The earth fault protection stages are labeled Ie>/tIe>, Ie>>/tIe>>, Ie>>>/tIe>>> and Ie>>>>/tIe>>>>.

Figure 7 shows the logic associated with the first stage phase overcurrent protection (I>/tI>). Figure 8 shows the logic for overcurrent stages two, three and four (logic is duplicated for each stage). The logic diagrams in Figure 7 and 8 are identical, which is why the earth fault logic is not shown.

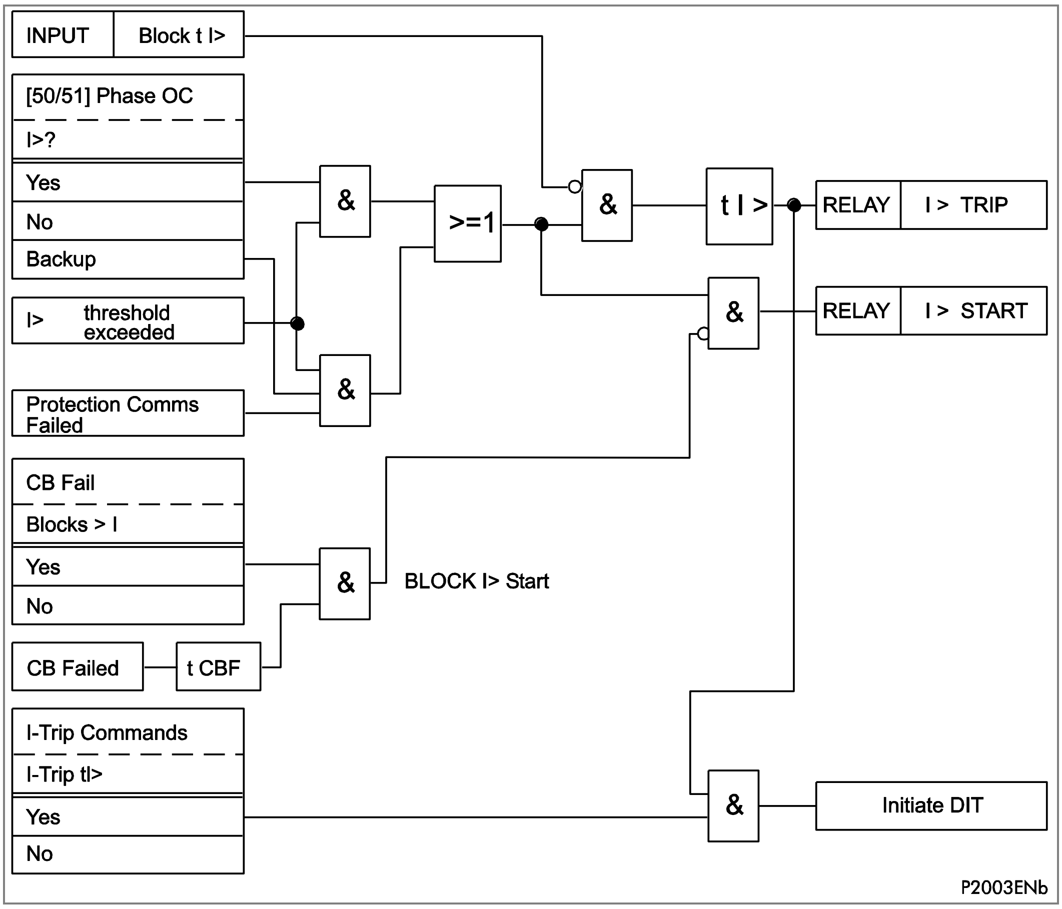


Figure 7 - First stage phase overcurrent protection (I>/tI>) logic

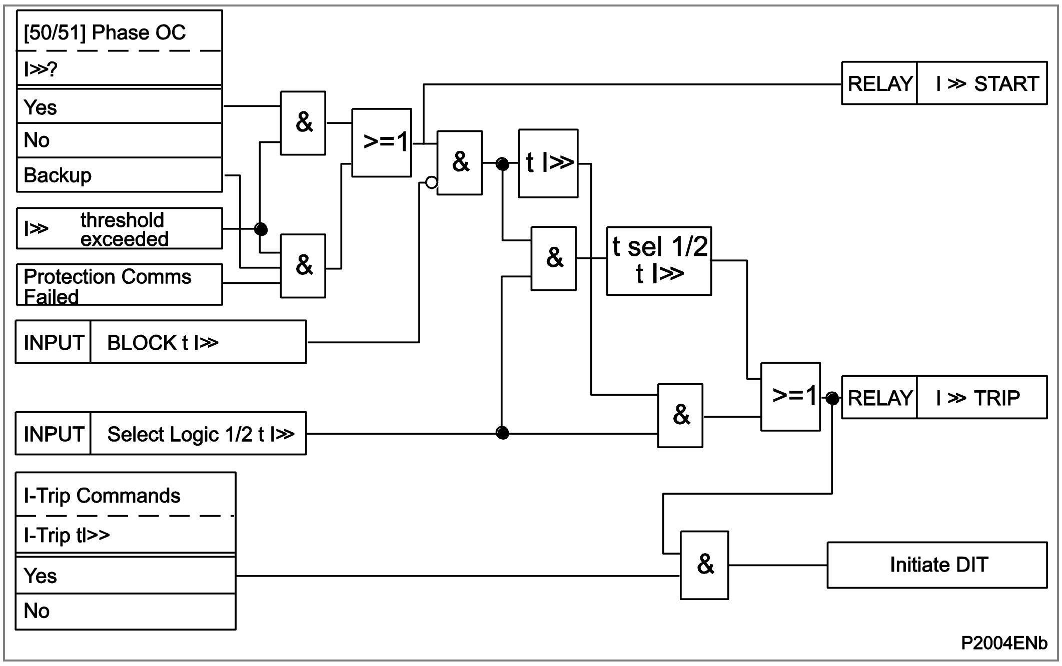


Figure 8 - Logic for overcurrent stages two, three and four

Note	*Both the overcurrent and earth fault protection operate from only the fundamental component of the line current.*

The overcurrent and earth fault elements will need to be co-ordinated with any other protection elements on the system, in order to provide discriminative fault clearance. The overcurrent menu column is shown in Table 5 below followed by the earth fault settings in Table 6.

[50/51] Phase OC	Default Setting	Min	Max	Step
I> ?	No	Yes, No, Backup		
I>	1 In	0.1 In	25 In	0.01 In
I> Delay Type	DMT	DMT, IDMT, RI		
tI>	40 ms	0 s	150 s	0.01 s
I> Curve	IEC SI	IEC STI, IEC SI, IEC VI, IEC EI, IEC LTI, CO2, IEEE MI, CO8, IEEE VI, IEEE EI		
I> Tms	1	0.025	1.5	0.025
I> Time Dial	1	0.1	100	0.1
K	0.1	0.1	10	0.005
Reset Type	DMT	DMT	IDMT	N/A
tReset	40 ms	40 ms	100 s	0.01 s
Rtms	0.025	0.025	3.2	0.025
I> ?	No	Yes, No, Backup		
I>>	1 In	0.5 In	40 In	0.05 In
{Remaining I>> cells are identical to I> above}				
I>>> ?	No	Yes, No, Backup		
I>>>	20 In	0.5 In	40 In	0.05 In
tI>>>	10 ms	0 s	150 s	0.01 s
I>>>> ?	No	Yes, No, Backup		
I>>>>	20 In	0.5 In	40 In	0.05 In

[50/51] Phase OC	Default Setting	Min	Max	Step
tI>>>>	10 ms	0 s	150 s	0.01 s

Table 5 - Overcurrent protection settings

[50N/51N] E/Gnd	Default Setting	Min	Max	Step
Ie> ?	Yes	Yes, No, Backup		
Ie>	0.1 Ien*, 0.01 Ien**, 0.002 Ien***	0.1 Ien*, 0.01 Ien**, 0.002 Ien***	25 Ien*, 1 Ien**, 1 Ien***	0.01 Ien*, 0.005 Ien**, 0.001***
Ie> Delay Type	DMT	DMT, IDMT, RI, LABOR		
tIe>	40 ms	0 s	150 s	0.01 s
Ie> Curve	IEC SI	IEC STI, IEC SI, IEC VI, IEC EI, IEC LTI, CO2, IEEE MI, CO8, IEEE EI; 1, 2, 3		
Ie> Tms	1	0.025	1.5	0.025
Ie> Time Dial	1	0.1	100	0.1
K	0.1	0.1	10	0.005
Reset Type	DMT	DMT	IDMT	N/A
tReset	40 ms	40 ms	100 s	0.01 s
Rtms	0.025	0.025	3.2	0.025
Ie>> ?	No	Yes, No, Backup		
Ie>>	1 In	0.5 Ien*, 0.01 Ien**, 0.002 Ien***	40 Ien*, 8 Ien**, 1 Ien***	0.01 Ien*, 0.005 Ien**, 0.001 Ien***
{Remaining Ie>> cells are identical to Ie> above}				
Ie>>> ?	No	Yes, No, Backup		
Ie>>>	1 In	0.5 Ien*, 0.01 Ien**, 0.002 Ien***	40 Ien*, 8 Ien**, 1 Ien***	0.01 Ien*, 0.005 Ien**, 0.001 Ien***
tIe>>>	10 ms	0 s	150 s	0.01 s
Ie>>>> ?	No	Yes, No, Backup		
Ie>>>>	20 In	0.5 Ien*, 0.01 Ien**, 0.002 Ien***	40 Ien*, 8 Ien**, 1 Ien***	0.01 Ien*, 0.005 Ien**, 0.001 Ien***
tIe>>>>	10 ms	0 s	150 s	0.01s
* denotes the standard earth fault board (0.1 to 40 Ien)				
** denotes the sensitive earth fault board (0.01 to 8 Ien)				
*** denotes the very sensitive earth fault board (0.002 to 1 Ien)				

Table 6 - Earth fault protection settings

2.2.1 Instantaneous (Start) Function (50/50N)

As soon as a phase (earth) threshold is exceeded, the instantaneous (start) output associated with this threshold is active. This output indicates that the protection has detected a phase (earth) fault and that the time delay associated with the threshold has started. This time delay can be blocked via the logic input "Blk Log" associated with this threshold. If this blocking input is activated by an output contact of a downstream relay, operation is blocked so that the relay closest to the fault can trip. This principle is known as «Blocking logic» or merely «Blocking». It is described in more detail later in this document.

2.2.2 Definite Time Operation (DMT)

The four phase (earth) overcurrent thresholds can be selected with a definite time delay. The operating time is equal to the set time delay, plus the operating time of the output contact (typically 20 to 30 ms; 20 ms for a current greater than or equal to twice the threshold) and the time required to detect the overcurrent state (maximum 20 ms at 50 Hz and 16.7 ms at 60 Hz).

2.2.3 IDMT Thresholds

2.2.3.1 Inverse Time Curves

The first and second phase (earth) overcurrent thresholds can be selected with an inverse time characteristic (IDMT). There are eleven IDMT characteristics in total. The operating time for all but the RI curve can be calculated with the following equation. The sensitive earth fault protection (0.01 to 8 Ien) has 3 additional LABORELEC curves. These are explained in section 2.2.4.

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

Where:

t = Operating time (seconds)

K = Constant (see Table 7)

I = Value of measured current

I_S = Value of the selected threshold (Pick-up value)

α = Constant (see Table 7)

L = ANSI/IEEE coefficient (zero for IEC curves)

T = Time Multiplier Setting (TMS) for IEC curves or Time Dial for IEEE/CO2/CO8 curves.

Type of Curve	Standard	K Factor	α Factor	L Factor
IEC STI (Short Time Inverse)	IEC	0.05	0.04	0
IEC SI (Standard Inverse)	IEC	0.14	0.02	0
IEC VI (Very Inverse)	IEC	13.5	1	0
IEC EI (Extremely Inverse)	IEC	80	2	0
UK LTI (Long Time Inverse)	UK	120	1	0
CO2 (Short Time Inverse)	CO2	0.02394	0.02	0.01694
IEEE MI (Moderately Inverse)	ANSI/IEEE	0.0515	0.02	0.114
CO8 (Inverse)	CO8	5.95	2	0.18
IEEE VI (Very Inverse)	ANSI/IEEE	19.61	2	0.491

Type of Curve	Standard	K Factor	α Factor	L Factor
IEEE EI (Extremely Inverse)	ANSI/IEEE	28.2	2	0.1215

Table 7 - IDMT characteristic coefficients

The operating time for the RI curve (electromechanical) is given by the following formula:

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

With K adjustable from 0.10 to 10 in steps of 0.05

This equation is valid for 1.1<= (I/Is) <= 20

Although the curves tend towards infinity, as the current approaches Is, the minimum guaranteed current, for all inverse time characteristics, is 1.1Is (with a tolerance of ±0.05Is). If DMT (definite time characteristic) is chosen the minimum operating current is equal to the selected threshold, which also has a tolerance of ±0.05Is.

2.2.4 Laborelec Curves

The first and second earth thresholds (sensitive version only) can be selected with one of three dedicated Laborelec curves.

The three Laborelec curves have the following formula:

$$t = aI + b$$

Where:

t	=	Operating time (seconds)
a and b	=	Constants (see Table 8)
I	=	Primary residual current

Type of Curve	a	b
LABORELEC 1	– 0.0897	4.0897
LABORELEC 2	– 0.0897	4.5897
LABORELEC 3	– 0.0897	5.0897

Table 8 - Laborelec curve coefficients

In order to be compliant with the Laborelec specifications the relay must be used with:

An earth current range of 0.01 Ien to 8 Ien

A rated current of 1 A

A core balanced CT with a ratio of 20/1.

For a complete operating curve, the relay must be set to 0.05 Ien (secondary residual current).

2.2.5 Reset Timer

The first and second phase and earth overcurrent stages in the P521 relay are provided with a timer hold facility "t Reset", which may be set to a definite time value or to an inverse time characteristic (IEEE/ANSI curves only). This may be useful in certain applications when the current differential protection has failed. For example, when grading with upstream electromechanical overcurrent relays which have inherent reset time delays.

Another possible situation where the timer hold facility may be used to reduce fault clearance times is where intermittent faults occur when the current differential protection has failed. An example of this may occur in a plastic insulated cable. In this application it is possible that the fault energy melts and reseals the cable insulation, thereby extinguishing the fault. This process repeats to give a succession of fault current pulses, each of increasing duration with reducing intervals between the pulses, until the fault becomes permanent. If the reset timer had been set to minimum the relay would repeatedly reset and not be able to trip until the fault becomes permanent. By using the Timer Hold facility the relay will integrate the fault current pulses, thereby reducing fault clearance time.

If the first and second phase (earth) threshold is selected with an IDMT IEC or RI curve, the reset timer "t Reset" has a definite time characteristic, settable between 40 ms and 100 s in steps of 10 ms. The reset time “tReset” can be found in the following locations:

PROTECTION G1 (G2) (G3) (G4)/[50/51] Phase OC /t Reset

and

PROTECTION G1 (G2) (G3) (G4)/[50N/51N] E/Gnd /t Reset

If the first phase (earth) threshold is selected with an IDMT IEEE or CO curve, the reset timer can be set either DMT or IDMT in the “Reset Type” cell. If DMT is chosen the reset time becomes definite time with the time set in the "t Reset" cell. If IDMT is chosen the reset time is based upon an inverse curve which is current dependent. A time multiplier “Rtms” can also be applied to this curve so that it can be tailored to the application. The reset function menu cells are located as follows:

PROTECTION G1 (G2) (G3) (G4)/[50/51] Phase OC /Reset Type

PROTECTION G1 (G2) (G3) (G4)/[50/51] Phase OC /t Reset (if Reset Type = DMT)

PROTECTION G1 (G2) (G3) (G4)/[50/51] Phase OC /Rtms (if Reset Type = IDMT)

and

PROTECTION G1 (G2) (G3) (G4)/[50N/51N] E/Gnd /Reset Type

PROTECTION G1 (G2) (G3) (G4)/[50N/51N] Phase OC /t Reset (if Reset Type = DMT)

PROTECTION G1 (G2) (G3) (G4)/[50N/51N] Phase OC /Rtms (if Reset Type = IDMT)

The IDMT reset time is dependent upon the chosen operating time curve and the selected “Rtms” value. The IDMT reset time formula, applicable to the 5 CO/ANSI/IEEE curves, is as follows:

$$t = T \times \left(\frac{K}{1 - (I/Is)^{2}} \right)$$

Where:

t	=	Reset time
K	=	Constant (see Table 9)

I = Value of the measured current

I_S = Value of the selected threshold (pick-up value)

T = Reset Time Multiplier (Rtms) between 0.025 and 3.2

Type of Curves	Standard	K Factor
CO2 (Short time inverse)	CO2	2.261
IEEE MI (Moderately inverse)	ANSI/IEEE	4.85
CO8 (Inverse)	CO8	5.95
IEEE VI (Very inverse)	ANSI/IEEE	21.6
IEEE EI (Extremely inverse)	ANSI/IEEE	29.1

Table 9 - Reset curve coefficients

2.2.6 Time Graded Protection

Inverse definite minimum time relays are time graded such that the relay nearer to the fault operates faster than the upstream relays. This is referred to as relay co-ordination because if the relay nearest to the fault fails operate, the upstream relay will trip in a slightly longer time. The time grading steps are typically 400 ms, therefore the operating time for each upstream relay becomes progressively longer.

Where difficulty is experienced in arranging the required time grading steps the use of a blocked overcurrent scheme should be considered (described in a later section).

2.3 Thermal Overload Protection

Thermal overload protection can be used to prevent electrical plant from operating at temperatures in excess of the designed maximum withstand. Prolonged overloading causes excessive heating, which may result in premature deterioration of the insulation, or in extreme cases, insulation failure.

The MiCOM P521 incorporates a current based thermal replica, using the RMS load current to model the heating and cooling of the protected plant. The element can be set with both alarm and trip stages.

The heat generated within an item of plant, such as a cable or a transformer, is created by the resistive loss (I^2R x t). Thus, heating is directly proportional to current squared. The thermal time characteristic used in the relay is therefore based on current squared, integrated over time. MiCOM relays automatically use the largest phase current for input to the thermal model.

Equipment is designed to operate continuously at a temperature corresponding to its full load rating, where heat generated is balanced with heat dissipated by radiation etc. Over-temperature conditions therefore occur when currents in excess of rating are allowed to flow for a period of time. It can be shown that temperatures during heating follow exponential time constants and a similar exponential decrease of temperature occurs during cooling.

In order to apply this protection element, the thermal time constant for the protected item of plant is therefore required. The settings associated with the thermal menu are shown in Table 10. These settings can found under ***PROTECTION G1 (G2) (G3) (G4)/[49] Therm OL***.

[49] Thermal OL	Default Setting	Min	Max	Step
Therm OL ?	No	Yes, No		
Iθ>	1 In	0.1 In	3.2 In	0.01 In
Te	1 mn	1 mn	200 mn	1 mn
K	1.05	1	1.5	0.01
θ Trip	100%	50%	200%	1%
θ Alarm ?	No	Yes, No		
θ Alarm	90%	50%	200%	1%

Table 10 - Thermal overload settings

The following sections will show that different items of plant possess different thermal characteristics, due to the nature of their construction.

2.3.1 Thermal Overload Characteristic

This characteristic is used to protect cables, dry type transformers (e.g. type AN), and capacitor banks. When protecting these devices, the trip time varies depending on the load current carried before application of the overload, i.e. whether the overload was applied from “hot” or “cold”.

Curves of the thermal overload time characteristic are given in the Technical Data and Curve Characteristics (*P521/EN TD*) section of the service manual.

The operating time of the thermal element is given by:

$$\text{Ttrip} = \text{Te}.\ \log_e\left(\frac{K^2 - \left(I_p / I\theta>\right)^2}{K^2 - \text{Trip}^2}\right)$$

With:

Ttrip = Time to trip (in seconds).

Te = Thermal time constant of the protected element (in seconds).

K = Thermal overload equal to Ieq/k Iθ >.

Ieq = Equivalent current, corresponds to the RMS value of the largest phase current.

Iθ> = Thermal current setting.

k = Overload factor by which the Iθ> setting must be multiplied to determine the trip threshold.

Ip = Steady state pre-loading before application of the overload.

Trip = Trip thermal state. If the trip thermal state is set at 100%, then Trip = 1

The calculation of the thermal state is given by the following formula:

$\theta_{t+1} = (\text{Ieq}/\ \text{I}\theta >)^2\ [1- \exp(-t/Te)] + \theta_t \exp(-t/Te)$

θ being calculated every 100 ms

2.3.2 Setting Guidelines

The thermal trip level in terms of current can be determined as follows:

$$\text{Thermal trip} = \sqrt{\frac{\text{Trip x K}^2}{100}} \text{ x } 1\theta>$$

Note	*The 'Trip' setting must be entered as a percentage i.e. 90 for 90%.*

There are two methods of setting the Iθ> and 'k' settings in the P521. The selected method may depend upon company standards or personal preference. This also assumes that the 'Trip' value is set to 100%.

The first method assumes that the Iθ> setting is set to the maximum current that the plant can withstand before it becomes damaged. This is normally greater than the permissible continuous load current. In this case the plant can not tolerate any further loading, which means the overload factor 'k' should be set to 1. Hence the thermal trip level, in amps, will be equal to Iθ>.

If, however, the Iθ> setting was set equal to the permissible continuous load current, an overload factor 'k' may be applied, since it is likely that the plant has been designed to tolerate a current in excess of this amount. For example, if a line has a permissible continuous load current of 762 A (Iθ> setting), but the line can actually tolerate 800 A, the 'k' factor can set to 1.05 (800 A/762 A). Hence the thermal trip level, in amps, will be 'k x Iθ>'.

The thermal trip threshold can also be modified by the 'Trip' setting if necessary. This sets the thermal threshold in terms of the thermal state (i.e. a percentage). If the 'Trip' threshold is set to 100% the relay will operate a thermal state of K^2 x 100%. For example, if the relay is has a 'K' factor of 1.05 and 'Trip' threshold of 100% the relay will trip at a thermal state of 110% (1.05^2 x 100%).

The relay also has a thermal alarm that can be used to indicate that the trip threshold has almost been exceeded. The alarm is also set in terms of the thermal state, as with the 'Trip' setting. It is common to set the alarm lower than the trip threshold (say 90%) in order to give a warning of an impending overload. Much like the 'Trip' setting the alarm threshold is also modified by the 'K' factor. Hence the actual alarm message will occur at K^2 x alarm setting.

The thermal state can be viewed in ***MEASUREMENTS/Current/General/Thermal θ***. If necessary the thermal state can be manually reset by pressing the **(C)** key when in this cell. The thermal state can also be reset by energizing an opto input that has been assigned to the 'θ Reset' command ***(AUTOMAT. CTRL/Inputs/Input #)***.

Note	*The thermal state is stored in none-volatile memory. In the event of a DC supply interruption the thermal state, prior to the interruption, will be recovered once the DC has been restored.*

As mentioned earlier, to accurately model thermal characteristics of a piece of plant, it is necessary to set a thermal time constant. The manufacturer of the plant should be able to supply this information but some typical time constants are given in the following tables.

Paper insulated lead sheathed cables or polyethylene insulated cables, placed above ground or in conduits. The table shows the time constant in minutes, for different cable rated voltages and conductor cross-sectional areas:

CSA mm^2	6 -11 kV	22 kV	33 kV	66 kV
25 - 50	10	15	40	-
70 - 120	15	25	40	60
150	25	40	40	60
185	25	40	60	60
240	40	40	60	60
300	40	60	60	90
	Time Constant Te (Minutes)			

Other Plant Items:

	Time Constant τ (Minutes)	Limits
Dry-type transformers	40 60 – 90	Rating < 400 kVA Rating 400 - 800 kVA
Air-core reactors	40	
Capacitor banks	10	
Overhead lines	10	Cross section ≥ 100 mm^2 Cu or 150 mm^2 Al
Busbars	60	

2.4 Circuit Breaker Failure Protection (CBF)

Following inception of a fault one or more main protection devices will operate and issue a trip output to the circuit breaker(s) associated with the faulted circuit. Operation of the circuit breaker is essential to isolate the fault, and prevent damage/further damage to the power system.

For transmission/sub-transmission systems, slow fault clearance can also threaten system stability. It is therefore common practice to install Circuit Breaker Failure (CBF) protection, which monitors that the circuit breaker has opened within a reasonable time. If the fault current has not been interrupted following a set time delay from circuit breaker trip initiation, CBF protection will operate.

CBF operation can be used to backtrip upstream circuit breakers to ensure that the fault is isolated correctly. CBF operation can also reset all start output contacts, ensuring that any blocks asserted on upstream protection are removed.

The settings associated with the circuit breaker fail protection is shown in Table 11. They can be found in ***AUTOMAT. CTRL/CB Fail.***

CB Fail	Default Setting	Min	Max	Step
CB Fail ?	No	Yes, No		
I<	0.1 In	0.02 In	1 In	0.01 In
CB Fail Time tBF	100 ms	30 ms	10 s	0.01 s
Block I> ?	No	Yes, No		
Block Ie> ?	No	Yes, No		

Table 11 - Circuit breaker fail settings

2.4.1 Circuit Breaker Failure Protection Operation

When a trip order is given through the output relay RL1, the t BF timer is started. The trip order can be issued either from a protection element, or a logic input. In order to initiate the tBF timer by a logic input the 'Start tBF' command must be assigned to that input ***(AUTOMAT. CTRL/Inputs/Input #)***. The MiCOM relay then monitors the currents in each phase and compares them with the zone defined by the undercurrent I< threshold (not to be confused with the [37] under current protection function). This threshold value is settable within the ***AUTOMAT. CTRL/CB Fail menu***.

Following the start of the t BF timer, the relay detects the first time that current goes out of the I< zone. On detection of this transition, the relay starts another timer which has a non-settable duration of 20 samples.

Since the relay sampling rate is 32 samples by cycle, this timer duration is 12.5 ms for a 50 Hz system and 10.4 ms for a 60 Hz system. During this time, the relay is checking if the current goes out of the I< zone again. In the case where the current is not switched off (CB has failed to trip), the current signal should again go out of the I< zone at a time equal to 16 samples after the former detection (i.e. half a cycle).

Each time the relay detects the current going out of the I< zone, the relay once again starts a timer which has a duration of 20 samples and it checks if the current goes out of the I< zone once again.

In the window of 20 samples, the relay checks that the current signal going out of the I< zone is in the opposite direction.

- If there is no current signal going out in the opposite direction within the 20 sample duration, the relay states that the CB pole has opened. The « CB pole open » internal signal is then initiated.

- If there is a current signal going out in opposite direction within the 20 sample duration the relay states that the CB pole has not yet opened. The « CB pole closed » internal signal is maintained.

Once the t BF time delay has elapsed, the relay checks the status of the « CB pole » internal signal for each pole of the circuit breaker. If one or more internal signals indicate that their CB poles have not yet opened, the relay initiates the CB FAIL signal. The CB fail signal can be arranged to remove the start signals of the I> and Ie> elements, in order to remove blocking signals from any upstream protection. Alternatively, the CB fail signal can operate a selectable contact ***(AUTOMAT. CTRL/ Output relays/ CB Fail)***.

This contact can be used to backtrip upstream switchgear, generally tripping all infeeds connected to the same busbar section.

To remove the I> and Ie> start signals once the breaker fail timer has elapsed the following cells must be set to ‘Yes’:

AUTOMAT. CTRL/CB Fail/Block I> ?

and

AUTOMAT. CTRL /CB Fail/Block Ie> ?

As mentioned earlier the CB fail timer can be started by an external input that can be connected to external protection equipment. Note the option to start the CB fail detection function by a digital input (labeled Strt TBF) without a trip order given by the MiCOM relay. In this case the tBF timer starts from the digital input. If the CB is not opened (by an another protection relay) at the end of tBF, the MiCOM relay outputs the CB FAIL signal.

It is possible to automatically send a direct intertrip command to the remote relay whenever a CB fail condition occurs. This is enabled by selecting ‘Yes’ in the “I-Trip CB Fail” cell (***AUTOMAT. CTRL/I-Trip Commands***).

Figure 9 shows a CB Fail detection start following a trip command:

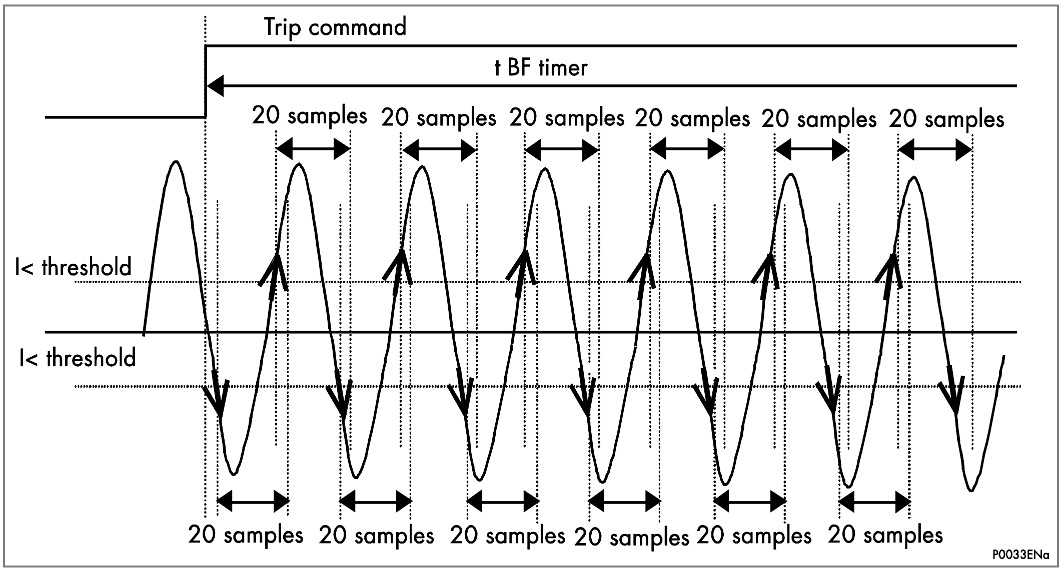


Figure 9 - CB fail detection principle

Figure 10 shows a normal CB operation before tBF expires. No CB fail signal is given.

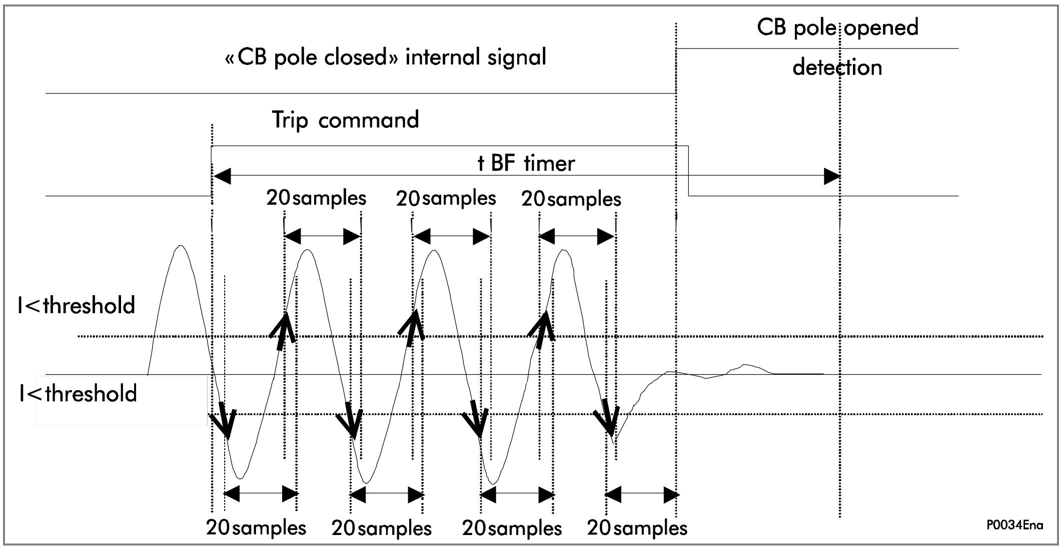


Figure 10 - CB open before TBF expired

Figure 11 shows a CB failure condition. At the drop off of the t BF timer, the relay has not detected an opening of the CB pole, hence a CB FAIL signal is initiated.

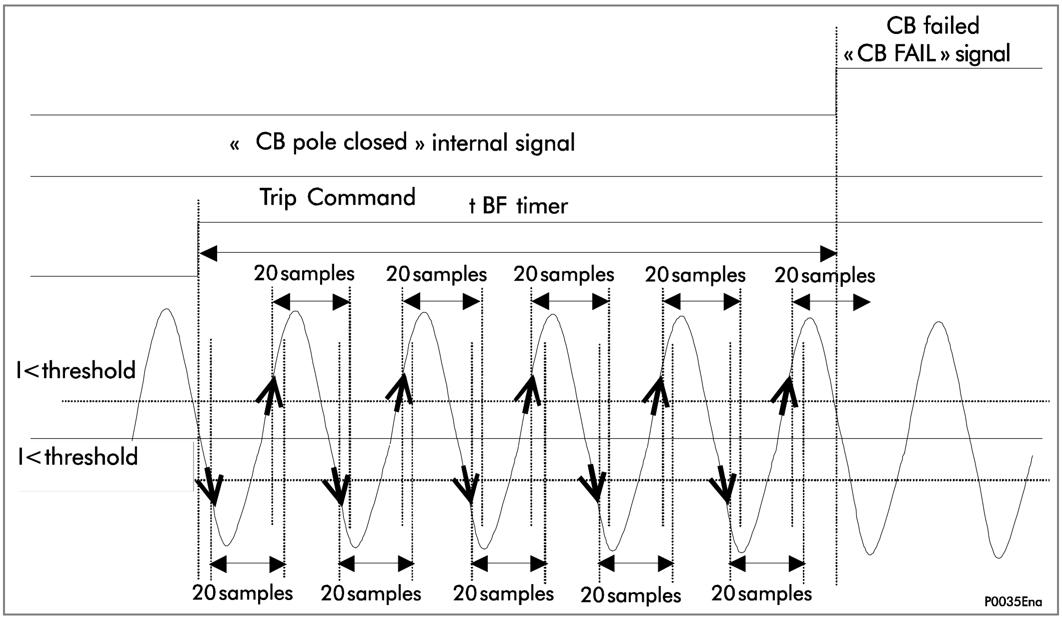


Figure 11 - CB not yet open before TBF expired

Figure 12 shows another case of normal CB operation. On fault clearance, the removal of the phase current signal takes time, often due to the de-energization of the phase CT. This is a typical case for TPY class CTs which are built with an air gap in their magnetic core. Before the drop off of the t BF timer, the relay has detected an opening of the CB pole, thus no CB failure signal is given. A basic Breaker Failure element based on a simple undercurrent element would detect a false CB failure condition as the current signal value is still outside the I< zone after the t BF timer has elapsed.

Note	*Both « CB pole closed » and « CB pole opened » internal signals mentioned in the above diagrams are derived from the Circuit Breaker Failure function algorithm. They are not affected by the status of the relay opto-inputs wired to the 52a and 52b CB auxiliary contacts.*

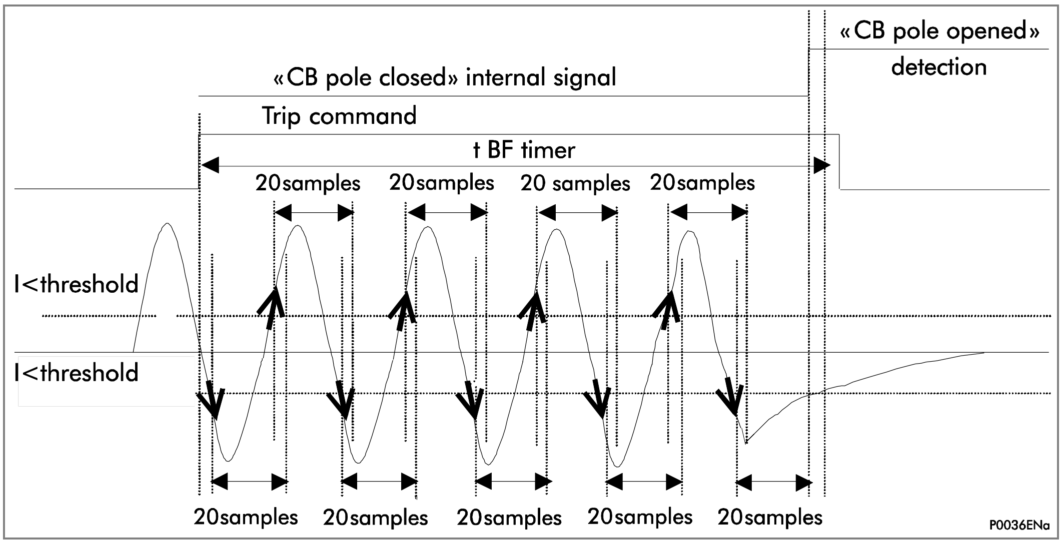


Figure 12 - De-energization of the phase CT

2.4.2 Breaker Fail Timer Settings

A typical timer setting used with a 2½ cycle circuit breaker is around 150 ms.

2.4.3 Breaker Fail Undercurrent Settings

The phase undercurrent settings (I<) must be set to less than load current, to ensure that I< operation indicates that the circuit breaker pole is open. A typical setting for overhead lines or cable circuits is 20% In.

2.4.4 CBF Fail Logic

Figure 13 shows the logic associated with circuit breaker failure protection.

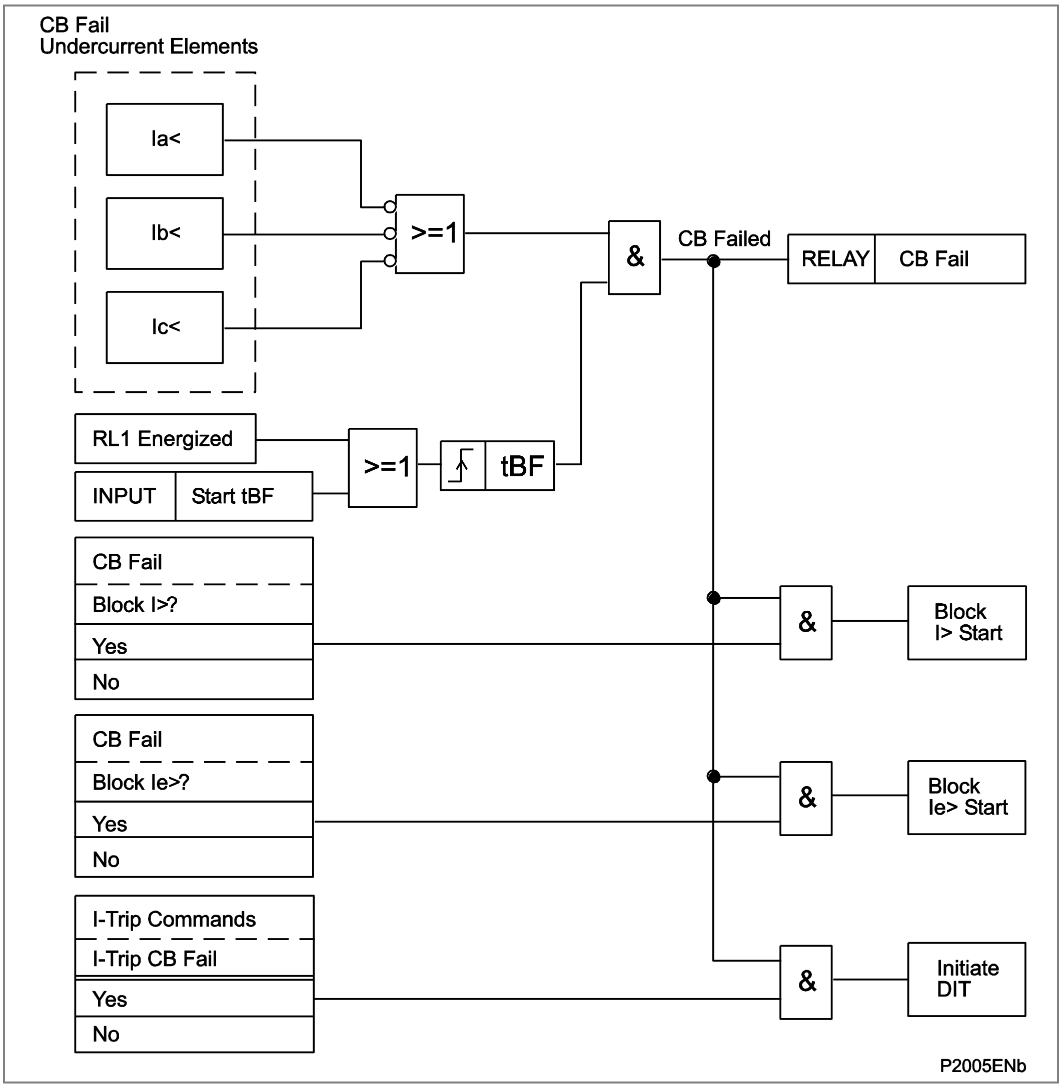


Figure 13 - Circuit breaker failure protection logic

2.5 Broken Conductor Detection

The majority of faults on a power system occur between one phase and ground or two phases and ground. These are known as shunt faults and arise from lightning discharges and other overvoltages which initiate flashovers. Alternatively, they may arise from other causes such as birds on overhead lines or mechanical damage to cables etc. Such faults result in an appreciable increase in current and in the majority of applications are easily detectable.

Another type of unbalanced fault, which can occur on the system, is the series or open circuit fault. These can arise from broken conductors, maloperation of single phase switchgear, or the operation of fuses. Series faults will not cause an increase in phase current on the system and hence are not readily detectable by standard overcurrent relays. However, they will produce an unbalance and a resultant level of negative phase sequence current, which can be detected.

It is possible to apply a negative phase sequence overcurrent relay to detect the above condition. However, on a lightly loaded line, the negative sequence current resulting from a series fault condition may be very close to, or less than, the full load steady state unbalance arising from CT errors, load unbalance etc. A negative sequence element therefore would not operate at low load levels.

The MiCOM P521 relay incorporates an element which measures the ratio of negative to positive phase sequence current (I2/I1). This will be affected to a lesser extent than the measurement of negative sequence current alone, since the ratio is approximately constant with variations in load current. Hence, a more sensitive setting may be achieved.

The settings associated with the broken conductor detection is shown in Table 12 below.

Broken Conductor	Default Setting	Min	Max	Step
Brkn. Cond ?	No	Yes, No		
tBC	1 s	0 s	14400 s	1 s
Ratio I2/I1	20%	20%	100%	1%

Table 12 - Broken conductor detection settings

2.5.1 Setting Guidelines

In the case of a single point earthed power system, there will be little zero sequence current flow and the ratio of I2/I1 that flows in the protected circuit will approach 100%. In the case of a multiple earthed power system (assuming equal impedances in each sequence network), the ratio I2/I1 will be 50%.

It is possible to calculate the ratio of I2/I1 that will occur for varying system impedances, by referring to the following equations:

$$I_{1F} = \frac{E_g\,(Z_2 + Z_0)}{Z_1 Z_2 + Z_1 Z_0 + Z_2 Z_0}$$

$$I_{2F} = \frac{-E_g\,Z_0}{Z_1 Z_2 + Z_1 Z_0 + Z_2 Z_0}$$

Where:

E_g = System Voltage

Z_0 = Zero sequence impedance

Z_1 = Positive sequence impedance

Z_2 = Negative sequence impedance

Therefore:

$$\frac{I_{2F}}{I_{1F}} = \frac{Z_0}{Z_0 + Z_2}$$

It follows that, for an open circuit in a particular part of the system, I2/I1 can be determined from the ratio of zero sequence to negative sequence impedance. It must be noted however, that this ratio may vary depending upon the fault location. It is desirable therefore to apply as sensitive a setting as possible. In practice, this minimum setting is governed by the levels of standing negative phase sequence current present on the system. This can be determined from a system study, or by making use of the relay measurement facilities at the commissioning stage. If the latter method is adopted, it is important to take the measurements during maximum system load conditions, to ensure that all single phase loads are accounted for.

Since sensitive settings are employed, it can be expected that the element will operate for any unbalance condition occurring on the system (for example, during a single pole auto-reclose cycle). Therefore, a long time delay is necessary to ensure co-ordination with other protective devices. A 60 second time delay setting may be typical.

2.5.2 Example Setting

The following information was recorded by the relay during commissioning;

$I_{full\ load}$ = 500 A

I2 = 50 A

Therefore the quiescent I2/I1 ratio is given by:

I2/I1 = 50/500 = 0.1

To allow for tolerances and load variations a setting of 200% of this value may be typical: Therefore set *RATIO I2/I1* = 20%

Set *tBC* = 60 s to allow adequate time for short circuit fault clearance by time delayed protections.

2.6 Intertripping Facilities

2.6.1 Permissive Intertrip

The P521 relay includes a facility to send a permissive intertrip command over the protection communication channel, as shown in Figure 14.

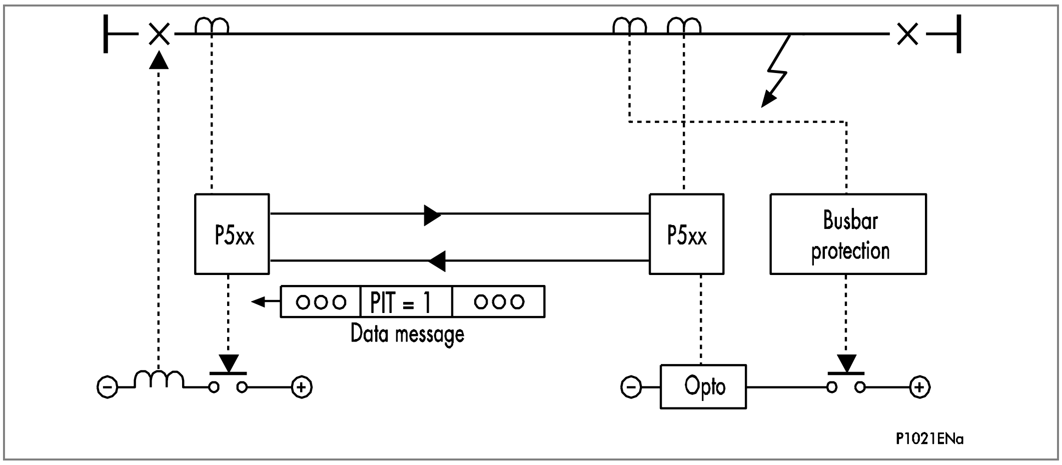


Figure 14 - Permissive intertrip

An opto input can be assigned for this *purpose* ***(AUTOMAT. CTRL/Inputs/Input # ext/ Permis IT)***. When the associated opto input is energized at END B, the PIT flag is set in the communication message. On receipt of this message the relay at END A (receiving end) initiates the PIT timer. When this timer expires, the receiving end relay will operate user-specified output contact(s), as selected in the ***AUTOMAT. CTRL/Output Relays/PIT*** menu cell, conditional on the current check if enabled. The receiving end relay provides the "PERMISSIVE" electrical system alarm indicating a permissive intertrip has occurred.

The permissive intertrip timer "PIT Time" is settable between 0 ms and 2 s. For standard permissive intertrip functionality, this time should be set to provide discrimination with other protection. For example, in Figure 14, the time delay should be set to allow the busbar protection to clear the fault in the event of a genuine busbar fault. A typical setting may be 100 – 150 ms.

If the current check is enabled, the receiving end relay can be set using the "PIT I Selection" menu cell, to either check the sending end (="Remote") current against a pre-configured threshold, or check the receiving end (="Local") overcurrent and/or earth fault stages' start statuses. When "Remote" is selected, the receiving end relay will operate the user-specified PIT output contact(s) if any of the sending end phase currents is above the value of the receiving end "PIT I Threshold" setting. When "Local" is selected, the receiving end relay will operate the user-specified PIT output contact(s) if any of the selected receiving end overcurrent or earth fault stages have started. The selection of overcurrent and earth fault stages for this check is made using the "PIT OC Stages" setting. This local current check facility is intended to allow PIT functionality to be applied to sensitive earth fault systems.

In some circumstances it may be desirable to disable the current check from the PIT function. This would give the user a second multipurpose direct intertrip if required. Disabling the current check facility makes the PIT function operate much the same as the Direct Intertrip command. The current check can be disabled by selecting 'Yes' in the "PIT I Disable" menu cell.

- The PIT function menu cells are located as follows:
  - PROTECTION G1 (G2) (G3) (G4)/[87] Current Diff /PIT Time

- PROTECTION G1 (G2) (G3) (G4)/[87] Current Diff /PIT I Disable
- PROTECTION G1 (G2) (G3) (G4)/[87] Current Diff /PIT I Selection
- PROTECTION G1 (G2) (G3) (G4)/[87] Current Diff /PIT OC Stages
- PROTECTION G1 (G2) (G3) (G4)/[87] Current Diff /PIT I Threshold

2.6.2 Direct Intertrip

This is an example of user defined intertripping. The P521 relay includes a facility to send a direct intertrip command over the protection communication channel as shown in Figure 15.

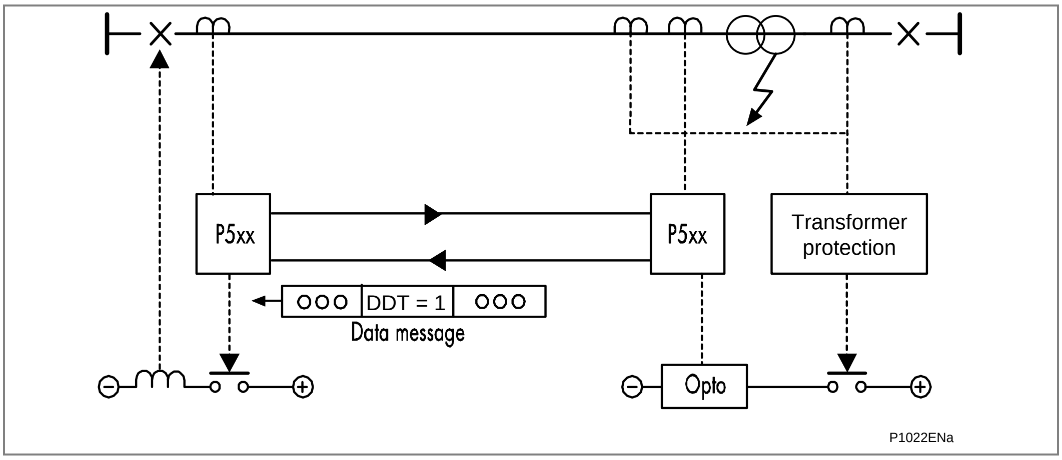


Figure 15 - Direct intertrip

An opto input can be assigned for this purpose. When energized, the DIT flag is set in the communication message. Upon receipt of this message the receiving end remote relay will operate user specified output contact(s) for a time not less than the value in the “DIT Rx tDwell” cell (***PROTECTION G1 (G2) (G3) (G4)/[87] Current Diff***). The receiving end remote relay will also provide indication of the direct intertrip by displaying the “DIRECT I-TRIP” system alarm.

2.6.3 Programmable Inter-Trip

In certain applications it may be desirable to send a digital signal to the remote end. For example, operation of overcurrent or earth fault protection will trip the local circuit breaker, but not the remote side. To initiate a remote trip, a digital signal should be transferred. Another example is circuit breaker operation inter-locking. As shown in Figure 16, when try to close the circuit breaker at End A, it is necessary to obtain the status of the earth switch at End B. Some users will also take into accounting the voltage signal status at End B. These signals can be collected by the P521 at End B and transferred to End A via the digital link.

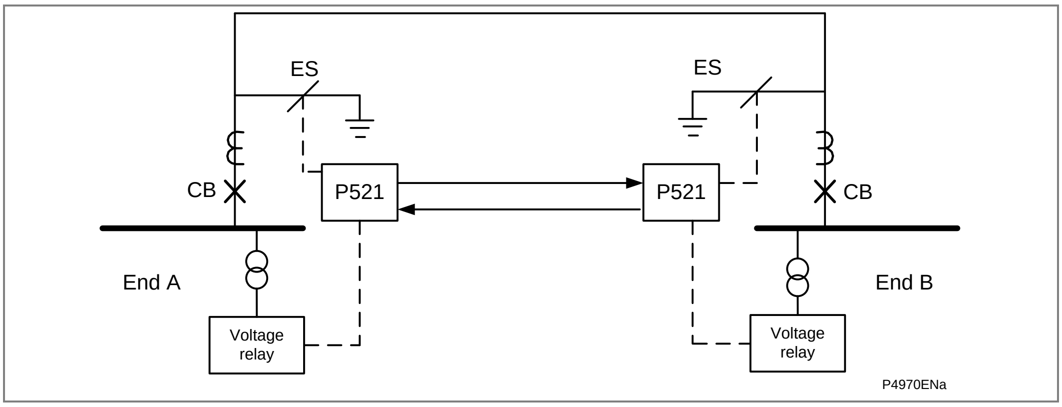


Figure 16 - Digital signal transfer

Since software version 12.A, P521 relay provides totally four programmable inter-trip signals. User can initiate any of the four programmable inter-trips by using of the "Program. I-Trip" menu under AUTOMAT. CTRL. By selecting a given function, the relay will initiate an inter-trip command when that function operates. The list of available functions that can be selected is shown in Table 13:

I-Trip Commands	Default Setting	Settings
I-Trip tI>	No	Yes, No
I-Trip tI>>	No	Yes, No
I-Trip tI>>>	No	Yes, No
I-Trip tI>>>>	No	Yes, No
I-Trip tIe>	No	Yes, No
I-Trip tIe>>	No	Yes, No
I-Trip tIe>>>	No	Yes, No
I-Trip tIe>>>>	No	Yes, No
I-Trip Thermal θ	No	Yes, No
I-Trip tI<	No	Yes, No
I-Trip tI2>	No	Yes, No
I-Trip tI2>>	No	Yes, No
I-Trip CB Fail	No	Yes, No
I-Trip Brkn. Cond	No	Yes, No
I-Trip tAux1	No	Yes, No
I-Trip tAux2	No	Yes, No
I-Trip Input 1	No	Yes, No
I-Trip Input 2	No	Yes, No
I-Trip Input 3	No	Yes, No
I-Trip Input 4	No	Yes, No

I-Trip Commands	Default Setting	Settings
I-Trip Input 5	No	Yes, No
I-Trip Equ A	No	Yes, No
I-Trip Equ B	No	Yes, No
I-Trip Equ C	No	Yes, No
I-Trip Equ D	No	Yes, No
I-Trip Equ E	No	Yes, No
I-Trip Equ F	No	Yes, No
I-Trip Equ G	No	Yes, No
I-Trip Equ H	No	Yes, No

Table 13 - Programmable I-Trip Command menu

After an Inter-trip signal is received, the relay will generate an event, but will not raise any Alarm. The received inter-trip signal can be mapped to output relays, LEDs and logic equations.

A time dwell setting is provided, which can be used to adjust the output width upon receiving an inter-trip signal.

Note 1	*Programmable Inter-trip function will work only when the relays are set in Extension communication mode in the menu COMMUNICATION/Protection/FRAME MODE.*
Note 2	*Since software version V12.A, the "Selective inter-tripping" menu is removed, as its function can be fully implemented by the programmable inter-trip commands.*

2.7 Negative Sequence Overcurrent Protection

When applying traditional phase overcurrent protection, the overcurrent elements must be set higher than maximum load current, thereby limiting the element's sensitivity. Most protection schemes also use an earth fault element operating from residual current, which improves sensitivity for earth faults. However, certain faults may arise which can remain undetected by such schemes.

Any unbalanced fault condition will produce negative sequence current of some magnitude. Thus, a negative phase sequence overcurrent element can operate for both phase-to-phase and phase to earth faults.

This section describes how negative phase sequence overcurrent protection may be applied in conjunction with standard overcurrent and earth fault protection in order to alleviate some less common application difficulties.

- Negative phase sequence overcurrent elements give greater sensitivity to resistive phase-to-phase faults, where phase overcurrent elements may not operate.
- In certain applications, residual current may not be detected by an earth fault relay due to the system configuration. For example, an earth fault relay applied on the delta side of a delta-star transformer is unable to detect earth faults on the star side. However, negative sequence current will be present on both sides of the transformer for any fault condition, irrespective of the transformer configuration. Therefore, a negative phase sequence overcurrent element may be employed to provide time-delayed back-up protection for any un-cleared asymmetrical faults.
- Where rotating machines are protected by fuses, a blown fuse produces a large amount of negative sequence current. This is a dangerous condition for the machine due to the heating effects of negative phase sequence current at double frequency. A negative phase sequence overcurrent element may be applied to provide efficient back-up protection for dedicated motor protection relays.
- It may also be required to simply alarm for the presence of negative phase sequence currents on the system. Operators are then prompted to investigate the cause of the unbalance.

The negative phase sequence overcurrent element has a current pick up setting 'I2>', and is time delayed in operation by the adjustable timer 'tI2> Delay Time.'

2.7.1 I2> and I2>> Setting Guidelines

The current pick-up threshold ***(PROTECTION G1 (G2) (G3) (G4)/[46] Neg Seq OC menu)*** must be set higher than the normal negative phase sequence current due to the normal load unbalance on the system. This can be set at the commissioning stage, making use of the relay measurement function to display the standing negative phase sequence current, and apply a setting at least 20% above this figure.

Where the negative phase sequence element is required to operate for specific un-cleared asymmetric faults, a precise threshold setting has to be based on an individual fault analysis for that particular system due to the complexities involved. However, to ensure operation of the protection, the current pick-up setting must be set approximately 20% below the lowest calculated negative phase sequence fault current for a specific remote fault condition.

The correct setting of the time delay for this function is vital. It should also be noted that this element is applied primarily to provide back-up protection to other protective devices or to provide an alarm. Therefore, it would be associated with a long time delay.

It must be ensured that the time delay is set greater than the operating time of any other protective device (at minimum fault level) on the system which may respond to unbalanced faults, such as:

- Phase overcurrent elements
- Earth fault elements
- Broken conductor elements
- Negative phase sequence influenced thermal elements

The I2> element can be set to either DMT, IDMT, RI inverse or definite time delay in the “I2> Delay Type” cell. The I2>> threshold is definite time only. The I2 settings are located in the ***PROTECTION G1 (G2) (G3) (G4)/[46] Neg Seq OC menu***. The time multiplier setting, time dial, curve selection and reset time, associated with the I2> threshold, are set in much the same way as the [50] phase overcurrent menu.

The settings associated with the negative sequence overcurrent protection are shown in Table 14:

[46] Neg Seq OC	Default Setting	Min	Max	Step
I2> ?	No	Yes, No		
I2>	1 In	0.1 In	40 In	0.01 In
I2> Delay Type	DMT	DMT, IDMT, RI		
tI2>	0 ms	0 s	150 s	0.01 s
I2> Curve	IEC SI	IEC STI, IEC SI, IEC VI, IEC EI, IEC LTI, CO2, IEEE MI, CO8, IEEE VI, IEEE EI		
I2> Tms	1	0.025	1.5	0.025
I2> Time Dial	0.1	0.1	100	0.1
K	0.1	0.1	10	0.005
Reset Type	DMT	DMT	IDMT	N/A
tReset	40 ms	40 ms	100 s	0.01 s
Rtms	0.025	0.025	3.2	0.025
I2>> ?	No	Yes, No		
I2>>	1 In	0.1 In	40 In	0.01 In
tI2>>	0 ms	0 s	150 s	0.01 s

Table 14 - Negative sequence overcurrent settings

2.8 Undercurrent Protection Function

The MiCOM P521 relay includes two undercurrent elements, one of which is dedicated to the CB fail detection (see CB failure protection section). Another undercurrent element is provided as a protection function to detect loss of load conditions.

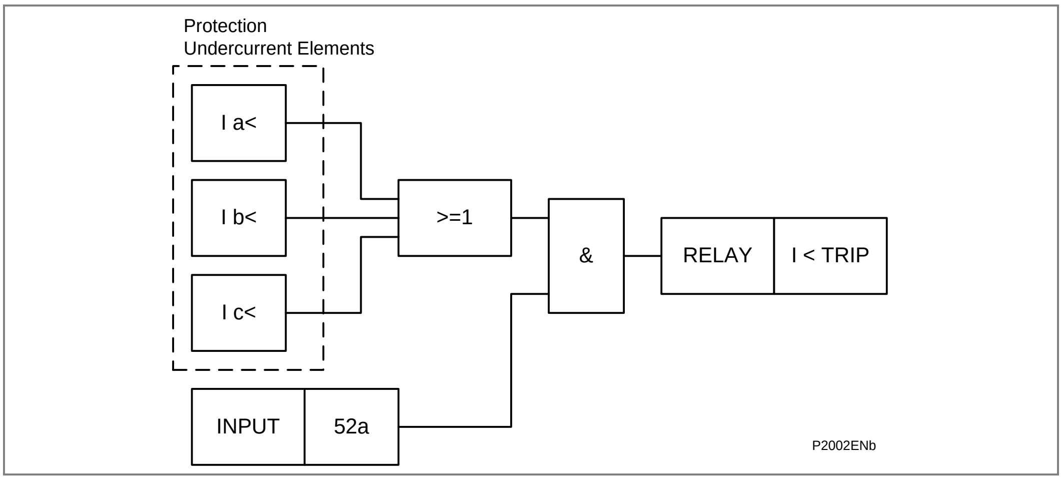


Figure 17 - Undercurrent protection logic

The undercurrent protection function is available only if the 52a auxiliary contact, indicating the CB status, is connected to one of the 5 logic inputs in the relay. The chosen logic input should be energized via the 52a contact of the circuit breaker.

To allocate a logic input to the 52a auxiliary contact, '52a' must be selected in the following location:

- AUTOMAT. CTRL/Inputs/Input #/ 52a

An "I<" alarm is given when at least one of the 3 phase current falls below the I< threshold and the CB is closed (indicated by the 52a input). When the alarm condition has been present for longer than the set time tI<, one or more output relays can be energized.

See the *AUTOMAT. CTRL/Trip Commands/ Trip tI<* menu for the allocation of tI< to the trip output relay RL1.

See the *AUTOMAT. CTRL/Output Relays/ tI<* menu for the allocation of tI< to the auxiliary output relays RL2 to RL8.

Table 15 below shows the undercurrent protection settings:

[37] Undercurrent	Default Setting	Min	Max	Step
I< ?	No	Yes, No		
I<	0.2 In	0.02 In	1 In	0.01 In
tI<	0 ms	0 s	150 s	0.01 s

Table 15 - Undercurrent protection settings

2.9 Blocked Overcurrent Protection

This type of protection is applicable for radial feeder circuits where there is a little or no back feed. However, for parallel feeders, ring circuits or where there can be a back feed from generators blocked overcurrent protection should not be used. In the case of the P521, blocked overcurrent protection is more likely to be used for back-up purposes only. Figure 18 shows a typical arrangement for blocked overcurrent protection.

This application relies on the up-stream IDMT relay being blocked by the start output from a down-stream relay that detects the presence of fault current above its setting. Both the up-stream and down-stream relays can then have the same current and time settings with grading being provided by the blocking feature. If the breaker failure protection is active, the block on the up-stream relay will be released if the down-stream circuit breaker fails to trip (see Circuit breaker failure section).

For a fault below relay C, the start contact from relay C will block operation of relay B. Furthermore, the start contact of relay B will block operation of relay A. Hence all 3 relays could have the same time and current settings, with the grading being obtained by the blocking signal received from a relay closer to the fault. This gives a constant, close time grading, but there will be no back-up protection in the event of the pilots being short circuited.

It is important to note that there is a small window where operation may not occur with this arrangement. This occurs because the start relay picks-up at the current setting (I>), but the IDMT curve requires the current to be 1.05 I> before it operates. Hence the up-stream relay should have a slightly lower current setting than the downstream relay to prevent this situation arising. However, the up-stream relay may have an increased current flowing through it due to the load current for other feeders and this may provide a solution.

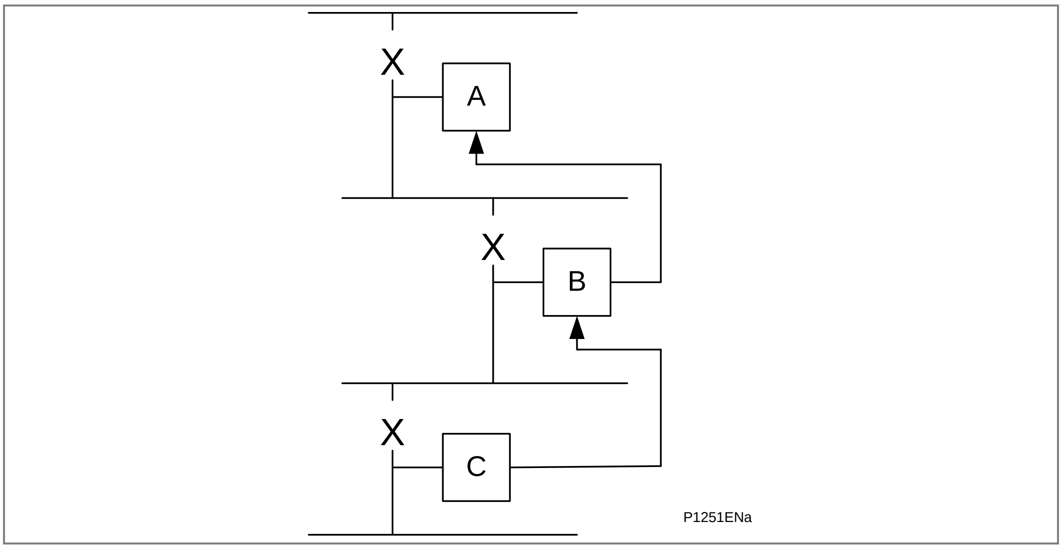


Figure 18 - Blocked overcurrent scheme

The blocking functions can be allocated in the "Blocking Logic 1 or 2" functions in the ***AUTOMAT. CTRL menu***. For more information on blocking functions refer to the blocking functions section.

2.10 Selective Scheme Logic

The blocked overcurrent protection section describes the use of non-cascade protection schemes which use the start contacts from downstream relays to block operation of upstream relays. In the case of Selective Overcurrent Logic (SOL), the start contacts are used to temporarily increase the time delays of upstream relays, instead of blocking them. This provides an alternative approach to achieving a non-cascade type of overcurrent scheme. It may be more familiar to some utilities than the blocked overcurrent arrangement.

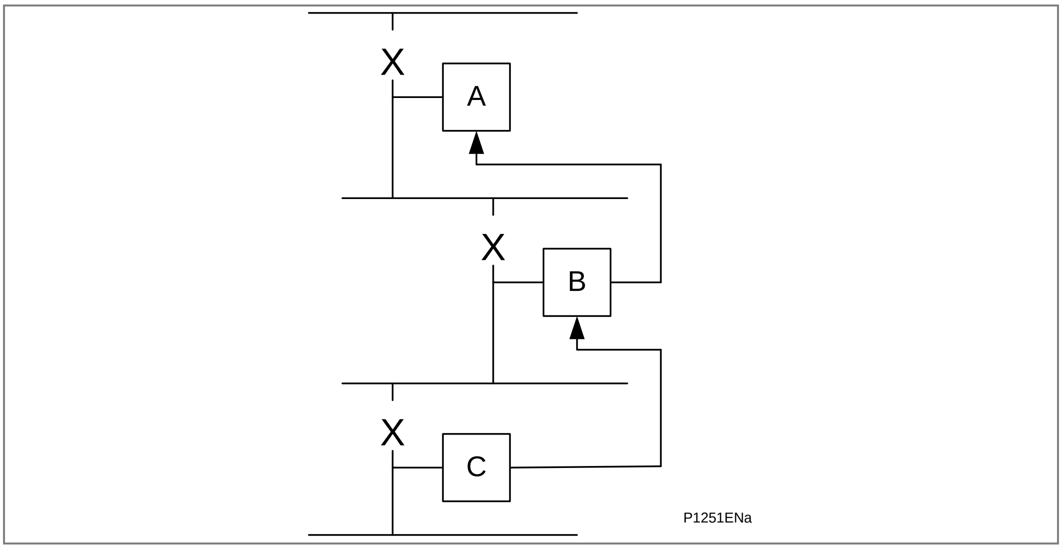


Figure 19 - Typical scheme logic

The SOL function temporarily changes the time delay settings of the second, third and fourth stages of phase overcurrent and earth fault elements (I>>, I>>>, I>>>>, Ie>>, Ie>>> and Ie>>>>) to the tSel1 or tSel2 timer settings. The choice of timers will depend upon which selective logic function is enabled, either Log Sel1 or Log Sel 2. The Log Sel1 or Log Sel2 functions are enabled by selecting, then energizing, one of the 5 opto inputs ***(AUTOMAT.CTRL/Inputs/Input #)***.

The Logic Select 1 settings ***(AUTOMAT. CTRL)*** are shown in the Table 16 below. These settings are identical to the Logic Select 2 menu.

Logic Select. 1 (2)	Default Setting	Min	Max	Step
Sel1 tI>>	No	Yes, No		
Sel1 tI>>>	No	Yes, No		
Sel1 tI>>>>	No	Yes, No		
Sel1 tIe>>	No	Yes, No		
Sel1 tIe>>>	No	Yes, No		
Sel1 tIe>>>>	No	Yes, No		
tsel1	0 ms	0 s	150 s	0.01 s

Table 16 - Selective logic settings

Note	*Choosing 'Yes' selects the function to modified by the Logic Select function.*

To allow time for a start contact to initiate a change of setting, the time settings of the second, third and fourth stages should include a nominal delay. Guidelines for minimum time settings are identical to those given for blocked overcurrent schemes.

2.11 Cold Load Pick-Up

The cold load pickup feature enables the selected settings of the MiCOM P521 relay to be changed to cater for temporary overload conditions that may occur during cold starts, such as switching on large heating loads after a sufficient cooling period, or loads that draw high initial starting currents.

When a feeder is energized, the current levels for a period of time following energization may differ greatly from the normal load levels. Although this will not affect the current differential protection, the back-up overcurrent settings that have been applied may not be suitable during this period.

The Cold Load Pick-up (CLP) logic serves to raise the settings of selected stages for a selectable duration. This allows the protection settings to be set closer to the load profile by automatically increasing them after energization. The CLP logic provides stability, without compromising protection performance during starting. Note that any of the disabled overcurrent stages in the main relay menu will not appear in the Cold Load PU Menu.

Table 17 below shows the relay menu for the '*Cold Load Pick-up*' logic, including the available setting ranges and factory defaults.

Cold Load PU	Default Setting	Min	Max	Step
Cold Load PU ?	No	Yes, No		
tI>?	No	Yes, No		
tI>>?	No	Yes, No		
tI>>>?	No	Yes, No		
tI>>>>?	No	Yes, No		
tIe>?	No	Yes, No		
tIe>>?	No	Yes, No		
tIe>>>?	No	Yes, No		
tIe>>>>	No	Yes, No		
tI2>?	No	Yes, No		
tI2>>?	No	Yes, No		
tTherm?	No	Yes, No		
Level	50%	20%	500%	1%
tCL	1 s	0.1 s	3600 s	0.1 s

Table 17 - Cold load pick-up settings

The tCL timer controls the time for which the relevant overcurrent and earth fault settings are altered following an external input (e.g. circuit breaker closure). When the set tCL time has elapsed, all of the relevant settings revert back to their original values. The tCL timer is initiated via a dedicated logic input (refer to ***AUTOMAT. CTRL/Inputs/Input #/ Cold L PU***) signal generated by connecting an auxiliary contact from the circuit breaker or starting device to the relay's opto-inputs.

The Level setting indicates by what percentage the current thresholds are modified. For example, a 0.8 A setting will be increased to 1.6 A if the Level setting is 200%.

The following sections describe applications where the CLP logic may be useful and the settings that need to be applied.

2.11.1 Air Conditioning/Resistive Heating Loads

Where a feeder is used to supply air conditioning or resistive heating loads there may be a conflict between the ‘steady state’ overcurrent settings and those required following energization. This is due to the temporary increase in load current that may arise during starting. The CLP logic is used to alter the applied settings during this time.

With the Cold Load PU enabled, the affected thresholds are selected to be adjusted for the required time to allow the start condition to subside. A percentage value is selected as the amount by which the selected threshold is increased/decreased.

The time for which the adjusted thresholds are valid is defined by the tCL setting. After this time, the settings return to normal.

It may not be necessary to alter the protection settings following a short supply interruption. In this case the CLP function is not activated.

2.11.2 Motor Feeders

In general, feeders supplying motor loads would be protected by a dedicated motor protection device, such as the MiCOM P220 or P241 relay. However, if no specific protection has been applied (possibly due to economic reasons) then the CLP function in the MiCOM P521 relay may be used to modify the overcurrent settings accordingly during starting.

Depending upon the magnitude and duration of the motor starting current, it may be sufficient to simply block operation of instantaneous elements or, if the start duration is long, the time delayed protection settings may also need to be raised. Hence, a combination of both blocking and raising of settings of the relevant overcurrent stages may be adopted. The CLP overcurrent settings in this case must be chosen with regard to the motor starting characteristic.

As previously described, the CLP logic includes the option of raising the current settings of the overcurrent and earth fault protection. This may be useful where instantaneous earth fault protection needs to be applied to the motor. During conditions of motor starting, it is likely that incorrect operation of the earth fault element would occur due to asymmetric CT saturation. This is a result of the high level of starting current causing saturation of one or more of the line CT’s feeding the overcurrent/earth fault protection. The resultant transient imbalance in the secondary line current quantities is thus detected by the residually connected earth fault element. For this reason, it is normal to either apply a nominal time delay to the element, or to utilize a series stabilizing resistor.

The CLP logic may be used to allow reduced operating times or current settings to be applied to the earth fault element under normal running conditions. These settings could then be raised prior to motor starting, via the logic.

2.11.3 Earth Fault Protection Applied TO Transformers

Where an earth fault relay is residually connected on the primary side of a delta-star transformer, no time delay is required for co-ordination purposes, due to the presence of the delta winding. However, a nominal time delay or stabilizing resistor is recommended to ensure transient stability during transformer energization.

The CLP logic may be used in a similar manner to that previously described for the motor application.

It should be noted that this method will not provide stability in the event of asymmetric CT saturation which occurs as a result of an unbalanced fault condition. If problems of this nature are encountered, the best solution would still be the use of a stabilizing resistor.

2.11.4 Switch OnTo Fault (SOTF) Protection

In some feeder applications, fast tripping may be required if a fault is present on the feeder when it is energized.

Such faults may be due to a fault condition not having been removed from the feeder, or due to earthing clamps having been left on following maintenance. In either case, it may be desirable to clear the fault condition in an accelerated time, rather than waiting for the time delay associated with IDMT overcurrent protection.

The above situation may be catered for by the CLP logic. Selected overcurrent/earth fault stages could be set to a lower threshold (typically 30% of the nominal threshold) for a defined period following circuit breaker closure (typically 200 ms). Hence, fault clearance would be achieved for a Switch OnTo Fault (SOTF) condition.

3 APPLICATION OF NON-PROTECTION FUNCTIONS

3.1 Auxiliary Timers (tAux 1 and tAux 2)

The active group can also be assigned to an output relay by selecting “Active Group” in *AUTOMAT.CRTL/OUTPUTS* menu.

3.2 Setting Group Selection

The MiCOM P521 relay has four setting groups related to the protection functions named PROTECTION G1 and G2 and G3 and G4. Only one group is active at any one time. Changes between the groups are done via the front interface (*CONFIGURATION/Group Select/Setting Group 1, 2 3 or 4)*, a dedicated logic input (*AUTOMAT CTRL/Inputs/Input #/Changeset*) where # is the chosen logic input or through the communication ports (refer to Communication Mapping Guide *P521/EN GC* for more detailed information).

The relative priority of the different ways of changing the active setting group is listed below:

ORIGIN OF THE ORDER	PRIORITY LEVEL
FRONT PANEL	HIGHEST
LOGIC INPUT	MEDIUM
REMOTE COMMUNICATION	LOWEST

To avoid nuisance tripping the setting group change is only executed when no protection function (except for current differential and thermal overload functions) or automation function is running. If a setting group change is received during any protection or automation function it is stored and executed after the last protection timer has elapsed.

The active group is displayed in the OP PARAMETERS menu.

The active group can also be assigned to an output relay by selecting “Active Group” in AUTOMAT. CTRL/Output relays.

3.2.1 Change of Setting Group by a Logic Input

It is possible to configure how the digital inputs are activated, either on a falling edge/ low level or on a rising edge/ high level. The choice is made in the ***CONFIGURATION***/***Configuration Inputs***/***Inputs menu*** (0=falling edge/ low level, 1=rising edge/ high level). The setting group input mode (EDGE or LEVEL) can be selected in the ***CONFIGURATION***/***Group Select***/***Change Group Input menu***.

3.2.2 Manual Setting Group Change via Front Interface

The setting group can be selected to be 1, 2, 3 or 4 in the ***CONFIGURATION***/***Group Select***/***Setting*** group menu. Manual changes can only be made if “EDGE” is selected in the “Change Group Input” cell.

3.3 Latch Functions

Following a protection trip the trip contact (RL1) remains closed until the current falls below the undercurrent threshold or for the “tOpen Pulse” time (***AUTOMAT. CTRL/CB Supervision*** menu), whichever is the greater. Some applications, however, demand that the trip contact must latch following a protection trip. The MiCOM P521 caters for this requirement by allowing the user to latch RL1 after being operated by one or several thresholds. This means, for example, that RL1 can be latched for a current differential trip, but could be selected not to latch for an overcurrent trip. Table 18 below shows the “Latch Functions” menu; to latch a given function, following a trip, select “Yes”. Selecting “No” means that the function will not be latched.

The "Latch Functions" menu can be found under ***AUTOMAT. CTRL.***

Latch Functions	Default Setting	Choices
Latch Idiff	No	Yes, No
Latch Direct I-Trip	No	Yes, No
Latch C Diff I-Trip	No	Yes, No
Latch PIT	No	Yes, No
Latch tI>	No	Yes, No
Latch tI>>	No	Yes, No
Latch tI>>>	No	Yes, No
Latch tI>>>>	No	Yes, No
Latch tIe>	No	Yes, No
Latch tIe>>	No	Yes, No
Latch tIe>>>	No	Yes, No
Latch tIe>>>>	No	Yes, No
Latch tI<	No	Yes, No
Latch tI2>	No	Yes, No
Latch tI2>>	No	Yes, No
Latch Thermal θ	No	Yes, No
Latch Brkn. Cond	No	Yes, No
Latch t Aux 1	No	Yes, No
Latch t Aux 2	No	Yes, No

Table 18 - Latch functions menu

The latched RL1 contact can be reset by reading (🕮) and clearing (**C**) the relevant protection alarm.

3.4 Blocking Functions

The P521 allows the user to block operation of any protection function by energizing a selected digital input. To block operation of a protection function the user must first select the function to be blocked, followed by a digital input to perform the block.

The Blocking Logic 1 and Blocking Logic 2 ***(AUTOMAT. CTRL)*** contain a list of protection functions that can be blocked. Selecting 'Yes' adds the chosen function to the list of functions that will be blocked when the appropriate input is energized. Table 19 shows a list of the protection functions available in the Blocking Logic 1 and Blocking Logic 2 menus.

Blocking Logic 1 (2)	Default Setting	Choices
Block Idiff	No	Yes, No
Block tI>	No	Yes, No
Block tI>>	No	Yes, No
Block tI>>>	No	Yes, No
Block tI>>>>	No	Yes, No
Block tIe>	No	Yes, No
Block tIe>>	No	Yes, No
Block tIe>>>	No	Yes, No
Block tIe>>>>	No	Yes, No
Block tI2>	No	Yes, No

Blocking Logic 1 (2)	Default Setting	Choices
Block tI2>>	No	Yes, No
Block Therm θ	No	Yes, No
Block Brkn. Cond	No	Yes, No
Block t Aux 1	No	Yes, No
Block t Aux 2	No	Yes, No

Table 19 - Blocking logic menu

Energizing the chosen digital input will block every protection function that has been selected. To perform the blocking function the digital input must be allocated to either Blk Log 1 or Blk Log 2.

Figure 20 illustrates the blocking logic for selected protection features.

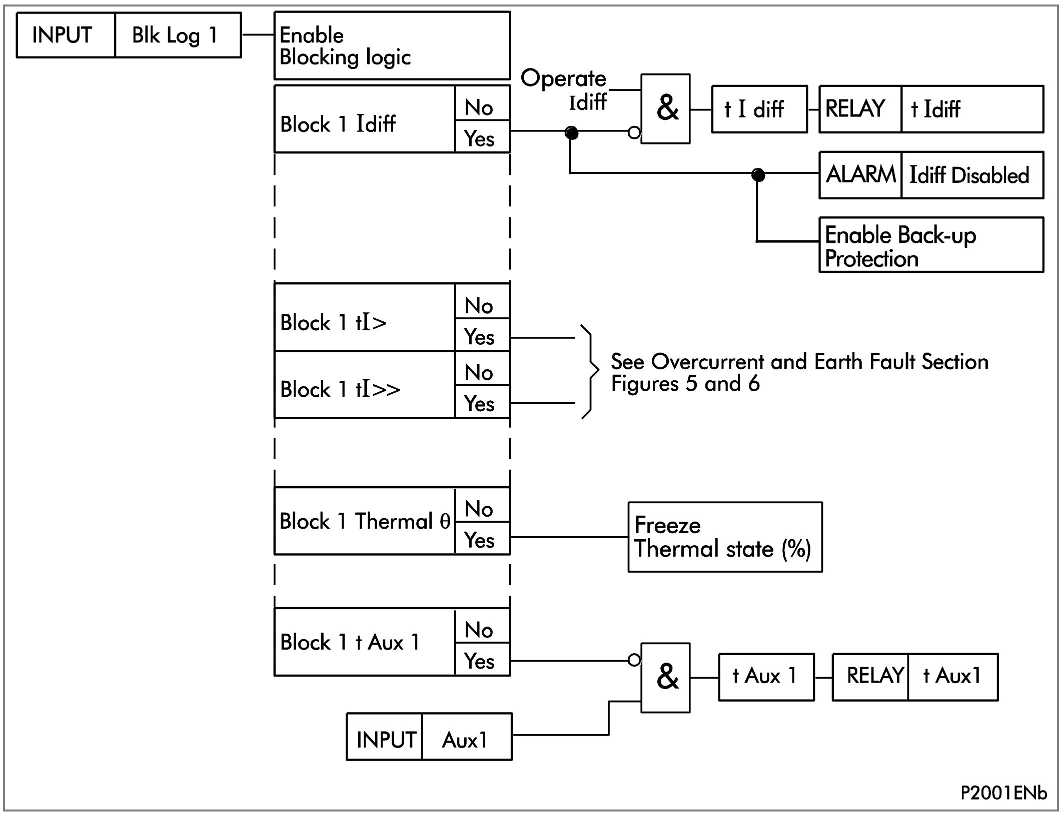


Figure 20 - Blocking logic for selected protection features

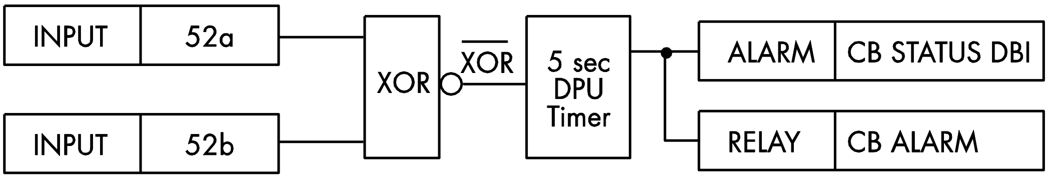
3.5 Circuit Breaker State Monitoring

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 MiCOM P521 relay incorporates circuit breaker state monitoring, giving an indication of the position of the circuit breaker. This indication is available either at the front of the relay or via the communication network.

The position of the circuit breaker is determined by wiring the 52a and 52b, circuit breaker auxiliary, contacts to the digital inputs (*AUTOMAT.CTRL/Inputs/Input #/52a or 52b)*.

The programmable LEDs on the front of the relay can be configured to indicate the position of the circuit breaker. This can be done by selecting the appropriate digital input in the LEDs menu (*CONFIGURATION/Led #/Led Input #)*.

Once the 52a and 52b contacts have been assigned to a digital input the P521 automatically checks that the circuit breaker auxiliary contacts are not simultaneously in the same state for more than 5 seconds (i.e. both open or both closed). This could only occur if there was a fault with the circuit breaker auxiliary contacts or if the circuit breaker becomes jammed whilst operating. In the event that both auxiliary contacts are in the same state for more than 5 seconds the relay issues the “CB STATUS DBI” latched alarm (‘DBI’ meaning “Don’t Believe It”). If necessary the “CB Alarm” output relay can be used to signal this condition to the annunciator. The logic behind this feature is shown in Figure 21.



52b	52a	$\overline{XOR}$
0	0	1
0	1	0
1	0	0
1	1	1

P2066ENa

Figure 21 - CB Status DBI logic diagram

3.6 CB Control

The P521 allows the circuit breaker to be manually tripped or closed by any one of these methods:

- Via user interface
- Via opto inputs
- Via control communications (SCADA etc.)

Methods 1 and 2 are explained below. Method 3, via control communications, is described in the P521 communication mapping guide (*P521/EN GC*).

If an attempt to close the breaker is being made, and a protection trip signal is generated, the protection trip command overrides the close command.

3.6.1 CB Trip and Close Via User Interface

To manually trip or close the circuit breaker via the user interface the user must first locate the "Trip and Close" cell in the OP PARAMETERS menu. Pressing the key in this cell, followed by or will display either "Trip", "Close" or "No Operation". If "No Operation" is selected a CB trip or close will not be performed. Selecting "Trip" will cause the trip contact (RL1) to operate for a duration equal to the "t Open Pulse" time (AUTOMAT. CTRL/CB Supervision). The operation will be accompanied by the illumination of the Trip LED and the "REM TRIP" alarm (indicating a remote trip has been performed). An event and fault record will be generated every time a remote trip is performed.

If "Close" is selected in the "Trip and Close" cell the relay closes the output contact assigned to "CB Close" for a duration equal o the "t Close Pulse" time. The "CB Close" command will also generate a protection event.

3.6.2 CB Trip and Close Via Opto Inputs

If necessary, the circuit breaker can be tripped or closed by energizing the appropriate opto input. To assign an opto to either of these functions the user must select either "Log Trip" or "Log Close" in the inputs column (AUTOMAT. CTRL). Energizing the Log Trip input will cause the trip contact to operation for a duration equal to the "t Trip Pulse" time + the total time the opto input is energized. The operation will be accompanied by the TRIP LED illuminating and the "REM TRIP" alarm being displayed. An event and fault record will be generated every time a remote trip is performed.

Energizing the "Log Close" input causes the contact assigned to "CB Close" to operate for a duration equal to "t Close Pulse" time + the total time the opto input is energized. Closing the breaker via an opto input will also generate a protection event.

3.6.3 CB Manual Trip and Close Delays

The P521 relay also offers the facility of delaying the manual trip or close operation. This would give personnel time to move away from the circuit breaker following a trip or close command. The associated delays are set using the "CB Man Trip Dly" and "CB Man Close Dly" settings (AUTOMAT. CTRL/CB Supervision). Once a manual trip or close has been initiated the relay displays either "Tripping" or "Closing" for the duration of the selected delays. Pressing the key, while either of the messages are being displayed, will cancel the operation. The manual delay time will apply to all manual CB trip or close commands from any interface (keypad, opto input, front port or rear port).

3.7 Circuit Breaker Condition Monitoring

Periodic maintenance of circuit breakers is necessary to ensure that the trip circuit mechanism operates correctly and also that the interrupting capability has not been compromised due to previous fault interruptions. Generally such maintenance is based on a fixed time interval or a fixed number of fault current interruptions. These methods of monitoring circuit breaker condition give a rough guide only and can lead to excessive maintenance.

The relay records various statistics related to each circuit breaker trip operation, allowing a more accurate assessment of the circuit breaker condition to be determined. These monitoring features are discussed in the following section.

3.7.1 Circuit Breaker Condition Monitoring Features

For each circuit breaker trip operation the relay records statistics as shown in the following table, taken from the relay menu. The *RECORDS/CB Monitoring* menu cells shown, are counter values only. In the event that any of the counters exceed a settable threshold (explained later), an output contact or LED can be operated (both labeled “CB Alarm”). In addition to operating an LED or contact, the relay will also display an alarm message, on the LCD, which is unique to each monitoring feature.

These cells are read only:

MENU TEXT	
CB Monitoring	
CB Opening Time	Displays the most recent CB opening time.
CB Closing Time	Displays the most recent CB closing time.
CB Operations	Displays the number of opening commands executed by the CB.
ΣAmps(n) IA	Displays the summation of the Amps (or Amps squared) interrupted by the phase A CB.
ΣAmps(n) IB	Displays the summation of the Amps (or Amps squared) interrupted by the phase B CB.
ΣAmps(n) IC	Displays the summation of the Amps (or Amps squared) interrupted by the phase C CB.

The counters may be reset to zero by pressing the **(C)** key in the relevant cell. The user may wish to reset the counters following a circuit breaker maintenance inspection or overhaul.

If necessary the counters can be frozen during commissioning or maintenance testing of the relay. To disable the counters select ‘Yes’ in the “Disable CB Stats” cell (AUTOMAT.CTRL/Commissioning).

3.7.2 CB Supervision Settings

Table 20 below, details the CB supervision settings that affect the CB condition monitoring functions. It includes the setup of the current broken facility and those features that can be set to raise an alarm.

All the settings are available in the AUTOMAT.CTRL/CB supervision menu.

CB supervision	Default Setting	Min	Max	Step
TC Supervision ?	No	Yes, No		
t trip circuit tSUP	100 ms	100 ms	10 s	50 ms
CB Open S’vision	No	Yes, No		
CB Open Time	50 ms	50 ms	1s	50 ms

CB supervision	Default Setting	Min	Max	Step
CB Close S'vision	No	Yes, No		
CB Close Time	50 ms	50 ms	1s	50 ms
CB Open Alarm ?	No	Yes, No		
CB Open NB =	0	0	50000	1
ΣAmps (n) ?	No	Yes, No		
ΣAmps (n)	0	0	4000 E6	1 E6
n	1	1	2	1
t Open Pulse	100 ms	100 ms	5 s	50 ms
t Close Pulse	100 ms	100 ms	5 s	50 ms
CB Man Trip Dly	0 s	0 s	60 s	0.1 s
CB Man Close Dly	0 s	0 s	60 s	0.1 s

Table 20 - CB supervision menu

For more information on the TC supervision refer the trip circuit supervision section.

3.7.3 Setting the Operating Time Thresholds (CB Open Time/CB Close Time)

Slow CB operation is also indicative of the need for mechanism maintenance. Therefore, two alarms are provided to indicate that the breaker is either slow to trip or slow to close. These timers are set in relation to the specified interrupting and closing times of the circuit breaker.

In the event that the opening time of the breaker exceeds the "CB Open Time" setting the relay will display the "T Operating CB" alarm message. If, however the circuit breaker closing time is no longer than the "CB Close Time" the relay will display the "CB CLOSE FAILURE" alarm message.

Note	*The 52a auxiliary contact must be mapped to a digital input in order for this feature to work. The feature will be automatically disabled if the 52a contact is not mapped to a digital input.*

3.7.4 Setting the Number of Operations Thresholds (CB Open NB =)

Every operation (opening or closing) of a circuit breaker results in some degree of wear for its components. Thus, routine maintenance, such as oiling of mechanisms, may be based upon the number of operations. Suitable setting of the maintenance threshold will allow an alarm to be raised, indicating when preventative maintenance is due.

Certain circuit breakers, such as oil circuit breakers (OCB's) can only perform a certain number of fault interruptions before requiring maintenance attention. This is because each fault interruption causes carbonizing of the oil, degrading its dielectric properties.

The circuit breaker condition monitoring counters will be updated every time the relay issues a trip command (RL1 operating) or when a remote trip is performed (see section 3.6). In cases where the breaker is tripped by an external protection device it is also possible to update the CB operations counter. This is achieved by allocating one of the logic inputs to close RL1 via an auxiliary timer (tAUX1 to tAUX2).

In the event that the number of circuit breaker operations exceeds the "CB Open NB =" setting the relay will display the "CB Open NB" alarm message.

3.7.5 Setting the ΣI^n thresholds (Σ Amps (n))

Where overhead lines are prone to frequent faults and are protected by Oil Circuit Breakers (OCBs), oil changes account for a large proportion of the life cycle cost of the switchgear. Generally, oil changes are performed at a fixed interval of circuit breaker fault operations. However, this may result in premature maintenance where fault currents tend to be low, and hence oil degradation is slower than expected.

The ΣI^n counter monitors the cumulative severity of the duty placed on the interrupter, allowing a more accurate assessment of the circuit breaker condition to be made.

For OCBs, the dielectric withstand of the oil generally decreases as a function of ΣI^2t. This is where 'I' is the fault current broken, and 't' is the arcing time within the interrupter tank (not the interrupting time). As the arcing time cannot be determined accurately, the relay would normally be set to monitor the sum of the broken current squared, by setting $n = 2$.

For other types of circuit breaker, especially those operating on higher voltage systems, practical evidence suggests that the value of $n = 2$ may be inappropriate. In such applications n may be set to 1.

An alarm in this instance may be indicative of the need for gas/vacuum interrupter HV pressure testing, for example.

It is imperative that any maintenance programme must be fully compliant with the switchgear manufacturer's instructions.

The P521 relay records the fault current at the instant the trip output (RL1) is initiated. This current is then summed with the value previously recorded. If the summed current exceeds the "Σ Amps (n)" threshold the relay will display the "Sum A n" alarm message.

In cases where the circuit breaker is tripped by an external protection device it is also possible to update the ΣI^n counter. This is achieved by allocating one of the logic inputs to close RL1 via an auxiliary timer (tAUX1 and tAUX2).

3.7.6 Setting the Trip and Close Pulse Times (t Open Pulse/t Close Pulse)

The length of the trip or close pulse can be set via the 't Open Pulse' and 't Close Pulse' settings respectively. These should be set long enough to ensure the breaker has completed its open or close cycle before the pulse has elapsed.

The duration of the opening time is measured from the trip pulse being issued to the opening of the 52a auxiliary contact. Conversely, the duration of the closing time is measured from the close pulse being issued to the 52a closing.

3.8 Trip Circuit Supervision

The trip circuit extends beyond the relay enclosure and passes through more components, such as fuse, links, relay contacts, auxiliary contacts and so on. These complications, coupled with the importance of the circuit, have directed attention to its supervision.

3.8.1 MiCOM P521 Trip Circuit Supervision Mechanism

The Trip Circuit Supervision function included in the MiCOM P521 relay is performed as follows:

A logic input can be assigned in the ***AUTOMAT.CTRL/Inputs/ Input #/Trip Circ*** menu cell. This logic input must be inserted in the trip circuit according to one of the typical application diagrams, shown later.

When the function TC Supervision is enabled by selecting ‘Yes’ within the AUTOMAT.CTRL/CB Supervision sub-menu, the relay continuously checks the trip circuit continuity whatever the CB status – opened CB or closed CB. This function is enabled when the trip output contact (relay RL1) is not energized and it is disabled as long as the trip output contact is operating.

A “TRIP CIRCUIT” alarm signal (trip circuit failure) is generated if the opto-input detects no voltage signal for a time longer than the settable timer tSUP ***(AUTOMAT.CTRL/CB Supervision)***. The “52 Fail” contact can be selectively closed in the event of a trip coil failure.

As the TC supervision function is disabled when the trip output contact is operating, this function is suitable for use with the product latching logic on.

The TC supervision function can be selectively blocked from an external trip contact, so that any external trip (not using the P521 to trip the CB) can be used, without the P521 giving the “TRIP CIRCUIT” alarm. The external trip contact is wired into a logic input, which is assigned in the ***AUTOMAT.CTRL/Inputs/ Input #/TCS Block*** menu cell.

The following table shows the setting associated with the trip circuit supervision function:

Menu	Setting Range		Step
	Min	Max	
TC Supervision ?	Yes	No	
tSUP	100 ms	10 s	50 ms

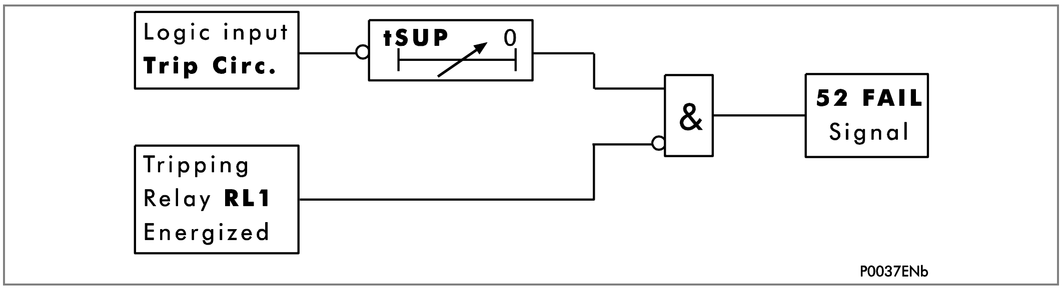


Figure 22 - Trip circuit supervision logic diagram

Three application examples are shown below.

Example 1

In this example only the 52a auxiliary contact is available, the MiCOM P521 relay monitors the trip coil whatever the CB status (CB open or CB closed). However, in this example the relay does not supervise the trip circuit prior to the trip contact.

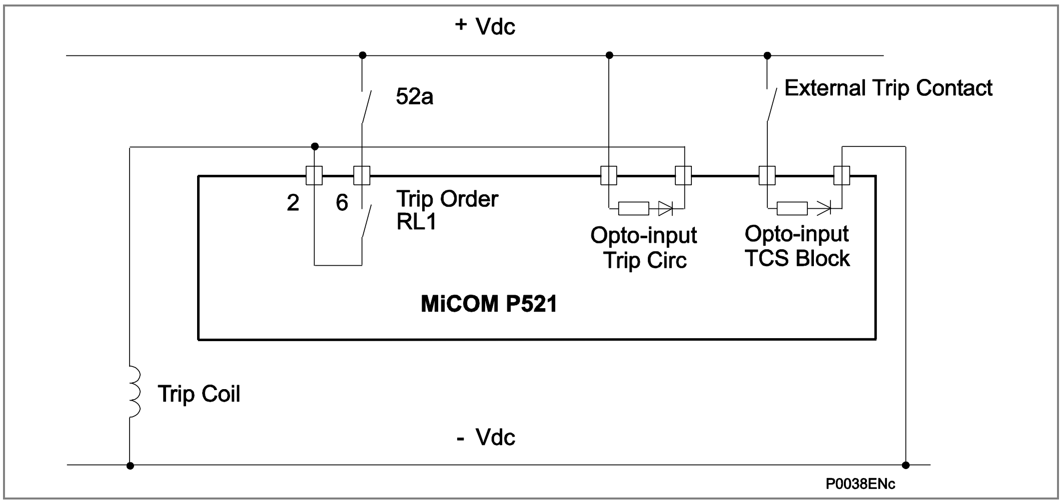


Figure 23 - Trip coil monitoring

Example 2

In this example both the 52a and 52b auxiliary contacts are available, the MiCOM P521 relay monitors the whole of the trip circuit when the CB is closed and part of the trip circuit when the CB is open. When the circuit breaker is open the supervision current bypasses the trip coil via the 52b contact, thus trip coil supervision is not provided whilst in this condition. If the circuit breaker is open, a fault in the trip path will only be detected on CB closing, after the tSUP delay time (typically set to 400 ms).

In this example resistor R1 needs to be placed in series with the 52b contact to prevent damage if the trip contact (RL1) is latched, stays involuntarily closed, or a long trip pulse time is programmed.

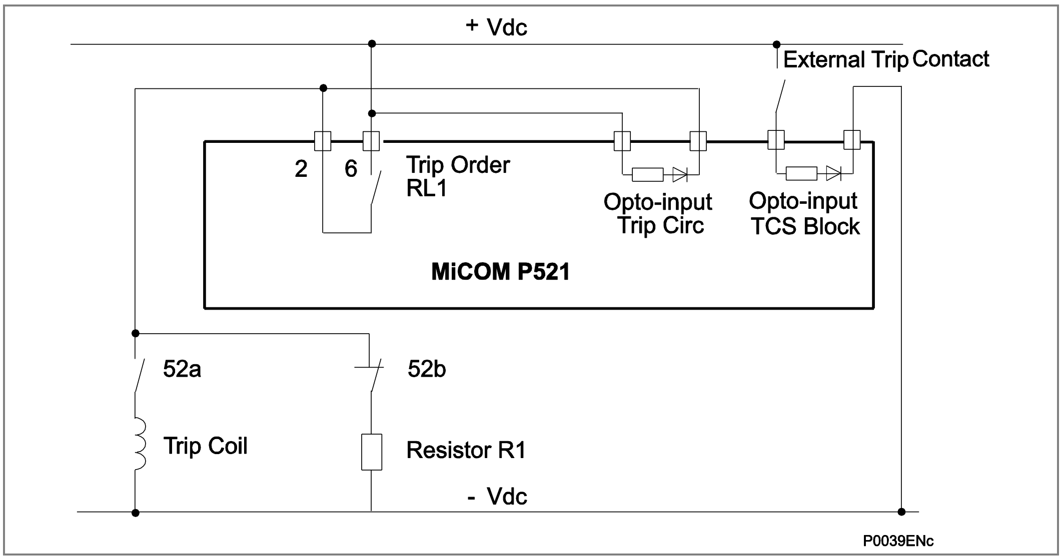


Figure 24 - Trip coil and auxiliary contact monitoring

Example 3

As with example 2, both the 52a and 52b auxiliary contacts are available. The MiCOM P521 relay monitors the whole of the trip circuit whatever the CB status (CB open or CB closed).

In this example resistor R1 needs to be fitted to prevent permanent trip coil energization, if the trip contact (RL1) is latched, stays involuntarily closed, or a long trip pulse time is programmed.

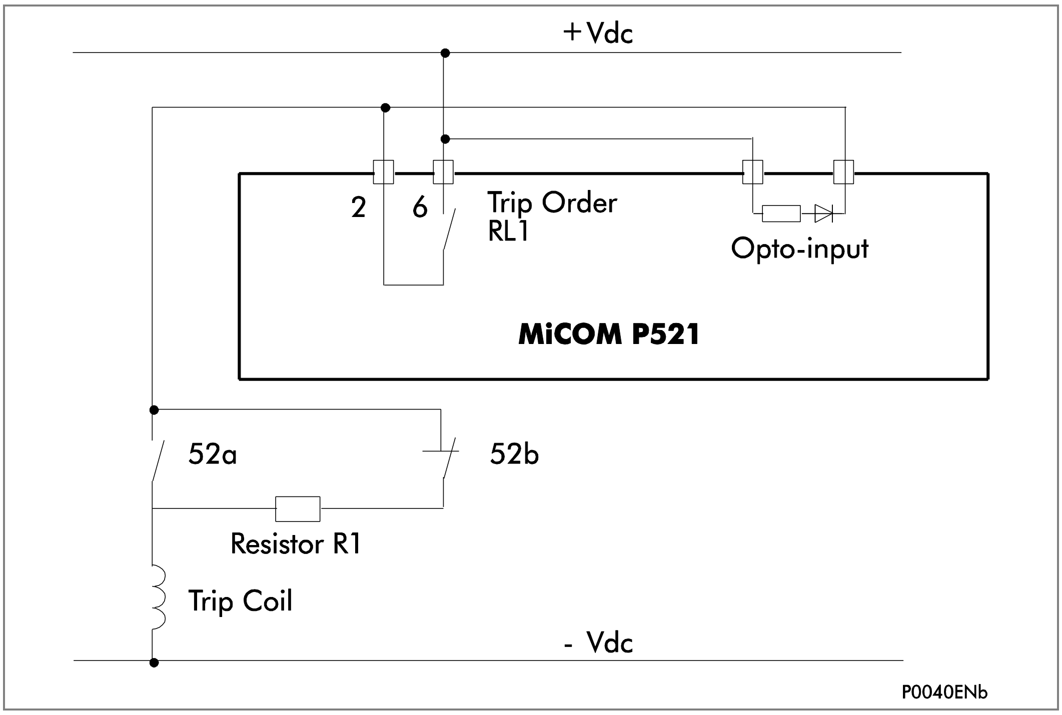


Figure 25 - Trip coil and auxiliary contact monitoring regardless of CB position

3.8.2 Calculation of External Resistor R1

The calculation of the R1 resistor value takes into account a minimum current value flowing through the opto-input. This minimum current value is a function of the relay auxiliary voltage range.

1 - Case of example No 2:

The R1 resistor maximum value (in Ohms) is defined by the following formula:

$R1 \leq (0.8 \times Vdc - V_{min})/I_{min}$

Where:

Vdc = auxiliary voltage value (dc voltage)

V_{min} = minimum voltage required for opto-input operation

I_{min} = minimum current required for opto-input operation

Relay Auxiliary Voltage Range		
24 – 60 Vdc	48 – 150 Vdc	130 – 250 Vdc/ 110-250 Vac
$R1 \leq (0.8 \times Vdc - 15)/0.0035$	$R1 \leq (0.8 \times Vdc - 25)/0.0035$	$R1 \leq (0.8 \times Vdc - 38)/0.0022$

In addition, the R1 resistor withstand value (in Watts) is defined below:

$P_{R1} > 2 \times (1.2 \times Vdc)^2 / R1$

2 - Case of example No 3:

The R1 resistor maximum value (in Ohm) is defined by the following formula:

$$R1 \leq \left[\frac{(0.8 \times Vdc - V_{min})}{I_{min}} \right] - R_{coil}$$

Where:

Vdc = auxiliary voltage value (dc voltage).

V_{min} = minimum voltage required for opto-input operation

I_{min} = minimum current required for opto-input operation

R_{coil} = Trip coil resistance value

Relay Auxiliary Voltage Range		
24 – 60 Vdc	48 – 150 Vdc	130 – 250 Vdc/ 110-250 Vac
$R1 \leq \left[\frac{(0.8 \times Vdc - 15)}{0.0035} \right] - R_{coil}$	$R1 \leq \left[\frac{(0.8 \times Vdc - 25)}{0.0035} \right] - R_{coil}$	$R1 \leq \left[\frac{(0.8 \times Vdc - 38)}{0.0022} \right] - R_{coil}$

In addition, the R1 resistor withstand value (in Watts) is defined below:

$P_{R1} > 2 * (1,2 * Vdc)^2 / (R1 + R_{coil})$

Note	*Any additional series impedances, such as anti-pumping relays, must be taken into account when calculating the value of resistor R1.*

It is assumed that the maximum auxiliary voltage variation is ±20%.

3.9 Event Records

The relay records and time tags up to 250 events and stores them in non-volatile 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 panel EIA(RS)232 port or remotely, via the rear EIA(RS)485 port.

For extraction from a remote source via communications, refer to the Communications Mapping Guide *P521/EN GC*, where the procedure is fully explained.

3.10 Fault Records

Each time any programmed threshold is exceeded a fault record is created and stored in memory. The fault record logs up to 25 faults and stores them in non-volatile memory. This enables the system operator to read and analyze information regarding the network failures. When the available space is exhausted, the oldest fault is automatically overwritten by the new one.

Any of the 25 stored fault records can be viewed in the RECORDS/Fault Record menu. The desired fault record can be selected in the “Record Number” cell which is selectable from up to 25 records, 25 being the most recent record and 1 being the oldest. These records consist of fault flags, 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 records are available for viewing either on the display, or via the front panel EIA(RS)232 port or remotely, via the rear EIA(RS)485 port.

For extraction from a remote source via communications, refer to the Communications Mapping Guide *P521/EN GC*, where the procedure is fully explained.

3.11 Instantaneous Recorder

Each time any programmed threshold is crossed an instantaneous record is created and displayed in the ***RECORDS/Instantaneous*** menu. The last five protection starts, with the duration of the information are available. The number of the faults, hour, date, origin (I>, I>>, I>>> or Ie>, Ie>>, Ie>>>), length (duration of start signal), trip (a trip has appeared, yes or no) are displayed.

3.12 Disturbance Recorder

The integral disturbance recorder has an area of memory specifically set aside for record storage. A total of 5 records can be stored while the total duration is 15s. The user can select the total number of disturbance records in the setting and then the duration of each record is determined, as below:

Number of Record	Duration of Each Record
5	3 s
4	3 s
3	5 s
2	7 s
1	9 s

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.

The recorder stores actual samples which are taken at a rate of 32 samples per cycle.

Each disturbance record consists of analogue data channels and digital data channels. The relay also provides the relevant CT ratios for the analogue channels, to enable scaling to primary quantities.

The *RECORDS/Disturb Record* settings are shown in Table 21:

Disturb Record	Default Setting	Min	Max	Step
Pre-Time	0.1 s	0.1 s	3 s	0.1 s
Note *From V12.A the Post-Time setting cell is removed from setting.*				
Post-Time	0.1 s	0.1 s	3 s	0.1 s
Disturb Rec Trig	ON INST	ON INST, ON TRIP		

Table 21 - Disturbance record menu

The total recording time consists of a combination of the pre and post fault recording times. For example, the default settings show that the total record number is 5 and the pre-time time is set to 100 ms, then post fault time is:

3 - 0.1 = 2.9 s.

The disturbance recorder can be triggered by a trip condition (operation of RL1) by selecting “ON TRIP”, in the disturbance recorder trigger cell. Alternatively, the disturbance recorder can be triggered by any start condition by selecting “ON INST”. It is also possible to trigger the disturbance recorder by energizing one of the programmable opto inputs (labeled “Strt Dist”), or via the remote control communications, or via the HMI in the menu OP Parameter/Disturb Trigger.

3.13 Rolling and Peak Demand Values

The MiCOM P521 relay is able to store the rolling average and peak values for the 3 phase currents. The calculation is performed over a selectable sub-period between 1 and 60 minutes. The calculation principle is described below.

3.13.1 Rolling Demand

There are two settings associated with the Rolling demand measurements, which are “Sub Period” and “Num of Sub Per”. These settings can be found under ***RECORDS/Rolling Demand***. The “Sub Period” setting determines the time over which the average RMS current values are calculated. The “Num of Sub Per” (Number of Sub Periods) setting, sets the number of sub periods (maximum 24) used in the calculation.

The calculation principle of the IA, IB and IC rolling demand values is as follows:

- Relay calculates the average value over the duration set by the sub period. The relay then displays the results at the end of the sub-period. The Rolling Average measurements can be found under the ***MEASUREMENTS/Current/General*** menu i.e.

  Rolling Average IA RMS
  Rolling Average IB RMS
  Rolling Average IC RMS

- If the number of sub periods is set to 1, the average will be calculated based upon the 1 sub period. If, however, the number of sub-periods is set to 2 or more (24 being the maximum), the calculation determines the rolling average value based upon the averages of the chosen number of sub-periods.
- The calculation can be reset by hand (press **(C)** key in the ROLLING AVERAGE cell) without use of the password, or a remote command. A modification of the settings (either "Sub Period" or "Num of Sub Periods" settings) will also reset the calculation.

Note	*In case of loss of power supply the rolling demand value is not stored.*

Example:

Sub Period = 5 mn
Num of Sub Period = 2

```
       Sub Period 1              Sub Period 2              Sub Period 3
/ ------------------------ / ------------------------ / ------------------------ /

           5 mn                      5 mn                      5 mn
 <----------------------->  <----------------------->  <----------------------->
```

At the end of the Sub Period 2:
Rolling average value = (average value 1 + average value 2)/2

At the end of the Sub Period 3:
New Rolling average value = (average value 2 + average value 3)/2

3.13.2 Peak Value Demand

The Peak demand value calculation principle, for IA, IB and IC currents, is as follows:

Every "Rolling Sub Period", a new average value is calculated and compared with the value calculated during the previous "Rolling Sub Period". If this new value is greater than the previous value already stored, then the previous value is overwritten with the new one. However, if this new value is lower than the previous value, already stored, then the previous value is kept. In this way, an average peak value will be refreshed each Sub Period;

The Sub Period setting, used for the peak value calculation, is the same as that used for the rolling average calculation (***RECORDS/Rolling Demand).***

The 3 phase Peak value demand are displayed in the ***MEASUREMENTS/Current/General*** menu:

MAX SUBPERIOD IA RMS
MAX SUBPERIOD IB RMS
MAX SUBPERIOD IC RMS

- The calculation can be reset by hand (press **(C)** key in the MAX. SUBPERIOD cell) without use of the password, or a remote command. A modification of the "Sub Period" setting will also reset the calculation.

Note	*In case of loss of power supply the Peak average values are stored in non-volatile memory.*

3.14 Measurements

The MiCOM P521 relay has three different measurement columns, each one dedicated to specific relay functions. The three measurement columns are as follows:

- Current Diff
- Current/General
- Protection Comms

The following section describes the contents of the three measurement columns.

Note	*All measurements listed below are updated on a per second basis.*

3.14.1 Current Diff

The measurements contained with the Current Diff column are associated with the current differential protection. These include remote phase currents and per phase differential and bias currents. Relays with firmware version 3 provide additional phase angle measurements: the phase angles between the currents in adjacent phases at the Local end, and the differential angles between each phase current at the Local end and the same phase current at the Remote end (time-aligned).

All measurements within this column are based upon the fundamental frequency only. All measurements contained within this column are multiplied by the local CT ratio setting, with the exception of the remote phase currents, which are scaled as follows:

$$\text{Remote Current (primary)} = \text{Remote Secondary Current x } \frac{\text{Local CT Ratio}}{\text{CT Correct Ratio}}$$

This calculation accounts for any CT mismatch between ends.

3.14.2 Current/General

The relay produces a variety of directly measured and calculated power system quantities. The list of measurements include:

- Local Phase and Neutral RMS Currents
- Positive and negative sequence currents (I1 and I2 respectively)
- Ratio of I2/I1
- Residual harmonic currents
- Thermal state (%)
- Peak and average currents
- Demand values

The following section describes some of these measurements in more detail.

3.14.2.1 Measured Currents

The RMS phase and earth currents are calculated by using the sum of the samples squared over a cycle of data.

3.14.2.2 Ratio of I2/I1

The ratio of I2/I1 is used to detect broken conductors. Refer to the broken conductor section for more information.

3.14.2.3 Residual Harmonic Currents (IN – fn)

This measurement allows the user to determine the harmonic currents (typically 3rd harmonic) flowing in the earth path. On pressing the **(C)** key, in the "IN – fn" cell, the relay will update the measurement of the actual RMS earth current minus the fundamental component. This measurement will only be updated on subsequent presses of the **(C)** key.

3.14.2.4 Peak and Average Currents

These measurements display the peak and average RMS currents over a settable time window of 5 to 60 minutes. The time window is set in the "Time Window" cell under the ***RECORDS/Time Peak Value*** menu. Once the time window has elapsed, the peak and average measurements will be stored until they are reset. To reset these measurements, and trigger another time window, the user must either press the **(C)** key, in the "Max & Average" cell, or modify the "Time Window" setting.

Note	*The peak and average measurements will be lost in the event of an auxiliary supply interruption.*

3.14.2.5 Demand Values

See "Rolling and peak demand values" section.

3.14.3 Protection Comms

This column allows the user to view various statistics relating to the protection communications channel.

A brief explanation of every measurement, contained in this column, can be found in section 3.5.3.3 of the User Guide (*P521/EN FT*).

The protection comms statistics can be reset (with the exception of the propagation delay) by either pressing the **(C)** key, in the "Comms Stats RST cell" or by energizing an opto input, which has been assigned to "Comms RST".

3.15 Logic Equations

The logic equations can be used to construct complex Boolean logic using the following operators: OR, OR NOT, AND, AND NOT.

An example logic implementation using Equation A is shown below:

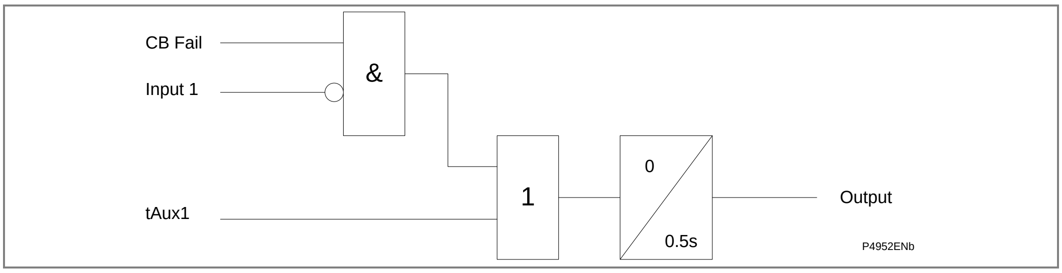


Figure 26 - Example of logic equation

There are 8 equations of 16 operands chosen within all instantaneous and time delayed events (thresholds and protections flags, tAux ...) and all inputs.

Every result of equation can be time delayed and assigned to any output relays, trip command, trip latching and/or HMI LEDs.

Every equation has a pick up time delay settable from 0 s to 600 s with a step of 0.01 s.

Every equation has a drop off time delay settable from 0 s to 600 s with a step of 0.01 s.

3.16 Current transformer supervision

Failure of current transformer circuit will result in mal-operation of any current depending protections, such as current differential, negative sequence, broken conductor and undercurrent. Now the P521 relay includes a current transformer supervision, which is called “Differential CTS”.

There are two modes of operation, Indication and Restrain. In Indication mode, a CTS alarm is raised but no effect on tripping. In Restrain mode, the differential protection is blocked during 20 ms after CT failure detection and then the Is1 setting for Current Differential is raised to above load current. Local Broken Conductor, Under Current and Negative Sequence Overcurrent protections are blocked immediately after local CT failure detection.

The Differential CTS uses the following principle to detect a single phase or two phases CT failure: when a CT failure happens, the negative sequence current reflected into the relay will occur at only one side.

The CTS function works on two current detectors:

I1 level detector – positive sequence current detector

The value of I1 shall be calculated compared with a user setting (I1>). The purpose of this element is to detect there is load current flowing in the line.

The output of this element shall be transferred to the remote ends via the signaling message.

I2/I1 level detector – negative to positive ratio

The value of I2/I1 will be calculated and compared with two user settings (low set is I2/I1>, and high set is I2/I1>>). If the result is lower than I2/I1>, it means that the currents are balanced. When the result is higher than I2/I1>>, it means that a significant unbalanced current has occurred.

If there is only end of P521 has detected I2/I1>> asserted while the other end has I2/I1> not asserted, it means only one end has detected a high unbalance current while the other end has not detected any unbalance current at all. Under these circumstances there is actually no unbalance current on the primary side. This very end of P521 which has local I2/I1 asserted has a CT failure.

The output from each element will be transferred to the remote ends via the signaling message.

The purpose of these elements is to discriminate CT problems from asymmetrical faults including Broken Conductor fault.

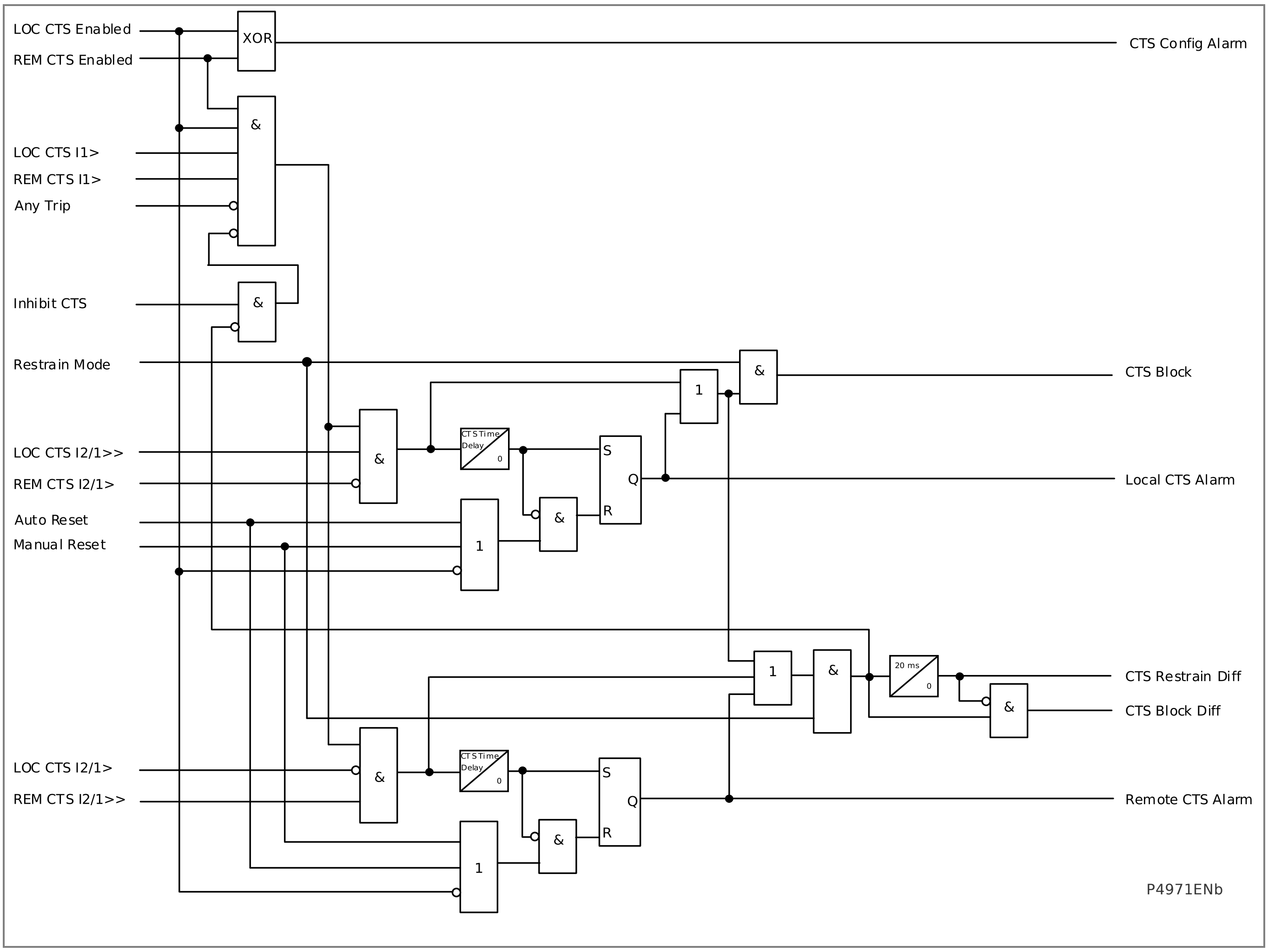


Figure 27 - Current transformer supervision

The logic diagram is shown in Figure 27. The “CTS Block” signal is used to inhibit the operating of broken conductor, negative sequence and undercurrent protections in local P521.

Opto inputs can be used to temporarily inhibit CTS function. However, this inhibit does not work when CTS has already started.

To use the CTS function, choose “Yes” under the menu AUTOMATIC. CTRL/CT Supervision/CTS ?. The settings are as below.

CT Supervision	Default Setting	Min	Max	Step
CTS ?	No	Yes, No		

CT Supervision	Default Setting	Min	Max	Step
CTS Reset mode	Manual	Manual, Auto		
CTS Reset RST=[C]	Press key (C) to reset CTS alarm. Visible only when CTS Reset mode is set in Manual.			
CTS I1>	0.1 In	0.050 In	4 In	0.01 In
CTS I2/I1>	5%	5%	100%	5%
CTS I2/I1>>	40%	5%	100%	5%
CTS TIME DLY	5 s	0 s	10 s	0.01 s
CTS Restrain?	No	Yes, No		

Note	*CTS function will work only when the relays are set in Extension communication mode in the menu COMMUNICATION/Protection/FRAME MODE.*

4 CURRENT TRANSFORMER REQUIREMENTS

4.1 Current Differential Protection

For accuracy, class X or class 5P current transformers (CTs) are strongly recommended, with a knee point voltage that complies with the requirements of the formula shown below. Simplified versions of the formula are shown in section 4.2, but these should only be used within the specified limits.

$$Vk \geq Ks \cdot Kt \cdot In (Rct + 2RL)$$

Where:

Vk	=	Required IEC knee point voltage
Ks	=	Dimensioning factor
Kt	=	Operating time factor
In	=	CT nominal secondary current
Rct	=	CT dc resistance
RL	=	One-way lead impedance from CT to relay

4.1.1 Ks Calculation

Ks is a constant depending upon:

If	=	Maximum value of through fault current for stability (multiple of In)
X/R	=	Primary system X/R ratio

Ks is determined as follows:

For $X/R < 40$

$$Ks = 0.023 \times If (X/R + 55) + 0.9 (X/R+26)$$

For $X/R \geq 40$

$$Ks = 0.024 \times If (X/R + 44) + 0.06 (X/R+725)$$

4.1.2 Kt Calculation

Kt is a constant depending upon:

X/R	=	Primary system X/R ratio
tIdiff	=	Current differential operating time setting (seconds)

For applications where the CT knee point is critical (e.g. a retrofit application where the CTs already exists), it may be possible to reduce the CT requirements by adding a small time delay to the relay. The 'tIdiff' ***(PROTECTION G1 (G2) (G3) (G4)/[87] Current Diff/tIdiff)*** setting allows the user to increase the relay operating time thus making the relay more stable. For some applications a time setting of 50ms may reduce the required CT knee point voltage by as much as 30%. Further reductions in CT knee point are possible with longer time delays.

Kt is determined as follows:

For $X/R < 40$

$Kt = 1 – (6.2 \times tIdiff)$ for $tIdiff \leq 0.15s$

$Kt = 0.07$ for $tIdiff > 0.15s$

For $X/R \geq 40$

$Kt = 1 – (2.5 \times tIdiff)$ for tIdiff not exceeding 0.25s

For applications where the relay is set to instantaneous (tIdiff=0), a Kt value of 1 should be used.

4.2 Typical Equations for Current Differential Protection

The following equations can be applied for simplicity. Care must be taken to ensure that X/R and fault levels conform to the limits specified. If the calculated Vk appears to be too large, it may be necessary to 'fine tune' the calculation by using the equations specified in section 4.1.

For X/R ≤ 20 and a fault level ≤ 25 In

Vk ≥ 85 . Kt . In (Rct + 2RL)

For X/R < 40 and a fault level ≤ 25 In

Vk ≥ 99 . Kt . In (Rct + 2RL)

Where Kt is determined as follows:

Kt = 1 – (6.2 x tIdiff) for tIdiff ≤ 0.15 s

Kt = 0.07 for tIdiff > 0.15 s

Note	*The equations shown in this section are based upon the equations in section 4.1 with the associated X/R and fault level figures already substituted.*

4.3 Selection of X/R Ratio and Fault Level

The value of X/R ratio and fault level will vary from one system to another, but selecting the correct value for the CT requirements is critical. In the case of single end fed (radial) systems the through fault level and X/R ratio should be calculated assuming the fault occurs at the location of the remote CT. For systems where the current can feed through the protected feeder in both directions, such as parallel feeders and ring main circuits, further consideration is required. In this case the fault level and X/R ratio should be calculated at both the local and remote CT's. In doing this the X/R ratio and fault level will be evaluated for both fault directions. The CT requirements, however, should be based upon the fault direction that gives the highest knee point voltage. Under no circumstances should the X/R ratio from one fault direction and the fault level from the other be used to calculate the knee point. Doing this may result in exaggerated and unrealistic CT requirements.

4.4 SEF Protection – as Fed by Core-Balance CT

Core balance current transformers of metering class accuracy are required and should have a limiting secondary voltage satisfying the formula given below:

Vk ≥ I_{fn} x (Rct + 2RL + Rrn)

Where:

Vk	=	Required IEC knee point voltage
I_{fn}	=	Maximum prospective secondary earth fault current
Rct	=	CT dc resistance
RL	=	One-way lead impedance from CT to relay
Rrn	=	Impedance of neutral current input

5 COMMUNICATION BETWEEN RELAYS

5.1 Communications Link Options

A number of communications options are available for the communication channel between P521 system ends. The various connection options are described below. Choosing between each of these options will depend on the type of communications equipment that is available.

Where existing suitable multiplexer communication equipment is installed, for other communication between substations, interfaces conforming to the G.703, V.35, and X.21 recommendations are available, by using the 850 nm fiber interface in the P521 plus a P591, P592 or P593 interface unit. For further information on the P591, P592 and P593 optical fiber to electrical interface units, refer to section 5.3.

Where no multiplexer is installed, the direct optical fiber connection can be used. The type of fiber used (multi-mode or single-mode) will be determined by the distance between the ends of the P521 relay system, refer to section 5.2.5.

For multiplexed or direct fiber communications the data rate may be selected as either 56 kbit/sec or 64 kbit/sec using the SDLC protocol. Slower data rates can be selected for these applications, but this is not recommended, as it would result in increased relay operating times.

Where a 2 wire unconditioned pilot wire circuit is available (i.e. pilot wires without any signal equalization equipment), baseband or mDSL modems can be used in conjunction with the P521 relays to communicate at 64 kbit/sec, refer also to section 5.5.

Where a 4 wire unconditioned pilot wire circuit is available a P595 can be used, refer also to section 5.4.

For 2 wire conditioned pilots (provided by a telecommunications company), a suitable type of modem must be used, and there is no strict limit to the distance. Refer to section 5.6.

For distances of 1.2 km or less and two twisted pairs of wires are available, EIA(RS)485 can be utilized at data rates of 64 kbit/sec, 56 kbit/sec, 19.2 kbit/sec and 9.6 kbit/sec, refer also to section 5.7.

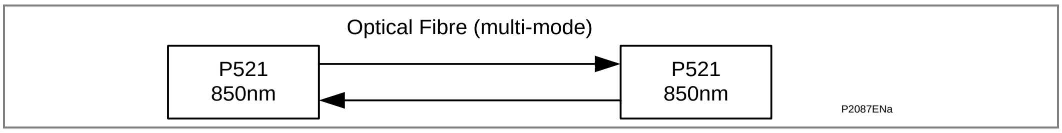
In certain circumstances the user may want to change the relay protection communications interface. For example, from electrical (EIA(RS)485/232) to fiber optic, when the P521 is fitted in a substation with existing pilot/telephone wires, which are to be replaced with fiber optic cables at a later date. With a minor hardware change the relay can be upgraded without the need for a software/firmware change. Refer to section 9.4.4 of the Commissioning and Maintenance section of this manual (*P521/EN CM*) for information regarding communications interface changes.

5.2 Direct Optical Fiber

5.2.1 Direct Optical Fiber Link, 850 nm Multi-Mode Fiber

The relays are fitted with the 850 nm multi-mode fiber interface, and connected directly using two 850 nm multi-mode optical fibers for the signaling channel.

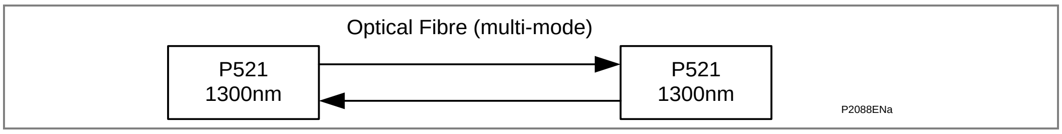
Multi-mode fiber type 50/125μm or 62.5/125μm is suitable. BFOC/2.5 type fiber optic connectors are used. These are commonly known as “ST” connectors (“ST” is a registered trademark of AT&T).



This is typically suitable for connection up to 1 km.

5.2.2 Direct Optical Fiber Link, 1300 nm Multi-Mode Fiber

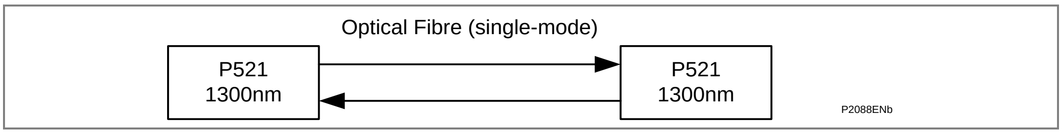
The relays are fitted with the 1300 nm multi-mode fiber interface, and connected directly using two 1300 nm multi-mode fibers for the signaling channel. Multi-mode fiber type 50/125 μm or 62.5/125 μm is suitable. BFOC/2.5 type fiber optic connectors are used.



This is typically suitable for connection up to approximately 50 km (from December 2008). Pre-December 2008 relays were suitable for connection up to approximately 30 km.

5.2.3 Direct Optical Fiber Link, 1300 nm Single-Mode Fiber

The relays are fitted with the 130 nm single-mode fiber interface, and connected directly using two 1300 nm single-mode fibers, type 9/125 μm for the signaling channel. BFOC/2.5 type fiber optic connectors are used.



This is typically suitable for connection up to approximately 100 km (from December 2008). Pre-December 2008 relays were suitable for connection up to approximately 60 km.

5.2.4 Switched Communication Networks

The P521 relay makes use of digital communication signaling channels for the differential protection. For the P521 a requirement of this link is that ‘go’ (tp1) and ‘return’ (tp2) times are similar (a difference of up to 1 ms can be tolerated). Times greater than this can result in relay instability.

Where switched communications networks are used, it is possible that during switching, a transient time period may exist with different ‘go’ and ‘return’ times. The P521 relay includes a facility to ensure protection stability during this transient period.

One of the checks performed on the communications link is a check on the calculated propagation delay for each data message. During normal operation the difference in calculated time should be minimal (possible delays being introduced by multiplexers or other intermediary communication equipment). If successive calculated propagation delay times exceed a user settable value (200 – 10000 μs) then the data message is discarded. This check is used to overcome switching problems.

Figure 28 shows a possible scenario for a switched network. Initially the P521 relays are communicating via path 1. The go and return times for this path are 2 ms and hence the calculated propagation delay is (2 + 2)/2 = 2 ms. When the channel is switched to path 2, a small time period exists where the P521's could be sending messages via path 1 and returning via path 2.

The calculated propagation delay will now be (2 + 5)/2 = 3.5 ms. The resultant 1.5 ms error at each line end may cause the relay to maloperate due to incorrect time alignment of current vectors (see section 2.1.2). After a short delay, both 'go' and 'return' paths will follow route 2 and the calculated propagation delay will be (5 + 5)/2 = 5 ms. The relay will now be stable as correct current vector time alignment exists at each line end.

The P521 relay uses the change in calculated propagation delay to initiate a change in relay characteristic for a short time period (***COMMUNICATION/Protection/ Char Mod Time*** setting) to overcome any switching delay. The Char Mod timer is settable in the range 0 to 100 seconds, default 10 seconds. The change in characteristic is shown in Figure 29 whereby the relay Is1 setting is increased to 200% of Is2 and the k1 slope is changed to 0%. This characteristic provides stability for all load conditions and will still allow tripping for most internal fault conditions.

The Char Mod timer is started when a change in propagation delay is detected. Any subsequent change during this period will not cause the timer to restart. In the above example the timer will start for the first change (2 to 3.5 ms). The second change (3.5 ms to 5 ms) will not cause the timer to restart, which would prolong the setting change.

Any transient "jitter" occurring on the communications path, which affected the propagation delay time, could therefore unnecessarily desensitize the relay. To overcome this possible problem, the P521 relay includes a feature whereby the Char Mod timer is reset if a change is detected during its timing period that returns the propagation delay to its original value. The dotted line of Figure 28 shows this, where the propagation delay changes from 2 to 3.5 ms and back to 2 ms.

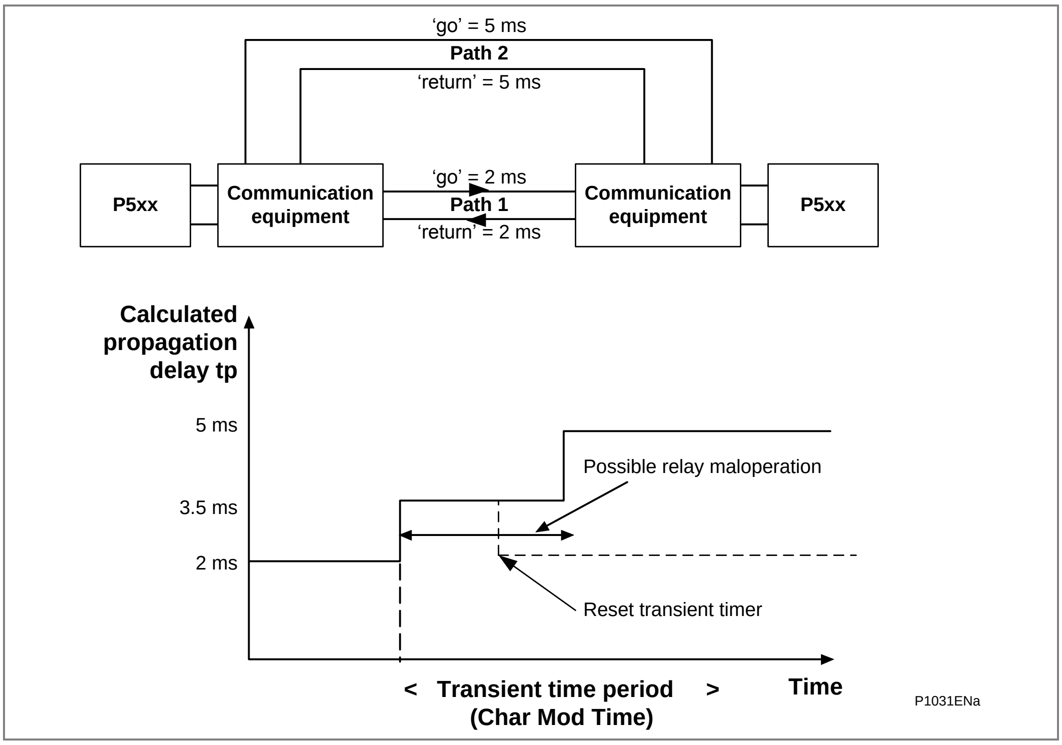


Figure 28 - Switched communication network

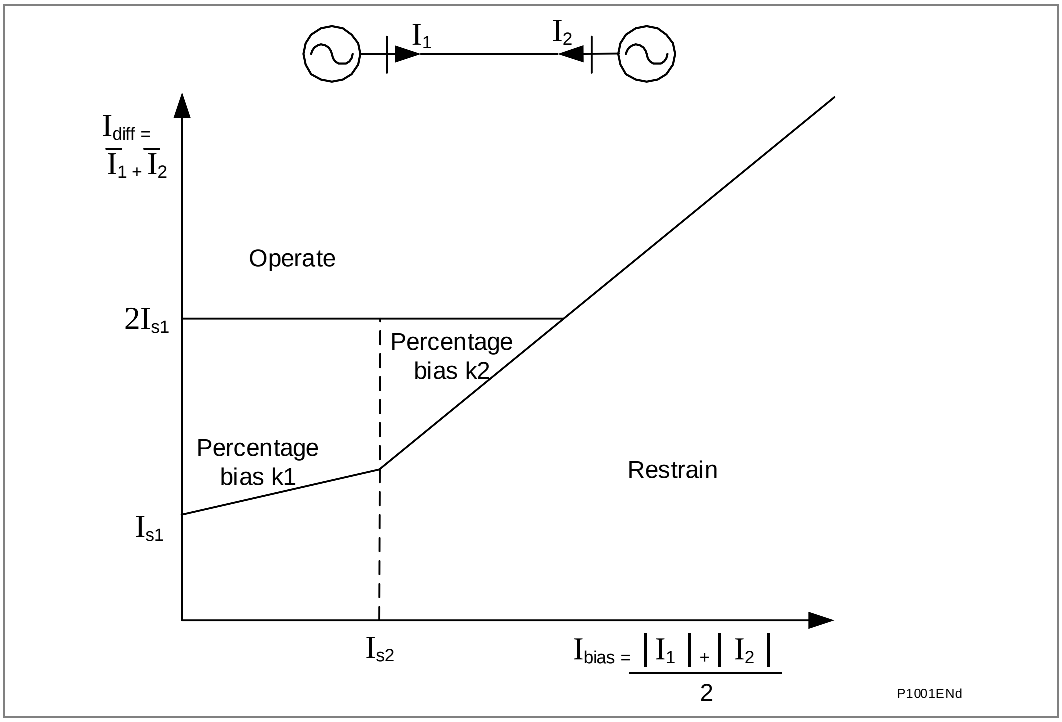


Figure 29 - Modified bias characteristic

5.2.5 Optical Budgets

When applying the P521 current differential relay, it is important to select the appropriate fiber interface. This will depend on the fiber used and distance between devices. Table 22 shows the optical budgets of the available communications interfaces.

From December 2008	850 nm Multi-Mode	1300 nm Multi-Mode	1300 nm Single-Mode
Min. transmit output level (average power)	-19.8 dBm	-6 dBm	-6 dBm
Receiver sensitivity (average power)	-25.4 dBm	-49 dBm	-49 dBm
Optical budget	5.6 dB	43.0 dB	43.0 dB
Less safety margin (3 dB)	2.6 dB	40.0 dB	40.0 dB
Typical cable loss	2.6 dB/km	0.8 dB/km	0.4 dB/km
Max. transmission distance	1 km	50.0 km	100.0 km

Table 22 - Optical budgets

Note	*From December 2008, the optical budgets and hence also the maximum transmission distances of the 1300 nm multi-mode and 1300 nm single-mode fiber interfaces have been increased, to the values shown in Table 22.*

The new interface cards are identified by “43dB” marked in the centre of the backplate, visible from the rear of the relay. These new fiber interfaces are fully backward-compatible with the original equivalent interface. However, in order to achieve the increased distance, both ends of the P521 scheme would need to use the new interface.

Pre-December 2008 relays will have the original optical budgets and maximum transmission distances, as shown in Table 23.

Pre-December 2008	850 nm Multi Mode	1300 nm Multi Mode	1300 nm Single Mode
Min. transmit output level (average power)	-19.8 dBm	-10 dBm	-10 dBm
Receiver sensitivity (average power)	-25.4 dBm	-37 dBm	-37 dBm

Pre-December 2008	850 nm Multi Mode	1300 nm Multi Mode	1300 nm Single Mode
Optical budget	5.6 dB	27.0 dB	27.0 dB
Less safety margin (3dB)	2.6 dB	24.0 dB	24.0 dB
Typical cable loss	2.6 dB/km	0.8 dB/km	0.4 dB/km
Max. transmission distance	1 km	30.0 km	60.0 km

Table 23 - Optical budgets

The total optical budget is given by the transmitter output level minus the receiver sensitivity and will indicate the total allowable losses that can be tolerated between devices. A safety margin of 3 dB is also included in Table 23. This allows for degradation of the fiber as a result of ageing and any losses in cable joints. The remainder of the losses will come from the fiber itself. The figures given are typical only and should only be used as a guide.

In general, the 1300 nm interfaces will be used for direct connections between relays. The 850 nm would be used where multiplexing equipment is employed.

5.3 Multiplexer Link via P59x Optical Fiber to Electrical Interface Units

In order to connect the P521 relay via a Pulse Code Modulation (PCM) multiplexer network or digital communication channel the P59x interface units are required. The following interface units are available:

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

The data rate for each unit can be 56kbit/sec or 64kbit/sec as required for the data communications link, refer to section 5.11.

One P59x unit is required per relay signaling channel (i.e. for each transmit and receive signal pair). It provides optical to electrical and electrical to optical signal conversion between the P521 relay and the multiplexer. The interface unit should be located as close to the PCM multiplexer as possible, to minimize any effects on the data of electromagnetic noise or interference.

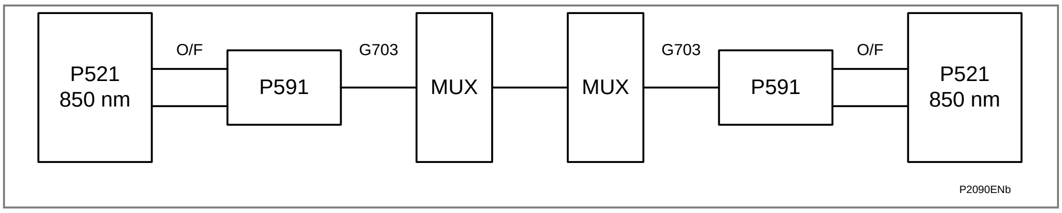
The units are housed in a 20 TE MiCOM case.

Fiber optic connections to the unit are made through BFOC/2.5 type connectors, more commonly known as ‘ST’ connectors.

The optical characteristics are similar to the P521 850 nm multi-mode fiber optic interface (refer to section 5.2.5 above).

5.3.1 Multiplexer Link with G.703 Electrical Interface Using Auxiliary Optical Fibers and Type P591 Interface

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



The P591 unit supports the ITU-T Recommendation G.703 co-directional interface.

The P591 interface unit should be located as close to the PCM multiplexer as possible, to minimize any effects on the data of electromagnetic noise or interference.

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

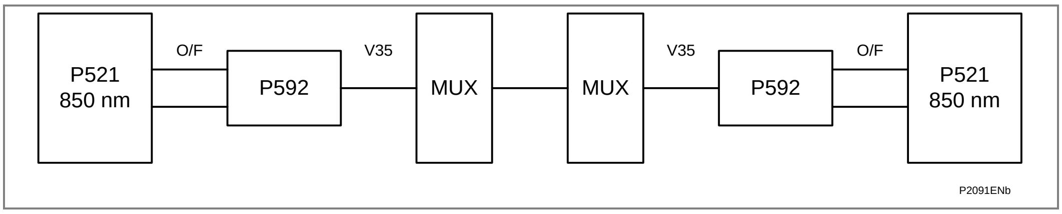
Since the G.703 signals are only of ±1V magnitude, the cable connecting the P591 unit and the multiplexer must be properly screened against electromagnetic noise and interference. The interface cable should consist of twisted pairs of 24 AWG, overall shielded, and have a characteristic impedance of about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

Electrical connections to the P591 unit are made via a standard 28-way Midos connector. Please refer to *P521/EN CO* for the external connection diagram.

The P521 must be set with Clock Source as ‘External’, refer to section 5.10.

5.3.2 Multiplexer Link with V.35 Electrical Interface Using Auxiliary Optical Fibers and Type P592 Interface

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



The P592 unit supports the ITU-T Recommendation V.35 interface.

The P592 interface unit should be located as close to the PCM multiplexer as possible, to minimize any effects on the data of electromagnetic noise or interference.

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

The P592 front panel consists of five indicating LEDs and six DIL (dual in line) switches.

The switch labeled ‘Clockswitch’ is provided to invert the V.35 transmit timing clock signal if required.

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

The switch labeled ‘V.35 Loopback’ is provided to allow a test loopback of the communication signal across the X.21 terminals. It loops the incoming V.35 ‘Rx’ data lines internally back to the outgoing V.35 ‘Tx’ data lines. When switched on, the red LED labeled ‘V.35 Loopback’ is illuminated.

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

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

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

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

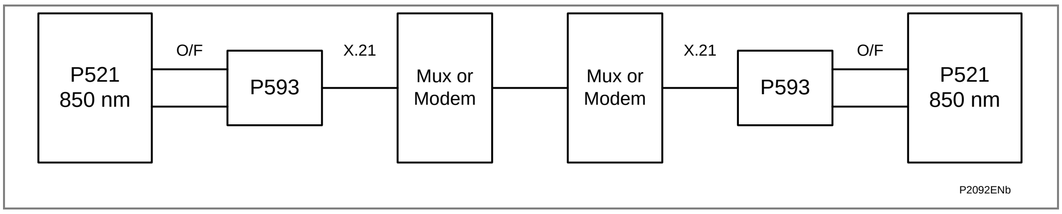
Please refer to *P521/EN CO* for the external connection diagram.

The P521 may be set either with Clock Source as 'External' for a multiplexer network which is supplying a master clock signal, or with Clock Source as 'Internal' for a multiplexer network deriving its signal timing from the equipment. Refer to section 5.10.

5.3.3 Multiplexer Link with X.21 Electrical Interface Using Auxiliary Optical Fibers and Type P593 Interface

The P593 unit supports the ITU-T Recommendation X.21 interface. It is approved as line interface equipment by the British Approvals Board for Telecommunications (BABT) for connection to the services described in this section; License Certificate Number NS/1423/1/T/605362.

The relays are fitted with the 850 nm optical interface, and connected to a P593 unit by 850 nm multi-mode optical fiber. Multi-mode fiber type 50/125 μm or 62.5/125 μm is suitable. BFOC/2.5 type fiber optic connectors are used. The P593 unit converts the data between optical fiber and ITU-T compatible X.21 electrical interface. The X.21 output must be connected to an ITU-T compatible X.21 channel on the multiplexer or ISDN digital data transmission link.



The P593 interface unit should be located as close to the PCM multiplexer as possible, to minimize any effects on the data of electromagnetic noise or interference.

The P521 relays require a permanently open communications channel. Consequently, no communications handshaking is required, and it is not supported in the P593 unit. The signals supported are shown in Table 23.

ITU-T Recommendation X.21 is closely associated with specifications EIA(RS)422 and EIA(RS)449. The P593 can be used with EIA(RS)422 or EIA(RS)449 communications channels which require only the signals shown in Table 24.

ITU-T Designation	Description	Connector Pin	Direction
-	Case earth	1	-
G	Common return	8	-
T	Transmit data A	2	From P593
T	Transmit data B	9	From P593
R	Receive data A	4	To P593
R	Receive data B	11	To P593
S	Signal element timing A	6	To P593
S	Signal element timing B	13	To P593

Table 24 - X.21 circuits supported by P593 unit

Connections of X.21 signals to the P593 unit are made via a standard male 15 way D-type connector, wired as a DTE device. The interface cable should consist of twisted pairs of 24 AWG, overall shielded, and have a characteristic impedance of about 100 Ω. It is generally recommended that the interface cable shield is connected to the multiplexer frame ground. The choice of grounding depends upon the local codes of practice.

Refer to *P521/EN CO* for the external connection diagram.

The P521 must be set with Clock Source as 'External', refer to section 5.10.

The P593 front panel consists of four indicating LEDs and two switches.

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

The green LED labeled ‘Clock’ provides indication that an appropriate X.21 signal element timing signal is presented to the unit.

One of the switches is labeled ‘Fiber Optic Loopback’. This is provided to allow a test loopback of the communication signal across the fiber optic terminals. When switched on, the red LED labeled ‘Fiber Optic Loopback’ is illuminated.

The second switch is labeled ‘X.21 Loopback’. This is provided to allow a test loopback of the communication signal across the X.21 terminals. It loops the incoming X.21 ‘Rx’ data lines internally back to the outgoing X.21 ‘Tx’ data lines, and also loops the incoming fiber optic ‘Rx’ data line (via the X.21 signal conversion circuitry) back to the outgoing fiber optic ‘Tx’ data line. When switched on, the red LED labeled ‘X.21 Loopback’ is illuminated.

5.4 Unconditioned 4 Wire Pilot Communications for Distances greater than 1.2 km (P595)

In order to increase the transmission distance of EIA(RS)485 up to 25 kilometres the P595 Interfacing Device can be used at each end of the line. To gain maximum performance of the P521, the data rate must be set to 19.2 kbit/sec and the protocol set to “NRZ” (Non Return to Zero).

The relays are fitted with the EIA(RS)485 interface, and connected using two pairs of unconditioned pilot wires of 0.4 mm (26 AWG) or larger gauge, twisted and shielded to ensure secure and reliable communications.

Pilot isolation must also be considered, when connecting the P595. If the longitudinal voltage exceeds 900 V the PCM-FLÜ 10 kV or 20 kV isolating transformers must be fitted in series with the P595. The PCM-FLÜ isolating transformer has “a”, “m” and “b” taps on both primary and secondary windings. For all P521 applications, connection must be made between taps ‘a’ and ‘m’, which has a maximum frequency of 2 MHz. Connection between ‘a’ and ‘b’ may result in unreliable communications as the maximum frequency for this tap configuration is 6 kHz. Connection to ‘a’ and ‘m’ taps must be adhered to on both primary and secondary so as to maintain a 1:1 ratio.

Refer to section *P521/EN CO* for connection diagrams.

Refer to the P595 manual (*P595/EN M*) for further information.

Note *The P595 interface device is identical to the Schneider Electric PZ511 interface except that the P595 has accessible setting switches. The switch settings, to allow communications between P521 relays, can be found in the P595 manual.*

5.5 Unconditioned 2 wire Pilot Communications for Distances greater than 1.2 km

When communicating via a pair of unconditioned pilots for distances greater than 1.2 km, a leased line or baseband modem can be used. For maximum security and performance it is strongly recommended that a screened twisted pair of 0.5 mm (or greater) conductors are used. Typical connection diagrams are shown in section *P521/EN CO*.

When choosing between leased line or baseband modems the following aspects should be considered:

- Leased line modems have a maximum transmission speed of 19.2 kbit/sec, whereas baseband modems can transmit at 64 kbit/sec.
- Baseband modems have longer re-training times, typically between 10 to 60 s. If the connection between is temporarily lost, the protection communications will be interrupted until the re-training period has elapsed.
- Since baseband modems use synchronous communication protocols, there is typically a 20% performance gain over leased line modems that use asynchronous protocols.

Modems tested:

- Westermo TD-32 leased line and dial-up modem. This model is obsolete and its replacement is:
- TD-36 modem
- Patton “Netlink” 1095 mDSL Baseband modem.
- Patton “Campus” 1092A Baseband Modem. This model is obsolete and its replacement is:
- Keymile LineRunner DTM modem with V36 interface.

Modem summary table. For full information see the modem configuration document *P521/EN MC*.

Type	Max Distance (km)	Recommended Data Rate (kbit/sec)	Typical Re-train Time (Seconds)
TD32 (Obsolete)	20	9.6	14
TD36	20	19.2	5
“Netlink”1095	9.4	64	25
“Campus” 1092A (Obsolete)	17.2	64	10
LineRunner DTM	19.8	64	-

The “Campus” 1092A modem may also be used for 4 wire pilot communications, giving extra security and a slightly improved maximum distance (18.2 km).

5.5.1 Leased Line Modem Set Up (e.g. TD36 Modem)

The data rate can be set to either 9.6 or 19.2 kbit/sec and the protocol set to “NRZ” (Non Return to Zero). Since the transmission speed is limited to 19.2 kbit/sec, connections to the modem can be made via EIA(RS)232 or EIA(RS)485 depending upon the type of modem.

Refer to *P521/EN MC* (modem configuration) for more information on setting up the modem.

5.5.2 Baseband Modem Set Up (Patton “Netlink” 1095 mDSL Modem, Patton “Campus” 1092A Modem)

The data rate must be set to 64 kbit/sec, the protocol set to “NRZ”. For more information, on setting up the modem, refer to *P521/EN MC* (modem configuration).

5.5.3 Modem Isolation

Pilot isolation must be considered when connecting modems to unconditioned circuits. Additional isolation can be provided by the PCM-FLÜ 10 kV or 20 kV isolating transformers. The PCM-FLÜ isolating transformer has “a”, “m” and “b” taps on both primary and secondary windings. For all P521 applications, connection must be made between taps ‘a’ and ‘m’, which has a maximum frequency of 2 MHz. Connection between ‘a’ and ‘b’ may result in unreliable communications as the maximum frequency for this tap configuration is 6 kHz. Connection to ‘a’ and ‘m’ taps must be adhered to on both primary and secondary so as to maintain a 1:1 ratio.

Refer to *P521/EN AC* for more information.

5.5.4 Clock Source Settings

Set relay Clock Source setting (COMMUNICATION/Protection/Clock Source CH1).

Modem Type	Clock Source Setting
Synchronous	External
Asynchronous	Internal

5.6 Conditioned Pilot Communications

When communicating via conditioned pilot wires (i.e. leased telecom circuits that run through signal equalization equipment) the P521 should be connected to leased line modems at each end of the line. The data rate can be set to either 9.6 or 19.2 kbit/sec. The protocol must be set to “NRZ” (Non Return to Zero).

Modem summary table: For full information see the modem configuration document *P521/EN MC*.

Type	Max Distance (km)	Recommended Data Rate (kbit/sec)	Typical Re-train Time (Seconds)
TD36	n/a	9.6	5

Connection to the modem can be made via the EIA(RS)485 or EIA(RS)232 outputs (of SK1), depending upon the type of modem. Typical connection diagrams are shown in section *P521/EN CO*. For more information on setting up the modem refer to *P521/EN MC* (modem configuration).

5.6.1 Gas Discharge Tubes (GDTs)

Gas Discharge Tubes (GDTs) are commonly used to provide overvoltage/surge protection for conditioned pilots circuits. These are dispersed at intervals along the pilot circuit to limit the voltage between pilots and ground during heavy earth faults. The GDTs limit the high potential by transiently shorting the pilots to both each other and ground. This, however, will temporarily interrupt the protection communications, thus preventing the protection from operating when required to do so. To prevent interruptions in the protection communications it is recommended that either:

- The earth fault level is checked to ensure that the resulting pilot voltage is less than the voltage threshold of the GDTs (use equations from section 5.8)
  or
- The GDTs be removed and replaced with pilot isolation transformers

5.7 Direct 4 wire EIA(RS)485 up to 1.2 km

Direct connection between two P521 relays using 4 wire EIA(RS)485 can be used at data rates of 9.6, 19.2, 56 and 64 kbit/sec. The protocol for this communication method can be either “SDLC” or “NRZ”. Ideally the interconnecting wires should be 2 screened twisted pairs.

For the direct EIA(RS)485 connections up to 1.2 km it is strongly recommended that the MT-RS485 be fitted. The MT-RS485 protects the relay communications interface from excessive transverse voltages (voltage between pilot cores) and static spikes. However, for reliable communications it must be ensured that the longitudinal voltage never exceeds 600 V as the MT-RS485 surge protection may corrupt the protection signaling. Figure 30 shows the connection diagram for the MT-RS485.

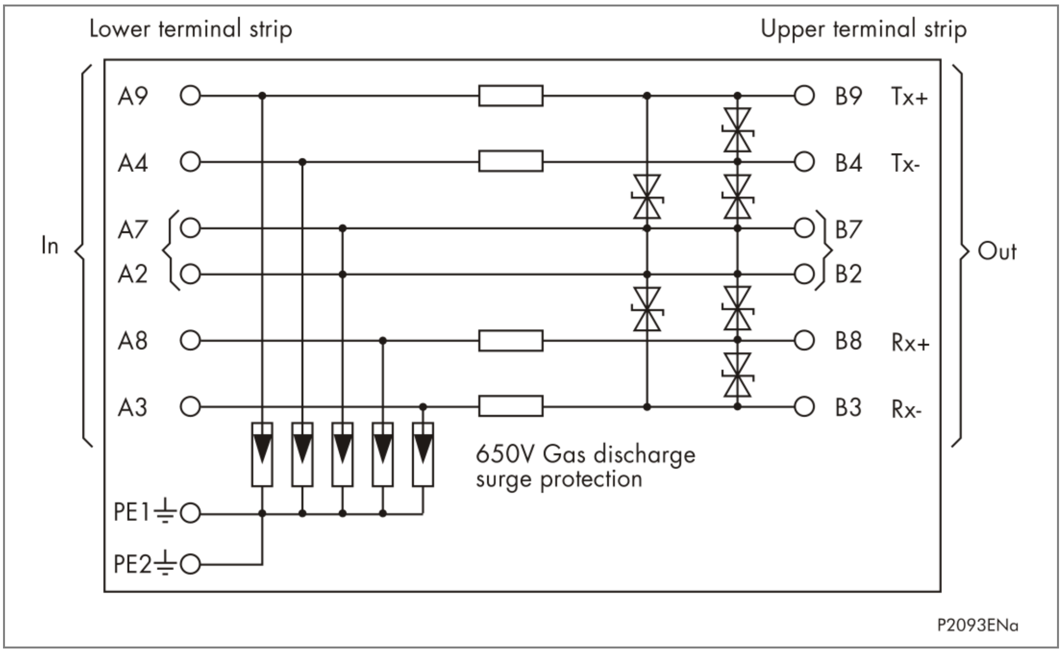


Figure 30 - MT-RS485 connection diagram

Refer to section *P521/EN CO* for application diagram.

5.8 Pilot Isolation

During primary earth faults the strong magnetic field generated can induce a significant voltage between the pilots and ground (longitudinal voltage). To prevent damage to any equipment connected to the pilot circuit it must be ensured that the modem can provide an adequate isolation barrier between the pilot itself and all other electrically isolated circuits. Although it may be difficult to accurately predict the induced pilot voltage during an earth fault, the following equations can be used to give an approximation:

Induced voltage for un-screened pilots $\approx 0.3 \times I_F \times L$

Induced voltage for screened pilots $\approx 0.1 \times I_F \times L$

Where:

I_F = Maximum prospective earth fault current in amperes

L = Length of pilot circuit in miles

In cases where the calculated voltage exceeds, typically 60% of the relay/modem isolation level, additional isolation must be added. Schneider Electric offer the PCM-FLÜ 10kV or 20kV isolating transformers (see *P521/EN AC* for more information). If necessary, these can be used in conjunction with leased line or mDSL modems. The choice of 10 kV or 20 kV will depend upon the magnitude of the induced voltage. Typical application diagrams of the PCM-FLÜ isolating transformer are shown in section *P521/EN CO* (connection diagrams).

5.9 Protection Communications Address

The protection communication messages include an address field to ensure correct scheme connection.

There are 32 addresses arranged into 16 groups ***(COMMUNICATION/ Protection/Relay Address)*** to select from. Each protection system has a single group applied to it.

All the address patterns are carefully chosen so as to provide optimum noise immunity against bit corruption. There is no preference as to which address group is better than another.

The groups of addresses available for a “2 Terminal” scheme are shown in Table 25:

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

Table 25 - Relay addresses

For two relays to communicate with one another their addresses have to be in the same address group. One relay should be assigned with address A and the other with address B. For example, if the group 1 addresses are to be used, the one relay should be set to address “1A” and the other relay should be set to address “1B”.

A relay with address “1A” will only accept messages from a relay with address “1B”, and vice versa.

5.10 Clock Source

A Clock Source is required to synchronize data transmissions between the system ends. This may be provided either by the P521 relay (internal) or may be a function of the telecommunications equipment (external). The P521 relay has a setting that allows the Clock Source to either “Internal” or “External” according to the communications system configuration ***(COMMUNICATION/Protection/Clock Source Ch1)***.

5.10.1 Internal Clock Source Signaling

The Clock Source should be set to “Internal” at all system ends, where they are connected by direct optical fiber as the P521 at each end has to supply the clock.

5.10.2 External Clock Source

The Clock Source should be set to “External” at all system ends, where the ends are connected by multiplexer equipment which is receiving a master clock signal from the multiplexer network. It is important that there is a single master Clock Source on the multiplexer network and that the multiplexer equipment at each end is synchronized to this clock.

5.11 Data Rate

The Data Rate for signaling between the two ends is application specific (COMMUNICATION/Protection/Data Rate).

If there is a direct fiber connection between the ends, the data rate would usually be set to 64kbit/sec, as this gives a slightly faster trip time.

If there is a multiplexer network between the ends, then this will determine the Data Rate to be used by the P521 system. The electrical interface to the multiplexer (G.703 co-directional, V.35, or X.21) will be provided on either a 64 kbit/sec or 56 kbit/sec channel, and the P521 at each end must be set to match this data rate.

Generally, North American multiplexer networks are based on 56 kbit/sec (and multiples thereof) channels, whereas multiplexer networks in the rest of the world are normally based on 64 kbit/sec (and multiples thereof) channels.

Refer to sections 5.4 to 5.7 for typical data rates for metallic/modem communications.

5.12 Communication Failure

An internal communication failure flag is raised if a valid message is not received by the time three power system cycles have elapsed. The flag is used to trigger the communications fail timer. The flag and timer reset when the first valid message is received.

5.12.1 'I DIFF FAIL' Alarm

The 'I DIFF FAIL' alarm is generated when the communication failure flag is raised (if a valid message is not received by the time three power system cycles have elapsed). At this time, the current differential protection is inhibited.

If the ***CONFIGURATION/Alarms/Inst.Self-reset?*** menu cell is set to "Yes", then the 'I DIFF FAIL' alarm automatically resets when the internal communication flag is reset; otherwise the alarm reset must be done by the push button.

5.12.2 'COMMS ALARM CH1' Alarm

The communication fail timer (***COMMUNICATION/Protection/Comm Fail Timer***) is the time for which communication errors must be continuously detected before the channel is declared failed. Expiry of the communication fail timer results in the generation of the 'COMMS ALARM CH1' alarm. The ***COMMUNICATION/Protection/Comm Fail Timer*** setting is normally set to the maximum of 9.9 seconds so that the alarm will not be given for short bursts of noise or interruptions.

If the ***CONFIGURATION/Alarms/Comm.Fail-reset?*** menu cell is set to "Yes", then the 'COMMS ALARM CH1' alarm automatically resets when the internal communication flag is reset; otherwise the alarm reset must be done by the push button.

5.12.3 Communications Failure Logic

Figure 31 details the operation of the communications fail logic.

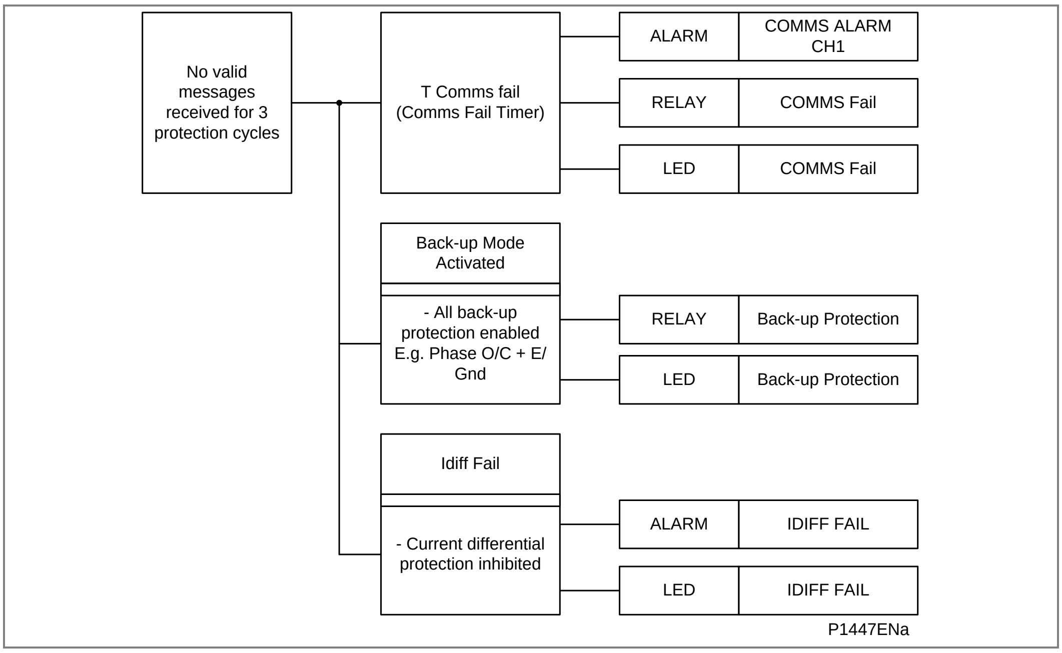


Figure 31 - Communications failure logic

5.13 Communication Error Statistics

To aid the bit error evaluation of the communication link, communication error statistics are kept by the relay. These give the number of Errored messages detected and the number of Valid Messages received for the communications channel. The number of errored messages detected complies with ITU-T G.821.

The stored error statistics are:		
Valid messages	-	Number of messages received OK
Errored messages	-	Number of messages received and rejected
Errored seconds	-	Number of seconds containing 1 or more errored messages. This is not updated for severely errored seconds
Severely errored seconds	-	Number of seconds containing ≥30% errored messages
Propagation delay	-	The delay introduced by the communications channel
Elapsed time since reset	-	The number of seconds since the communications error statistics were last reset

The error statistics are automatically restored on power-up. They can also be cleared using the Clear Statistics setting in Measurements column of the menu.

5.14 Communications Delay Tolerance Timer

The communications delay tolerance timer (***COMMUNICATION/Protection/ Comms Delay Tol***) is the maximum difference in the measured channel propagation delay time between consecutive messages that the relay will tolerate before switching the settings, as described in section 5.2.4.

It is settable in the range 200 µs to 10 ms. The default value is 10 ms, which is suitable for protection communications using metallic/modem communications at lower data rates. A setting of 200 µs is more appropriate for a data rate of 56 or 64 kbit/sec. It can be increased to a suitable value if the propagation delay time is expected to vary considerably such as in the case of a microwave link with multiple repeaters.

5.15 Communication Compatibility

The compatibilities among various software versions are (also refer to the chapter P521_EN_VC):

- Among phase 1: all V1 up to V5.A
- Between phase 1 and phase 2: V5.B and later to V10.A and later
- Among all phase 2: V10.A and later

Notes:

COMMUNICATIONS
MODBUS AND DNP3.0 DATABASE
IEC 60870-5-103

CHAPTER 7

Date:	January 2012
Software version:	13
Hardware Suffix:	B
Connection diagram:	10P52101

CONTENTS

Page (GC) 7-

TABLES

1 INTRODUCTION

1.1 Purpose of this Document

This chapter describes the data model of the different communication protocols of the P521 relay.

The available communication protocols of the MiCOM P521 relay are as follows:

- MODBUS RTU
- IEC 60870-5-103
- DNP3.0

2 MODBUS PROTOCOL

MiCOM P521 relays can communicate by an EIA(RS)485 link behind the unit following the MODBUS RTU protocol.

2.1 Technical Characteristics of the MODBUS Connection

2.1.1 MODBUS Setting Parameters

- Isolated two-point EIA(RS)485 connection (2 kV 50 Hz)
- MODBUS line protocol using RTU mode
- Selectable baud rate
    - 300
    - 600
    - 1200
    - 2400
    - 4800
    - 9600
    - 19200
    - 38400
- Selectable parity and No of stop bits parameters

No. of Start Bits (Fixed at 1)	No. of Data Bits (Fixed at 8)	Parity	No Stop Bits	Total Word Length
1	8	None	1	10
1	8	Even	1	11
1	8	Odd	1	11
1	8	None	2	11

Table 1 - Selectable parity and stop bits parameters

2.1.2 Message Synchronization

A firm start is defined as an absence of data transmission after the last transmission for a time equal or greater to that required to send 3 characters.

2.1.3 Message Validity Check

The frame validity checking used is a 16-bit cyclical redundancy code (CRC).

The generator polynomial used is:

$1 + x^2 + x^{15} + x^{16}$ = 1010 0000 0000 0001 binary = A001h

2.1.4 MiCOM Relay Addressing

MiCOM relay addresses on the same MODBUS network should be set between 1 and 255. The 0 address is reserved for broadcast messages.

2.2 MODBUS Functions of MiCOM Relays

The MODBUS functions implemented on the MiCOM relays are:

Function No.	Function Name	Description
Function 1	Read Coils	Read n bits
Function 2	Read Discrete Inputs	Read n bits
Function 3	Read Holding Registers	Read n words
Function 4	Read Input Registers	Read n words
Function 5	Write Single Coil	Write 1 bit
Function 6	Write Single Register	Write 1 word
Function 7	Read Exception Status	Fast 1 byte read
Function 8	Diagnostics	Communications Diagnostics
Function 11	Get Comm Event Counter	No. of Message Completions
Function 15	Write Multiple Coils	Write n bits
Function 16	Write Multiple Registers	Write n words

Table 2 - MODBUS functions

2.3 MODBUS Function Operation

2.3.1 Introduction

MODBUS is a master/slave protocol that requires a data model of each slave device it is to communicate with. The master initiates all communication therefore the slave can only respond with either the requested data or an exception.

2.3.2 Request by the Master

Slave Address	Function Code	Information	16 Bit CRC
1 byte	1 byte	n bytes	2 bytes

2.3.2.1 Slave Address

The slave number can be between 1 and 255.

A network broadcast frame is available in MODBUS and has an address of 0 but is unsupported in the P521.

2.3.2.2 Function Codes

See section 2.2.

2.3.2.3 Structure of the Information Field by MODBUS Function

Functions 1 to 4

Starting Address	No. of Registers Requested (N)
2 bytes	2 bytes

Functions 5 and 6

Register Address	Register Value
2 bytes	2 bytes

Function 8

Sub-Function code	Loopback Data
2 bytes	N * 2 bytes

Functions 15 and 16

Starting Address	No. of Registers to be Written to (N)	No. of Bytes Requested	Register Value
2 bytes	2 bytes	1 byte	N * 2 bytes

The information field is blank for MODBUS functions 7 and 11.

2.3.2.4 CRC16

See section 2.1.3.

2.3.3 Format of the P521 Response to a Request from a Master

Frame sent by the MiCOM relay (response).

Slave Number	Function Code	Data	CRC16
1 byte	1 byte	n bytes	2 bytes

2.3.3.1 Slave Number

The slave number is situated between 1 and 255.

2.3.3.2 Function Code

See section 2.2.

2.3.3.3 Structure of the Data Field by MODBUS Function

Functions 1 and 2

Byte Count (N)	Coil Value
1 byte	$\frac{N}{8}$ * 1 byte

Functions 3 and 4

Byte Count (N)	Register Value
1 byte	N * 2 bytes

Functions 5 and 6

Register Address	Register Value
2 bytes	2 bytes

Function 7

Output Data
1 byte

Function 8

Sub-Function Code	Data
2 bytes	N * 2 bytes

Function 11

Status	Event Count
2 bytes	N * 2 bytes

Functions 15 and 16

Starting Address	No. of Register Written
2 bytes	2 bytes

2.3.3.4 Byte and Word Order

Each MODBUS word consists of 2 bytes. The bytes are transmitted in the order, low byte then high byte. If a MODBUS register consists of 2 words then the high word is transmitted before the low word.

2.3.3.5 CRC16

See section 2.1.3.

2.3.4 Messages Validity Check

When **MiCOM P521** relays receive a master query, it validates the frame:

If the CRC is incorrect, the frame is invalid. **MiCOM P521** relays do not reply to the query. The master must re-transmit its query.

If the CRC is correct but the MiCOM relay can not process the query, it sends an exception response.

2.3.4.1 Exception Response

Slave Number	Function Code	Exception Code	CRC16
1 byte	1 byte	1 byte	2 bytes

2.3.4.2 Slave Number

The slave number can be between 1 and 255.

2.3.4.3 Function Code

The function code returned by the MiCOM relay in the exception response is the function code sent by the master but with the most significant bit (Bit 7) forced to 1.

2.3.4.4 Exception Code

The MiCOM P521 relay supports 4 exception codes.

- Code 01 Illegal Function: The function code received in the request is invalid
- Code 03 Illegal Data Value: A value contained in a request data field is invalid

  The No. of registers written to/read from is incorrect

  The address of registers written to/read from is incorrect
- Code 05 Acknowledge: If the MiCOM P521 is processing a request from the master and a further request is sent from the master this exception code is sent to prevent any timeouts occurring in the master device.
- Code 0F: No disturbance record available

2.3.4.5 CRC16

See section 2.1.3.

2.3.5 Slave Access Control

The front panel access takes priority over rear panel control communication. While the password is active due to a front panel setting change, access via the front and rear control communications is prevented by the P521 responding to all requests with an exception.

3 MODBUS IMPLEMENTATION

The MODBUS implementation of the relay is based on a number of memory pages being available for access via one or more MODBUS functions.

3.1 Overview

Page	Address Range	Access Rights	MODBUS Function	Usage
Page 0	0000-00FF h	Read only	1, 2, 3 or 4	Product information, event flags and measurements
Page 1	0100-01FF h	Read/Write	3, 4, 6 or 16	Non-protection settings
Page 2	0200-02FF h	Read/Write	3, 4, 6 or 16	Group 1 protection settings
Page 3	0300-03FF h	Read/Write	3, 4, 6 or 16	Group 2 protection settings
Page 4	0400-0403 h	Read only	5 or 6 or 15	Remote control words
Page 5	0500-05FF h	Read/Write	3, 4, 6 or 16	Operators & Operands of Logic Equations
Page 6	0600-06FF h	Read/Write	3, 4, 6 or 16	Delay Timers of Logic Equations and CTS Settings
Page 7	0700 h	Read only	7	Quick read status byte
Page 8	0800-0803 h	Write only	16	Time synchronization
Pages 9 to 21	0900-21FA h	Read only	3 or 4	Disturbance record channel data
Page 22	2200 h	Read only	3 or 4	Disturbance record index frame
Page 24	2400-2479 h	Read only	3, 4, 6 or 16	Group 3 protection settings
Page 25	2500-2579 h	Read only	3, 4, 6 or 16	Group 4 protection settings
Page 35	3500-35F9 h	Read only	3 or 4	Event records
Page 36	3600 h	Read only	3 or 4	Oldest event records
Page 37	3700 – 3704 h	Read only	3 or 4	Fault records
Pages 38 to 3C	3800-3C06 h	Read only	3 or 4	Disturbance recorder channel selection and configuration
Page 3D	3D00 h	Read only	3 or 4	Summary disturbance records
Page 3E	3E00 h	Read only	3 or 4	Oldest fault record

Note *The recommended MODBUS functions for each page are in* ***bold*** *type.*

Table 3 - Overview of memory pages

3.2 3-Dimensional MODBUS Registers

MODBUS registers from page 9 onwards i.e. event, fault and disturbance records are three-dimensional. In order to read all the data the register contains, the specified number of words must be read. If an incorrect number of words are requested then a MODBUS exception code 03 will be returned. The number of words contained and the format of the data to be read has been documented in the format section included with each register type.

3.3 Mapping

The detailed mapping of the relay pages 0 to 8 are shown in sections 3.3.1 to 3.3.8.

The codes shown in the cell types columns are detailed in the table of register formats in section 3.4.

3.3.1 Page 0H: Product Information

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Product Information								
Reserved	0000	0002	-	-	-	-	-	-
Reference	0003	0004	F10	32	127	1	-	"SE "
Software Version	0005	0005	F21	10	65536	1	-	13.A
Communications Type	0006	0006	F41	0	2	1	-	-
Internal Phase Ratio	0007	0007	F1	N/A	N/A	N/A	-	800
Internal Earth Ratio	0008	0008	F1	N/A	N/A	N/A	-	See Note 1
Reserved	0009	000C	-	-	-	-	-	-
Active Setting Group	000D	000D	F1	1	2	1	-	1
Password Active	000E	000E	F24	N/A	N/A	N/A	-	0
Hardware Alarm Status	000F	000F	F45	0	FFFF	2N	-	-
Remote Signalling								
Logic Input States	0010	0010	F12	0	FFFF	2N	-	-
Logic Inputs Functions Status (Word 1)	0011	0011	F20	0	FFFF	2N	-	-
Logic Inputs Functions Status (Word 2)	0012	0012	F20'	0	FFFF	2N	-	-
Trip Condition Control Logic	0013	0013	F22	0	FFFF	2N	-	-
Output Contact Hardware State	0014	0014	F13	0	FFFF	2N	-	-
Idiff Status Flags	0015	0015	F52	0	FFFF	2N	-	-
I> Status Flags	0016	0016	F17	0	FFFF	2N	-	-
I>> Status Flags	0017	0017	F17	0	FFFF	2N	-	-
I>>> Status Flags	0018	0018	F17	0	FFFF	2N	-	-
I>>>> Status Flags	0019	0019	F17	0	FFFF	2N	-	-
Ie> Status Flags	001A	001A	F16	0	FFFF	2N	-	-
Ie>> Status Flags	001B	001B	F16	0	FFFF	2N	-	-
Ie>>> Status Flags	001C	001C	F16	0	FFFF	2N	-	-
Ie>>>> Status Flags	001D	001D	F16	0	FFFF	2N	-	-
Idiff Alarm Flags	001E	001E	F53	0	FFFF	2N	-	-
Intertrip Alarm Flags	001F	001F	F54	0	FFFF	2N	-	-
Reserved	0020	0020	-	-	-	-	-	-
I> Alarm Flags	0021	0021	F17	0	FFFF	2N	-	-
I>> Alarm Flags	0022	0022	F17	0	FFFF	2N	-	-
I>>> Alarm Flags	0023	0023	F17	0	FFFF	2N	-	-
I>>>> Alarm Flags	0024	0024	F17	0	FFFF	2N	-	-
tI> Alarm Flags	0025	0025	F17	0	FFFF	2N	-	-

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
tI>> Alarm Flags	0026	0026	F17	0	FFFF	2N	-	-
tI>>> Alarm Flags	0027	0027	F17	0	FFFF	2N	-	-
tI>>>> Alarm Flags	0028	0028	F17	0	FFFF	2N	-	-
Thermal State Status Flags	0029	0029	F37	0	FFFF	2N	-	-
I< Status Flags	002A	002A	F17	0	FFFF	2N	-	-
I2> Status Flags	002B	002B	F16	0	FFFF	2N	-	-
I2>> Status Flags	002C	002C	F16	0	FFFF	2N	-	-
Broken Conductor / CB Failure / CB Status Flags	002D	002D	F38	0	FFFF	2N	-	-
I< Alarm Flags	002E	002E	F17	0	FFFF	2N	-	-
General Alarm Flags (Word 1)	002F	002F	F36	0	FFFF	2N	-	-
General Alarm Flags (Word 2)	0030	0030	F44	0	FFFF	2N	-	-
Number of Available Disturbance Records	0031	0031	F31	0	5	1	-	-
Type of Fault Record Generated for the Fault	0032	0032	F1	0	18	1	-	-
CB Supervision Status Flags	0033	0033	F43	0	FFFF	2N	-	-
Output Contact Latching Status	0034	0034	F13	0	FFFF	2N	-	-
Command Status to UnLatch Latched Output Contacts	0035	0035	F1	0	FFFF	2N	-	-
Commissioning Status Flags	0036	0036	F56	0	FFFF	2N	-	-
All Protection Elements Tripped During the Fault (Word 1)	0037	0037	F64	0	FFFF	2N	-	-
All Protection Elements Tripped During the Fault (Word 2)	0038	0038	F65	0	FFFF	2N	-	-
Output Contact Function State	0039	0039	F13	0	FFFF	2N	-	-
Boolean Equation Status Flags	003A	003A	F81	0	FFFF	2N	-	-
Boolean Equation Alarm Flags	003B	003B	F81	0	FFFF	2N	-	-
Programmable Intertrip Status Flags	003C	003C	F82	0	FFFF	2N	-	-
Reserved	003D	003F	-	-	-	-	-	-
Remote Measurements								
Phase A Current RMS Value	0040	0041	F18	0	6000000	1	1/100 A	-
Phase B Current RMS Value	0042	0043	F18	0	6000000	1	1/100 A	-
Phase C Current RMS Value	0044	0045	F18	0	6000000	1	1/100 A	-
Earth Current RMS Value	0046	0047	F18	0	1200000	1	1/100 A	-
Thermal State	0048	0048	F1	0	1000	1	%	-
Reserved	0049	0049	-	-	-	-	-	-
Phase A Current Peak RMS Value	004A	004B	F18	0	6000000	1	1/100 A	-
Phase B Current Peak RMS Value	004C	004D	F18	0	6000000	1	1/100 A	-
Phase C Current Peak RMS Value	004E	004F	F18	0	6000000	1	1/100 A	-
Phase A Current Rolling RMS Value	0050	0051	F18	0	6000000	1	1/100 A	-
Phase B Current Rolling RMS Value	0052	0053	F18	0	6000000	1	1/100 A	-
Phase C Current Rolling RMS Value	0054	0055	F18	0	6000000	1	1/100 A	-
Ie Harmonique	0056	0057	F18	0	6000000	1	1/100 A	-

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Negative Phase Sequence Current Value (Fundamental)	0058	0059	F18	0	6000000	1	1/100 A	-
Positive Phase Sequence Current Value (Fundamental)	005A	005B	F18	0	6000000	1	1/100 A	-
Ratio of Positive to Negative Sequence Current	005C	005C	F1	0	1000	1	%	-
Reserved	005D	005F	-	-	-	-	-	-
Current Differential Measurements								
Phase A Local Current	0060	0061	F18	0	6000000	1	1/100 A	-
Phase B Local Current	0062	0063	F18	0	6000000	1	1/100 A	-
Phase C Local Current	0064	0065	F18	0	6000000	1	1/100 A	-
Reserved	0066	006B	-	-	-	-	-	-
Phase A Remote Current	006C	006D	F18	0	6000000	1	1/100 A	-
Reserved	006E	006F	-	-	-	-	-	-
Phase B Remote Current	0070	0071	F18	0	6000000	1	1/100 A	-
Reserved	0072	0073	-	-	-	-	-	-
Phase C Remote Current	0074	0075	F18	0	6000000	1	1/100 A	-
Reserved	0076	0083	-	-	-	-	-	-
Phase A Differential Current	0084	0085	F18	0	6000000	1	1/100 A	-
Phase B Differential Current	0086	0087	F18	0	6000000	1	1/100 A	-
Phase C Differential Current	0088	0089	F18	0	6000000	1	1/100 A	-
Phase A Bias Current	008A	008B	F18	0	6000000	1	1/100 A	-
Phase B Bias Current	008C	008D	F18	0	6000000	1	1/100 A	-
Phase C Bias Current	008E	008F	F18	0	6000000	1	1/100 A	-
Channel 1 Valid Messages	0090	0091	F57	0	4294967294	1	-	-
Channel 1 Error Messages	0092	0093	F57	0	4294967294	1	-	-
Channel 1 Errored Seconds	0094	0095	F57	0	4294967294	1	s	-
Channel 1 Severely Errored Seconds	0096	0097	F57	0	4294967294	1	s	-
Reserved	0098	0099	-	-	-	-	-	-
Channel 1 Propagation Delay	009A	009B	F57	0	12000000	1	ms	-
Reserved	009C	00A7	-	-	-	-	-	-
Elapsed Communications Time	00A8	00A9	F57	0	4294967294	1	s	-
Phase A Local Angle	00AA	00AA	F2	-180	179	1	degrees	400 (Error)
Phase B Local Angle	00AB	00AB	F2	-180	179	1	degrees	400 (Error)
Phase C Local Angle	00AC	00AC	F2	-180	179	1	degrees	400 (Error)
Phase A Differential Angle	00AD	00AD	F2	-180	179	1	degrees	400 (Error)
Phase B Differential Angle	00AE	00AE	F2	-180	179	1	degrees	400 (Error)
Phase C Differential Angle	00AF	00AF	F2	-180	179	1	degrees	400 (Error)
Fourier Module								
Modulus IA	00B0	00B0	F1	0	65534	1	-	-
Modulus IB	00B1	00B1	F1	0	65534	1	-	-
Modulus IC	00B2	00B2	F1	0	65534	1	-	-
Modulus IE	00B3	00B3	F1	0	65534	1	-	-

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Fourier Argument								
Argument IA	00B4	00B4	F1	0	65534	1	-	-
Argument IB	00B5	00B5	F1	0	65534	1	-	-
Argument IC	00B6	00B6	F1	0	65534	1	-	-
Argument IE	00B7	00B7	F1	0	65534	1	-	-
Module I2	00B8	00B8	F1	0	65534	1	-	-
Module I1	00B9	00B9	F1	0	65534	1	-	-
Recloser Statistics								
Reserved	00BA	00C0	-	-	-	-	-	-
Rolling Demand								
RMS IA Average Value for Rolling Menu	00C1	00C2	F18	0	6000000	1	1/100 A	-
RMS IB Average Value for Rolling Menu	00C3	00C4	F18	0	6000000	1	1/100 A	-
RMS IC Average Value for Rolling Menu	00C5	00C6	F18	0	6000000	1	1/100 A	-
RMS IA Max Value for Rolling Menu	00C7	00C8	F18	0	6000000	1	1/100 A	-
RMS IB Max Value for Rolling Menu	00C9	00CA	F18	0	6000000	1	1/100 A	-
RMS IC Max Value for Rolling Menu	00CB	00CC	F18	0	6000000	1	1/100 A	-
Inrush								
Inrush Block Control Flags	00CD	00CD	F70	0	FFFF	2N	-	-
Inrush Block Alarm Flags	00CE	00CE	F71	0	FFFF	2N	-	-
CTS								
CTS Control Flags	00CF	00CF	F72	0	FFFF	2N	-	-
CTS Alarm Flags	00D0	00D0	F73	0	FFFF	2N	-	-
Frame Mode								
Frame Mode Flag	00D1	00D1	F87	0	1	1	-	-
Frame Mode Alarm Flag	00D2	00D2	F87	0	1	1	-	-
CORTEC Information								
Model Number	00D3	00DA	F86	-	-	-	-	-
Serial Number	00DB	00DE	F86	-	-	-	-	-
auxiliary powers supply	00DF	00DF	F98	0	FFFF	2N	-	-
analogic inputs transformer	00E0	00E0	F99	0	FFFF	2N	-	-
Reserved	00E1	00FF	-	-	-	-	-	-

Note 1:			
Sensitivity Range	0.1 to 40 Ien Range	0.01 to 8 Ien Range	0.002 to 1 Ien Range
Internal CT Value	Internal CT Value is 800	Internal CT Value is 3277	Internal CT Value is 32700

Table 4 - Page 0H: Product Information

3.3.2 Page 1: Non Protection Settings

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Non Protection Settings - Remote Parameters								
Address	0100	0100	F1	1	255	1	-	1
Language	0101	0101	F1	0	7	1	-	1
Password	0102	0103	F10	65	90	1	-	AAAA
Frequency	0104	0104	F1	50	60	10	Hz	50
Phase A Label	0105	0105	F25	L1	A-R	1	-	L1
Phase B Label	0106	0106	F25	L2	B-W	1	-	L2
Phase C Label	0107	0107	F25	L3	C-B	1	-	L3
Earth Label	0108	0108	F25	N	o-E	1	-	N
Default Display	0109	0109	F26	1	4	1	-	1
User Reference (Characters 1 and 2)	010A	010B	F10	48	90	1	-	"AAAA"
Fault Record to Display in Menu	010C	010C	F31	1	5	1	-	5
Logic Inputs Edge Configuration Setting	010D	010D	F12	0	FFFF	2N	-	0
Instantaneous Fault Record to Display in Menu	010E	010E	F31	1	5	1	-	5
Logic Inputs Voltage Input Setting	010F	010F	F50	0	1	1	-	0
Non Protection Settings - CB Monitoring Measurements								
Number of CB Operations Value	0110	0110	F1	0	600000	1	-	-
CB Opening Time Value	0111	0111	F1	0	600000	1	1/100 s	-
IA Summation Current Value	0112	0113	F18	0	600000	1	An	-
IB Summation Current Value	0114	0115	F18	0	600000	1	An	-
IC Summation Current Value	0116	0117	F18	0	600000	1	An	-
CB Closing Time Value	0118	0118	F1	0	600000	1	1/100 s	-
CB Trip and Close Control	0119	0119	F63	0	2	1	-	0
Manual CB Tripping Delay Time Value	011A	011A	F1	0	6000	10	1/100 s	0
Manual CB Closing Delay Time Value	011B	011B	F1	0	6000	10	1/100 s	0
Reserved	011C	011E	-	-	-	-	-	-
Enabled/Disabled State of the Output Relay Latching	011F	011F	F14	0	FFFF	2N	-	0
Non Protection Settings - Ratio								
Primary Phase CT Value	0120	0120	F1	1	9999	1	-	1000
Secondary Phase CT Value	0121	0121	F1	1	5	4	-	1
Primary Earth CT Value	0122	0122	F1	1	9999	1	-	1000
Secondary Earth CT Value	0123	0123	F1	1	5	4	-	1
CT Correction Ratio	0124	0124	F1	50	10000	1	1/1000	1000
Vectorial Compensation	0125	0125	F66	0	14	1	-	0
Reserved	0126	012E	-	-	-	-	-	-
Direction of Phase Rotation	012F	012F	F51	0	1	1	-	0
Non Protection Settings - Communications								
Speed	0130	0130	F4	0	7	1	-	6

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Parity	0131	0131	F5	0	2	1	-	0
Stop Bits	0132	0132	F29	0	1	1	-	0
COM Available	0133	0133	F30	0	1	1	-	1
Data Format	0134	0134	F48	0	1	1	-	0
Reserved	0135	013F						
Non Protection Settings - Protection Communications								
Protocol	0140	0140	F58	0	2	1	-	0
Data Rate	0141	0141	F59	0	3	1	-	0
Relay Address	0142	0142	F60	0	31	1	-	0
Channel 1 Clock Source	0143	0143	F61	0	1	1	-	0
Reserved	0144	0147	-	-	-	-	-	-
Communications Fail Timer	0148	0148	F1	0	999	1	1/100s	999
Communications Delay Tolerance	0149	014A	F57	20	1000	2	1/100s	1000
Characteristic Modification Time	014B	014C	F57	0	10000	10	1/100s	10000
Reserved	014D	014E	-	-	-	-	-	-
Non Protection Settings - Configuration								
Comms Fail Auto-Reset Enable	014F	014F	F1	0	1	1	-	0
Active Setting Group Selection	0150	0150	F1	1	4	1	-	1
Self-Reset Alarm Enabled State	0151	0151	F1	0	1	1	-	1
Change Group Input Level Type	0152	0152	F47	0	1	1	-	1
Battery Alarm Enabled State	0153	0153	F1	0	1	1	-	1
Non Protection Settings - LED Allocation								
LED 5 Function Allocation (Word 1)	0154	0154	F19	0	FFFF	2N	-	0
LED 6 Function Allocation (Word 1)	0155	0155	F19	0	FFFF	2N	-	0
LED 7 Function Allocation (Word 1)	0156	0156	F19	0	FFFF	2N	-	0
LED 8 Function Allocation (Word 1)	0157	0157	F19	0	FFFF	2N	-	0
LED 5 Function Allocation (Word 2)	0158	0158	F19'	0	FFFF	2N	-	0
LED 6 Function Allocation (Word 2)	0159	0159	F19'	0	FFFF	2N	-	0
LED 7 Function Allocation (Word 2)	015A	015A	F19'	0	FFFF	2N	-	0
LED 8 Function Allocation (Word 2)	015B	015B	F19'	0	FFFF	2N	-	0
LED 5 Function Allocation (Word 3)	015C	015C	F19"	0	FFFF	2N	-	0
LED 6 Function Allocation (Word 3)	015D	015D	F19"	0	FFFF	2N	-	0
LED 7 Function Allocation (Word 3)	015E	015E	F19"	0	FFFF	2N	-	0
LED 8 Function Allocation (Word 3)	015F	015F	F19"	0	FFFF	2N	-	0
Non Protection Settings - Commissioning Options								
Commissioning Options ?	0160	0160	F24	0	1	1	-	0
Initiate LED Test	0161	0161	F24	0	1	1	-	0
Disable Output Contact Operation	0162	0162	F24	0	1	1	-	0
Output Contacts Selected for Test	0163	0163	F62	0	FFFF	2N	-	0
Perform Output Contact Test	0164	0164	F24	0	1	1	-	0
Inhibit Circuit Breaker Measurements	0165	0165	F24	0	1	1	-	0

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Enable Communications Loopback	0166	0166	F75	0	1	1	-	0
Non Protection Settings - Logic Input Allocation								
Logic Input 1 Function Allocation (Word 1)	0167	0167	F15	0	FFFF	2N	-	0
Logic Input 2 Function Allocation (Word 1)	0168	0168	F15	0	FFFF	2N	-	0
Logic Input 3 Function Allocation (Word 1)	0169	0169	F15	0	FFFF	2N	-	0
Logic Input 4 Function Allocation (Word 1)	016A	016A	F15	0	FFFF	2N	-	0
Logic Input 5 Function Allocation (Word 1)	016B	016B	F15	0	FFFF	2N	-	0
Reserved	016C	016F	-	-	-	-	-	-
Logic Input 1 Function Allocation (Word 2)	0170	0170	F15'	0	FFFF	2N	-	0
Logic Input 2 Function Allocation (Word 2)	0171	0171	F15'	0	FFFF	2N	-	0
Logic Input 3 Function Allocation (Word 2)	0172	0172	F15'	0	FFFF	2N	-	0
Logic Input 4 Function Allocation (Word 2)	0173	0173	F15'	0	FFFF	2N	-	0
Logic Input 5 Function Allocation (Word 2)	0174	0174	F15'	0	FFFF	2N	-	0
Reserved	0175	0178	-	-	-	-	-	-
Auxiliary Timer 1	0179	0179	F1	0	20000	1	1/100 sec	0
Auxiliary Timer 2	017A	017A	F1	0	20000	1	1/100 sec	0
Reserved	017B	017F	-	-	-	-	-	-
Non Protection Settings - Output Relay Allocation								
Broken Conductor Detection	0180	0180	F14	0	FFFF	2N	-	0
CB Failure	0181	0181	F14	0	FFFF	2N	-	0
I<	0182	0182	F14	0	FFFF	2N	-	0
I2>	0183	0183	F14	0	FFFF	2N	-	0
I2>>	0184	0184	F14	0	FFFF	2N	-	0
Thermal Overload Alarm	0185	0185	F14	0	FFFF	2N	-	0
Thermal Overload Trip	0186	0186	F14	0	FFFF	2N	-	0
tAux1	0187	0187	F14	0	FFFF	2N	-	0
tAux2	0188	0188	F14	0	FFFF	2N	-	0
CB Close	0189	0189	F14	0	FFFF	2N	-	0
CB Alarm	018A	018A	F14	0	FFFF	2N	-	0
Trip Circuit Supervision Failure	018B	018B	F14	0	FFFF	2N	-	0
Active Group	018C	018C	F14	0	FFFF	2N	-	0
Trip Relay	018D	018D	F14	0	FFFF	2N	-	0
tI>	018E	018E	F14	0	FFFF	2N	-	0
tI>>	018F	018F	F14	0	FFFF	2N	-	0
tI>>>	0190	0190	F14	0	FFFF	2N	-	0
tI>>>>	0191	0191	F14	0	FFFF	2N	-	0
tIe>	0192	0192	F14	0	FFFF	2N	-	0
tIe>>	0193	0193	F14	0	FFFF	2N	-	0
tIe>>>	0194	0194	F14	0	FFFF	2N	-	0
tIe>>>>	0195	0195	F14	0	FFFF	2N	-	0
I>	0196	0196	F14	0	FFFF	2N	-	0

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
I>>	0197	0197	F14	0	FFFF	2N	-	0
I>>>	0198	0198	F14	0	FFFF	2N	-	0
I>>>>	0199	0199	F14	0	FFFF	2N	-	0
Ie>	019A	019A	F14	0	FFFF	2N	-	0
Ie>>	019B	019B	F14	0	FFFF	2N	-	0
Ie>>>	019C	019C	F14	0	FFFF	2N	-	0
Ie>>>>	019D	019D	F14	0	FFFF	2N	-	0
Idiff Trip	019E	019E	F14	0	FFFF	2N	-	0
Backup Protection On	019F	019F	F14	0	FFFF	2N	-	0
Protection Communications Fail	01A0	01A0	F14	0	FFFF	2N	-	0
Direct Intertrip	01A1	01A1	F14	0	FFFF	2N	-	0
Current Differential Intertrip	01A2	01A2	F14	0	FFFF	2N	-	0
Permissive Intertrip	01A3	01A3	F14	0	FFFF	2N	-	0
Output Contact Inversion	01A4	01A4	F14	0	FFFF	2N	-	0
Trip Circuit Supervision Block	01A5	01A5	F14	0	FFFF	2N	-	0
Non Protection Settings - Trip Relay Logic								
Trip Relay Function Allocation (Word 1)	01A6	01A6	F6	0	FFFF	2N	-	FFFF
Trip Relay Function Allocation (Word 2)	01A7	01A7	F6'	0	FFFF	2N	-	000F
Trip Relay Latching Function Allocation (Word 1)	01A8	01A8	F8	0	FFFF	2N	-	0
Trip Relay Latching Function Allocation (Word 2)	01A9	01A9	F8'	0	FFFF	2N	-	0
Blocking Logic 1 Function Allocation(Word 1)	01AA	01AA	F8''	0	FFFF	2N	-	0
Blocking Logic 2 Function Allocation(Word 1)	01AB	01AB	F8''	0	FFFF	2N	-	0
Non Protection Settings - Broken Conductor Detection								
Broken Conductor Detection ?	01AC	01AC	F24	0	1	1	-	0
tBC Value	01AD	01AD	F1	0	14400	1	s	5
I2 / I1 Threshold	01AE	01AE	F1	20	100	1	%	20
Non Protection Settings - Cold Load Start								
Cold Load Start ?	01AF	01AF	F24	0	1	1	-	0
Cold Load Start Function Allocation	01B0	01B0	F33	0	FFFF	2N	-	0
Cold Load Start %	01B1	01B1	F1	20	500	1	%	200
Cold Load Start Delay	01B2	01B2	F1	1	36000	1	1/10s	400
Non Protection Settings - Selective Scheme Logic								
Selective Scheme Logic 1 Function Allocation	01B3	01B3	F40	0	FFFF	2N	-	0
tSEL1 Value	01B4	01B4	F1	0	15000	1	1/100 s	0
Selective Scheme Logic 2 Function Allocation	01B5	01B5	F40	0	FFFF	2N	-	0
tSEL2 Value	01B6	01B6	F1	0	15000	1	1/100 s	0
Reserved	01B7	01BF						

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Non Protection Settings - Disturbance Records								
Pre-Time Value	01C0	01C0	F1	1	90	1	1/10 s	1
Reserved	01C1	01C1						
Disturbance Record Starting Condition	01C2	01C2	F32	0	1	1	-	1
Non Protection Settings - Circuit Breaker Supervision								
TC Supervision ?	01C3	01C3	F24	0	1	1	-	0
Trip Circuit Time Value	01C4	01C4	F1	10	10000	5	1/100s	40
CB Open Supervision ?	01C5	01C5	F24	0	1	1	-	0
CB Opening Time Threshold	01C6	01C6	F1	5	100	5	1/100s	5
CB Close Supervision ?	01C7	01C7	F24	0	1	1	-	0
CB Closing Time Threshold	01C8	01C8	F1	5	100	5	1/100s	5
CB Open Alarm ?	01C9	01C9	F1	0	1	2	-	0
CB Number of Opens Threshold	01CA	01CA	F1	0	50000	1	-	0
Summation Amps (n) ?	01CB	01CB	F24	0	1	1	-	0
Summation Amps (n) Threshold	01CC	01CC	F1	0	4000	1	MA^n	0
Summation Amps N Type	01CD	01CD	F1	1	2	1	-	1
Open Pulse Time Value	01CE	01CE	F1	10	500	5	1/100 s	10
Close Pulse Time Value	01CF	01CF	F1	10	500	5	1/100 s	10
Non Protection Settings - Time Peak Value								
Time Window Value	01D0	01D0	F42	5	60	TI	Mins	5
Non Protection Settings - CB Fail								
CB Failure ?	01D1	01D1	F24	0	1	1	-	0
I< Threshold	01D2	01D2	F1	2	100	1	1/100In	10
tBF Value	01D3	01D3	F1	3	1000	1	1/100s	10
Block Phase Start	01D4	01D4	F24	0	1	1	-	0
Block Earth Start	01D5	01D5	F24	0	1	1	-	0
Non Protection Settings - Rolling Demand								
Sub Period Value	01D6	01D6	F1	1	60	1	Mins	1
Number of Sub Periods	01D7	01D7	F1	1	24	1	-	1
Non Protection Settings - Output Relay Allocation (Addtional)								
Equation A	01D8	01D8	F14	0	FFFF	2N	-	0
Equation B	01D9	01D9	F14	0	FFFF	2N	-	0
Equation C	01DA	01DA	F14	0	FFFF	2N	-	0
Equation D	01DB	01DB	F14	0	FFFF	2N	-	0
Equation E	01DC	01DC	F14	0	FFFF	2N	-	0
Equation F	01DD	01DD	F14	0	FFFF	2N	-	0
Equation G	01DE	01DE	F14	0	FFFF	2N	-	0
Equation H	01DF	01DF	F14	0	FFFF	2N	-	0
Input 1	01E0	01E0	F14	0	FFFF	2N	-	0
Input 2	01E1	01E1	F14	0	FFFF	2N	-	0

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Input 3	01E2	01E2	F14	0	FFFF	2N	-	0
Input 4	01E3	01E3	F14	0	FFFF	2N	-	0
Input 5	01E4	01E4	F14	0	FFFF	2N	-	0
Programmable Intertrip A	01E5	01E5	F14	0	FFFF	2N	-	0
Programmable Intertrip B	01E6	01E6	F14	0	FFFF	2N	-	0
Programmable Intertrip C	01E7	01E7	F14	0	FFFF	2N	-	0
Programmable Intertrip D	01E8	01E8	F14	0	FFFF	2N	-	0
CTS local CT Alarm	01E9	01E9	F14	0	FFFF	2N	-	0
CTS remote CT Alarm	01EA	01EA	F14	0	FFFF	2N	-	0
CTS Block	01EB	01EB	F14	0	FFFF	2N	-	0
CTS Cdiff Restrain	01EC	01EC	F14	0	FFFF	2N	-	0
Convention Mode	01ED	01ED	F14	0	FFFF	2N	-	0
Non Protection Settings -Block Allocation (Addtional)								
Blocking Logic 1 Function Allocation (Word 2)	01EE	01EE	F8'''	0	FFFF	2N	-	0
Blocking Logic 2 Function Allocation (Word 2)	01EF	01EF	F8'''	0	FFFF	2N	-	0
Non Protection Settings - LED Allocation (Addtional)								
LED 5 Function Allocation (Word 4)	01F0	01F0	F19'''	0	FFFF	2N	-	0
LED 6 Function Allocation (Word 4)	01F1	01F1	F19'''	0	FFFF	2N	-	0
LED 7 Function Allocation (Word 4)	01F2	01F2	F19'''	0	FFFF	2N	-	0
LED 8 Function Allocation (Word 4)	01F3	01F3	F19'''	0	FFFF	2N	-	0
Non Protection Settings - Record (Addtional)								
Disturb Trigger	01F4	01F4	F24	0	1	1	-	0
Frame Mode	01F5	01F5	F80	0	1	1	-	1
Record Number	01F6	01F6	F1	1	5	1	-	5
Non Protection Settings - Configuration (Addtional)								
Diff Disable Alarm	01F7	01F7	F24	0	1	1	-	1
Non Protection Settings - Output Relay Allocation (Addtional2)								
Diff Disable (Output Relay Allocation)	01F8	01F8	F14	0	FFFF	2N	-	0
Active setting group after a group swap	01F9	01F9	F1	0	4	1	-	0
Active setting group when logical input = 0	01FA	01FA	F1	1	4	1	-	1
Active setting group when logical input = 1	01FB	01FB	F1	1	4	1	-	2
Fail safe mode Enabled ?	01FC	01FC	F1	0	1	1	-	0
Reserved	01FD	01FF						

Table 5 - Page 1: Non Protection Settings

3.3.3 Page 2h: Group 1 Protection Settings

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Protection Settings - Current Differential								
Current Diff. ?	0200	0200	F24	0	1	1	-	1
Is1	0201	0201	F1	10	200	5	1/100	20
Is2	0202	0202	F1	100	3000	5	1/100	200
k1	0203	0203	F1	0	150	5	%	30
k2	0204	0204	F1	30	150	5	%	150
Time Delay Type	0205	0205	F27	0	1	1	-	0
tIdiff Value	0206	0206	F1	0	15000	1	1/100 s	0
IDMT Curve Type	0207	0207	F3	0	9	1	-	1
TMS	0208	0208	F1	25	1500	25	1/1000	1000
Time Dial	0209	020A	F57	100	100000	100	1/1000	1000
PIT Time	020B	020B	F1	5	200	1	1/100 s	20
PIT I Disabled	020C	020C	F24	0	1	1	-	0
Inrush Restraint	020D	020D	F72	0	2	1	-	0
Received DIT Dwell Time	020E	020E	F1	10	500	5	1/100s	10
Inrush High Set	020F	020F	F1	400	3200	1	1/100In	400
Protection Settings - Phase Fault Overcurrent								
I> ?	0210	0210	F24	0	2	1	-	0
I> Threshold	0211	0211	F1	10	2500	1	1/100 In	100
I> Time Delay Type	0212	0212	F27	0	2	1	-	0
I> IDMT Curve Type	0213	0213	F3	0	9	1	-	1
I> TMS Value	0214	0214	F1	25	1500	25	1/1000	1000
I> TD Value	0215	0216	F57	100	100000	100	1/1000	100
I> K value (RI curve)	0217	0217	F1	100	10000	5	1/1000 s	100
tI> Value	0218	0218	F1	0	15000	1	1/100 s	4
I> Reset Type	0219	0219	F27	0	1	1	-	0
I> RTMS Value	021A	021A	F1	25	3200	25	1/1000	25
I> tReset Value	021B	021B	F1	4	10000	1	1/100 s	4
I>> ?	021C	021C	F24	0	2	1	-	0
I>> Threshold	021D	021D	F1	50	4000	5	1/100 In	100
I>> Time Delay Type	021E	021E	F27	0	2	1	-	0
I>> IDMT Curve Type	021F	021F	F3	0	9	1	-	1
I>> TMS Value	0220	0220	F1	25	1500	25	1/1000	1000
I>> TD Value	0221	0222	F57	100	100000	100	1/1000	100
I>> K Value (RI Curve)	0223	0223	F1	100	10000	5	1/1000	100
tI>> Value	0224	0224	F1	0	15000	1	1/100 s	1
I>> Reset Type	0225	0225	F27	0	1	1	-	0
I>> RTMS Value	0226	0226	F1	25	3200	25	1/1000	25
I>> tReset Value	0227	0227	F1	4	10000	1	1/100 s	4
I>>> ?	0228	0228	F24	0	2	1	-	0

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
I>>> Value	0229	0229	F1	50	4000	5	1/100 In	2000
tI>>> Value	022A	022A	F1	0	15000	1	1/100 s	1
I>>>> ?	022B	022B	F24	0	2	1	-	0
I>>>> Value	022C	022C	F1	50	4000	5	1/100 In	2000
tI>>>> Value	022D	022D	F1	0	15000	1	1/100 s	1
Protection Settings - Earth Fault Overcurrent								
Ie> ?	022E	022E	F24	0	2	1	-	0
Ie> Value	022F	022F	F1	10	1000	5	1/1000 Ion	10
Ie> Time Delay Type	0230	0230	F27	0	3	1	-	0
Ie> IDMT Curve Type	0231	0231	F3	0	9	1	-	1
Ie> TMS Value	0232	0232	F1	25	1500	25	1/1000	1000
Ie> TD Value	0233	0234	F57	100	100000	100	1/1000	100
Ie> K Value (RI Curve)	0235	0235	F1	100	10000	5	1/1000	100
tIe> Value	0236	0236	F1	0	15000	1	1/100	4
Ie> Type Tempo Reset	0237	0237	F27	0	1	1	-	0
Ie> RTMS Value	0238	0238	F1	25	3200	25	1/1000	25
Ie> tReset Value	0239	0239	F1	4	10000	1	1/100s	4
Ie> Laborelec	023A	023A	F3'	0	2	1	-	0
Ie>> ?	023B	023B	F24	0	2	1	-	0
Ie>> Value	023C	023C	F1	10	8000	5	1/1000 Ion	100
Ie>> Time Delay Type	023D	023D	F1	0	3	1	-	0
Ie>> IDMT Curve Type	023E	023E	F3	0	9	1	-	1
Ie>> TMS Value	023F	023F	F1	25	1500	25	1/1000	1000
Ie>> TD Value	0240	0241	F57	100	100000	100	1/1000	100
Ie>> K Value (RI Curve)	0242	0242	F1	100	10000	5	1/1000	100
tIe>> Value	0243	0243	F1	0	15000	1	1/100	1
Ie>> Type Tempo Reset	0244	0244	F27	0	1	1	-	0
Ie>> RTMS Value	0245	0245	F1	25	3200	25	1/1000	25
Ie>> tReset Value	0246	0246	F1	4	10000	1	1/100s	4
Ie>> Laborelec	0247	0247	F3'	0	2	1	-	0
Ie>>> ?	0248	0248	F24	0	2	1	-	0
Ie>>> Value	0249	0249	F1	10	8000	5	1/1000 Ion	100
tIe>>> Value	024A	024A	F1	0	15000	1	1/100	1
Ie>>>> ?	024B	024B	F24	0	2	1	-	0
Ie>>>> Value	024C	024C	F1	10	8000	5	1/1000 Ion	100
tIe>>>> Value	024D	024D	F1	0	15000	1	1/100	1
Protection Settings - Thermal Overload								
Ith> ?	024E	024E	F24	0	1	1	-	0
Ith> Value	024F	024F	F1	10	320	1	1/100	100
Reserved	0250	0250	-	-	-	-	-	-
Ith> K Value	0251	0251	F1	100	150	1	1/100 %	105
Ith> Trip Threshold	0252	0252	F1	50	200	1	%	100

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Ith> Alarm	0253	0253	F24	0	1	1	-	0
Ith> Alarm Threshold	0254	0254	F1	50	200	1	%	90
Ith> Te1	0255	0255	F1	1	200	1	Mins	1
Reserved	0256	0256	-	-	-	-	-	-
Protection Settings - Negative Sequence Overload								
I2> ?	0257	0257	F24	0	1	1	-	0
I2> Threshold	0258	0258	F1	10	4000	1	1/100 In	100
I2> Time Delay Type	0259	0259	F27	0	2	1	-	0
I2> IDMT Type	025A	025A	F3	0	9	1	-	1
I2> TMS Value	025B	025B	F1	25	1500	25	1/1000	1000
I2> TD Value	025C	025D	F57	100	100000	100	1/1000	100
I2> K Value (RI)	025E	025E	F1	100	10000	5	1/1000	100
tI2> Value	025F	025F	F1	0	15000	1	1/100s	0
I2> Reset Type	0260	0260	F27	0	1	1	-	0
I2> RTMS Value	0261	0261	F1	25	3200	25	1/1000	25
I2> tReset Value	0262	0262	F1	4	10000	1	1/100 s	4
I2>> ?	0263	0263	F27	0	1	1	-	0
I2>> Threshold	0264	0264	F1	10	4000	1	1/100 In	100
I2>> Time Delay Type	0265	0265	F1	0	15000	1	1/100s	0
Protection Settings - Undercurrent								
I< ?	0266	0266	F24	0	1	1	-	0
I< Threshold	0267	0267	F1	2	100	1	1/100	20
tI2< Value	0268	0268	F1	0	15000	1	1/100	0
Reserved	0269	026F	-	-	-	-	-	-
Protection Settings - Current Differential (Additional)								
PIT Local or Remote Current Selection	0270	0270	F68	0	1	1	-	0
PIT Remote Current Threshold	0271	0271	F1	10	4000	1	1/100 In	20
PIT Local Current Overcurrent Mapping	0272	0272	F69	0	FFFF	2N	-	0
Transient Bias Enable/Disable	0273	0273	F24	0	1	1	-	1
DIT Alarm	0274	0274	F24	0	1	1	-	1
PIT Alarm	0275	0275	F24	0	1	1	-	1
Kr	0276	0276	F1	3	20	1	-	4
Harmonic Ratio	0277	0277	F1	5	50	1	1%	15
Reserved	0278	0278	-	-	-	-	-	-
CTS Is1	0279	0279	F1	20	400	5	1/100 In	120

Table 6 - Page 2h: Group 1 Protection Settings

3.3.4 Page 4h: Remote Control Words

MODBUS Text	MODBUS Address		Min	Max	Step	Default Value	Units
	Start	End					
Remote Control							
Remote Control Word 1	0400	0400	F9	0	FFFF	2N	-
Reserved	0401	0402	-	-	-	-	-
Remote Control Word 3	0403	0403	F46	0	FFFF	2N	-
Remote Control Word 4	0404	0404	F46A	0	FFFF	2N	-

Table 7 - Page 4h: Remote Control Words

3.3.5 Pages 5h and 6h: Boolean Equation

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Boolean Equation								
Equation A Operator 0	0500	0500	F84	0	3	1	-	-
Equation A Operand 0	0501	0501	F83	0	61	1	-	-
Equation A Operator 1	0502	0502	F84	0	3	1	-	-
Equation A Operand 1	0503	0503	F83	0	61	1	-	-
Equation A Operator 2	0504	0504	F84	0	3	1	-	-
Equation A Operand 2	0505	0505	F83	0	61	1	-	-
Equation A Operator 3	0506	0506	F84	0	3	1	-	-
Equation A Operand 3	0507	0507	F83	0	61	1	-	-
Equation A Operator 4	0508	0508	F84	0	3	1	-	-
Equation A Operand 4	0509	0509	F83	0	61	1	-	-
Equation A Operator 5	050A	050A	F84	0	3	1	-	-
Equation A Operand 5	050B	050B	F83	0	61	1	-	-
Equation A Operator 6	050C	050C	F84	0	3	1	-	-
Equation A Operand 6	050D	050D	F83	0	61	1	-	-
Equation A Operator 7	050E	050E	F84	0	3	1	-	-
Equation A Operand 7	050F	050F	F83	0	61	1	-	-
Equation A Operator 8	0510	0510	F84	0	3	1	-	-
Equation A Operand 8	0511	0511	F83	0	61	1	-	-
Equation A Operator 9	0512	0512	F84	0	3	1	-	-
Equation A Operand 9	0513	0513	F83	0	61	1	-	-
Equation A Operator 10	0514	0514	F84	0	3	1	-	-
Equation A Operand 10	0515	0515	F83	0	61	1	-	-
Equation A Operator 11	0516	0516	F84	0	3	1	-	-
Equation A Operand 11	0517	0517	F83	0	61	1	-	-
Equation A Operator 12	0518	0518	F84	0	3	1	-	-
Equation A Operand 12	0519	0519	F83	0	61	1	-	-
Equation A Operator 13	051A	051A	F84	0	3	1	-	-
Equation A Operand 13	051B	051B	F83	0	61	1	-	-

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Equation A Operator 14	051C	051C	F84	0	3	1	-	-
Equation A Operand 14	051D	051D	F83	0	61	1	-	-
Equation A Operator 15	051E	051E	F84	0	3	1	-	-
Equation A Operand 15	051F	051F	F83	0	61	1	-	-
Equation B Operator 0	0520	0520	F84	0	3	1	-	-
Equation B Operand 0	0521	0521	F83	0	61	1	-	-
Equation B Operator 1	0522	0522	F84	0	3	1	-	-
Equation B Operand 1	0523	0523	F83	0	61	1	-	-
Equation B Operator 2	0524	0524	F84	0	3	1	-	-
Equation B Operand 2	0525	0525	F83	0	61	1	-	-
Equation B Operator 3	0526	0526	F84	0	3	1	-	-
Equation B Operand 3	0527	0527	F83	0	61	1	-	-
Equation B Operator 4	0528	0528	F84	0	3	1	-	-
Equation B Operand 4	0529	0529	F83	0	61	1	-	-
Equation B Operator 5	052A	052A	F84	0	3	1	-	-
Equation B Operand 5	052B	052B	F83	0	61	1	-	-
Equation B Operator 6	052C	052C	F84	0	3	1	-	-
Equation B Operand 6	052D	052D	F83	0	61	1	-	-
Equation B Operator 7	052E	052E	F84	0	3	1	-	-
Equation B Operand 7	052F	052F	F83	0	61	1	-	-
Equation B Operator 8	0530	0530	F84	0	3	1	-	-
Equation B Operand 8	0531	0531	F83	0	61	1	-	-
Equation B Operator 9	0532	0532	F84	0	3	1	-	-
Equation B Operand 9	0533	0533	F83	0	61	1	-	-
Equation B Operator 10	0534	0534	F84	0	3	1	-	-
Equation B Operand 10	0535	0535	F83	0	61	1	-	-
Equation B Operator 11	0536	0536	F84	0	3	1	-	-
Equation B Operand 11	0537	0537	F83	0	61	1	-	-
Equation B Operator 12	0538	0538	F84	0	3	1	-	-
Equation B Operand 12	0539	0539	F83	0	61	1	-	-
Equation B Operator 13	053A	053A	F84	0	3	1	-	-
Equation B Operand 13	053B	053B	F83	0	61	1	-	-
Equation B Operator 14	053C	053C	F84	0	3	1	-	-
Equation B Operand 14	053D	053D	F83	0	61	1	-	-
Equation B Operator 15	053E	053E	F84	0	3	1	-	-
Equation B Operand 15	053F	053F	F83	0	61	1	-	-
Equation C Operator 0	0540	0540	F84	0	3	1	-	-
Equation C Operand 0	0541	0541	F83	0	61	1	-	-
Equation C Operator 1	0542	0542	F84	0	3	1	-	-
Equation C Operand 1	0543	0543	F83	0	61	1	-	-
Equation C Operator 2	0544	0544	F84	0	3	1	-	-
Equation C Operand 2	0545	0545	F83	0	61	1	-	-
Equation C Operator 3	0546	0546	F84	0	3	1	-	-

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Equation C Operand 3	0547	0547	F83	0	61	1	-	-
Equation C Operator 4	0548	0548	F84	0	3	1	-	-
Equation C Operand 4	0549	0549	F83	0	61	1	-	-
Equation C Operator 5	054A	054A	F84	0	3	1	-	-
Equation C Operand 5	054B	054B	F83	0	61	1	-	-
Equation C Operator 6	054C	054C	F84	0	3	1	-	-
Equation C Operand 6	054D	054D	F83	0	61	1	-	-
Equation C Operator 7	054E	054E	F84	0	3	1	-	-
Equation C Operand 7	054F	054F	F83	0	61	1	-	-
Equation C Operator 8	0550	0550	F84	0	3	1	-	-
Equation C Operand 8	0551	0551	F83	0	61	1	-	-
Equation C Operator 9	0552	0552	F84	0	3	1	-	-
Equation C Operand 9	0553	0553	F83	0	61	1	-	-
Equation C Operator 10	0554	0554	F84	0	3	1	-	-
Equation C Operand 10	0555	0555	F83	0	61	1	-	-
Equation C Operator 11	0556	0556	F84	0	3	1	-	-
Equation C Operand 11	0557	0557	F83	0	61	1	-	-
Equation C Operator 12	0558	0558	F84	0	3	1	-	-
Equation C Operand 12	0559	0559	F83	0	61	1	-	-
Equation C Operator 13	055A	055A	F84	0	3	1	-	-
Equation C Operand 13	055B	055B	F83	0	61	1	-	-
Equation C Operator 14	055C	055C	F84	0	3	1	-	-
Equation C Operand 14	055D	055D	F83	0	61	1	-	-
Equation C Operator 15	055E	055E	F84	0	3	1	-	-
Equation C Operand 15	055F	055F	F83	0	61	1	-	-
Equation D Operator 0	0560	0560	F84	0	3	1	-	-
Equation D Operand 0	0561	0561	F83	0	61	1	-	-
Equation D Operator 1	0562	0562	F84	0	3	1	-	-
Equation D Operand 1	0563	0563	F83	0	61	1	-	-
Equation D Operator 2	0564	0564	F84	0	3	1	-	-
Equation D Operand 2	0565	0565	F83	0	61	1	-	-
Equation D Operator 3	0566	0566	F84	0	3	1	-	-
Equation D Operand 3	0567	0567	F83	0	61	1	-	-
Equation D Operator 4	0568	0568	F84	0	3	1	-	-
Equation D Operand 4	0569	0569	F83	0	61	1	-	-
Equation D Operator 5	056A	056A	F84	0	3	1	-	-
Equation D Operand 5	056B	056B	F83	0	61	1	-	-
Equation D Operator 6	056C	056C	F84	0	3	1	-	-
Equation D Operand 6	056D	056D	F83	0	61	1	-	-
Equation D Operator 7	056E	056E	F84	0	3	1	-	-
Equation D Operand 7	056F	056F	F83	0	61	1	-	-
Equation D Operator 8	0570	0570	F84	0	3	1	-	-
Equation D Operand 8	0571	0571	F83	0	61	1	-	-

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Equation D Operator 9	0572	0572	F84	0	3	1	-	-
Equation D Operand 9	0573	0573	F83	0	61	1	-	-
Equation D Operator 10	0574	0574	F84	0	3	1	-	-
Equation D Operand 10	0575	0575	F83	0	61	1	-	-
Equation D Operator 11	0576	0576	F84	0	3	1	-	-
Equation D Operand 11	0577	0577	F83	0	61	1	-	-
Equation D Operator 12	0578	0578	F84	0	3	1	-	-
Equation D Operand 12	0579	0579	F83	0	61	1	-	-
Equation D Operator 13	057A	057A	F84	0	3	1	-	-
Equation D Operand 13	057B	057B	F83	0	61	1	-	-
Equation D Operator 14	057C	057C	F84	0	3	1	-	-
Equation D Operand 14	057D	057D	F83	0	61	1	-	-
Equation D Operator 15	057E	057E	F84	0	3	1	-	-
Equation D Operand 15	057F	057F	F83	0	61	1	-	-
Equation E Operator 0	0580	0580	F84	0	3	1	-	-
Equation E Operand 0	0581	0581	F83	0	61	1	-	-
Equation E Operator 1	0582	0582	F84	0	3	1	-	-
Equation E Operand 1	0583	0583	F83	0	61	1	-	-
Equation E Operator 2	0584	0584	F84	0	3	1	-	-
Equation E Operand 2	0585	0585	F83	0	61	1	-	-
Equation E Operator 3	0586	0586	F84	0	3	1	-	-
Equation E Operand 3	0587	0587	F83	0	61	1	-	-
Equation E Operator 4	0588	0588	F84	0	3	1	-	-
Equation E Operand 4	0589	0589	F83	0	61	1	-	-
Equation E Operator 5	058A	058A	F84	0	3	1	-	-
Equation E Operand 5	058B	058B	F83	0	61	1	-	-
Equation E Operator 6	058C	058C	F84	0	3	1	-	-
Equation E Operand 6	058D	058D	F83	0	61	1	-	-
Equation E Operator 7	058E	058E	F84	0	3	1	-	-
Equation E Operand 7	058F	058F	F83	0	61	1	-	-
Equation E Operator 8	0590	0590	F84	0	3	1	-	-
Equation E Operand 8	0591	0591	F83	0	61	1	-	-
Equation E Operator 9	0592	0592	F84	0	3	1	-	-
Equation E Operand 9	0593	0593	F83	0	61	1	-	-
Equation E Operator 10	0594	0594	F84	0	3	1	-	-
Equation E Operand 10	0595	0595	F83	0	61	1	-	-
Equation E Operator 11	0596	0596	F84	0	3	1	-	-
Equation E Operand 11	0597	0597	F83	0	61	1	-	-
Equation E Operator 12	0598	0598	F84	0	3	1	-	-
Equation E Operand 12	0599	0599	F83	0	61	1	-	-
Equation E Operator 13	059A	059A	F84	0	3	1	-	-
Equation E Operand 13	059B	059B	F83	0	61	1	-	-
Equation E Operator 14	059C	059C	F84	0	3	1	-	-

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Equation E Operand 14	059D	059D	F83	0	61	1	-	-
Equation E Operator 15	059E	059E	F84	0	3	1	-	-
Equation E Operand 15	059F	059F	F83	0	61	1	-	-
Equation F Operator 0	05A0	05A0	F84	0	3	1	-	-
Equation F Operand 0	05A1	05A1	F83	0	61	1	-	-
Equation F Operator 1	05A2	05A2	F84	0	3	1	-	-
Equation F Operand 1	05A3	05A3	F83	0	61	1	-	-
Equation F Operator 2	05A4	05A4	F84	0	3	1	-	-
Equation F Operand 2	05A5	05A5	F83	0	61	1	-	-
Equation F Operator 3	05A6	05A6	F84	0	3	1	-	-
Equation F Operand 3	05A7	05A7	F83	0	61	1	-	-
Equation F Operator 4	05A8	05A8	F84	0	3	1	-	-
Equation F Operand 4	05A9	05A9	F83	0	61	1	-	-
Equation F Operator 5	05AA	05AA	F84	0	3	1	-	-
Equation F Operand 5	05AB	05AB	F83	0	61	1	-	-
Equation F Operator 6	05AC	05AC	F84	0	3	1	-	-
Equation F Operand 6	05AD	05AD	F83	0	61	1	-	-
Equation F Operator 7	05AE	05AE	F84	0	3	1	-	-
Equation F Operand 7	05AF	05AF	F83	0	61	1	-	-
Equation F Operator 8	05B0	05B0	F84	0	3	1	-	-
Equation F Operand 8	05B1	05B1	F83	0	61	1	-	-
Equation F Operator 9	05B2	05B2	F84	0	3	1	-	-
Equation F Operand 9	05B3	05B3	F83	0	61	1	-	-
Equation F Operator 10	05B4	05B4	F84	0	3	1	-	-
Equation F Operand 10	05B5	05B5	F83	0	61	1	-	-
Equation F Operator 11	05B6	05B6	F84	0	3	1	-	-
Equation F Operand 11	05B7	05B7	F83	0	61	1	-	-
Equation F Operator 12	05B8	05B8	F84	0	3	1	-	-
Equation F Operand 12	05B9	05B9	F83	0	61	1	-	-
Equation F Operator 13	05BA	05BA	F84	0	3	1	-	-
Equation F Operand 13	05BB	05BB	F83	0	61	1	-	-
Equation F Operator 14	05BC	05BC	F84	0	3	1	-	-
Equation F Operand 14	05BD	05BD	F83	0	61	1	-	-
Equation F Operator 15	05BE	05BE	F84	0	3	1	-	-
Equation F Operand 15	05BF	05BF	F83	0	61	1	-	-
Equation G Operator 0	05C0	05C0	F84	0	3	1	-	-
Equation G Operand 0	05C1	05C1	F83	0	61	1	-	-
Equation G Operator 1	05C2	05C2	F84	0	3	1	-	-
Equation G Operand 1	05C3	05C3	F83	0	61	1	-	-
Equation G Operator 2	05C4	05C4	F84	0	3	1	-	-
Equation G Operand 2	05C5	05C5	F83	0	61	1	-	-
Equation G Operator 3	05C6	05C6	F84	0	3	1	-	-
Equation G Operand 3	05C7	05C7	F83	0	61	1	-	-

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Equation G Operator 4	05C8	05C8	F84	0	3	1	-	-
Equation G Operand 4	05C9	05C9	F83	0	61	1	-	-
Equation G Operator 5	05CA	05CA	F84	0	3	1	-	-
Equation G Operand 5	05CB	05CB	F83	0	61	1	-	-
Equation G Operator 6	05CC	05CC	F84	0	3	1	-	-
Equation G Operand 6	05CD	05CD	F83	0	61	1	-	-
Equation G Operator 7	05CE	05CE	F84	0	3	1	-	-
Equation G Operand 7	05CF	05CF	F83	0	61	1	-	-
Equation G Operator 8	05D0	05D0	F84	0	3	1	-	-
Equation G Operand 8	05D1	05D1	F83	0	61	1	-	-
Equation G Operator 9	05D2	05D2	F84	0	3	1	-	-
Equation G Operand 9	05D3	05D3	F83	0	61	1	-	-
Equation G Operator 10	05D4	05D4	F84	0	3	1	-	-
Equation G Operand 10	05D5	05D5	F83	0	61	1	-	-
Equation G Operator 11	05D6	05D6	F84	0	3	1	-	-
Equation G Operand 11	05D7	05D7	F83	0	61	1	-	-
Equation G Operator 12	05D8	05D8	F84	0	3	1	-	-
Equation G Operand 12	05D9	05D9	F83	0	61	1	-	-
Equation G Operator 13	05DA	05DA	F84	0	3	1	-	-
Equation G Operand 13	05DB	05DB	F83	0	61	1	-	-
Equation G Operator 14	05DC	05DC	F84	0	3	1	-	-
Equation G Operand 14	05DD	05DD	F83	0	61	1	-	-
Equation G Operator 15	05DE	05DE	F84	0	3	1	-	-
Equation G Operand 15	05DF	05DF	F83	0	61	1	-	-
Equation H Operator 0	05E0	05E0	F84	0	3	1	-	-
Equation H Operand 0	05E1	05E1	F83	0	61	1	-	-
Equation H Operator 1	05E2	05E2	F84	0	3	1	-	-
Equation H Operand 1	05E3	05E3	F83	0	61	1	-	-
Equation H Operator 2	05E4	05E4	F84	0	3	1	-	-
Equation H Operand 2	05E5	05E5	F83	0	61	1	-	-
Equation H Operator 3	05E6	05E6	F84	0	3	1	-	-
Equation H Operand 3	05E7	05E7	F83	0	61	1	-	-
Equation H Operator 4	05E8	05E8	F84	0	3	1	-	-
Equation H Operand 4	05E9	05E9	F83	0	61	1	-	-
Equation H Operator 5	05EA	05EA	F84	0	3	1	-	-
Equation H Operand 5	05EB	05EB	F83	0	61	1	-	-
Equation H Operator 6	05EC	05EC	F84	0	3	1	-	-
Equation H Operand 6	05ED	05ED	F83	0	61	1	-	-
Equation H Operator 7	05EE	05EE	F84	0	3	1	-	-
Equation H Operand 7	05EF	05EF	F83	0	61	1	-	-
Equation H Operator 8	05F0	05F0	F84	0	3	1	-	-
Equation H Operand 8	05F1	05F1	F83	0	61	1	-	-
Equation H Operator 9	05F2	05F2	F84	0	3	1	-	-

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Equation H Operand 9	05F3	05F3	F83	0	61	1	-	-
Equation H Operator 10	05F4	05F4	F84	0	3	1	-	-
Equation H Operand 10	05F5	05F5	F83	0	61	1	-	-
Equation H Operator 11	05F6	05F6	F84	0	3	1	-	-
Equation H Operand 11	05F7	05F7	F83	0	61	1	-	-
Equation H Operator 12	05F8	05F8	F84	0	3	1	-	-
Equation H Operand 12	05F9	05F9	F83	0	61	1	-	-
Equation H Operator 13	05FA	05FA	F84	0	3	1	-	-
Equation H Operand 13	05FB	05FB	F83	0	61	1	-	-
Equation H Operator 14	05FC	05FC	F84	0	3	1	-	-
Equation H Operand 14	05FD	05FD	F83	0	61	1	-	-
Equation H Operator 15	05FE	05FE	F84	0	3	1	-	-
Equation H Operand 15	05FF	05FF	F83	0	61	1	-	-

Table 8 - Pages 5h and 6h: Boolean Equation

3.3.6 Page 6h: Boolean Equation Timers, Programmable Inter-trip and CTS

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Boolean Equation Timers								
Equation A Rising Timer	0600	0600	F57	0	60000	1	10ms	0
Equation A Falling Timer	0601	0601	F57	0	60000	1	10ms	0
Equation B Rising Timer	0602	0602	F57	0	60000	1	10ms	0
Equation B Falling Timer	0603	0603	F57	0	60000	1	10ms	0
Equation C Rising Timer	0604	0604	F57	0	60000	1	10ms	0
Equation C Falling Timer	0605	0605	F57	0	60000	1	10ms	0
Equation D Rising Timer	0606	0606	F57	0	60000	1	10ms	0
Equation D Falling Timer	0607	0607	F57	0	60000	1	10ms	0
Equation E Rising Timer	0608	0608	F57	0	60000	1	10ms	0
Equation E Falling Timer	0609	0609	F57	0	60000	1	10ms	0
Equation F Rising Timer	060A	060A	F57	0	60000	1	10ms	0
Equation F Falling Timer	060B	060B	F57	0	60000	1	10ms	0
Equation G Rising Timer	060C	060C	F57	0	60000	1	10ms	0
Equation G Falling Timer	060D	060D	F57	0	60000	1	10ms	0
Equation H Rising Timer	060E	060E	F57	0	60000	1	10ms	0
Equation H Falling Timer	060F	060F	F57	0	60000	1	10ms	0
Reserved	0610	061F						
Programmable Intertrip								
Programmable Intertrip 1 Function Allocation Word 1	0620	0620	F85	0	FFFF	2N	-	-
Programmable Intertrip 1 Function Allocation Word 2	0621	0621	F85'	0	FFFF	2N	-	-

Modbus Description	Modbus Address		Cell Type	Address Value				
	Start	End		Min	Max	Step	Units	Default
Programmable Intertrip 2 Function Allocation Word 1	0622	0622	F85	0	FFFF	2N	-	-
Programmable Intertrip 2 Function Allocation Word 2	0623	0623	F85'	0	FFFF	2N	-	-
Programmable Intertrip 3 Function Allocation Word 1	0624	0624	F85	0	FFFF	2N	-	-
Programmable Intertrip 3 Function Allocation Word 2	0625	0625	F85'	0	FFFF	2N	-	-
Programmable Intertrip 4 Function Allocation Word 1	0626	0626	F85	0	FFFF	2N	-	-
Programmable Intertrip 4 Function Allocation Word 2	0627	0627	F85'	0	FFFF	2N	-	-
Dwell Timer	0628	0628	F1	10	500	5	10ms	10
CTS								
CTS ?	0629	0629	F24	0	1	1	-	0
CTS Reset Mode	062A	062A	F74	0	1	1	-	0
CTS I1>	062B	062B	F1	5	400	1	1/100 In	10
CTS I2/I1>	062C	062C	F1	5	100	1	1%	5
CTS I2/I1>>	062D	062D	F1	5	100	1	1%	40
CTS TIME DLY	062E	062E	F1	0	1000	1	10ms	500
CTS Restrain ?	062F	062F	F24	0	1	1	-	0
Reserved	0630	06FF						
Quick Read Status Byte								
Status Byte	0700	0700	F23	0	FFFF	2N	-	-

Table 9 - Page 6h: Boolean Equation Timers, Programmable Inter-trip and CTS

3.3.7 Page 7h: Quick Read Relay Status (MODBUS 07 Function)

MODBUS Text	MODBUS Address		Cell Type	Min	Max	Step	Default Value	Units
	Start	End						
Relay Status								
0700	0700	0701	F23	0	7	1		-

Note Page7 is a read only page and the address 0x0700 is the status byte of the relay.

Table 10 - Page 7h: Quick Read Relay Status (MODBUS 07 Function)Page 8h: Time Synchronization

3.3.8 Page 8h: Time Synchronization

The time synchronization format is set by the date format setting at MODBUS address 134h.

Following successful time synchronization via the rear port communications, an acknowledgement bit is set at address 0700h for a period of 60 s.

3.3.8.1 Private Format

MODBUS Text	MODBUS Address		Min	Max	Step	Default Value	Units
	Start	End					
Year (MSB + LSB)	0800	0800	1994	2092	1	1994	Years
Month (MSB)	0801	0801	1	12	1	01	Months
Day (LSB)	0801	0801	1	31	1	01	Days
Hour (MSB)	0802	0802	0	23	1	01	Hours
Minute (LSB)	0802	0802	0	59	1	01	Minutes
millisecond (MSB + LSB)	0803	0803	0	59999	1	0	Milliseconds

Table 11 - Private format

3.3.8.2 IEC Time and Date Format

Inverted IEC 870-5-4 CP56Time2a:

<table>
<tr><th>MODBUS Address</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0800</td><td colspan="8">R</td><td>R</td><td colspan="7">R</td></tr>
<tr><td>0801</td><td colspan="4">R</td><td colspan="4">Month</td><td colspan="3">Day of Week</td><td colspan="5">Day of Month</td></tr>
<tr><td>0802</td><td>S</td><td colspan="2">R</td><td colspan="5">Hours</td><td>IV</td><td>R</td><td colspan="6">Minutes</td></tr>
<tr><td>0803</td><td colspan="8">Millisecond (MSB)</td><td colspan="8">Millisecond (LSB)</td></tr>
<tr><td colspan="17">Notes Summer time (SU): Standard = 0, Summer Time = 1
Iv = Invalid value: Valid = 0,
Non valid or non synchronized in system case = 1
The first day of the week is Monday
R = Reserved bit</td></tr>
</table>

Table 12 - Private format

3.3.9 Page 24: Group 3 Protection Settings

MODBUS Text	MODBUS Address (Hex)		Cell Type	Min	Max	Step	Default Value	Units
	Start	End						
Setting Group 1								
Current Differential								
Current Diff.?	2400	2400	F24	0	1	1	1 = Yes	-
Is1	2401	2401	F1	10	200	2	20	1/100
Is2	2402	2402	F1	100	3000	5	200	1/100
K1	2403	2403	F1	0	150	5	30	%
K2	2404	2404	F1	30	150	5	150	%
Time Delay Type	2405	2405	F27	0	1	1	0 = DMT	
tIdiff Value	2406	2406	F1	0	15000	1	0	1/100s
IDMT Curve Type	2407	2407	F3	0	9	1	1 = SI	-
TMS	2408	2408	F1	25	1500	25	1000	1/1000
Time Dial	2409	240A	F57	100	100000	100	100	1/1000
PIT Time	240B	240B	F1	0	200	1	20	1/100s
PIT I Disable	240C	240C	F24	0	1	1	0	-
PIT I Selection	2470	2470	F68	0	1	1	0	-
PIT I Threshold	2471	2471	F1	10	4000	1	20	1/100 In
PIT OC Stages	2472	2472	F69	0	FFFF	2_N	0	-
Inrush Restraint	240D	240D	F24	0	1	1	0	-
Transient Bias	2473	2473	F24	0	1	1	0	-
DIT Alarm	2474	2474	F24	0	1	1	1	-
PIT Alarm	2475	2475	F24	0	1	1	1	-
Rx DIT Dwell Time	240E	240E	F1	10	500	0	10	1/100s
IDiff High Set	240F	240F	F1	400	3200	1	400	1/100 In
Kr	2476	2476	F1	3	20	1	4	
Reserved	2477	24FF						-
Overcurrent								
I>	2410	2410	F24	0	2	1	0 = No	-
I> Threshold	2411	2411	F1	10	2500	1	100	1/100 In
I> Delay Type	2412	2412	F27	0	2	1	0 = DMT	-
I> Curve Type	2413	2413	F3	0	9	1	1 = SI	-
I> TMS Value	2414	2414	F1	25	1500	25	1000	1/1000
t> TD Value	2415	2416	F57	100	100000	100	1000	1/1000
I> K Value (RI Curve)	2417	2417	F1	100	10000	5	100	1/1000s
tI> Value	2418	2418	F1	0	15000	1	4	1/100s
I> Reset Type	2419	2419	F27	0	1	1	0	-
I> RTMS Value	241A	241A	F1	25	3200	25	25	1/1000
I> tRESET Value	241B	241B	F1	4	10000	1	4	1/100 s
I>>	241C	241C	F24	0	2	1	0 = No	-
I>> Threshold	241D	241D	F1	50	4000	5	100	1/100 In
I>> Delay Type	241E	241E	F27	0	2	1	0 = DMT	-
I>> Curve Type	241F	241F	F3	0	9	1	1 = SI	-

MODBUS Text	MODBUS Address (Hex)		Cell Type	Min	Max	Step	Default Value	Units
	Start	End						
I>> TMS Value	2420	2420	F1	25	1500	25	1000	1/1000
I>> TD Value	2421	2422	F57	100	100000	100	100	1/1000
I>> K Value (RI Curve)	2423	2423	F1	100	10000	5	100	1/1000
tI>> Value	2424	2424	F1	0	15000	1	4	1/100 s
I>> Reset Type	2425	2425	F27	0	1	1	0	-
I>> RTMS Value	2426	2426	F1	25	3200	25	25	1/1000
I>> tRESET Value	2427	2427	F1	4	10000	1	4	1/100s
I>>>	2428	2428	F24	0	2	1	0 = No	-
I>>> Value	2429	2429	F1	50	4000	5	2000	1/100 In
tI>>> Value	242A	242A	F1	0	15000	1	1	1/100 s
I>>>>	242B	242B	F24	0	2	1	0 = No	-
I>>>> Value	242C	242C	F1	50	4000	5	2000	1/100
tI>>>> Value	242D	242D	F1	0	15000	1	1	1/100 s
Ie>	242E	242E	F24	0	2	1	0 = No	-
Ie> Value (Normal)	242F	242F	F1	10	2500	1	10	1/100 Ion
Ie> Value (Sensitive)	242F	242F	F1	10	1000	5	10	1/1000 Ion
Ie> Value (V. Sensitive)	242F	242F	F1	2	1000	1	2	1/1000 Ion
Ie> Time Delay Type	2430	2430	F27	0	3	1	0 = DMT	-
Ie> IDMT Curve Type	2431	2431	F3	0	9	1	1 = SI	-
Ie> TMS Value	2432	2432	F1	25	1500	25	1000	1/1000
Ie> TD Value	2433	2434	F57	100	100000	100	100	1/1000
Ie> K Value RI Curve)	2435	2435	F1	100	10000	5	100	1/1000
tIe> Value	2436	2436	F1	0	15000	1	4	1/100
Ie> Reset Type	2437	2437	F27	0	1	1	0 = DMT	-
Ie> RTMS Value	2438	2438	F1	25	3200	25	25	1/1000
Ie> tRESET Value	2439	2439	F1	4	10000	1	4	1/100s
Ie> Laborlec	243A	243A	F3'	0	2	1	0 = Curve 1	-
Ie>>	243B	243B	F24	0	2	1	0 = No	-
Ie>> Value (Normal)	243C	243C	F1	50	4000	1	100	1/100 Ion
Ie>> Value (Sensitive)	243C	243C	F1	10	8000	5	100	1/1000 Ion
Ie>> Value (V. Sensitive)	243C	243C	F1	2	1000	1	100	1/1000 Ion
Ie>> Time Delay Type	243D	243D	F1	0	3	1	0 =DMT	-
Ie>> IDMT Curve Type	243E	243E	F3	0	9	1	1 = SI	-
Ie>> TMS Value	243F	243F	F1	25	1500	25	1000	1/1000
Ie>> TD Value	2440	2441	F57	100	100000	100	100	1/1000
Ie>> K Value (RI Curve)	2442	2442	F1	100	10000	5	100	1/1000
tIe>> Value	2443	2443	F1	0	15000	1	1	1/100
Ie>> Reset Type	2444	2444	F27	0	1	1	0 = DMT	-
Ie>> RTMS Value	2445	2445	F1	25	3200	25	25	1/1000
Ie>> tRESET Value	2446	2446	F1	4	10000	1	4	1/100s

MODBUS Text	MODBUS Address (Hex)		Cell Type	Min	Max	Step	Default Value	Units
	Start	End						
Ie>>Laborlec	2447	2447	F3'	0	2	1	0 = Curve 1	-
Ie>>>	2448	2448	F24	0	2	1	0 = No	-
Ie>>> Value (Normal)	2449	2449	F1	50	4000	1	100	1/100 Ion
Ie>>> Value (Sensitive)	2449	2449	F1	10	8000	5	100	1/1000 Ion
Ie>>> Value (V. Sensitive)	2449	2449	F1	2	1000	1	100	1/1000 Ion
tIe>>> Value	244A	244A	F1	0	15000	1	1	1/100
Ie>>>>	244B	244B	F24	0	2	1	0 = No	-
Ie>>>> Value (Normal)	244C	244C	F1	50	4000	1	100	1/100 Ion
Ie>>>> Value (Sensitive)	244C	244C	F1	10	8000	5	100	1/1000 Ion
Ie>>>> Value (V. Sensitive)	244C	244C	F1	2	1000	1	100	1/1000 Ion
tIe>>>> Value	244D	244D	F1	0	15000	1	1	1/100
Thermal								
Ith>	244E	244E	F24	0	1	1	0 = No	-
Ith> Value	244F	244F	F1	10	320	1	100	1/100
Reserved	2450	2450						-
Ith> K Value	2451	2451	F1	100	150	1	105	1/100 %
Ith> Trip Threshold	2452	2452	F1	50	200	1	100	-
Ith> Alarm	2453	2453	F24	0	1	1	0 = No	-
Ith> Alarm Threshold	2454	2454	F1	50	200	1	90	%
Te1	2455	2455	F1	1	200	1	1	Mn
Reserved	2456	2456						
Negative sequence								
I2>	2457	2457	F24	0	1	1	0 = No	-
I2> Threshold	2458	2458	F1	10	4000	1	100	In/100
I2> Delay Type	2459	2459	F27	0	2	1	0 = DMT	-
I2> Curve	245A	245A	F3	0	9	1	1 = SI	-
I2> TMS Value	245B	245B	F1	25	1500	25	1000	1/1000
I2> TD Value	245C	245D	F57	100	100000	100	100	1/1000
I2> K Value (RI)	245E	245E	F1	100	10000	5	100	1/1000
tI2> Value	245F	245F	F1	0	15000	1	0	1/100s
I2> Reset Type	2460	2460	F27	0	1	1	0 = DMT	-
I2> RTMS Value	2461	2461	F1	25	3200	25	25	1/1000
I2> tRESET Value	2462	2462	F1	4	10000	1	4	1/100 s
I2>>	2463	2463	F27	0	1	1	0 = No	-
I2>> Threshold	2464	2464	F1	10	4000	1	100	1/100
tI2>>	2465	2465	F1	0	15000	1	0	1/100s
Undercurrent								
I<	2466	2466	F24	0	1	1	0 = No	-
I< Threshold	2467	2467	F1	2	100	1	20	1/100
tI2< Value	2468	2468	F1	0	15000	1	0	1/100

MODBUS Text	MODBUS Address (Hex)		Cell Type	Min	Max	Step	Default Value	Units
	Start	End						
Reserved	2469	24FF						-
Protection Settings - Current Differential (Additional)								
Harmonic Ratio	2477	2477	F1	5	50	1	1%	
Reserved	2478	2478						
CTS Is1	2479	2579	F1	20	400	5	1/100 In	

3.3.10 Page 25: Group 4 Protection Settings

MODBUS Text	MODBUS Address (Hex)		Cell Type	Min	Max	Step	Default Value	Units
	Start	End						
Setting Group 1								
Current Differential								
Current Diff.?	2500	2500	F24	0	1	1	1 = Yes	-
Is1	2501	2501	F1	10	200	2	20	1/100
Is2	2502	2502	F1	100	3000	5	200	1/100
K1	2503	2503	F1	0	150	5	30	%
K2	2504	2504	F1	30	150	5	150	%
Time Delay Type	2505	2505	F27	0	1	1	0 = DMT	
tIdiff Value	2506	2506	F1	0	15000	1	0	1/100s
IDMT Curve Type	2507	2507	F3	0	9	1	1 = SI	-
TMS	2508	2508	F1	25	1500	25	1000	1/1000
Time Dial	2509	250A	F57	100	100000	100	100	1/1000
PIT Time	250B	250B	F1	0	200	1	20	1/100s
PIT I Disable	250C	250C	F24	0	1	1	0	-
PIT I Selection	2570	2570	F68	0	1	1	0	-
PIT I Threshold	2571	2571	F1	10	4000	1	20	1/100 In
PIT OC Stages	2572	2572	F69	0	FFFF	2_N	0	-
Inrush Restraint	250D	250D	F24	0	1	1	0	-
Transient Bias	2573	2573	F24	0	1	1	0	-
DIT Alarm	2574	2574	F24	0	1	1	1	-
PIT Alarm	2575	2575	F24	0	1	1	1	-
Rx DIT Dwell Time	250E	250E	F1	10	500	0	10	1/100s
IDiff High Set	250F	250F	F1	400	3200	1	400	1/100 In
Kr	2576	2576	F1	3	20	1	4	
Reserved	2577	25FF						-
Overcurrent								
I>	2510	2510	F24	0	2	1	0 = No	-
I> Threshold	2511	2511	F1	10	2500	1	100	1/100 In
I> Delay Type	2512	2512	F27	0	2	1	0 = DMT	-
I> Curve Type	2513	2513	F3	0	9	1	1 = SI	-

MODBUS Text	MODBUS Address (Hex)		Cell Type	Min	Max	Step	Default Value	Units
	Start	End						
I> TMS Value	2514	2514	F1	25	1500	25	1000	1/1000
t> TD Value	2515	2516	F57	100	100000	100	1000	1/1000
I> K Value (RI Curve)	2517	2517	F1	100	10000	5	100	1/1000s
tI> Value	2518	2518	F1	0	15000	1	4	1/100s
I> Reset Type	2519	2519	F27	0	1	1	0	-
I> RTMS Value	251A	251A	F1	25	3200	25	25	1/1000
I> tRESET Value	251B	251B	F1	4	10000	1	4	1/100 s
I>>	251C	251C	F24	0	2	1	0 = No	-
I>> Threshold	251D	251D	F1	50	4000	5	100	1/100 In
I>> Delay Type	251E	251E	F27	0	2	1	0 = DMT	-
I>> Curve Type	251F	251F	F3	0	9	1	1 = SI	-
I>> TMS Value	2520	2520	F1	25	1500	25	1000	1/1000
I>> TD Value	2521	2522	F57	100	100000	100	100	1/1000
I>> K Value (RI Curve)	2523	2523	F1	100	10000	5	100	1/1000
tI>> Value	2524	2524	F1	0	15000	1	4	1/100 s
I>> Reset Type	2525	2525	F27	0	1	1	0	-
I>> RTMS Value	2526	2526	F1	25	3200	25	25	1/1000
I>> tRESET Value	2527	2527	F1	4	10000	1	4	1/100s
I>>>	2528	2528	F24	0	2	1	0 = No	-
I>>> Value	2529	2529	F1	50	4000	5	2000	1/100 In
tI>>> Value	252A	252A	F1	0	15000	1	1	1/100 s
I>>>>	252B	252B	F24	0	2	1	0 = No	-
I>>>> Value	252C	252C	F1	50	4000	5	2000	1/100
tI>>>> Value	252D	252D	F1	0	15000	1	1	1/100 s
Ie>	252E	252E	F24	0	2	1	0 = No	-
Ie> Value (Normal)	252F	252F	F1	10	2500	1	10	1/100 Ion
Ie> Value (Sensitive)	252F	252F	F1	10	1000	5	10	1/1000 Ion
Ie> Value (V. Sensitive)	252F	252F	F1	2	1000	1	2	1/1000 Ion
Ie> Time Delay Type	2530	2530	F27	0	3	1	0 = DMT	-
Ie> IDMT Curve Type	2531	2531	F3	0	9	1	1 = SI	-
Ie> TMS Value	2532	2532	F1	25	1500	25	1000	1/1000
Ie> TD Value	2533	2534	F57	100	100000	100	100	1/1000
Ie> K Value RI Curve)	2535	2535	F1	100	10000	5	100	1/1000
tIe> Value	2536	2536	F1	0	15000	1	4	1/100
Ie> Reset Type	2537	2537	F27	0	1	1	0 = DMT	-
Ie> RTMS Value	2538	2538	F1	25	3200	25	25	1/1000
Ie> tRESET Value	2539	2539	F1	4	10000	1	4	1/100s
Ie> Laborlec	253A	253A	F3'	0	2	1	0 = Curve 1	-
Ie>>	253B	253B	F24	0	2	1	0 = No	-
Ie>> Value (Normal)	253C	253C	F1	50	4000	1	100	1/100 Ion
Ie>> Value (Sensitive)	253C	253C	F1	10	8000	5	100	1/1000 Ion

MODBUS Text	MODBUS Address (Hex)		Cell Type	Min	Max	Step	Default Value	Units
	Start	End						
Ie>> Value (V. Sensitive)	253C	253C	F1	2	1000	1	100	1/1000 Ion
Ie>> Time Delay Type	253D	253D	F1	0	3	1	0 =DMT	-
Ie>> IDMT Curve Type	253E	253E	F3	0	9	1	1 = SI	-
Ie>> TMS Value	253F	253F	F1	25	1500	25	1000	1/1000
Ie>> TD Value	2540	2541	F57	100	100000	100	100	1/1000
Ie>> K Value (RI Curve)	2542	2542	F1	100	10000	5	100	1/1000
tIe>> Value	2543	2543	F1	0	15000	1	1	1/100
Ie>> Reset Type	2544	2544	F27	0	1	1	0 = DMT	-
Ie>> RTMS Value	2545	2545	F1	25	3200	25	25	1/1000
Ie>> tRESET Value	2546	2546	F1	4	10000	1	4	1/100s
Ie>>Laborlec	2547	2547	F3'	0	2	1	0 = Curve 1	-
Ie>>>	2548	2548	F24	0	2	1	0 = No	-
Ie>>> Value (Normal)	2549	2549	F1	50	4000	1	100	1/100 Ion
Ie>>> Value (Sensitive)	2549	2549	F1	10	8000	5	100	1/1000 Ion
Ie>>> Value (V. Sensitive)	2549	2549	F1	2	1000	1	100	1/1000 Ion
tIe>>> Value	254A	254A	F1	0	15000	1	1	1/100
Ie>>>>	254B	254B	F24	0	2	1	0 = No	-
Ie>>>> Value (Normal)	254C	254C	F1	50	4000	1	100	1/100 Ion
Ie>>>> Value (Sensitive)	254C	254C	F1	10	8000	5	100	1/1000 Ion
Ie>>>> Value (V. Sensitive)	254C	254C	F1	2	1000	1	100	1/1000 Ion
tIe>>>> Value	254D	254D	F1	0	15000	1	1	1/100
Thermal								
Ith>	254E	254E	F24	0	1	1	0 = No	-
Ith> Value	254F	254F	F1	10	320	1	100	1/100
Reserved	2550	2550						-
Ith> K Value	2551	2551	F1	100	150	1	105	1/100 %
Ith> Trip Threshold	2552	2552	F1	50	200	1	100	-
Ith> Alarm	2553	2553	F24	0	1	1	0 = No	-
Ith> Alarm Threshold	2554	2554	F1	50	200	1	90	%
Te1	2555	2555	F1	1	200	1	1	Mn
Reserved	2556	2556						
Negative sequence								
I2>	2557	2557	F24	0	1	1	0 = No	-
I2> Threshold	2558	2558	F1	10	4000	1	100	In/100
I2> Delay Type	2559	2559	F27	0	2	1	0 = DMT	-
I2> Curve	255A	255A	F3	0	9	1	1 = SI	-
I2> TMS Value	255B	255B	F1	25	1500	25	1000	1/1000
I2> TD Value	25C	255D	F57	100	100000	100	100	1/1000
I2> K Value (RI)	255E	255E	F1	100	10000	5	100	1/1000

MODBUS Text	MODBUS Address (Hex)		Cell Type	Min	Max	Step	Default Value	Units
	Start	End						
tI2> Value	255F	255F	F1	0	15000	1	0	1/100s
I2> Reset Type	2560	2560	F27	0	1	1	0 = DMT	-
I2> RTMS Value	2561	2561	F1	25	3200	25	25	1/1000
I2> tRESET Value	2562	2562	F1	4	10000	1	4	1/100 s
I2>>	2563	2563	F27	0	1	1	0 = No	-
I2>> Threshold	2564	2564	F1	10	4000	1	100	1/100
tI2>>	2565	2565	F1	0	15000	1	0	1/100s
Undercurrent								
I<	2566	2566	F24	0	1	1	0 = No	-
I< Threshold	2567	2567	F1	2	100	1	20	1/100
tI2< Value	2568	2568	F1	0	15000	1	0	1/100
Reserved	2569	25FF						-
Protection Settings - Current Differential (Additional)								
Harmonic Ratio	2577	2577	F1	5	50	1	1%	
Reserved	2578	2578						
CTS Is1	2579	2579	F1	20	400	5	1/100 In	

3.3.11 Diagnostics and Communications Event Counters

The MODBUS Diagnostics and Communications Event Counters can be accessed by the use of MODBUS Functions 8 and 11 respectively. These counters allow users to monitor the performance of the communications system, alongside the aiding in the detection of the communication systems internal error conditions.

3.3.11.1 Diagnostics Counters (MODBUS Function 8)

The MODBUS sub-functions supported by the MODBUS Diagnostics function are:

Sub-Function No. (Decimal)	Sub-Function Name
0	Return Query Data
1	Restart Communications Option
4	Force Listen Only Mode
10	Clear Counter and Diagnostic Register
11	Return Bus Message Count
12	Return Bus Communication Error Count
13	Return Bus Exception Error Count
14	Return Slave Message Count
15	Return Slave No Response Count

Table 13 - MODBUS sub-functions supported by MODBUS Diagnostics

Return Query Data:

Data sent in the Information Field is echoed back in the response allowing a loopback test to be performed.

Restart Communications Option:

Forces the communications in the slave device to be re-initialized and all event counters to be cleared. This command is the only command that will bring the slave device out of the Listen Only Mode.

Force Listen Mode Only:

Forces the slave device to enter the Listen Only Mode isolating the device from other devices on the network. While in this mode, no actions will be taken to any messages sent to the slave device via the slave or broadcast address. To remove the slave device from this mode, the Restart Communications Option command must be used.

Clear Counters and Diagnostic Register:

Forces all counters to be cleared.

Note	*All counters are cleared on slave power-up.*

Return Bus Message Count:

A response to this request returns the number of valid messages seen on the communications system by the slave device since the counters were previously cleared.
For rear port communications only, a hardware address filter is used to increase the efficiency of the communications processing, therefore the counter value is only valid for messages addressed to the slave device via the slave or broadcast address.

Return Bus Communication Error Count:

A response to this request returns the number of CRC errors that the slave device has detected on the communications system since the counters were previously cleared.
For rear port communications only, a hardware address filter is used to increase the efficiency of the communications processing, therefore the counter value is only valid for messages addressed to the slave device via the slave or broadcast address.

Return Bus Exception Error Count:

A response to this request returns the number of exception responses that have been sent by the slave device since the counters were previously cleared.

Return Slave Message Count:

A response to this request returns the number of processed messages that have been addressed to the slave device via the slave or broadcast address since the counters were previously cleared.

Return Slave No Response Count:

A response to this request returns the number of processed messages that have been addressed to the slave device but no response has been sent to the master.

3.3.11.2 Communications Event Counter (MODBUS Function 11)

This counter allows the user to determine the number of successful message completions that have been performed by the slave device. The counter does not include the following message completions:

- Exception responses
- Poll commands

- Fetch event counter commands

Using the following diagnostics sub-functions the event counter can be reset:

- Restart communications option
- Clear counters and diagnostics register

The status word in the response shows the busy state of the relay communications. This value is always zero due to the nature of the communications implemented in the slave device.

3.4 Register Format

Code	Description	Flag Information		
		Bit	**Value**	**Data**
F1	Unsigned Integer – Numerical Data: 65535			
F2	Signed Integer – Numerical Data: -32768 – 32767			
F3	Unsigned Integer – Curves Type	-	0	STI (IEC)
		-	1	SI (IEC)
		-	2	VI (IEC)
		-	3	EI (IEC)
		-	4	LTI (IEC)
		-	5	TI (C02)
		-	6	MI (ANSI)
		-	7	LTI (CO8)
		-	8	VI (ANSI)
		-	9	EI (ANSI)
F3'	Unsigned Integer Type Ground Curves	-	0	Network 1
		-	1	Network 2
		-	2	Source 3
F4	Unsigned Integer: Rear Port Data Rate	-	0	300
		-	1	600
		-	2	1200
		-	3	2400
		-	4	4800
		-	5	9600
		-	6	19200
		-	7	38400
		-	8-15	Reserved
F5	Unsigned Integer: Parity	-	0	None
		-	1	Even
		-	2	Odd
			3-15	Reserved
F6	Unsigned Integer: Tripping Configuration	0	1	tI>
		1	2	tI>>
		2	4	tI>>>
		3	8	tIe>
		4	16	tIe>>
		5	32	tIe>>>
		6	64	I<
		7	128	tIth>
		8	256	Broken Conductor Detection

Code	Description	Flag Information		
		Bit	Value	Data
		9	512	tAux 1
		10	1024	tAux 2
		11	2048	tI2>
		12	4096	tI2>>
		13	8192	tI>>>>
		14	16384	tIe>>>>
		15	32768	tidiff
F6’	Unsigned Integer: Extended Tripping Configuration	0	1	Trip Direct Intertrip
		1	2	Trip Current Differential Intertrip
		2	3	Trip Permissive Intertrip
		3	8	Trip Circuit Supervision Block
		4	16	Equation A
		5	32	Equation B
		6	64	Equation C
		7	128	Equation D
		8	256	Equation E
		9	512	Equation F
		10	1024	Equation G
		11	2048	Equation H
		12 - 15	-	Reserved
F7	Reserved			
F8	Unsigned Integer: Latching Configuration	0	1	I> Latching
		1	2	I>>
		2	4	I>>>
		3	8	Ie>
		4	16	Ie>>
		5	32	Ie>>>
		6	64	I<
		7	128	tIth>
		8	256	Broken Conductor Detection
		9	512	tAux 1
		10	1024	tAux 2
		11	2048	I2>
		12	4096	I2>>
		13	8192	I>>>>
		14	16384	Ie>>>>
		15	32768	Idiff
F8'	Unsigned Integer: Extended Latching Configuration	0	1	Latch Direct Intertrip
		1	2	Latch Current Differential Intertrip
		2	4	Latch Permissive Intertrip
		3	8	Trip Circuit Supervision Block

Code	Description	Flag Information		
		Bit	**Value**	**Data**
		4	16	Equation A
		5	32	Equation B
		6	64	Equation C
		7	128	Equation D
		8	256	Equation E
		9	512	Equation F
		10	1024	Equation G
		11	2048	Equation H
		12 - 15	-	Reserved
F8''	Unsigned Integer: Blocking Logic Configuration	0	1	I> Blocking
		1	2	I>>
		2	4	I>>>
		3	8	Ie>
		4	16	Ie>>
		5	32	Ie>>>
		6	64	Reserved
		7	128	tIth>
		8	256	Broken Conductor Detection
		9	512	tAux 1
		10	1024	tAux 2
		11	2048	tI2>
		12	4096	I2>>
		13	8192	I>>>>
		14	16384	Ie>>>>
		15	32768	Idiff
F8'''	Blocking Logic Mapping Part 2	0	1	Equation A
		1	2	Equation B
		2	4	Equation C
		3	8	Equation D
		4	16	Equation E
		5	32	Equation F
		6	64	Equation G
		7	128	Equation H
F9	Unsigned Integer: Remote Control 1	0	1	Tripping Contact De-latched
		1	2	1st Alarm Acknowledge
		2	4	All Alarms Acknowledge
		3	8	Remote Tripping
		4	16	Remote Closing
		5	32	Setting Group Change *Note* *The Change Group Input setting must be set to EDGE.*

Code	Description	Flag Information		
		Bit	Value	Data
		6	64	Thermal State Reset
		7	128	Reset Max and Average Current Measurements
		8	256	Disturbance Record Remote Start
		9	512	Reserved
		10	1024	Reserved
		11	2048	Reserved
		12	4096	Acknowledgement
		13	8192	Oldest Event Acknowledge
		14	16384	Oldest Fault Acknowledge
		15	32768	Hardware SRAM Alarm Acknowledge
F10	2 Characters ASCII		32-127	ASCII Character1
			32-127	ASCII Character 2
F11	Reserved			
F12	Unsigned Integer: Logic Input Status	0	1	Logic Input Number 1
		1	2	Logic Input Number 2
		2	4	Logic Input Number 3
		3	8	Logic Input Number 4
		4	16	Logic Input Number 5
		5 - 15		Reserved
F13	Unsigned Integer: Logic Outputs Status	0	1	Logic Output Number RL1 (Tripping)
		1	2	Logic Output Number RL2
		2	4	Logic Output Number RL3
		3	8	Logic Output Number RL4
		4	16	Logic Output Number RL0 (Watchdog)
		5	32	Logic Output Number RL5
		6	64	Logic Output Number RL6
		7	128	Logic Output Number RL7
		8	256	Logic Output Number RL8
		9 - 15	-	Reserved
F14	Unsigned Integer: Logic Outputs Configuration	0	1	Selection Logic Output Number RL2
		1	2	Selection Logic Output Number RL3
		2	4	Selection Logic Output Number RL4
		3	8	Selection Logic Output Number RL5
		4	16	Selection Logic Output Number RL6
		5	32	Selection Logic Output Number RL7
		6	64	Selection Logic Output Number RL8
		7 - 15	-	Reserved
F15	Unsigned Integer: Logical Input Allocation	0	1	De-latch Allocation
		1	2	Allocation 52 a
		2	4	Allocation 52 b
		3	8	Allocation External CB Failure

Code	Description	Flag Information		
		Bit	Value	Data
		4	16	Allocation External Input 1
		5	32	Allocation External Input 2
		6	64	Allocation Logic Blocking 1
		7	128	Allocation Logic Blocking 2
		8	256	Allocation Disturbance Start
		9	512	Allocation Cold Load Start
		10	1024	Allocation Selective Scheme Logic 1
		11	2048	Allocation Selective Scheme Logic 2
		12	4096	Allocation Change of Setting Group
		13	8192	Allocation Re-closer Locked
		14	16384	Allocation Thermal State Reset
		15	32768	Allocation Trip Circuit Supervision
F15'	Unsigned Integer: Logical Input Allocation	0	1	Start tBF
		1	2	Permissive Intertrip
		2	4	Direct Intertrip
		3	8	Communication Reset
		4	16	Remote Trip via Logic Input
		5	32	Remote Close via Logic Input
		6	64	Trip Circuit Supervision Block
		7	128	GPS Sync
		8	256	LED Reset
		9	512	CTS Inhibit
		10 - 15	-	Reserved
F16	Unsigned Integer: Threshold Earth Information Status	0	1	Overcurrent start (Ie>, Ie>>, Ie>>>, Ie>>>>)
		1	2	Reserved
		1 - 4	-	Reserved
		5	32	Start Information Ie> or Ie>> or Ie>>> or Ie>>>>
		6	64	Tripping Information tIe> or tIe>> or tIe>>> or tIe>>>>
		7 - 15	-	Reserved
F17	Unsigned Integer: Threshold Phase Information Status	0	1	Overcurrent Start (I>, I>>, I>>>, I>>>>)
		1	2	Instantaneous IA
		2	4	Instantaneous IB
		3	8	Instantaneous IC
		4	16	Reserved
		5	32	Instantaneous Information I> or I>> or I>>> or I>>>>
		6	64	Tripping Information tI> or tI>> or tI>>> tI>>>>
		7 - 15	-	Reserved
F18	Long Integer:	-	-2147483648 to 2147483647	Numerical Data

Code	Description	Flag Information		
		Bit	Value	Data
F19	Unsigned Integer: LEDs Allocation	0	1	I>
		1	2	tI>
		2	4	I>>
		3	8	tI>>
		4	16	I>>>
		5	32	tI>>>
		6	64	Ie>
		7	128	tIe>
		8	256	Ie>>
		9	512	tIe>>
		10	1024	Ie>>>
		11	2048	tIe>>>
		12	4096	Thermal Overload Trip
		13	8192	tI2>
		14	16384	Broken Conductor Trip
		15	32768	CB Failure
F19'	Unsigned Integer: Extended LEDs Allocation	0	1	Logic Input 1
		1	2	Logic Input 2
		2	4	Logic Input 3
		3	8	Logic Input 4
		4	16	Logic Input 5
		5	32	Reserved
		6	64	Reserved
		7	128	Aux 1
		8	256	Aux2
		9	512	t12>>
		10	1024	I>>>>
		11	2048	tI>>>>
		12	4096	Ie>>>>
		13	8192	tIe>>>>
		14 - 15		Reserved
F19''	Unsigned Integer: 2nd Extension LEDs Allocation	0 - 1		Reserved
		2	4	Idiff
		3	8	Idiff Fail
		4	16	Back-up Protection Enabled
		5	32	Protection Comms Fail
		6	64	Direct Intertrip
		7	128	Current Differential Intertrip
		8	256	Permissive Intertrip
		9	512	CB Alarm
		10	1024	Convention Mode
		11 - 15	-	Reserved

Code	Description	Flag Information		
		Bit	Value	Data
F19'''	User Configurable LED Mapping (Part 4)	0	1	Equation A
		1	2	Equation B
		2	4	Equation C
		3	8	Equation D
		4	16	Equation E
		5	32	Equation F
		6	64	Equation G
		7	128	Equation H
		8	256	Programmable Intertrip A
		9	512	Programmable Intertrip B
		10	1024	Programmable Intertrip C
		11	2048	Programmable Intertrip D
		12	4096	CTS local CT Alarm
		13	8192	CTS remote CT Alarm
		14	16384	CTS Block
		15	32768	CTS Cdiff Restrain
F20	Unsigned Integer: Logic Input Data Status	0	1	Selective Scheme Logic 1
		1	2	Selective Scheme Logic 2
		2	4	Relay De-latch
		3	8	CB Position (52 a)
		4	16	CB Position (52 b)
		5	32	CB Failure
		6	64	Aux. 1
		7	128	Aux. 2
		8	256	Blocking Logic 1
		9	512	Blocking Logic 2
		10	1024	Disturbance Record Start
		11	2048	Cold Load Start
		12	4096	Setting Group Change
		13		Reserved
		14	16384	Thermal State Reset
		15	32768	Trip Circuit Supervision
F20'	Unsigned Integer: Extended Logic Data Status	0	1	Start tBF Input Energized
		1	2	Idiff Permissive Input Energized
		2	4	Idiff Direct Input Energized
		3	8	Idiff Comms Input Energized
		4	16	Manual CB Trip
		5	32	Manual CB Close
		6	64	TCS Block Input Energized
		7	128	GPS Sync
		8	256	LED RESET

Code	Description	Flag Information		
		Bit	Value	Data
		9	64	CTS Inhibit
		10-15	-	Reserved
F21	Unsigned Integer: Software Version		12	e.g. 12 = Version 1.A
F22	Unsigned Integer: Internal Logic Data	0	1	Latching
		1 - 15	-	Reserved
F23	Unsigned Integer: Relay Status	0	1	Major Hardware Alarm
		1	2	Minor Hardware Alarm
		2	4	Presence of Non Acknowledged Event
		3	8	Time Synchronization Acknowledgement
		4	16	Presence of Non Acknowledged Disturbance Record
		5	32	Presence of Non Acknowledged Fault Record
		6 - 7	-	Reserved
F24	Unsigned Integer: Relay Function Status	0	-	Function disabled
		1	-	Function enabled
		2 - 15		Reserved
F25	Phase Indication Text Selection	-	0	L1, L2, L3 and N
			1	A, B, C and E
			2	R, S, T and O
			3	Y and B
			4	W
F26	IA, IB, IC, IN Measurement Display (True RMS)	-	1	IA Measurement Display (True RMS)
		-	2	IB Measurement Display (True RMS)
		-	3	IC Measurement Display (True RMS)
		-	4	IN Measurement Display (True RMS)
F27	Time Delay Type	-	0	DMT Time Delay
		-	1	IDMT Time Delay
		-	2	RI Time Delay
F27'	Time Delay Type	-	0	DMT Time Delay
		-	1	IDMT Time Delay
		-	2	RI Time Delay
		-	3	Belgium Curves
F28	Reserved			
F29	Communications Stop Bits	-	0	1 Stop Bit
		-	1	2 Stop Bits
F30	Communication Availability		0	Communications Not Available
			1	Communications Available
F31	Unsigned Integer: Number of Available Disturbance Records		0	None
			1	1 Disturbance Record Available
			2	2 Disturbance Record Available
			3	3 Disturbance Record Available

Code	Description	Flag Information		
		Bit	Value	Data
			4	4 Disturbance Record Available
			5	5 Disturbance Record Available
F32	Unsigned Integer: Disturbance Record Start Status		0	Disturbance Record Start on any Instantaneous Event.
			1	Disturbance Record Start on any Trip Event
F33	Cold Load Start Thresholds	0	1	tI>
		1	2	tI>>
		2	4	tI>>>
		3	8	tIe>
		4	16	tIe>>
		5	32	tIe>>>
		6	64	Thermal Overload Trip
		7	128	tI2>
		8	256	tI2>>
		9	512	tI2>>>>
		10	1024	tIe>>>>
		11 - 15	-	Reserved
F34	Reserved			
F35	Disturbance Record Uploading Status	-	0	No Disturbance Record Uploaded
		-	1	Disturbance Record Upload Running
F36	Memorized Flags of Non Acknowledged Alarms:	0	1	Ie>
		1	2	tIe>
		2	4	Ie>>
		3	8	tIe>>
		4	16	Ie>>>
		5	32	tIe>>>
		6	64	Thermal Overload Alarm
		7	128	Thermal Overload Trip
		8	256	Broken Conductor
		9	512	CB Failure
		10	1024	I2>
		11	2048	I2>>
		12	4096	tI2>
		13	8192	tAux1
		14	16384	tAux2
		15	32768	tI2>>
F36'	Memorized Flags of Non Acknowledged Alarms 2:	0	1	CB Open Timer Expired
		1	2	CB Number of Operations
		2	4	Summation Amps Exceeded Threshold
		3	8	CB Supervision
		4	16	CB Supervision CB Close Timer Expired

Code	Description	Flag Information		
		Bit	Value	Data
		5	32	Ie>>>> Start Alarm
		6	64	Ie>>>> Trip Alarm
		7 - 15	-	Reserved
F37	Unsigned Integer: Thermal Overload Information	0	1	Thermal Overload Alarm
		1	2	Thermal Overload Trip
		2 - 15	-	Reserved
F38	Unsigned Integer: CB Alarm/CB Failure/Broken Conductor Flags	0	1	Reserved
		1	2	CB Failure
		2	4	Pole A Opening
		3	8	Pole B Opening
		4	16	Pole C Opening
		5	32	Broken Conductor
		6	64	tAux1
		7	128	tAux2
		8	256	Broken Conductor Time Delay
		9	512	CB Failure Time Delay
		10	1024	Cold Load Pickup Time Delay
		11	2048	CB Alarms or Bits 0, 1, 2, 4 of F43
		12	4096	CB In Unknown State (DBI)
		13	8192	Remote Trip Delay
		14	16384	Remote Close Delay
		15	-	Reserved
F39	Reserved			
F40	Unsigned Integer: Selective Scheme Logic Configuration	0	1	tI>>
		1	2	tI>>>
		2	4	tIe>>
		3	8	tIe>>>
		4	16	tI>>>>
		5	32	tIe>>>>
		6 - 15	-	Reserved
F41	Rear Port Allocation for Communications	-	1	MODBUS
		-	2	Reserved
		-	4	IEC 60870-5-103
		-	-	Reserved
F42	Time Window Format	-	0	5 Minutes
		-	1	10 Minutes
		-	2	15 Minutes
		-	3	30 Minutes
		-	4	60 Minutes
F43	Unsigned Integer: CB Supervision Flag	0	1	CB Operating Time Expired

Code	Description	Flag Information		
		Bit	Value	Data
		1	2	CB Operation Number Expired
		2	4	Square Amps Sum Exceeded
		3	8	Trip Circuit Supervision
		4	16	CB Closing Time Expired
		5 - 15	-	Reserved
F44	Unsigned Integer: Alarm Information 2	0	1	CB Operating Time Overreach, Memorized Alarm
		1	2	CB Operation Number Overreach, Memorized Alarm
		2	4	Square Amps Sum Overreach, Memorized Alarm
		3	8	Trip Circuit Self-Test, Memorized Alarm
		4	16	CB Closing Time Overreach, Memorized Alarm
		5	32	Ie>>>> Alarm
		6	64	tIe>>>> Alarm
		7	128	TCS Block
		8-15	-	Reserved
F45	Unsigned Integer: Relay Status	0	1	Watchdog
		1	2	User Communication Failure
		2	4	EEPROM Data Failure
		3	8	CT Failure
		4	16	Calibration Failure
		5	32	Real Time Clock Failure
		6	64	SRAM Failure
		7	128	Reserved
		8	256	Protection Communications Card Failure
		9	512	Protection Communications Card Recovery in Progress
		10	1024	Factory Default Settings Restored
		11	2048	Mains Power Supply
		12	4096	Auxiliary Power Supplies
		13	8196	Transformers Offset Failure
F46	Unsigned Integer: Remote Control Word 3	0	1	Initiate Ie Harmonic Calculation
		1	2	De-latch Trip Relay Only (RL1)
		2	4	Acknowledge Oldest Disturbance Record
		3	8	Reserved
		4	16	Reset Rolling Demand Measurements
		5	32	Reset Peak Average Measurements
		6	64	Clear the Protection Communication Statistics
		7	128	Cancel Remote Trip Sequence
		8	256	Cancel Remote Close Sequence
		9	512	Reserved
		10	1024	Reserved
		11	2048	Reserved

Code	Description	Flag Information		
		Bit	Value	Data
		12	4096	Reserved
		13	8192	Reserved
		14	16384	Erase all records (events, faults, alarms, disturbances, etc)
		15	32768	Reserved
F46A	Setting Groups selection	0	1	Settings group 1 selection
		1	2	Settings group 2 selection
		2	4	Settings group 3 selection
		3	8	Settings group 4 selection
F47	Change Group Input		0	Edge triggered changes of logic inputs
			1	Level triggered changes of logic inputs
F48	MODBUS Date Format		0	Private Date Format
			1	IEC Date Format
F49	Reserved		-	-
F50	Opto Power Supply		0	DC
			1	AC
F51	Phase Rotation		0	Direct Phase Rotation ABC
			1	Inverse Phase Rotation ACB
F52	In Progress Flag for Current Differential	0	1	Disable Current Differential Protection
		1	2	Protection Communication Fail (Alarm Not Activated)
		2	4	Current differential fail
		3	8	Current differential protection ok
		4	16	Idiff Trip Any Phase
		5	32	Idiff A Phase Fault
		6	64	Idiff B Phase Fault
		7	128	Idiff C Phase Fault
		8	256	Back-Up Enabled
		9	512	Protection Communications alarm (Fail Timer Expired)
		10	1024	Protection Communications Ok
		11	2048	Idiff Start on any phase
		12	4096	Direct Intertrip Rx
		13	8192	Permissive Intertrip Rx
		14	16384	Idiff Intertrip Rx
		15	32768	Permissive Intertrip Start Rx
F53	Current Differential Memory Protection Flags	0	1	Current Differential protection disabled
		1	2	Reserved
		2	4	Current differential fail
		3	8	Reserved
		4	16	Idiff Trip any phase
		5 - 8		Reserved

Code	Description	Flag Information		
		Bit	Value	Data
		9	512	Protection Communications Alarm (Fail timer Expired)
		10 - 15	-	Reserved
F54	Intertrip Flags	0	1	Direct Intertrip R1 Trip
		1	2	Current Differential Intertrip R1 Trip CH1
		2	4	Permissive Intertrip Start CH1
		3	8	Permissive Intertrip Trip CH1
		4-15	-	Reserved
F55	Reserved			
F56	Commissioning Flags		0	Output Contacts Disabled
			1	Protection Communications Loopback Mode Enabled
			2	Reserved
F57	Unsigned Long Integer		4294967295	Numerical Data
F58	Protection Communication Protocol		0	SDLC
			1	NRZ
			2	Inverted NRZ
F59	Protection Communication Data Rate		0	64 kbits/Sec
			1	56 kbits/Sec
			2	19.2 kbits/Sec
			3	9.6 kbits/Sec
F60	Protection Communication Relay Address		0	1A
			1	1B
			2	2A
			3	2B
			4	3A
			5	3B
			6	4A
			7	4B
			8	5A
			9	5B
			10	6A
			11	6B
			12	7A
			13	7B
			14	8A
			15	8B
			16	9A
			17	9B
			18	10A
			19	10B
			20	11A
			21	11B

Code	Description	Flag Information		
		Bit	Value	Data
			22	12A
			23	12B
			24	13A
			25	13B
			26	14A
			27	14B
			28	15A
			29	15B
			30	16A
			31	16B
F61	Protection Communication Clock Source		0	Internal
			1	External
F62	Unsigned Integer : Logic Outputs Configuration		0	Selection Logic Output Number RL1
			1	Selection Logic Output Number RL2
			2	Selection Logic Output Number RL3
			3	Selection Logic Output Number RL4
			4	Selection Logic Output Number RL5
			5	Selection Logic Output Number RL6
			6	Selection Logic Output Number RL7
			7	Selection Logic Output Number RL8
F63	Unsigned Integer: Manual CB Trip and Close		0	No Operation
			1	Trip
			2	Close
F64	Latest Fault Record Register	0	1	I2> Fault
		1	2	I2>> Fault
		2	4	Thermal Fault
		3	8	Aux. 1
		4	16	Aux. 2
		5	32	I<
		6	64	Broken Conductor
		7	128	Ie>>>>
		8	256	Ie>>>
		9	512	Ie>>
		10	1024	Ie>
		11	2048	I>>>>
		12	4096	I>>>
		13	8192	I>>
		14	16384	I>
		15	32768	Current Differential Intertrip
F65	Latest Fault Record Register 2	0	1	Current Differential Fault
		1	2	CB Fail

Code	Description	Flag Information		
		Bit	Value	Data
		2	4	TCS Block
		3	8	Equation A Fault Occurred
		4	16	Equation B Fault Occurred
		5	32	Equation C Fault Occurred
		6	64	Equation D Fault Occurred
		7	128	Equation E Fault Occurred
		8	256	Equation F Fault Occurred
		9	512	Equation G Fault Occurred
		10	1024	Equation H Fault Occurred
F66	Vector Compensation Type		0	Off
			1	Yy0 (0°)
			2	Yd1 (-30°)
			3	Yy2 (-60°)
			4	Yd3 (-90°)
			5	Yy4 (-120°)
			6	Yd5 (-150°)
			7	Yy6 (-180°)
			8	Yd7 (+150°)
			9	Yy8 (+120°)
			10	Yd9 (+90°)
			11	Yy10 (+60°)
			12	Yd11 (+30°)
			13	Ydy0 (0°)
			14	Ydy6 (-180°)
F67	Selective Intertripping	0	1	DIT on tI> Trip
		1	2	DIT on tI>> Trip
		2	4	DIT on tI>>> Trip
		3	8	DIT on tI>>>> Trip
		4	16	DIT on tIe> Trip
		5	32	DIT on tIe>> Trip
		6	64	DIT on tIe>>> Trip
		7	128	DIT on tIe>>>> Trip
		8	256	DIT on tI< Trip
		9	512	DIT on tI2> Trip
		10	1024	DIT on tI2>> Trip
		11	2048	DIT on Thermal Trip
		12	4096	DIT on Broken Conductor Trip
		13	8192	DIT on tAux1 Trip
		14	16384	DIT on tAux2 Trip
		15	32768	DIT on CB Fail
F68	PIT I Selection	0	1	Remote
		1	2	Local
F69	PIT OC Stages	0	1	I>

Code	Description	Flag Information		
		Bit	Value	Data
		1	2	I>>
		2	4	I>>>
		3	8	I>>>>
		4	16	Ie>
		4	32	Ie>>
		5	64	Ie>>>
		7	128	Ie>>>>
F70	Inrush Block Control Flags	0	1	Local Cross Block
		1	2	Local Phase A Block
		2	4	Local Phase B Block
		3	8	Local Phase C Block
		4	16	Remote Cross Block
		5	32	Remote Phase A Block
		6	64	Remote Phase B Block
		7	128	Remote Phase C Block
		8	256	Remote Inrush Block Enabled
		9	512	Inrush Block Configure Error
F71	Inrush Block Control Alarms	0	1	Inrush Block Configure Error Alarm
F72	CTS Control Flags	0	1	Local CTS Fail
		1	2	Remote CTS Fail
		2	4	CTS Block
		3	8	CTS Cdiff Block
		4	16	CTS Cdiff Restrain
		5	32	CTS Inhibited
		6	64	CTS Conf Fail
F73	CTS Control Alarms	0	1	Local CTS Fail Alarm
		1	2	Remote CTS Fail Alarm
		2	4	CTS Block Alarm
		3	8	Reserved
		4	16	CTS Cdiff Restrain Alarm
		5	32	CTS Inhibited Alarm
		6	64	CTS Conf Fail Alarm
F74	CTS reset mode		0	Manual
			1	Auto
F75	Loopback mode		0	Off
			1	Channel 1
			2	Internal
F76	Reserved			
F77	Reserved			
F78	Reserved			
F79	Reserved			
F80	FRAME mode		0	Extension
			1	Convention

Code	Description	Flag Information		
		Bit	Value	Data
F81	Logic Equation Flag	0	1	Equation A
		1	2	Equation B
		2	4	Equation C
		3	8	Equation D
		4	16	Equation E
		5	32	Equation F
		6	64	Equation G
		7	128	Equation H
F82	Programmable Intertrip	0	1	Intertrip 1
		1	2	Intertrip 2
		2	4	Intertrip 3
		3	8	Intertrip 4
F83	Logic Equation Operand		0	Null
			1	Any Trip
			2	CDiff Trip
			3	Backup Enable
			4	Comm. Fail
			5	Direct IT
			6	CDiff IT
			7	Permissive IT
			8	I> Start
			9	I> Trip
			10	I>> Start
			11	I>> Trip
			12	I>>> Start
			13	I>>> Trip
			14	I>>>> Start
			15	I>>>> Trip
			16	I0> Start
			17	I0> Trip
			18	I0>> Start
			19	I0>> Trip
			20	I0>>> Start
			21	I0>>> Trip
			22	I0>>>> Start
			23	I0>>>> Trip
			24	I< Start
			25	I< Trip
			26	I2> Start
			27	I2> Trip
			28	I2>> Start
			29	I2>> Trip
			30	Thermal Alarm

Code	Description	Flag Information		
		Bit	Value	Data
			31	Thermal Trip
			32	CB Alarm
			33	52 Fail
			34	Broken Cond.
			35	CB Fail
			36	CB Close
			37	Aux1 Trip
			38	Aux2 Trip
			39	Active Group
			40	TCS Block
			41	Input 1
			42	Input 2
			43	Input 3
			44	Input 4
			45	Input 5
			46	Equ A
			47	Equ B
			48	Equ C
			49	Equ D
			50	Equ E
			51	Equ F
			52	Equ G
			53	Equ H
			54	Prgm IT 1
			55	Prgm IT 2
			56	Prgm IT 3
			57	Prgm IT 4
			58	CTS Local Alarm
			59	CTS Remote Alarm
			60	CTS Block
			61	CTS Restrain
			62	Convention Mode
			63	Cdiff Disabled
F84	Logic Equation Operator		0	OR
			1	OR NOT
			2	AND
			3	AND NOT
F85	Programmable Intertrip Allocation	0	0	I> Trip
		1	2	I>> Trip
		2	4	I>>> Trip
		3	8	I>>>> Trip
		4	16	I0> Trip

Code	Description	Flag Information		
		Bit	Value	Data
		5	32	I0>> Trip
		6	64	I0>>> Trip
		7	128	I0>>>> Trip
		8	256	Thermal Trip
		9	512	I< Trip
		10	1024	I2> Trip
		11	2048	I2>> Trip
		12	4096	CB Fail
		13	8192	Broken Cond.
		14	16384	Aux1 Trip
		15	32768	Aux2 Trip
F85’	Programmable Intertrip Allocation Word 2	0	1	Input 1
		1	2	Input 2
		2	4	Input 3
		3	8	Input 4
		4	16	Input 5
		5	32	Equ A
		6	64	Equ B
		7	128	Equ C
		8	256	Equ D
		9	512	Equ E
		10	1024	Equ F
		11	2048	Equ G
		12	4096	Equ H
F86	Message Display			
F87	FRAME Mode	0	1	Convention
		1	2	Reserved
		2	4	Conf conflict comms
F98		0	1	-3V3 out of range
		1	2	5V0 out of range
		2	4	3V3 out of range
		3	8	12V out of range
		4	16	1V3 out of range
		5	32	0V out of range
F99		0	1	Abnormal offset with transformer 1
		1	2	Abnormal offset with transformer 2
		2	4	Abnormal offset with transformer 3
		3	8	Abnormal offset with transformer 4
		4	16	Abnormal offset with transformer 5
		5	32	Abnormal offset with transformer 6
		6	64	Abnormal offset with transformer 7
		7	128	Abnormal offset with transformer 8

Code	Description	Flag Information		
		Bit	Value	Data
		8	256	Abnormal offset with transformer 9

Table 14 - Register format

3.5 Event Record

There are two methods of event record extraction.

1. Request a specific event record (see section 3.5.1)
2. Request the oldest non-acknowledged event record (see section 3.5.2)

3.5.1 Specific Event Record Extraction

3.5.1.1 Page 35h: contains 250 Event Records from 3500h to 35F9h

The events number is extended from 75 to 250 since P521 V12.A.
Prior to P521 V12.A, Page 35h contains 75 Event Records from 3500h to 354Ah.
Since P521 V12.A Page 35h contains 250 Event Records from 3500h to 35F9h.

One event record can be accessed from each address.

Each event is one 3-dimensional MODBUS register (see section 0) that consists of 9 data words. The format is detailed in section 3.5.1.2.

3.5.1.2 Event Record Format

Word N° 1:	Event meaning see ref. 0
Word N° 2:	MODBUS associated value
Word N° 3:	MODBUS address
Word N° 4:	Reserved
Word N° 5 & 6:	Event date (second) number of second since 01/01/94
Word N° 7 & 8:	Event date (millisecond)
Word N° 9:	Acknowledge 0 = Event Non acknowledged 1 = Event Acknowledged

Table 15 - Event record format

3.5.1.3 Events and Alarms Table

Code	Event Meaning	Type	MODBUS Address
0	No Event	-	-
1	Remote Close Operation Command Acknowledged	-	-
2	Remote Trip Operation Command Acknowledged	-	-
3	Disturbance Recording Started	-	-
4	Remote De-Latch Latched Contacts Command Acknowledged	-	-
5	Setting Change Occurred	ADDRESS	-
6	Remote Thermal Reset Command Acknowledged	-	-
7	Maintenance Mode Enabled/Disabled	-	-

Code	Event Meaning	Type	MODBUS Address
8	Output Contact State Change While in Maintanance Mode	F13↑↓	014H
9	I>	F17↑↓	016H
10	I>>	F17↑↓	017H
11	I>>>	F17↑↓	018H
12	I>>>>	F17↑↓	019H
13	Ie>	F16↑↓	01AH
14	Ie>>	F16↑↓	01BH
15	Ie>>>	F16↑↓	01CH
16	Ie>>>>	F16↑↓	01DH
17	Thermal Overload Alarm Threshold Exceeded	F37↑↓	029H
18	Thermal Overload Trip Threshold Exceeded	F37↑↓	029H
19	tI>	F17↑↓	016H
20	tI>>	F17↑↓	017H
21	tI>>>	F17↑↓	018H
22	tI>>>>	F17↑↓	019H
23	tIe>	F16↑↓	01AH
24	tIe>>	F16↑↓	01BH
25	tIe>>>	F16↑↓	01CH
26	tIe>>>>	F16↑↓	01DH
27	tI<	F17↑↓	02AH
28	Broken Conductor	F38↑↓	02DH
29	tAux1 Expired	F38↑↓	02DH
30	tAux2 Expired	F38↑↓	02DH
31	CB Failure Occurred	F38↑↓	02DH
32	Selective Scheme Logic 1 Activated	F20↑↓	011H
33	Selective Scheme Logic 2 Activated	F20↑↓	011H
34	Blocking Logic 1 Activated	F20↑↓	011H
35	Blocking Logic 2 Activated	F20↑↓	011H
36	Setting Group Change Activated	F20↑↓	011H
37	52a State Changed	F20↑↓	011H
38	52b State Changed	F20↑↓	011H
39	Acknowledgement Of The Latched Output Relays Release	F20↑↓	011H
40	CB Failure Occurred	F20↑↓	011H
41	Cold Load Start Activated	F20↑↓	011H
42	NULL	-	-
43	NULL	-	-
44	NULL	-	-
45	Change of Logic Input State	F12↑↓	010H
46	Trip Relay Activated: Thermal Overload	F37↑↓	029H
47	Trip Relay Activated: tI>	F17↑↓	016H
48	Trip Relay Activated: tI>>	F17↑↓	017H
49	Trip Relay Activated: tI>>>	F17↑↓	018H

Code	Event Meaning	Type	MODBUS Address
50	Trip Relay Activated: tI>>>>	F17↑↓	019H
51	Trip Relay Activated: tIe>	F17↑↓	01AH
52	Trip Relay Activated: tIe>>	F17↑↓	01BH
53	Trip Relay Activated: tIe>>>	F17↑↓	01CH
54	Trip Relay Activated: tIe>>>>	F17↑↓	01DH
55	Trip Relay Activated: tI<	F17↑↓	02AH
56	Trip Relay Activated: Broken Conductor	F38↑↓	02DH
57	Trip Relay Activated: tAux1	F38↑↓	02DH
58	Trip Relay Activated: tAux2	F38↑↓	02DH
59	Change of Output Contact State	F13↑↓	014H
60	Front Panel Single Alarm Acknowledgement Command Acknowledged	-	-
61	Front Panel All Alarms Acknowledgement Command Acknowledged	-	-
62	Remote Single Alarm Acknowledgement Command Acknowledged	-	-
63	Remote All Alarms Acknowledgement Command Acknowledged	-	-
64	Major Hardware Alarms	F45↑↓	00FH
65	Minor Hardware Alarms	F45↑↓	00FH
66	I2> Start	F16↑↓	02BH
67	tI2> Trip	F16↑↓	02BH
68	CB Supervision Open Timer Expired	F43↑↓	033H
69	Number Of CB Operations Exceeded Threshold	F43↑↓	033H
70	Summation Amps Exceeded Threshold	F43↑↓	033H
71	CB Supervision CB Trip	F43↑↓	033H
72	CB Supervision Closed Timer Expired	F43↑↓	033H
73	CB Status Is In-Determinate	F38↑↓	02DH
74	NULL	-	-
75	NULL	-	-
76	NULL	-	-
77	Trip Relay Activated: tI2>	F16↑↓	014H
78	NULL	-	-
79	NULL	-	-
80	NULL	-	
81	Change of Latched Output Contact State	F13↑	034H
82	tBF Started	F20'↑↓	012H
83	I< Start	F17↑↓	02AH
84	I2>> Start	F16↑↓	02CH
85	tI2>> Trip	F16↑↓	02CH
86	Trip Relay Activated: tI2>>	F16↑↓	02BH
87	NULL	-	-
88	Channel 1 Protection Communications Alarm	F52↑	015H
89	NULL	-	-

Code	Event Meaning	Type	MODBUS Address
90	Current Differential Trip	F52↑↓	015H
91	Channel 1 Direct Intertrip Occurred	F52↑	015H
92	Channel 1 Current Differential Intertrip Occurred	F52↑	015H
93	Channel 1 Permissive Intertrip Occurred	F52↑	015H
94	NULL	-	-
95	NULL	-	-
96	NULL	-	-
97	Current Differential Protection Fail	F52↑	015H
98	Current Differential Protection Disabled	F52↑↓	015H
99	Protection Communications Loopback Mode Active	F24↑↓	166H
100	Output Contacts Disabled	F24↑↓	162H
101	Current Differential Start	F52↑↓	015H
102	Current Differential Phase A Start	-	-
103	Current Differential Phase B Start	-	-
104	Current Differential Phase C Start	-	-
105	Current Differential Phase A Trip	-	-
106	Current Differential Phase B Trip	-	-
107	Current Differential Phase C Trip	-	-
108	Protection Communications Fail	F52↑↓	015H
109	Protection Communications Channel 1 Ok	F52↑↓	015H
110	NULL	-	-
111	Backup Protection Active	F52↑↓	015H
112	Differential Protection Ok	F52↑	015H
113	Permissive Intertrip Start	F52↑↓	015H
114	NULL	-	-
115	Trip Relay Activated: Current Differential	F52↑↓	015H
116	Trip Relay Activated: Direct Intertrip	F52↑↓	015H
117	Trip Relay Activated: Current Differential Intertrip	F52↑↓	015H
118	Trip Relay Activated: Permissive Intertrip	F52↑↓	015H
119	Manual Trip Delay Timer Start	F38↑↓	02DH
120	Manual Close Delay Timer Start	F38↑↓	02DH
121	Reset Protection Communications Statistics Acknowledged	-	-
122	TCS Block Input Energised	F20'↑↓	012H
123	Equation A	F81	03AH
124	Equation B	F81	03AH
125	Equation C	F81	03AH
126	Equation D	F81	03AH
127	Equation E	F81	03AH
128	Equation F	F81	03AH
129	Equation G	F81	03AH
130	Equation H	F81	03AH
131	Programmable Intertrip 1	F82	03CH
132	Programmable Intertrip 2	F82	03CH

Code	Event Meaning	Type	MODBUS Address
133	Programmable Intertrip 3	F82	03CH
134	Programmable Intertrip 4	F82	03CH
135	local Inrush Block	F70	0CDH
136	Remote Inrush Block	F70	0CDH
137	Inrush Block Config Error Alarm	F70	0CDH
138	Local CTS Alarm	F72	0CFH
139	Remote CTS Alarm	F72	0CFH
140	CTS Block	F72	0CFH
141	CTS Cdiff Block	F72	0CFH
142	CTS Cdiff Restrain	F72	0CFH
143	CTS Inhibit	F72	0CFH
144	CTS Config Alarm	F72	0CFH
145	LED RESET	-	-
146	Convention Mode	F87	012H
147	Synchronization	-	-
148	Cortec Mismatch	-	-
149	Conf Conflict Comms	F87	0D1H
150	main power supply	F45	00FH
151	-3V3 power supply	F98	00DFH
152	5V0 power supply	F98	00DFH
153	3V3 power supply	F98	00DFH
154	12V power supply	F98	00DFH
155	0V power supply	F98	00DFH
156	ground offset	F98	00DFH
157	offset on transformer 1	F99	00E0H
158	offset on transformer 2	F99	00E0H
159	offset on transformer 3	F99	00E0H
160	offset on transformer 4	F99	00E0H
161	offset on transformer 5	F99	00E0H
162	offset on transformer 6	F99	00E0H
163	offset on transformer 7	F99	00E0H
164	offset on transformer 8	F99	00E0H
165	offset on transformer 9	F99	00E0H

Note *↑↓ The Double Arrow signifies that the Event is Generated on Event Occurrence (↑) and Disappearance (↓).*
On Event Occurrence, the Corresponding Bit of the Associated Format is Set to 1.
On Event Disappearance, the Corresponding Bit of the Associated Format is Set to 0.

Code	Event Meaning	Type	MODBUS Address
	Note — *The Event Record consists of 9 Words:* *Word Number 1 : Event Meaning* *Word Number 2 : MODBUS Associated Value* *Word Number 3 : Modbus Address* *Word Number 4 : Reserved* *Word Number 5 and 6 : Event Time (Number of Seconds Since 01/01/94)* *Word Number 6 and 7 : Event Time (Milliseconds)* *Word Number 8 : Acknowledge: 0 = Non-Acknowledged or 1 = Acknowledged*		

Table 16 - MODBUS Events and Alarms table

3.5.2 Page 36h: Oldest Event Record

Reading address 3600h using MODBUS function 3 can retrieve the oldest event record.

3.5.3 Event Acknowledgement

There are two ways to acknowledge an event, automatically or manually.

3.5.3.1 Event Acknowledgement Mode

In order to set the acknowledgement mode for events and faults, bit 12 in remote control word 1 (0400h) has to be written to with the required mode see ref. [3.5.3.4 Event acknowledgement control]

3.5.3.2 Automatic Event Acknowledgement Mode

Acknowledgement of the oldest non-acknowledged event record takes place on retrieval.

3.5.3.3 Manual Event Acknowledgement

With the acknowledgement mode set to manual, the oldest non-acknowledged event record must be retrieved. Bit 13 of remote control word 1 (0400h) can then be set to 1 to acknowledge the oldest non-acknowledged event ref. [3.5.3.4 Event acknowledgement control].

3.5.3.4 Event Acknowledgement Control

Remote Control Word 1 : 0400h	Function
Bit 12	0 = Automatic event/fault acknowledgement mode 1 = Manual event/fault acknowledgement mode
Bit 13	0 = Event not acknowledged manually 1 = Event acknowledged manually

Table 17 - Event acknowledgement control

3.6 Fault Record

There are two methods of fault record extraction.

- Request a specific fault record (see section 3.6.1)
- Request the oldest non-acknowledged fault record (see section 3.6.2).

3.6.1 Specific Fault Record

3.6.1.1 Page 37h: Fault Record Mapping

Each fault record is one 3-dimensional MODBUS register (see section 0) that consists of 25 data words. The format is detailed in section 0.

Address	Contents
3700h	Fault Record N° 1
3701h	Fault Record N° 2
3702h	Fault Record N° 3
3703h	Fault Record N° 4
3704h	Fault Record N° 5
3705h	Fault Record N° 6
3706h	Fault Record N° 7
3707h	Fault Record N° 8
3708h	Fault Record N° 9
3709h	Fault Record N° 10
370Ah	Fault Record N° 11
370Bh	Fault Record N° 12
370Ch	Fault Record N° 13
370Dh	Fault Record N° 14
370Eh	Fault Record N° 15
370Fh	Fault Record N° 16
3710h	Fault Record N° 17
3711h	Fault Record N° 18
3712h	Fault Record N° 19
3713h	Fault Record N° 20
3714h	Fault Record N° 21
3715h	Fault Record N° 22
3716h	Fault Record N° 23
3717h	Fault Record N° 24
3718h	Fault Record N° 25
3E00h	Oldest Non-Acknowledged Fault Record

Table 18 - Page 37h: fault record mapping

3.6.1.2 Fault Record Format

Word Number	Contents
1	Fault number
2 & 3	Fault time in seconds since 01/01/94
4 & 5	Fault time (milliseconds)
6	Fault date (season) 0 = winter 1= Summer 2 = Undefined
7	Active setting group
8	Fault type (see Table 19)
9	Fault element (see Table 20)
10 & 11	Fault value current (see note 1)
12	Phase A current (see note 2)
13	Phase B current (see note 2)
14	Phase C current (see note 2)
15	Earth current value (see note 2)
16 & 17	IA differential current (see note 3)
18 & 19	IB differential current (see note 3)
20 & 21	IC differential current (see note 3)
22 & 23	Ibias highest current (see note 3)
24	Cdiff control flags (see F52)
25	Acknowledge fault : Fault non acknowledged = 0 Fault acknowledged = 1

Table 19 - Fault types

0	None
1	Phase A
2	Phase B
3	Phase C
4	Phases A - B
5	Phases A - C
6	Phases B - C
7	Phases A – B - C
8	Earth

Table 20 - Fault element meanings

Code	Fault Origin
00	Null event
01	Remote trip
02	Thermal overload trip
03	tI> trip
04	tI>> trip
05	tI>>> trip
06	tI>>>> trip
07	tIe> trip
08	tIe>> trip
09	tIe>>> trip

Code	Fault Origin
10	tIe>>>> trip
11	tI < trip
12	Broken conductor trip
13	t Aux 1 trip
14	t Aux 2 trip
15	tI2> trip
16	tI2>> trip
17	Idiff trip
18	Intertrip
19	TCS Block
20	EQU A Trip
21	EQU B Trip
22	EQU C Trip
23	EQU D Trip
24	EQU E Trip
25	EQU F Trip
26	EQU G Trip
27	EQU H Trip
	Note 1 *For trip codes 17 & 18 (in Table 20) refer to note 3 to calculate the value. For all other trip codes refer to note 2 to calculate the value.*
	Note 2 *The nominal current value not including any CT ratio settings.*
	Note 3 *Current differential value calculation.*

Table 21 - Fault origin codes

3.6.1.3 Fault Record Calculation Formulae

Line Current Differential/Bias Value =

$$\frac{\text{Differential or Bias Current (word 16 \& 17 or 18 \& 19 or 20 \& 21 or 22 \& 23)}}{100}$$

Line Phase Current Value =

$$\frac{\text{Phase Sampled Value (word 11, 12, 13 or 14) *Phase Primary CT Ratio (0120h)}}{\text{Phase Internal CT Ratio (0007h)}}$$

Line Earth Current Value =

$$\frac{\text{Earth Sampled Value (word 10 or 15) *Earth Primary CT Ratio (0122h)}}{\text{Earth Internal CT Ratio (0008h)}}$$

The earth internal CT ratio is dependent on the earth current range as shown in the table below:

3.6.1.4 Internal CT Value for each Sensitivity Range

Sensitivity Range	0.1 to 40 Ien	0.01 to 8 Ien	0.002 to 1 Ien
Internal CT Value	800	3277	32700

Table 22 - Sensitivity Ranges and internal CT values

Line Current Differential/Bias Value =

$$\frac{\text{Differential or Bias Current (word 16 \& 17 or 18 \& 19 or 20 \& 21 or 22 \& 23)}}{100}$$

3.6.2 Oldest Non-Acknowledged Fault Record

3.6.2.1 Page 3Eh: Oldest Non-Acknowledged Fault Record

Reading address 3E00h using MODBUS function 3 can retrieve the oldest non-acknowledged fault record.

3.6.3 Fault Record Acknowledgement

3.6.4 Event Acknowledgement

There are two ways to acknowledge an event, automatically or manually.

3.6.4.1 Event Acknowledgement Mode

In order to set the acknowledgement mode for events and faults, bit 12 in remote control word 1 (0400h) has to be written to with the required mode see ref. [3.5.3.4 Event acknowledgement control]

3.6.4.2 Automatic Event Acknowledgement Mode

Acknowledgement of the oldest non-acknowledged event record takes place on retrieval.

3.6.4.3 Manual Event Acknowledgement

With the acknowledgement mode set to manual, the oldest non-acknowledged event record must be retrieved. Bit 14 of remote control word 1 (0400h) can then be set to 1 to acknowledge the oldest non-acknowledged event see section 3.5.3.4.

Remote Control Word 1 : 0400h	Function
Bit 12	0 = Automatic event/fault acknowledgement mode 1 = Manual event/fault acknowledgement mode
Bit 14	0 = Fault record not acknowledged manually 1 = Fault record acknowledged manually

Table 23 - Remote control words, bits and functions

3.7 Disturbance Records

In order to extract a disturbance record the following requests need to be sent to the relay.

1. An optional request can be sent to extract a summary of all the disturbance records in SRAM, the mapping and format of the data returned is shown in section 3.6.1.
2. Read the configuration information for the first set of channel data. The first set is IA. The MODBUS mapping and format are detailed in section 3.3. Reading the channel configuration data is required to selects which channel data is available for reading.
3. Read the first 250 words of the selected channel data. The MODBUS mapping and format is detailed in section 3.3 Channel data.
4. Continue to request configuration information and then channel data in 250 word blocks until all the disturbance record has been extracted. Data words 10 and 11 of the configuration information specify the end of the channel extraction.
5. Read the upload index frame to complete the disturbance record extraction and to acknowledge the disturbance record extraction. Refer to section 3.3 for the format and MODBUS mapping details.

3.7.1 Summary Disturbance Records

3.7.1.1 Page 3Dh: Summary Disturbance Records

The summary disturbance record is one 3 dimensional MODBUS register (see section 3.2) that consists of 36 data words. The format is detailed in section 3.7.1.2.

MODBUS function 3 can be used to read all the summary disturbance records. Note that the disturbance records are not fixed and will be changed according to the different setting. Please refer to section 3.7.1.2 for details.

3.7.1.2 Format of Summary Disturbance Records

Word Number	Contents
1	Number of disturbance records available
2	Oldest disturbance record number
3 & 4	Oldest disturbance record time (seconds)
5 & 6	Oldest disturbance record time (milliseconds)
7	Disturbance record starting origin 1 = Trip relay (RL1), 2 = Instantaneous threshold, 3 = Remote command, 4 = Logic input
8	Acknowledge
9	Oldest disturbance record number +1
10 & 11	Disturbance record time (seconds)
12 & 13	Disturbance record time (milliseconds)
14	Disturbance record starting origin 1 = Trip relay (RL1), 2 = Instantaneous threshold, 3 = Remote command, 4 = Logic input
15	Acknowledge

Word Number	Contents
16	Oldest disturbance record number +2
17 & 18	Disturbance record time (seconds)
19 & 20	Disturbance record time (milliseconds)
21	Disturbance record starting origin 1 = Trip relay (RL1), 2 = Instantaneous threshold, 3 = Remote command, 4 = Logic input
22	Acknowledge
23	Oldest disturbance record number +3
24 & 25	Disturbance record time (seconds)
26 & 27	Disturbance record time (milliseconds)
28	Disturbance record starting origin 1 = Trip relay (RL1) , 2 = Instantaneous threshold, 3 = Remote command, 4 = Logic input
29	Acknowledge
30	Latest disturbance record
31 & 32	Latest disturbance record time (seconds)
33 & 34	Latest disturbance record time (milliseconds)
35	Disturbance record starting origin 1 = Trip relay (RL1), 2 = Instantaneous threshold, 3 = Remote command, 4 = Logic input
36	Acknowledge

Table 24 - Word numbers and content

3.7.2 Channel Selection and Configuration

3.7.2.1 Pages 38h to 3Ch: Data Mapping

All channel selection and configuration registers are 3-dimensional MODBUS registers (see section 3.2) which consist of 11 data words. The format is detailed in section 0.

MODBUS function 3 can be used to read the summary disturbance records.

Address	Disturbance Record No.	Format
3800h	1	IA
3801h	1	IB
3802h	1	IC
3803h	1	IE
3804h	1	Timing
3805h	1	Logic input and output 1
3806h	1	Logic input and output 2
3900h	2	IA
3901h	2	IB
3902h	2	IC
3903h	2	IE

Address	Disturbance Record No.	Format
3904h	2	Timing
3905h	2	Logic input and output 1
3906h	2	Logic input and output 2
3A00h	3	IA
3A01h	3	IB
3A02h	3	IC
3A03h	3	IE
3A04h	3	Timing
3A05h	3	Logic input and output 1
3A06h	3	Logic input and output 2
3B00h	4	IA
3B01h	4	IB
3B02h	4	IC
3B03h	4	IE
3B04h	4	Timing
3B05h	4	Logic input and output 1
3B06h	4	Logic input and output 2
3C00h	5	IA
3C01h	5	IB
3C02h	5	IC
3C03h	5	IE
3C04h	5	Timing
3C05h	5	Logic input and output 1
3C06h	5	Logic input and output 2

Table 25 - Addresses and disturbance records

3.7.2.2 Disturbance Record Channel Selection and Configuration Format

Word Number	Format
Word No 1	Number of samples to be extracted
Word No 2	Number of samples in pre-time
Word No 3	Number of samples in post-time
Word No 4	Primary phase CT ratio
Word No 5	Secondary phase CT ratio
Word No 6	Primary earth CT ratio
Word No 7	Secondary earth CT ratio
Word No 8	Internal phase CT ratio
Word No 9	Internal earth CT ratio
Word No 10	Address of the last page of disturbance record data
Word No 11	Number of data words on the last page of the disturbance record for this channel

Table 26 - Disturbance word numbers and formats

3.7.3 Channel Data

3.7.3.1 Page 9h to 21h: Channel Data Mapping

Addresses	Contents
0900H to 09FAH	250 Disturbance data words
0A00H to 0AFAH	250 Disturbance data words
0B00H to 0BFAH	250 Disturbance data words
0C00H to 0CFAH	250 Disturbance data words
0D00H to 0DFAH	250 Disturbance data words
0E00H to 0EFAH	250 Disturbance data words
0F00H to 0FFAH	250 Disturbance data words
1000H to 10FAH	250 Disturbance data words
1100H to 11FAH	250 Disturbance data words
1200H to 12FAH	250 Disturbance data words
1300H to 13FAH	250 Disturbance data words
1400H to 14FAH	250 Disturbance data words
1500H to 15FAH	250 Disturbance data words
1600H to 16FAFH	250 Disturbance data words
1700H to 17AFH	250 Disturbance data words
1800H to 18AFH	250 Disturbance data words
1900H to 19AFH	250 Disturbance data words
1A00H to 1AAFH	250 Disturbance data words
1B00H to 1BAFH	250 Disturbance data words
1C00H to 1CAFH	250 Disturbance data words
1D00H to 1DAFH	250 Disturbance data words
1E00H to 1EAFH	250 Disturbance data words
1F00H to 1FAFH	250 Disturbance data words
2000H to 20FAH	250 Disturbance data words
2100H to 21FAH	250 Disturbance data words

Table 27 - Page 9h to 21h: Channel Data Mapping

3.7.3.2 Format of the Disturbance Record Channel Data

Channel Name	Format
IA	16 bit word equivalent to the ADC count (Ref. Note 1)
IB	16 bit word equivalent to the ADC count (Ref. Note 1)
IC	16 bit word equivalent to the ADC count (Ref. Note 1)
IE	16 bit word equivalent to the ADC count (Ref. Note 2)
Timing	Time between two samples in microseconds
Logic channel 1	16 bit word (see Table 30 for format)
Logic channel 2	16 bit word (see Table 30 for format)

Table 28 - Channel names and formats

3.7.3.3 Calculation Formulae

Line Phase Current Value =

$$\frac{\text{Phase Sampled Value (word 11, 12, 13 or 14) *Phase Primary CT Ratio (0120h)}}{\text{Phase Internal CT Ratio (0007h)}}$$

Line Earth Current Value =

$$\frac{\text{Earth Sampled Value (word 10 or 15) *Earth Primary CT Ratio (0122h)}}{\text{Earth Internal CT Ratio (0008h)}}$$

The earth internal CT ratio is dependent on the earth current range as shown in the table below:

Sensitivity range	0.1 to 40 Ien	0.01 to 8 Ien	0.002 to 1 Ien
Internal CT Value	800	3277	32700

Table 29 - Sensitivity range and Internal CT Values

Format Of Logic Channel 1	
Logic Channel	**Content**
Bit 0	Trip Relay (RL1)
Bit 1	Output Relay 2 (RL2)
Bit 2	Output Relay 3 (RL3)
Bit 3	Output Relay 4 (RL4)
Bit 4	Watch Dog Relay 0 (RL0)
Bit 5	Output Relay 5 (RL5)
Bit 6	Output Relay 6 (RL6)
Bit 7	Output Relay 7 (RL7)
Bit 8	Output Relay 8 (RL8)
Bit 9	Reserved
Bit 10	Logic Input 1 (EL1)
Bit 11	Logic Input 2 (EL2)
Bit 12	Logic Input 3 (EL3)
Bit 13	Logic Input 4 (EL4)
Bit 14	Logic Input 5 (EL5)
Bit 15	Reserved

Format Of Logic Channel 2	
Logic Channel	**Content**
Bit 0	Cdiff Trip
Bit 1	Cdiff IA
Bit 2	Cdiff IB
Bit 3	Cdiff IC
Bit 4	Cdiff Comms Fail
Bit 5	Cdiff Protection Fail
Bit 6	Direct I-Trip
Bit 7	Permissive I-Trip
Bit 8	Cdiff I-Trip
Bit 9	CDiff HighSet Element
Bit 10	CDiff Start
Bit 11	Reserved
Bit 12	Reserved
Bit 13	Reserved
Bit 14	Reserved
Bit 15	Reserved

Table 30 - Format Of Logic Channel 1 and Channel 2

3.7.4 Disturbance Recorder Index Frame

3.7.4.1 Page 22h: Index Frame Mapping

Reading 7 words from address 2200h using MODBUS function 3 obtains the final information of the disturbance record and acknowledges the record.

3.7.4.2 Index Frame Format

Word Number	Contents
1	Disturbance record number
2 & 3	Disturbance record finish time (seconds)

Word Number	Contents
4 & 5	Disturbance record finish time (milliseconds)
6	Disturbance record triggering condition 1: Tripping 2: Instantaneous condition 3 : Remote condition 4: Logic input condition
7	Start of post time record time stamp

Table 31 - Index frame formats

3.8 Commonly Required Functionality

3.8.1 CB Trip and Close

Remote Control Word 1 : 0400h Write Only	Function
Bit 3	Initiate remote trip
Bit 4	Initiate remote close

Table 32 - CB Trip and Close

As shown in the overview table in section 3.1, page 4 is write only and can be written to using MODBUS function 5, 6 or 15.

3.8.2 Bit Address

Using MODBUS function 5 to initiate a remote trip, the address of the bit to be written to is made up of the register address then the bit number. That is, in order to access bit 3 at register address 400h the address is 4003h.

3.8.3 Bit Value

The bit value in the message must be FFFF or 0000, which corresponds to setting bit 1 or 0 in the MODBUS register. Any other value results in an exception error 3.

Relay Address	MODBUS Function	Bit Address	Bit Value	CRC
1-255	5	4003	FFFF	

Table 33 - Bit values

3.8.4 Change Setting Group

Remote Control Word 1 : 0400h Write Only	Function
Bit 5	Change setting group

Table 34 - Change Setting Group

As for the previous example, function 5 can be used to write to bit 5 of the control word and change the setting group.

Note	*The setting group can only be remotely changed if the 'change group input' setting is set to edge.*

3.8.4.1 Change Setting Group Request

Relay Address	MODBUS Function	Register Address	Command Data	CRC
1-255	5	4005	FFFF	

Table 35 - Change Setting Group Request

4 IEC 60870-5-103 PROTOCOL

The IEC 60870-5-103 protocol operates a master/slave interface with the relay as the slave. This protocol is based on the VDEW communications protocol and conforms to the IEC 60870-5-103 standard.

A detailed implementation of the protocol is provided in Section 4.3, but an Interoperability statement can be found in Appendix 1.

4.1 Technical Characteristics of the IEC 60870-5-103 Connection

The connection parameters are:

- Isolated two-point EIA(RS)485 connection (2 kV, 50 Hz)
- Communications baud rates of 9600 or 19200, configurable via the local interfaces
- Communication Parameters of Even Parity, 8 Data Bits and 1 Stop Bit
- Address Range of 1 to 255 (255 as the Broadcast Address), configurable via the local interfaces.

4.2 IEC 60870-5-103 Compatible Application Functions

The following application functions are supported by this interface:

- Initialization (reset)
- Time Synchronization
- Event Record Extraction
- General Interrogation
- Cyclic Measurements
- General Commands
- Disturbance Record Extraction
- Setting Cell Extraction and Writing

4.3 Application Functions

4.3.1 Initialization (Reset)

Whenever the relay has been powered up, or if the communications parameters have been changed, a Reset Command is required to initialize the communications. The following two reset commands are supported:

- Reset CU
- Reset FCB

The difference between the two commands is that the Reset CU will clear any unsent messages in the relays transmit buffer and Reset FCB will reset the frame control bit in the connection layer protocol.

The relay will respond to the reset command with the ASDU 5 identification message. The Cause of Transmission value in the message shall be dependent upon the nature of the reset command. The following information will be contained in the data section of this ASDU:

Manufacturers Name and Product Type: MiCOM P

The software identification section of the ASDU 5 message will contain the first four characters of the relay model number to identify the type of relay, and the current software version. The breakdown of the information contained in the data and identification sections can be shown as:

“MiCOM P” + 16bit Model + 8bit Major Version + 1 character Minor Version

e.g. “MiCOM P” + 521 + 3 + ‘A’

In addition to the above identification message, if the relay has been powered up, a power up event will be generated.

4.3.2 Time Synchronization

Using the time synchronization feature of the IEC 60870-5-103 protocol allows the relay time and date to be modified. The relay will correct for the transmission delay as specified in the IEC 60870-5-103 standard.

If the time synchronization message is sent as a send/confirm message then the relay will respond with a confirm. If a time synchronization message is sent as either a send/confirm or a send/no reply (broadcast message), a time synchronization message will be returned as Class 1 data.

4.3.3 Event Record Extraction

The events generated by the relay can be transmitted to the IEC 60870-5-103 master station using either standard information numbers or private information numbers. All standard information numbers are transmitted using the standard function types; all private information numbers are transmitted using private function types.

Therefore the events are categorized using the following information:

- Function Type
- Information Number

Section 5 contains a complete listing of all events produced by the relay.

4.3.4 General Interrogation

The General Interrogation request can be used to read the current status of the relay. The status information that will be returned during a General Interrogation cycle is shown in Section 5.

4.3.5 Cyclic Measurements

The relay will produce measured values using ASDU 9 only on a cyclical basis. This can be read from the relay using a Class 2 poll.

It should be noted that the measurements are transmitted as a proportion of 2.4 times the rated value of the analogue inputs.

4.3.6 General Commands

A list of the supported commands is shown in Section 5. The relay will respond to unsupported commands with an ASDU 1 message with a Cause Of Transmission (COT) of negative acknowledgement. Note that a negative acknowledgement will also be returned if the password is entered on the front panel interface, to prevent multiple access to the relay controls. The timeout for this condition is 5 minutes.

4.3.7 Disturbance Record Extraction

The disturbance records stored by the relay can be extracted using the mechanism defined in the IEC 60870-5-103 standard. The relay also maintains compatibility with the VDEW control system by transmitting an ASDU 23 with the oldest disturbance record list at the start of every General Interrogation cycle.

4.3.7.1 Extracting Disturbance Records via the MODBUS Front Port

To provide IEC 60870-5-103 rear port compatibility for disturbance records extracted via the MODBUS front port, the following tables should be referred to, for determining the correct descriptions of the values contained in the binary channels of a disturbance record extracted via the MODBUS front port of a P521 model with IEC 60870-5-103 rear port. This does not apply for a P521 model with MODBUS rear port.

Binary Channel 1 Mapping:			**Binary Channel 2 Mapping**		
Bit Number	**IEC 60870-5-103 Reference**	**Description**	**Bit number**	**IEC 60870-5-103 reference**	**Description**
0	INF No: 84	General Start	0	INF No: 95	I>>>> Trip
1	INF No: 67	Any IN Start	1	INF No: 92	IN> Trip
2	INF No: 68	General Trip	2	INF No: 93	IN>> Trip
3	INF No: 85	Breaker Failure	3	INF No: 96	IN>>> Trip
4	INF No: 122	Differential Trip	4	INF No: 97	IN>>>> Trip
5	INF No: 69	Differential Trip L1	5	INF No: 161	Logic Input 1
6	INF No: 70	Differential Trip L2	6	INF No: 162	Logic Input 2
7	INF No: 71	Differential Trip L3	7	INF No: 163	Logic Input 3
8	INF No: 191	Idiff Comms Failure	8	INF No: 164	Logic Input 4
9	INF No: 192	Idiff Protection Failure	9	INF No: 165	Logic Input 5
10	INF No: 120	Direct Intertrip	10	Reserved	Reserved
11	INF No: 121	Permissive Intertrip Trip	11	Reserved	Reserved
12	INF No: 123	Idiff Intertrip	12	Reserved	Reserved
13	INF No: 90	I> Trip	13	Reserved	Reserved
14	INF No: 91	I>> Trip	14	Reserved	Reserved
15	INF No: 94	I>>> Trip	15	Reserved	Reserved

Table 36 - Binary Channel 1 and 2 Mapping

4.3.8 Reading and Writing Settings

Table 37 gives information about reading and writing settings.

Type identification	17 (Analog protection parameter)
Variable Struct. Qualifier	81H
Cause of Transmission	18H, 45H, 46H, (7FH)
Device Address	Common address of ASDU
Function byte (FUN)	Parameter y-Value
Information Number (INF)	Parameter x-Value
Value low-byte	MW (low)
Value high-byte	MW (high)
TT (time tag)	ms low
	ms high
	IV 0 m m m m m m
	SU 0 h h h h h

Table 37 - Information about reading and writing settings

Additional information about reading and writing these settings is shown below:

Private ASDUs Information in Control Direction in EIC103 Setting

Type identification	140 (Analog protection parameter)
Variable Struct. Qualifier	81H
Cause of Transmission	14H
Device Address	Common address of ASDU
Function byte (FUN)	Parameter y-Value
Information Number (INF)	Parameter x-Value

Type identification	144 (Write analog protection param.)
Variable Struct. Qualifier	81H
Cause of Transmission	14H
Device Address	Common address of ASDU
Function byte (FUN)	Parameter y-Value
Information Number (INF)	Parameter x-Value
Value low-byte	MW (low)
Value high-byte	MW (high)

Type identification	201 (Write analog protection param.)
Variable Struct. Qualifier	81H
Cause of Transmission	14H
Device Address	Common address of ASDU
Function byte (FUN)	Parameter y-Value
Information Number (INF)	Parameter x-Value
Byte 1	Low word (low)
Byte 2	Low word (high)
Byte 3	High word (low)
Byte 4	High word (high)

Type identification	232 (Write binary protection param.)
Variable Struct. Qualifier	81H
Cause of Transmission	14H
Device Address	Common address of ASDU
Function byte (FUN)	Parameter y-Value
Information Number (INF)	Parameter x-Value
Value low-byte	BS (low)
Value high-byte	BS (high)

Private ASDUs Information in Control Direction in EIC103 Setting

Type identification	17 (Analog protection parameter)
Variable Struct. Qualifier	81H
Cause of Transmission	18H, 45H, 46H, (7FH)
Device Address	Common address of ASDU
Function byte (FUN)	Parameter y-Value
Information Number (INF)	Parameter x-Value
Value low-byte	MW (low)
Value high-byte	MW (high)
TT (time tag)	ms low
	ms high
	IV 0 m m m m m m
	SU 0 h h h h h

Type identification	169 (Analog protection parameter)
Variable Struct. Qualifier	81H
Cause of Transmission	0BH, 0CH, 14H, 15H

Table 38 - Additional information about reading and writing settings

4.3.9 Blocking of Monitor Direction

The relay does not support the facility to Block Messages in the Monitor direction.

4.3.10 Test Mode

The relay does not support the Test Mode function.

5 IEC 60870-5-103 DETAILED IMPLEMENTATION

5.1 Compatible Range Information Numbers in Monitor Direction

ASDU TYPE	COT	FUN	INF NO.	Description	GI	Interpretation
System Functions						
8	10	255	0	End of General Interrogation		
6	8	255	0	Time Synchronization		
5	3	192	2	Reset FCB		
5	4	192	3	Reset CU		
5	5	192	4	Start/Restart		
5	6	192	5	Power On		
Status Indication						
1	12,20,21	192	19	LED Reset		Indications and Latches Reset
1	9,12	192	22	Local Parameter Setting	*	Password Entered Locally
1	9,12,20,21	192	23	Characteristic 1	*	Setting Group 1 Changed
1	9,12,20,21	192	24	Characteristic 2	*	Setting Group 2 Changed
1	9,12,20,21	192	25	Characteristic 3	*	Setting Group 3 Changed
1	9,12,20,21	192	26	Characteristic 4	*	Setting Group 4 Changed
1	1,9	192	27	Auxiliary Input 1	*	Auxiliary 1 Timer Expiry
1	1,9	192	28	Auxiliary Input 2	*	Auxiliary 2 Timer Expiry
Supervision Indications						
1	1,9	192	36	Trip Circuit Supervision	*	Trip Circuit Supervision Trip
Fault Indications						
2	1,9	192	64	Start /Pickup L1	*	Differential Start L1
2	1,9	192	65	Start /Pickup L2	*	Differential Start L2
2	1,9	192	66	Start /Pickup L3	*	Differential Start L3
2	1,9	192	67	Start /Pickup N	*	Any IN Start
2	1	192	68	General Trip		Any Trip
2	1	192	69	Trip L1		Differential Trip L1
2	1	192	70	Trip L2		Differential Trip L2
2	1	192	71	Trip L3		Differential Trip L3
2	1,9	192	84	General Start	*	Any Start
1	1	192	85	Breaker Failure		Breaker Failure (tBF)
2	1	192	90	Trip I>		I> Overcurrent Trip
2	1	192	91	Trip I>>		I>> Overcurrent Trip
2	1	192	92	Trip IN>		IN> Overcurrent Trip
2	1	192	93	Trip IN>>		IN>> Overcurrent Trip
2	1,9	192	94	Equation A		
2	1,9	192	95	Equation B		
2	1,9	192	96	Equation C		
2	1,9	192	97	Equation D		
2	1,9	192	98	Equation E		
2	1,9	192	99	Equation F		

ASDU TYPE	COT	FUN	INF NO.	Description	GI	Interpretation
2	1,9	192	100	Equation G		
2	1,9	192	101	Equation H		
2	1	192	102	Inter-Trip 1		
2	1	192	103	Inter-Trip 2		
2	1	192	104	Inter-Trip 3		
2	1	192	105	Inter-Trip 4		
1	1,9	192	106	Local Inrush Block		
1	1,9	192	107	Local Phase A Block		
1	1,9	192	108	Local Phase B Block		
1	1,9	192	109	Local Phase C Block		
1	1,9	192	110	Remote Inrush Block		
1	1,9	192	111	Remotel Phase A Block		
1	1,9	192	112	Remotel Phase B Block		
1	1,9	192	113	Remotel Phase C Block		
1	1,9	192	114	Inrush Block Configure Error		
1	1,9	192	115	CTS Cdiff Block		
1	1,9	192	116	Local CTS Fail		
1	1,9	192	117	Remote CTS Fail		
1	1,9	192	118	CTS Block		
1	1,9	192	119	CTS Cdiff Restrain		
1	1,9	192	120	CTS Inhibited		
1	1,9	192	121	CTS Conf Fail		
1	1,9	192	122	Convention Mode		
1	1,9	192	123	Time Synchronization		
1	1	192	124	reset led		
1	1	192	125	cortec mismatch		
1	1	192	126	Conf Conflict Comms		
Measurands						
9	2	192	148	Measurands IL1,2,3,VL1,2,3,P,Q,f		Measurement = 2.4 x Rated Value

Table 39 - Compatible Range Information Numbers in Monitor Direction

5.2 Compatible Range Information Numbers in Control Direction

ASDU TYPE	COT	FUN	INF NO.	Description	GI	Interpretation
System Functions						
7	9	255	0	Init. General Interrogation		
6	8	255	0	Time Synchronization		
General Commands						
20	20	192	19	LED Reset		Reset Indications and Latches
20	20	192	23	Characteristic 1 (must be in Edge Mode)		Activate Setting Group 1
20	20	192	24	Characteristic 2 (must be in Edge Mode)		Activate Setting Group 2
20	20	192	25	Characteristic 3 (must be in Edge Mode)		Activate Setting Group 3
20	20	192	26	Characteristic 4 (must be in Edge Mode)		Activate Setting Group 4

Table 40 - Compatible Range Information Numbers in Control Direction

5.3 Private Range Information Numbers in Monitor Direction

ASDU TYPE	COT	FUN	INF NO.	Description	GI	Interpretation
Fault Indications						
2	1	194	94	Trip I>>>		I>>> Overcurrent Trip
2	1	194	95	Trip I>>>>		I>>>> Overcurrent Trip
2	1	194	96	Trip IN>>>		IN>>> Overcurrent Trip
2	1	194	97	Trip IN>>>>		IN>>>> Overcurrent Trip
2	1,9	194	98	Start I>	*	I> Overcurrent Start
2	1,9	194	99	Start I>>	*	I>> Overcurrent Start
2	1,9	194	100	Start I>>>	*	I>>> Overcurrent Start
2	1,9	194	101	Start I>>>>	*	I>>>> Overcurrent Start
2	1,9	194	102	Start IN>	*	IN> Overcurrent Start
2	1,9	194	103	Start IN>>	*	IN>> Overcurrent Start
2	1,9	194	104	Start IN>>>	*	IN>>> Overcurrent Start
2	1,9	194	105	Start IN>>>>	*	IN>>>> Overcurrent Start
2	1,9	194	106	Start I<	*	I< Undercurrent Start
2	1	194	107	Trip I<		I< Undercurrent Trip
2	1,9	194	108	Start I2>	*	I2> Negative Sequence Start
2	1	194	109	Trip I2>		I2> Negative Sequence Trip
2	1,9	194	110	Start I2>>	*	I2>> Negative Sequence Start
2	1	194	111	Trip I2>>		I2>> Negative Sequence Trip
2	1,9	194	112	Alarm Thermal	*	Thermal Overload Alarm
2	1	194	113	Trip Thermal		Thermal Overload Trip
2	1	194	114	Broken Conductor		Broken Conductor Trip
1	1	194	120	CH1 Direct Intertrip		Direct Intertrip Received on CH1
2	1	194	121	CH1 Permissive Intertrip Trip		Permissive Intertrip Trip from CH1
2	1	194	122	Current Differential Trip		Current Diff Trip
1	1	194	123	CH1 IDiff Intertrip		Current Diff Intertrip RX on CH1

ASDU TYPE	COT	FUN	INF NO.	Description	GI	Interpretation
2	1,9	194	124	CH1 Permissive Intertrip Start	*	Permissive Intertrip Start from CH1
Relay Indications						
1	1,9	194	140	CB Closed	*	CB Change of State - Closed State
1	1,9	194	141	CB Open	*	CB Change of State - Open State
1	12,20,21	194	142	Remote CB Trip		Remote CB Trip Acknowledged
1	12,20,21	194	143	Remote CB Close		Remote CB Close Acknowledged
Logical Statuses						
1	1,9	194	161	Logic Input 1	*	Change of Logic Input 1 State
1	1,9	194	162	Logic Input 2	*	Change of Logic Input 2 State
1	1,9	194	163	Logic Input 3	*	Change of Logic Input 3 State
1	1,9	194	164	Logic Input 4	*	Change of Logic Input 4 State
1	1,9	194	165	Logic Input 5	*	Change of Logic Input 5 State
1	1,9	194	176	Relay Contact 0	*	Change of Trip Relay State
1	1,9	194	177	Relay Contact 1	*	Change of Relay Output 1 State
1	1,9	194	178	Relay Contact 2	*	Change of Relay Output 2 State
1	1,9	194	179	Relay Contact 3	*	Change of Relay Output 3 State
1	1,9	194	180	Relay Contact 4	*	Change of Watchdog Relay State
1	1,9	194	181	Relay Contact 5	*	Change of Relay Output 5 State
1	1,9	194	182	Relay Contact 6	*	Change of Relay Output 6 State
1	1,9	194	183	Relay Contact 7	*	Change of Relay Output 7 State
1	1,9	194	184	Relay Contact 8	*	Change of Relay Output 8 State
Alarm Indications						
1	1,9	194	190	IDiff CH1 Comms Alarm	*	CH1 Protection Comms Alarm
1	1,9	194	191	IDiff Comms Failure	*	Total Protection Comms Failure
1	1,9	194	192	IDiff Protection Failure	*	Current Diff Protection Failure
1	1,9	194	193	Backup Protection Active	*	Overcurrent Backup Protection Active
1	1,9	194	195	Output Contacts Disabled	*	Commissioning Mode
1	1,9	194	196	Loopback Mode Selected	*	Commissioning Mode
1	1,9	194	197	IDiff Protection Disabled	*	Current Diff Protection Disabled
1	1,9	194	198	CB Status DBI	*	CB Fail

Table 41 - Private Range Information Numbers in Monitor Direction

5.4 Private Range Information Numbers in Control Direction

ASDU TYPE	COT	FUN	INF NO.	Description	GI	Interpretation
General Commands						
20	20	194	142	Remote CB Trip		Perform a Remote CB Trip
20	20	194	143	Remote CB Close		Perform a Remote CB Close

Table 42 - Private Range Information Numbers in Control Direction

6 DNP3.0 INTRODUCTION

6.1 Purpose of this Document

The purpose of this document is to describe the specific implementation of the Distributed Network Protocol (DNP) 3.0 within P521 MiCOM relay.

P521 uses the Triangle MicroWorks, Inc. DNP 3.0 Slave Source Code Library Version 2.18.

This document, in conjunction with the DNP 3.0 Basic 4 Document Set, and the DNP Subset Definitions Document, provides complete information on how to communicate with P521 via the DNP 3.0 protocol.

This implementation of DNP 3.0 is fully compliant with DNP 3.0 Subset Definition Level 2, contains many Subset Level 3 features, and contains some functionality even beyond Subset Level 3.

6.2 DNP V3.00 Device Profile

Table 43 provides a “Device Profile Document” in the standard format defined in the DNP 3.0 Subset Definitions Document. While it is referred to in the DNP 3.0 Subset Definitions as a “Document,” it is only a component of a total interoperability guide. This table, in combination with the following should provide a complete interoperability/configuration guide for P521:

- The Implementation Table provided in Section 6.3 - Implementation Table (beginning on page 93).
- The Point List Tables provided in Section 6.4 - Point List (beginning on page 96).
- And a description of configuration methods and user-interface.

DNP 3.0 Device Profile Document (Also see section 6.3 - Implementation Table - beginning on page 93).				
Vendor Name:	**Schneider Electric**			
Device Name:	**SERIAL 20 Platform using the Triangle MicroWorks, Inc. DNP 3.0 Slave Source Code Library, Version 2.18.**			
Highest DNP Level Supported: For Requests: **Level 2** For Responses: **Level 2**	Device Function: ☐ Master ✓ **Slave**			
Notable objects, functions, and/or qualifiers supported in addition to the highest DNP levels supported (the complete list is described in the DNP 3.0 Implementation Table): **For static (non-change event) object requests, request qualifier codes 00 and 01 (start-stop), 07 and 08 (limited quantity), and 17 and 28 (index) are supported in addition to the request qualifier code 06 (no range (all points). Static object requests sent with qualifiers 00, 01, 06, 07, or 08 will be responded with qualifiers 00 or 01. Static object requests sent with qualifiers 17 or 28 will be responded with qualifiers 17 or 28.** **For change-event object requests, qualifiers 17 or 28 are always responded 16-bit and 32-bit analog change events with time may be requested. The read function code for Object 50 (time and date) variation 1 is supported**				
Maximum Data Link Frame Size (octets): Transmitted: **292** Received: **292**	Maximum Application Fragment Size (octets) Transmitted: **2048** Received: **2048**			
Maximum Data Link Retries: ☐ None ✓ **Fixed at 2** ✓ Configurable	Maximum Application Layer Retries: ✓ **None** ☐ Configurable			
Requires Data Link Layer Confirmation: ✓ **Never** ☐ Always ☐ Sometimes ☐ Configurable				
Requires Application Layer Confirmation: ☐ Never ☐ Always ✓ **When reporting event data** ✓ **When sending multi-fragment responses** ☐ Sometimes ☐ Configurable				
Timeouts while waiting for:				
Data Link Confirm:	☐ None	✓ **Fixed at 100ms**	☐ Variable	☐ Configurable
Complete Appl. Fragment:	✓ **None**	☐ Fixed at ___	☐ Variable	☐ Configurable
Application Confirm:	☐ None	✓ **Fixed at 1s** ___	☐ Variable	☐ Configurable
Complete Appl. Response:	✓ **None**	☐ Fixed at ___	☐ Variable	☐ Configurable
Others:				
Binary input change scanning period: 5ms Analogue input change scanning period: 1s				
Sends/Executes Control Operations:				
Write Binary Outputs:	✓ **Never**	☐ Always	☐ Sometimes	☐ Configurable
Select/Operate:	☐ Never	✓ **Always**	☐ Sometimes	☐ Configurable
Direct Operate:	☐ Never	✓ **Always**	☐ Sometimes	☐ Configurable
Direct Operate – No Ack:	☐ Never	✓ **Always**	☐ Sometimes	☐ Configurable

DNP 3.0

Device Profile Document
(Also see section 6.3 - Implementation Table - beginning on page 93).

Count > 1	✓	**Never**	☐	Always	☐	Sometimes	☐	Configurable
Pulse On/NUL/Trip/Close	☐	Never	✓	**Always**	☐	Sometimes	☐	Configurable
Pulse Off/NUL/Trip/Close	✓	**Never**	☐	Always	☐	Sometimes	☐	Configurable
Latch On/NUL	✓	**Never**	☐	Always	☐	Sometimes	☐	Configurable
Latch Off/NUL	☐	**Never**	☐	Always	☐	Sometimes	☐	Configurable
Queue	✓	**Never**	☐	Always	☐	Sometimes	☐	Configurable
Clear Queue	✓	**Never**	☐	Always	☐	Sometimes	☐	Configurable

Reports Binary Input Change Events when no specific variation requested: ☐ Never ✓ **Only time-tagged** ✓ **Only non-time-tagged** ☐ Configurable	Reports time-tagged Binary Input Change Events when no specific variation requested: ✓ **Never** ✓ **Binary input change with time** ☐ Binary input change with relative time ☐ Configurable
Sends Unsolicited Responses: ✓ **Never** ☐ Configurable ☐ Certain objects only ☐ Sometimes ☐ Enable/Disable unsolicited functions ☐ codes supported	Sends Static Data in Unsolicited Responses: ✓ **Never** ☐ When device restarts ☐ When status flags changes No other options are permitted
Default Counter Object/Variation: ☐ No counters reported ☐ Configurable ✓ **Default object: 20** ✓ **Default variation: 5** ☐ **Point-by-point list attached**	Counters Roll Over at: ☐ No counters reported ☐ Configurable ✓ **16 bits** ✓ **32 bits** ☐ Other value: _____ ✓ **Point-by-point list attached**
Sends multi-fragment responses: ✓ **Yes** ▫ No	

Table 43 - Device Profile Document

6.3 Implementation Table

The following table identifies the variations, function codes, and qualifiers supported by the P521 in both request and response messages.

In the table below the text shaded as: indicates Subset Level 3 functionality

Subset Level 3

(beyond Subset Level 2), and text shaded as: indicates functionality beyond Subset Level 3.

Subset Level 3

Object			Request				Response			
Object Number	Variation Number	Description	Function Codes (Dec)		Qualifier Codes (Hex)		Function Codes (Dec)		Qualifier Codes (Hex)	
1	0	Binary Input (Variation 0 is used to request default variation)	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)				
1	1 (default - see Note 1)	Binary Input	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
1	2	Binary Input with status	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
2	0	Binary Input Change (Variation 0 is used to request default variation)	1	(read)	06 07, 08	(no range, or all) (limited qty)				
2	1	Binary Input Change without Time	1	(read)	06 07, 08	(no range, or all) (limited qty)	129	response	17, 28	(index)
2	2 (default - see Note 1)	Binary Input Change with Time	1	(read)	06 07, 08	(no range, or all) (limited qty)	129	response	17, 28	(index)
10	0	Binary Output Status (Variation 0 is used to request default variation)	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)				
10	2 (default - see Note 1)	Binary Output Status	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
12	1	Control Relay Output Block	3 4 5 6	(select) (operate) (direct op) (dir. op, no ack)	00, 01 06 07, 08 17, 28	(start-stop) (limited qty) (index)	129	response	echo of request	
20	0	Binary Counter (Variation 0 is used to request default variation)	1 7 8 9 10	(read) (freeze) (freeze no ack) (freeze clear) (frz. cl. no ack)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)				
20	1	32-Bit Binary Counter with Flag	1 7 8 9 10	(read) (freeze) (freeze no ack) (freeze clear) (frz. cl. no ack)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
20	2	16-Bit Binary Counter with Flag	1 7 8 9 10	(read) (freeze) (freeze no ack) (freeze clear) (frz. cl. no ack)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
20	5 (default - see Note 1)	32-Bit Binary Counter without Flag	1 7 8 9 10	(read) (freeze) (freeze no ack) (freeze clear) (frz. cl. no ack)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
20	6	16-Bit Binary Counter without Flag	1 7 8 9 10	(read) (freeze) (freeze no ack) (freeze clear) (frz. cl. no ack)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
21	0	Frozen Counter (Variation 0 is used to request default variation)	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)				

Object			Request				Response			
Object Number	Variation Number	Description	Function Codes (Dec)		Qualifier Codes (Hex)		Function Codes (Dec)		Qualifier Codes (Hex)	
21	1	32-Bit Frozen Counter with Flag	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
21	2	16-Bit Frozen Counter with Flag	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
21	9 (default - see Note 1)	32-Bit Frozen Counter without Flag	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
21	10	16-Bit Frozen Counter without Flag	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
30	0	Analog Input (Variation 0 is used to request default variation)	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)				
30	1 (default - see Note 1)	32-Bit Analog Input	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
30	2 (default - see Note 1)	16-Bit Analog Input	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
30	3	32-Bit Analog Input without Flag	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
30	4	16-Bit Analog Input without Flag	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
32	0	Analog Change Event (Variation 0 is used to request default variation)	1	(read)	06 07, 08	(no range, or all) (limited qty)				
32	1	32-Bit Analog Change Event without Time	1	(read)	06 07, 08	(no range, or all) (limited qty)	129	response	17, 28	(index)
32	2 (default - see Note 1)	16-Bit Analog Change Event without Time	1	(read)	06 07, 08	(no range, or all) (limited qty)	129	response	17, 28	(index)
32	3	32-Bit Analog Change Event with Time	1	(read)	06 07, 08	(no range, or all) (limited qty)	129	response	17, 28	(index)
32	4	16-Bit Analog Change Event with Time	1	(read)	06 07, 08	(no range, or all) (limited qty)	129	response	17, 28	(index)
50	0	Time and Date	1	(read)	00, 01 06 07, 08 17, 28	(start-stop) (no range, or all) limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
50	1 (default - see Note 1)	Time and Date	1 2	(read) (write)	00, 01 06 07 08 17, 28	(start-stop) (no range, or all) (limited qty = 1) (limited qty) (index)	129	response	00, 01 17, 28	(start-stop) (index - see Note 2)
52	2	Time Delay Fine					129	response	07	(limited qty) (qty = 1)
60	0	Class 0, 1, 2, and 3 Data	1	(read)	06	(no range, or all)				
60	1	Class 0 Data	1	(read)	06	(no range, or all)	129	response	17, 28	(index)
60	2	Class 1 Data	1	(read)	06 07, 08	(no range, or all) (limited qty)	129	response	17, 28	(index)
60	3	Class 2 Data	1	(read)	06 07, 08	(no range, or all) (limited qty)	129	response	17, 28	(index)
60	4	Class 3 Data	1	(read)	06 07, 08	(no range, or all) (limited qty)	129	response	17, 28	(index)
80	1	Internal Indications	2	(write)	00	(start–stop) (index must = 7)				
		No Object (function code only)	13	(cold restart)						
		No Object (function code only)	14	(warm restart)						

Object			Request				Response			
Object Number	Variation Number	Description	Function Codes (Dec)		Qualifier Codes (Hex)		Function Codes (Dec)		Qualifier Codes (Hex)	
		No Object (function code only)	23	(delay meas.)						

Note 1 *A Default variation refers to the variation responded when variation 0 is requested and/or in class 0, 1, 2, or 3 scans.*

Note 2 *For static (non-change-event) objects, qualifiers 17 or 28 are only responded when a request is sent with qualifiers 17 or 28, respectively. Otherwise, static object requests sent with qualifiers 00, 01, 06, 07, or 08, will be responded with qualifiers 00 or 01. (For change-event objects, qualifiers 17 or 28 are always responded.)*

Note 3 *For P521, a cold restart is implemented as a warm restart – the executable is not restarted, but the DNP process is restarted.*

Table 44 - Implementation Table

6.4 Point List

The tables in the following sections identify all the individual data points provided by this implementation of DNP 3.0.

6.4.1 Binary Input Points

Every Binary Input Status points are included in class 0 polls, because they are included in one of classes 1, 2 or 3.

Binary Input Points

Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **1 (Binary input without status)**
Change Event Variation reported when variation 0 requested: **2 (Binary input change with time)**

P521 Point Index	Name/Description	Latched Alarm (See Note 1)	Initial Value	Change Event Class (1, 2, 3, or none)
	Inputs and Outputs			
0	Output Relay 1 (Trip)		0	1
1	Output Relay 2		0	2
2	Output Relay 3		0	2
3	Output Relay 4		0	2
4	Output Relay 0 (Watchdog)		0	2
5	Output Relay 5		0	2
6	Output Relay 6		0	2
7	Output Relay 7		0	2
8	Output Relay 8		0	2
9	Logic Input 1		0	2
10	Logic Input 2		0	2
11	Logic Input 3		0	2
12	Logic Input 4		0	2
13	Logic Input 5		0	2
	Protection			
14	Current Differential Start		0	1
15	Current Differential Trip		0	1
16	Current Differential Intertrip Received		0	1
17	Permissive Intertrip Start		0	1
18	Permissive Intertrip Trip		0	1
19	Direct Intertrip Received		0	1
20	Phase Overcurrent 1st Stage Start (I>)		0	1
21	Phase Overcurrent 1st Stage Trip (tI>)		0	1
22	Phase Overcurrent 2nd Stage Start (I>>)		0	1
23	Phase Overcurrent 2nd Stage Trip (tI>>)		0	1
24	Phase Overcurrent 3rd Stage Start (I>>>)		0	1
25	Phase Overcurrent 3rd Stage Trip (tI>>>)		0	1
26	Phase Overcurrent 4th Stage Start (I>>>>)		0	1
27	Phase Overcurrent 4th Stage Trip (tI>>>>)		0	1
28	Earth Overcurrent 1st Stage Start (Ie>)		0	1

Binary Input Points

Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **1 (Binary input without status)**
Change Event Variation reported when variation 0 requested: **2 (Binary input change with time)**

P521 Point Index	Name/Description	Latched Alarm (See Note 1)	Initial Value	Change Event Class (1, 2, 3, or none)
29	Earth Overcurrent 1st Stage Trip (tIe>)		0	1
30	Earth Overcurrent 2nd Stage Start (Ie>>)		0	1
31	Earth Overcurrent 2nd Stage Trip (tIe>>)		0	1
32	Earth Overcurrent 3rd Stage Start (Ie>>>)		0	1
33	Earth Overcurrent 3rd Stage Trip (tIe>>>)		0	1
34	Earth Overcurrent 4th Stage Start (Ie>>>>)		0	1
35	Earth Overcurrent 4th Stage Trip (tIe>>>>)		0	1
36	Undercurrent Start (I<)		0	1
37	Undercurrent Trip (tI<)		0	1
38	Negative Sequence 1st Stage Start (I2>)		0	1
39	Negative Sequence 1st Stage Trip (tI2>)		0	1
40	Negative Sequence 2nd Stage Start (I2>>)		0	1
41	Negative Sequence 2nd Stage Trip (tI2>>)		0	1
42	Thermal Start		0	1
43	Thermal Trip		0	1
44	Broken Conductor		0	1
	Non-Protection Functions			
45	Auxiliary Timer 1 (tAux1)		0	1
46	Auxiliary Timer 2 (tAux2)		0	1
47	Logic Select Timer Enabled (tSEL1)		0	1
48	Logic Select Timer Enabled (tSEL2)		0	1
49	Blocking Logic 1 Enabled		0	1
50	Blocking Logic 2 Enabled		0	1
51	Cold Load Pick-Up Enabled		0	1
52	Unlatch Contacts (inc. Trip Contact) Initiated via Logic Input		0	1
	Main Protection Monitoring			
54	Protection Communications CH1 Status		0	1
55	Protection Communications Status		0	1
56	Differential Protection Status		0	1
57	Differential Protection Disabled		0	1
58	Backup Protection Enabled		0	1
	Circuit Breaker Monitoring			
59	CB Failure		0	1
60	CB Open Time Threshold Exceeded		0	1
61	CB Close Time Threshold Exceeded		0	1
62	Number of CB Operations Threshold Exceeded		0	1
63	Summation Amps Threshold Exceeded (SA2n)		0	1
64	Trip Circuit Supervision		0	1

Binary Input Points

Static (Steady-State) Object Number: **1**
Change Event Object Number: **2**
Request Function Codes supported: **1 (read)**
Static Variation reported when variation 0 requested: **1 (Binary input without status)**
Change Event Variation reported when variation 0 requested: **2 (Binary input change with time)**

P521 Point Index	Name/Description	Latched Alarm (See Note 1)	Initial Value	Change Event Class (1, 2, 3, or none)
65	52a State		0	1
66	52b State		0	1
67	Reserved		0	1
68	CB Fail Timer State (tBF)		0	1
69	CB Status DBI		0	1
	Remote Commands			
70	Unlatch Contacts (inc. Trip Relay) Command		0	1
71	Remote CB Trip Command		0	1
72	Remote CB Close Command		0	1
73	CB Trip Delay Timer State		0	1
74	CB Close Delay Timer State		0	1
75	Thermal State Reset Command		0	1
	Hardware Status Monitoring			
77	Major Hardware Alarm Present		0	1
78	Minor Hardware Alarm Present		0	1
	Latched Alarms			
79	Current Differential Trip	*	0	3
80	Current Differential Intertrip Received	*	0	3
81	Permissive Intertrip Trip	*	0	3
82	Direct Intertrip Received	*	0	3
83	Phase Overcurrent 1st Stage Trip (tI>)	*	0	3
84	Phase Overcurrent 2nd Stage Trip (tI>>)	*	0	3
85	Phase Overcurrent 3rd Stage Trip (tI>>>)	*	0	3
86	Phase Overcurrent 4th Stage Trip (tI>>>>)	*	0	3
87	Earth Overcurrent 1st Stage Trip (tIe>)	*	0	3
88	Earth Overcurrent 2nd Stage Trip (tIe>>)	*	0	3
89	Earth Overcurrent 3rd Stage Trip (tIe>>>)	*	0	3
90	Earth Overcurrent 4th Stage Trip (tIe>>>>)	*	0	3
91	Undercurrent Trip (tI<)	*	0	3
92	Negative Sequence 1st Stage Trip (tI2>)	*	0	3
93	Negative Sequence 2nd Stage Trip (tI2>>)	*	0	3
94	Thermal Start	*	0	3
95	Thermal Trip	*	0	3
96	Auxiliary Timer 1 (tAux1)	*	0	3
97	Auxiliary Timer 2 (tAux2)	*	0	3
98	Broken Conductor	*	0	3
99	Protection Communications CH1 Status	*	0	3
100	Differential Protection Status	*	0	3
101	Differential Protection Disabled	*	0	3

Binary Input Points Static (Steady-State) Object Number: **1** Change Event Object Number: **2** Request Function Codes supported: **1 (read)** Static Variation reported when variation 0 requested: **1 (Binary input without status)** Change Event Variation reported when variation 0 requested: **2 (Binary input change with time)**				
P521 Point Index	**Name/Description**	**Latched Alarm (See Note 1)**	**Initial Value**	**Change Event Class (1, 2, 3, or none)**
102	CB Failure	*	0	3
103	CB Open Time Threshold Exceeded	*	0	3
104	CB Close Time Threshold Exceeded	*	0	3
105	Number of CB Operations Threshold Exceeded	*	0	3
106	Summation Amps Threshold Exceeded (SA2n)	*	0	3
107	Trip Circuit Supervision	*	0	3
108	CB Status DBI	*	0	3
109	Equation A		0	1
110	Equation B		0	1
111	Equation C		0	1
112	Equation D		0	1
113	Equation E		0	1
114	Equation F		0	1
115	Equation G		0	1
116	Equation H		0	1
117	Inter-Trip 1		0	1
118	Inter-Trip 2		0	1
119	Inter-Trip 3		0	1
120	Inter-Trip 4		0	1
121	Local Inrush Block		0	1
122	Local Phase A Block		0	1
123	Local Phase B Block		0	1
124	Local Phase C Block		0	1
125	Remote Inrush Block		0	1
126	Remote Phase A Block		0	1
127	Remote Phase B Block		0	1
128	Remote Phase C Block		0	1
129	Inrush Block Configure Error		0	1
130	Local CTS Fail		0	1
131	Remote CTS Fail		0	1
132	CTS Block		0	1
133	CTS Cdiff Block		0	1
134	CTS Cdiff Restrain		0	1
135	CTS Inhibited		0	1
136	CTS Conf Fail		0	1
137	Equation A Alarm		0	3
138	Equation B Alarm		0	3
139	Equation C Alarm		0	3
140	Equation D Alarm		0	3

Binary Input Points Static (Steady-State) Object Number: **1** Change Event Object Number: **2** Request Function Codes supported: **1 (read)** Static Variation reported when variation 0 requested: **1 (Binary input without status)** Change Event Variation reported when variation 0 requested: **2 (Binary input change with time)**				
P521 Point Index	**Name/Description**	**Latched Alarm (See Note 1)**	**Initial Value**	**Change Event Class (1, 2, 3, or none)**
141	Equation E Alarm		0	3
142	Equation F Alarm		0	3
143	Equation G Alarm		0	3
144	Equation H Alarm		0	3
145	Inrush Block Alarm		0	3
146	Local CTS Fail Alarm		0	3
147	Remote CTS Fail Alarm		0	3
148	CTS Block Alarm		0	3
149	CTS Cdiff Block Alarm		0	3
150	CTS Cdiff Restrain Alarm		0	3
151	CTS Inhibited Alarm		0	3
152	CTS Conf Fail Alarm		0	3
153	Led Reset		0	3
154	Convention Mode		0	3
155	Time Synchronization		0	3
156	Conf Conflict Comms		0	1

Note 1 *Points marked as Latched Alarms are latched on when the condition has occurred and not cleared until the alarms are acknowledged (cleared) via the Remote Communications or Front Panel Interface. Note that if the Alarm is an auto-clear type then the alarm will automatically be removed when the condition is cleared (Controlled via the Auto Alarm acknowledgement Setting in the Configuration Menu). Points not marked as Latched Alarms shall follow the state of the relevant condition (real-time value).*

Table 45 - Binary Input Points

6.4.2 Binary Output Status Points and Control Relay Output Block

The following table lists both the Binary Output Status Points (Object 10) and the Control Relay Output Block (Object 12). Binary Output Status Points are not included in class 0 polls.

Binary Output Status Points				
Object Number:	**10**			
Request Function Code supported:	**1 (read)**			
Default Variation reported when variation 0 requested:	**2 (Binary Output Status)**			
Control Relay Output Blocks (CROB)				
Object Number:	**12**			
Request Function Code supported:	**5 (direct operate), 6 (direct operate, Nack)**			
P521 Point Index	**Name/Description**	**Initial Value**	**Include in Class 0 Poll**	**Supported CROB Fields**
0	Reset All Latched Contacts (inc Trip Contact)	0	Yes	Pulse On/Trip/Close /Unpaired
1	Acknowledge First Alarm Only	0	Yes	Pulse On/Trip/Close /Unpaired
2	Acknowledge All Alarms	0	Yes	Pulse On/Trip/Close /Unpaired
3	Remote CB Trip Command	0	Yes	Pulse On/Trip/Unpaired
4	Remote CB Close Command	0	Yes	Pulse On/Close/Unpaired
5	Cancel CB Trip	0	Yes	Pulse On/Trip/Close /Unpaired
6	Cancel CB Close	0	Yes	Pulse On/Trip/Close /Unpaired
7	Setting Group Change (See Note 2)	0	Yes	Pulse On/Trip/Close /Unpaired
8	Thermal State Reset	0	Yes	Pulse On/Trip/Close /Unpaired
9	Reset Average and Max Measurements	0	Yes	Pulse On/Trip/Close /Unpaired
10	Reset Rolling Average Measurements	0	Yes	Pulse On/Trip/Close /Unpaired
11	Reset Rolling Max Measurements	0	Yes	Pulse On/Trip/Close /Unpaired
12	Reset Protection Communications Statistics	0	Yes	Pulse On/Trip/Close /Unpaired
13	Selection of Group 1	0	Yes	Pulse On/Trip/Close /Unpaired
14	Selection of Group 2	0	Yes	Pulse On/Trip/Close /Unpaired
15	Selection of Group 3	0	Yes	Pulse On/Trip/Close /Unpaired
16	Selection of Group 4	0	Yes	Pulse On/Trip/Close /Unpaired
Note 2 *Edge Mode must be selected in the Change Input Group Menu Setting.*				

Table 46 - Binary Output Status Points and Control Relay Output Block

6.4.3 Counters

The following table lists both Binary Counters (Object 20) and Frozen Counters (Object 21). When a freeze function is performed on a Binary Counter point, the frozen value is available in the corresponding Frozen Counter point.

Binary Counters and Frozen Counters are not included in class 0 polls.

Binary Counters	
Static (Steady State) Object Number:	**20**
Change Event Object Number:	**Not Supported**
Request Function Codes Supported:	**1 (Read), 7 (Freeze), 8 (Freeze NoAck)** **9 (Freeze and Clear), 10 (Freeze and Clear, NoAck)**
Static Variation reported when Variation 0 requested:	**5 (32-Bit Binary Counter without Flag) Change Event**
Variation reported when Variation 0 requested:	**None - Not Supported**
Frozen Counters	
Static (Steady State) Object Number:	**21**
Change Event Object Number:	**Not Supported**
Request Function Codes Supported:	**1 (Read)**
Static Variation reported when Variation 0 requested:	**9 (32-Bit Frozen Binary without Flag)**
Change Event Variation reported when Variation 0 requested:	**None - Not Supported**

P521 Point Index	Name/Description	Clear Group Note 3	Scaling See Note 4	Valid Range	Units
	Max and Average Measurements				
0	Max IA RMS	1	x In/100	0 … 400000In	A
1	Max IB RMS	1	x In/100	0 … 400000In	A
2	Max IC RMS	1	x In/100	0 … 400000In	A
3	Average IA RMS	1	x In/100	0 … 400000In	A
4	Average IB RMS	1	x In/100	0 … 400000In	A
5	Average IC RMS	1	x In/100	0 … 400000In	A
	CB Monitoring Measurements				
6	Number of CB Operations	2	x 1	0 … 65535	-
7	IA Summation Amps	3	x In	0 … 4294967295In	An
8	IB Summation Amps	3	x In	0 … 4294967295In	An
9	IC Summation Amps	3	x In	0 … 4294967295In	An
	Rolling Average and Max Measurements				
10	IA RMS Rolling Average	4	x In/100	0 … 400000In	A
11	IB RMS Rolling Average	4	x In/100	0 … 400000In	A
12	IC RMS Rolling Average	4	x In/100	0 … 400000In	A
13	IA RMS Rolling Max	5	x In/100	0 … 400000In	A
14	IB RMS Rolling Max	5	x In/100	0 … 400000In	A
15	IC RMS Rolling Max	5	x In/100	0 … 400000In	A
	Protection Communications Statistics				
16	Number of Valid Messages	6	x 1	0 … 4294967295	-
17	Number of Error Messages	6	x 1	0 … 4294967295	-
18	Number of Errored Seconds	6	x 1	0 … 4294967295	-
19	Number of Severely Errored Seconds	6	x 1	0 … 4294967295	-
20	CH1 Propagation Delay	6	x 1	0 … 200000	µs
21	Elapsed Time since Last Protection Comms Reset	6	x 1	0 … 4294967295	s

Note 3	*A Freeze & Clear Command should only be requested on 1 point within each Group in any 1 request. For a Freeze & Clear All, it is recommended that a List Of Points is used were the list specifies 1 Point in each group.*
Note 4	*In' related Counter Values are not Per Unit Values and include the CT Ratio Factor. The Per Unit Value can be determined by:* *PU Value = -Value Output from Slave CT / Ratio Factor*

Table 47 - Binary Counters (Object 20) and Frozen Counters (Object 21)

6.4.4 Analog Inputs

The following table lists Analog Inputs (Object 30). It is important to note that 16-bit and 32-bit variations of Analog Inputs, Analog Output Control Blocks, and Analog Output Statuses are transmitted through DNP as signed numbers. Even for analog input points that are not valid as negative values, the maximum positive representation is 32767. For each point, the "Scaling and Units" column indicates the value of a transmitted 32767. This also implies the value of a transmitted –32767. The entry in the column does not imply a valid value for the point.

Always indicating the representation of 32767 in the tables below is a consistent method for representing scale, applicable to all scaling possibilities.

The "Default Deadband," and the "Default Change Event Assigned Class" columns are used to represent the absolute amount by which the point must change before an analog change event will be generated, and once generated in which class poll (1, 2, 3) will the change event be reported. Only the default values for these columns are documented here because the values may change in operation due to either local (user-interface) or remote (through DNP) control.

Every Analog Inputs points are included in class 0 polls, because they are included in one of classes 1, 2 or 3.

Analog Inputs

Static (Steady State) Object Number:	**30**
Change Event Object Number:	**32**
Request Function Codes supported:	**1 (read)**
Static Variation reported when variation 0 requested:	**2 (16-Bit Analog Input)**
Change Event Variation reported when variation 0 requested:	**2 (Analog Change Event without Time)**
Change Event Scan Rate:	**Fixed at 1s**

P521 Point Index	Name/Description	Scaling see Note 5	Valid Range	Change Event Deadband	Change Event Class (1, 2, 3 or none)	Initial Value	Units
	Active Setting Group						
0	Active Setting Group	x 1	1…4	1	3	1	(None)
	Peak (Fundamental) Measurements						
1	IA Modulus	x In/800	0 … 40In	0.1In	3	0	A
2	IB Modulus	x In/800	0 … 40In	0.1In	3	0	A
3	IC Modulus	x In/800	0 … 40In	0.1In	3	0	A
4	IN Modulus	See Note 6	See Note 6	See Note 6	3	0	A
5	Negative Sequence (I2) Modulus	x In/800	0 … 40In	0.1In	3	0	A
6	Positive Sequence (I1) Modulus	x In/800	0 … 40In	0.1In	3	0	A
	RMS Measurements						
7	IA RMS	x In/100	0 … 40In	0.1In	3	0	A
8	IB RMS	x In/100	0 … 40In	0.1In	3	0	A
9	IC RMS	x In/100	0 … 40In	0.1In	3	0	A
10	IN RMS	x In/1000	See Note 6	See Note 6	3	0	A
	General Measurements						
11	Thermal State	x 1	0 … 500	10	3	0	%
	CB Monitoring Measurements						
12	CB Open Time	x 0.01	0 … 10	01	3	0	s
13	CB Close Time	x 0.01	0 … 10	01	3	0	s
	Current Differential Measurements						
14	IA Differential	x In/100	0 … 40In	0.1In	3	0	A
15	IB Differential	x In/100	0 … 40In	0.1In	3	0	A

Analog Inputs							
Static (Steady State) Object Number: **30** Change Event Object Number: **32** Request Function Codes supported: **1 (read)** Static Variation reported when variation 0 requested: **2 (16-Bit Analog Input)** Change Event Variation reported when variation 0 requested: **2 (Analog Change Event without Time)** Change Event Scan Rate: **Fixed at 1s**							
P521 Point Index	**Name/Description**	**Scaling see Note 5**	**Valid Range**	**Change Event Deadband**	**Change Event Class (1, 2, 3 or none)**	**Initial Value**	**Units**
16	IC Differential	x In/100	0 … 40In	0.1In	3	0	A
17	IA Remote	x In/100	0 … 40In	0.1In	3	0	A
18	IB Remote	x In/100	0 … 40In	0.1In	3	0	A
19	IC Remote	x In/100	0 … 40In	0.1In	3	0	A
20	IA Bias	x In/100	0 … 40In	0.1In	3	0	A
21	IB Bias	x In/100	0 … 40In	0.1In	3	0	A
22	IC Bias	x In/100	0 … 40In	0.1In	3	0	A
23	IA Local Angle (IA-IB)	x1	-180 … 179	5	3	0	degs
24	IB Local Angle (IB-IC)	x1	-180 … 179	5	3	0	degs
25	IC Local Angle (IC-IA)	x1	-180 … 179	5	3	0	degs
26	IA Differential Angle	x1	-180 … 179	5	3	0	degs
27	IB Differential Angle	x1	-180 … 179	5	3	0	degs
28	IC Differential Angle	x1	-180 … 179	5	3	0	degs
	Latest Fault Record						
29	Fault Number	x 1	1 … 65535	1	2	0	None
30	Active Setting Group	x 1	1 … 4	Each New Fault	2	0	None
31	Faulted Phase	x 1	0 … 8	Each New Fault	2	0	See Note 7
32	Fault Flags	x 1	0 … 19	Each New Fault	2	0	See Note 8
33	Fault Magnitude	See Note 10	See Note 10	Each New Fault	2	0	A
34	Fault IA Magnitude	x In/800	0 … 40In	Each New Fault	2	0	A
35	Fault IB Magnitude	x In/800	0 … 40In	Each New Fault	2	0	A
36	Fault IC Magnitude	x In/800	0 … 40In	Each New Fault	2	0	A
37	Fault IN Magnitude	See Note 6	See Note 6	Each New Fault	2	0	A
38	Fault IA Differential Magnitude	x In/100	0 … 40In	Each New Fault	2	0	A
39	Fault IB Differential Magnitude	x In/100	0 … 40In	Each New Fault	2	0	A
40	Fault IC Differential Magnitude	x In/100	0 … 40In	Each New Fault	2	0	A
41	Fault Max Bias Magnitude	x In/100	0 … 40In	Each New Fault	2	0	A
42	Channel 1 Communications Status	x 1	0 … 1	Each New Fault	2	0	See Note 9

Note 5 All Analog Input Values are specified as Per Unit Values (i.e. do not consider the CT Ratio Factor).

Analog Inputs

Static (Steady State) Object Number:	**30**
Change Event Object Number:	**32**
Request Function Codes supported:	**1 (read)**
Static Variation reported when variation 0 requested:	**2 (16-Bit Analog Input)**
Change Event Variation reported when variation 0 requested:	**2 (Analog Change Event without Time)**
Change Event Scan Rate:	**Fixed at 1s**

P521 Point Index	Name/Description	Scaling see Note 5	Valid Range	Change Event Deadband	Change Event Class (1, 2, 3 or none)	Initial Value	Units

Note 6

For Normal Earth Fault Sensitivity:
Scaling: x In/800
Valid Range: 0.1 … 40 In
Change Event Deadband: 0.1In
For Sensitive Earth Fault Sensitivity:
Scaling: x In/3277
Valid Range: 0.01 … 8 In
Change Event Deadband: 0.04 In
For Very Sensitive Earth Fault Sensitivity:
Scaling: x In/32700
Valid Range: 0.002 … 1In
Change Event Deadband: 0.005 In

Note 7	*0 None*	*1 Phase A*	*2 Phase B*	*3 Phase C*	*4 Phase A B*
	5 Phase A C	*6 Phase B C*	*7 Phase A B C*	*8 Phase N*	

Note 8	*0 Null*	*1 Remote Trip*	*2 Thermal Overload*	*3 tI>*	*4 tI>>*
	5 tI>>>	*6 tI>>>>*	*7 tIe>*	*8 tIe>>*	*9 tIe>>>*
	10 tIe>>>>	*11 tI<*	*12 Broken Conductor*	*13 tAux1*	*14 tAux2*
	15 tI2>	*16 tI2>>*	*17 Idiff*	*18 Intertrip*	*19 TCS Block*

Note 9	*0 Comms OK*	*1 Comms Failed*

Note 10

Fault Type	Fault Magnitude Scaling	Description
(See Note 8)		
0	N/A	N/A
1	N/A	N/A
2	N/A	N/A
3	x In/800	Phase Peak (Fundamental) Current
4	x In/800	Phase Peak (Fundamental) Current
5	x In/800	Phase Peak (Fundamental) Current
6	x In/800	Phase Peak (Fundamental) Current
7	See Note 6	Earth Peak (Fundamental) Current
8	See Note 6	Earth Peak (Fundamental) Current
9	See Note 6	Earth Peak (Fundamental) Current
10	See Note 6	Earth Peak (Fundamental) Current
11	x In/800	Phase Peak (Fundamental) Current
12	x In/800	Phase Peak (Fundamental) Current
13	N/A	N/A
14	N/A	N/A

Analog Inputs							
Static (Steady State) Object Number:				**30**			
Change Event Object Number:				**32**			
Request Function Codes supported:				**1 (read)**			
Static Variation reported when variation 0 requested:				**2 (16-Bit Analog Input)**			
Change Event Variation reported when variation 0 requested:				**2 (Analog Change Event without Time)**			
Change Event Scan Rate:				**Fixed at 1s**			
P521 Point Index	**Name/Description**	**Scaling see Note 5**	**Valid Range**	**Change Event Deadband**	**Change Event Class (1, 2, 3 or none)**	**Initial Value**	**Units**
	15	x In/800		Negative Sequence Peak (Fundamental) Current			
	16	x In/800		Negative Sequence Peak (Fundamental) Current			
	17	x In/100		Differential Current			
	18	x In/100		Differential Current			
	19	N/A		N/A			

Table 48 - Analog Inputs

Notes:

COMMISSIONING AND MAINTENANCE

CHAPTER 8

Date:	January 2012
Software version:	13
Hardware Suffix:	B
Connection diagram:	10P52101

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TABLES

FIGURES

Notes:

1 REQUIREMENTS PRIOR TO COMMISSIONING

The MiCOM P521 relay is fully numerical in its design, implementing all protection and non-protection functions in software. The MiCOM 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-numerical relays (static or electromechanical).

To commission MiCOM relays it is only necessary to verify that the hardware is functioning correctly and the application-specific software settings have been applied to the MiCOM relay. It is considered unnecessary to test every function of the relay if the settings have been verified by one of the following methods:

- Extracting the settings applied to the relay using the appropriate setting software (preferred method)
- Via the front panel user interface.

Reminder	*It is not possible to download a new setting file as long as the programming mode is active (i.e. password entered via key pad).*

To confirm that the product is operating correctly once the application-specific settings have been applied a test should be performed on at least one protection element.

Unless previously agreed to the contrary, the customer will be responsible for determining the application-specific settings to be applied to the MiCOM relays and for testing of any scheme logic applied by external wiring.

Blank commissioning test and setting records are provided in chapter *P521/EN RS* of the Technical Guide for completion as required.

When P59x interface units are used to convert the optical signal from the P521 relay to an electrical signal for the multiplexer, the P59x units should be commissioned in conjunction with the relay.

Warning	**Before carrying out any work on the equipment, the user should be familiar with the contents of the Safety and Technical Data Chapters and the ratings on the equipment's rating label.**

2 SETTING FAMILIARISATION

When commissioning a MiCOM P521 relay for the first time, sufficient time should be allowed to become familiar with the method by which the settings are applied.

The User Guide contains a detailed description of the menu structure of the P521 relay.

To change any of the settings via the relay key pad the appropriate password must first be entered. When attempting to change a setting the user will be prompted to enter the password if it has not already been entered.

Alternatively, if a portable PC is available together with suitable setting software (such as MiCOM S1 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 disk 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.

3 EQUIPMENT REQUIRED FOR COMMISSIONING

3.1 Minimum Equipment Required

Overcurrent test set with interval timer.

Multimeter with suitable ac current ranges.

Continuity tester (if not included in multimeter)

2 Lengths of 50/125 µm fiber optic cable (approximately 1 meter long) terminated at each end with a ST connector

Optical power meter with sensitivity 0 to –50 dBm (to measure the optical signal level)

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 500 V (for insulation resistance testing when required).

A portable PC, with appropriate software (this enables the front or rear communication ports to be tested and will also save considerable time during commissioning).

KITZ K-Bus to EIA(RS)232 protocol converter.

EIA(RS)485 to EIA(RS)232 converter (if EIA(RS)485 MODBUS rear port is being tested).

A printer (for printing a setting record from the portable PC).

4 PRODUCT CHECKS

Product checks cover all aspects of the relay and 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 diskette 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 in section *P521/EN RS*, to record the settings as the relay's menu is sequentially stepped through via the front panel user interface.

4.1 With the Relay De-Energized

The following group of tests should be carried out without the auxiliary supply being applied to the relay and with the trip circuit isolated.

Caution	**The current 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.**

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. For example, the test block may be associated with protection current transformer circuits. It is essential that the sockets in the test plug which correspond to the current transformer secondary windings are linked before the test plug is inserted into the test block.

DANGER	**Never open the secondary circuit of a current transformer since the high voltage produced may be lethal and could damage insulation.**

If a test block is not provided the 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.

Visually check that the current transformer shorting switches, fitted on the terminal block inside the rear of the case, are wired into the correct circuit. The shorting switches are between terminals 41 and 42, 43 and 44, 45 and 46, 47 and 48, 49 and 50, 51 and 52, 53 and 54, 55 and 56. Ensure that while the relay module is withdrawn the shorting switches are closed by checking with a continuity tester.

Ensure that the case earthing connections are used to connect the relay to a local earth bar using an adequate conductor. Where there is more than one relay in a tier, it is recommended that a copper bar should be fitted connecting the earth terminals of each case in the same tier together. However, as long as an adequate earth connection is made between relays, the use of a copper earth bar is not essential.

4.1.2 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 500 V. Terminals of the same circuits should be temporarily connected together.

The main groups of relay terminals are:

- Current transformer circuits
- Auxiliary voltage supply
- Opto-isolated control inputs
- Relay contacts
- EIA(RS)485 communication port
- Case earth

The insulation resistance should be greater than 100 MΩ at 500 V

On completion of the insulation resistance tests ensure all external wiring is correctly reconnected to the relay.

4.1.3 External Wiring

Check that the external wiring is correct to the relay connection diagram (supplied in the Connection Diagrams chapter P521/EN CO) or scheme diagram.

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 [colored 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.

4.1.4 Watchdog Contact

If not already done to perform the insulation tests, isolate the trip contacts and re-insert the relay module. Using a continuity tester, check that the watchdog contact (terminals 35 and 36) is closed when the relay is de-energized and open when the relay is energized.

4.1.5 Auxiliary Supply

The P521 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 1.

Without energizing 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
48 – 250 Vdc	48 – 240 Vac	38.4 - 300 Vdc	38.4 - 264 Vac
24 – 250 Vdc	48 – 240 Vac	19.2 - 300 Vdc	38.4 - 264 Vac

Note *The P521 relay can withstand an ac ripple of up to 12% of the upper rated voltage on the dc auxiliary supply.*

Note *Nominal supply rating DC [AC rms] 24 – 60 V/ DC Operating Range 19.2 - 76 V can not be provided.*

Table 1 - Operational range of auxiliary supply Vx.

Caution **Do not energize the relay or interface unit using the battery charger with the battery disconnected as this can irreparably damage the relay's power supply circuitry.**

Caution **Energize 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 Energized

The following group of tests verify that the relay hardware and software is functioning correctly and should be carried out with the auxiliary supply applied to the relay and, if installed, the P590 interface units.

Caution	**The current 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 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. Lightly press on the battery to prevent it from falling out of the battery compartment and pull the red tab to remove the isolation strip.

Set the date and time to the correct local time and date using cells “Date” and “Time” in the PARAMETERS menu.

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-energization the date and time should be correct.

4.2.2 Light Emitting Diodes (LEDs)

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 and trip LEDs when the relay was last energized from an auxiliary supply. Therefore these indicators may also illuminate when the auxiliary supply is applied.

The 8 LEDs, on the front of the relay, can be tested selecting “Yes” in the “LED Test” cell (AUTOMAT. CTRL/Commissioning). The LEDs should remain illuminated for approximately 5 seconds after the LED test is initiated.

4.2.3 Input Opto-Isolators

This test checks that all the opto-isolated inputs on the relay are functioning correctly. The P521 relay has a total of 5 opto-isolated inputs.

The opto-isolated inputs should be energized one at a time, see external connection diagrams (chapter, P521/EN CO) for terminal numbers. Ensuring correct polarity, connect the auxiliary supply voltage to the appropriate terminals for the input being tested.

The status of each opto-isolated input can be viewed using the “Input Status” cell, in the OP PARAMETERS menu, a ‘1’ indicating an energized input and a ‘0’ indicating a de-energized input. When each opto-isolated input is energized one of the characters on the bottom line of the display will change to indicate the new state of the inputs.

4.2.4 Output Relays

This test checks that all the output relays are functioning correctly. The P521 relay has a total of 8 output relays (not including the watchdog).

Ensure that the commissioning menu is enabled (AUTOMAT. CTRL/Commissioning). The output relays to be tested can be selected in the "Trip Test" cell, 0 = do not close relay and 1 = close relay. Once the output relays have been selected, they can be operated by selecting "yes" in the "Contact Test" cell. The contacts will remain closed until "No" is selected once again.

Note	*The contact test will be disabled if "Yes" is selected in the "Disable Relays" cell (also in COMMISSIONING menu).*

The output relays should be energized one at a time and the appropriate terminals should be checked with a continuity tester. Operation will be confirmed by the continuity tester operating for a normally open contact and ceasing to operate for a normally closed contact.

Reset the output relays by selecting "No" in the Contact Test" cell.

Note	*Ensure that thermal ratings of anything connected to the output relays during the contact test procedure are 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.*

4.2.5 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.

Note	*The rear communications port must be enabled before access can commence. The port is enabled by selecting "Yes" in the "CTRL Comms" cell (COMMUNICATIONS menu).*

EIA(RS)485 connection	P521 terminal
Screen	29
+ve	31
–ve	32

Table 2 - Rear communications port terminals

4.2.5.1 MODBUS Communications

Connect a portable PC running the appropriate MODBUS Master Station software to the relay's EIA(RS)485 port via an EIA(RS)485 to EIA(RS)232 interface converter. The terminal numbers for the relay's EIA(RS)485 port are given in Table 2.

Ensure that the relay address, baud rate, stop bits and parity settings in the application software are set the same as those in cells "Relay Address", "Baud rate", "stop bits" and "Parity" (COMMUNICATIONS menu) of the relay.

Check that communications with this relay can be established.

4.2.5.2 IEC 60870-5-103 (VDEW) Communications

IEC 60870-5-103/VDEW communication systems are designed to have a local Master Station and this should be used to verify that the relay's EIA(RS)485 port is working. The terminal numbers for the relay's EIA(RS)485 port are given in Table 2.

Ensure that the relay address and baud rate settings in the application software are set the same as those in cells "Relay Address" and "Baud rate" (COMMUNICATIONS menu) of the relay.

Check that, using the Master Station, communications with the relay can be established.

4.2.5.3 DNP3.0 Communications

Connect a portable PC running appropriate DNP3.0 Master Station software to the relay's EIA(RS)485 port via an EIA(RS)485 to EIA(RS)232 interface converter. The terminal numbers for the relay's EIA(RS)485 port are given in Table 2.

Ensure that the relay address, baud rate, stop bits and parity settings in the application software are set the same as those in cells Relay Address", "Baud rate", "Stop bits" and "Parity" (COMMUNICATIONS menu) of the relay.

Check that communications with this relay can be established.

4.2.6 Current Differential Communications

This test verifies that the relay's current differential EIA(RS)232/EIA(RS)485/fiber optic communications ports and any other peripheral devices (P59x, P595 etc.) used for communications between the P521 current differential relays, at each end of the feeder being protected, are operating correctly.

4.2.6.1 Direct Fiber Optic Communications

Set the "Loopback Test" cell (AUTOMAT. CTRL/Commissioning menu) to "CHANNEL_1" (=ON).

Using a length of fiber optic cable, terminated with an ST connector at each end, connect the transmit (Tx) and receive (Rx) ports on the rear of the relay together. The relay will now respond as if it is connected to a remote relay with the current at the remote end equal to and in phase with the current injected at the local end. Reset any alarm indications and check that no further communications failure alarms are raised. As the loopback alarm is still active it will not reset. Check communication statistics (error messages etc.) in the "Protection Comms" column (MEASUREMENTS menu).

Caution **When connecting or disconnecting optical fibers care should be taken not to look directly into the transmit port or end of the optical fiber.**

4.2.6.2 Direct EIA(RS)485 Communications

Set the "Loopback Test" cell (AUTOMAT. CTRL/Commissioning menu) to "CHANNEL_1" (=ON).

Using 2 short link wires connect the following:

SK1 terminal 4 to SK1 terminal 6

And

SK1 terminal 5 to SK1 terminal 7

The relay will now respond as if it is connected to a remote relay with the current at the remote end equal to and in phase with the current injected at the local end. Reset any alarm indications and check that no further communications failure alarms are raised. As the loopback alarm is still active it will not reset. Check the communication statistics (e.g. Errored messages etc.) in the "Protection Comms" column (MEASUREMENTS menu).

4.2.6.3 EIA(RS)232 Communications

The EIA(RS)232 connections would normally be used to connect the P521 to a modem, or similar device, as a direct link between relays would be practically impossible with EIA(RS)232's limited transmission distance.

Set the "Loopback Test" cell (AUTOMAT. CTRL/Commissioning menu) to "ON".

Using a short link wire connect the transmit (SK1 terminal 1) and receive (SK1 terminal 2) ports on the rear of the relay together. The relay will now respond as if it is connected to a remote relay with the current at the remote end equal to and in phase with the current injected at the local end. Reset any alarm indications and check that no further communications failure alarms are raised. As the loopback alarm is still active it will not reset. Check the communication statistics (e.g. Errored messages etc.) in the "Protection Comms" column (MEASUREMENTS menu).

4.2.6.4 Communications using Modems

Carefully examine the unit to see that no physical damage has occurred since installation. Check that the external wiring to the modem is correct to the relevant connection diagram or scheme diagram, supplied by the modem manufacturer. Ensure that the modem is being supplied with the correct auxiliary voltage.

Initiate a "Local Analog Loopback" test following the modem user manual.

Return to the P521 relay and select "CHANNEL_1" (=ON) in the "Loopback" cell (AUTOMAT. CTRL/Commissioning). The relay will then respond as if it is connected to a remote relay with the current at the remote end equal to and in phase with the current injected at the local end.

Reset any alarm indications and check that no further communications failure alarms are raised. As the loopback alarm is still active it will not reset. Check channel status, propagation delays and communication statistics in "Protection Comms" column (MEASUREMENTS menu).

4.2.6.5 Communications using P595 Interfacing Device

Carefully examine the unit to see that no physical damage has occurred since installation. Check that the external wiring to the P595 is correct to the relevant connection diagram or scheme diagram. Ensure that the applied auxiliary supply voltage corresponds to that stated on the rating label. The rating label is located on the underside of the unit and on the lower side face in front of the terminal strip.

Set the "Loopback Test" cell (AUTOMAT. CTRL/Commissioning menu) to "ON".

Using 2 short link wires connect the following:

-X9 terminal 4 to –X9 terminal 1

And

-X9 terminal 5 to –X9 terminal 2

The relay will now respond as if it is connected to a remote relay with the current at the remote end equal to and in phase with the current injected at the local end. Reset any alarm indications and check that no further communications failure alarms are raised. As the loopback alarm is still active it will not reset. Check the communication statistics (e.g. Errored messages etc.) in the "Protection Comms" column (MEASUREMENTS menu).

4.2.6.6 Communications using P591 Interface Units

The P591 converts the optical output of the P521 relay to an electrical signal for a PCM multiplexer with G.703 interfaces. The unit is housed in a size 20TE case and should be located near to the multiplexer.

Before loopback testing can begin some other checks must be completed.

P591 Visual Inspection

Carefully examine the unit to see that no physical damage has occurred since installation.

The rating information given under the top access cover on the front of the unit should be checked to ensure it is correct for the particular installation.

Ensure that the case earthing connection, top left-hand corner at the rear of the case, is used to connect the unit to a local earth bar using an adequate conductor.

P591 Insulation

Insulation resistance tests are only necessary during commissioning if it is required for them to be done and they haven't been performed during installation.

Isolate all wiring from the earth and test the insulation with an electronic or brushless insulation tester at a dc voltage not exceeding 500 V. The auxiliary dc supply terminals should be temporarily connected together.

The insulation resistance should be greater than 100 MΩ at 500 V.

On completion of the insulation resistance tests, ensure all external wiring is correctly reconnected to the P591.

P591 External Wiring

Check that the external wiring is correct to the relevant connection diagram or scheme diagram. The connection diagram number appears on the rating label under the top access cover on the front of the P591. The corresponding connection diagram will have been supplied with the Schneider Electric order acknowledgement for the P591.

Note	*It is especially important that the dc supplies are wired with the correct polarity.*

P591 Auxiliary Supply

P591 units operate from a dc only auxiliary supply within the operative range of 19 V to 65 V for a 24 – 48 V version and 87.5 V to 300 V for a 110 – 250 V version.

Without energizing the P591 units measure the auxiliary supply to ensure it is within the operating range.

Note	*The P591 interface unit is designed to withstand an ac ripple component of up to 12% of the normal dc auxiliary supply. However, in all cases the peak value of the dc supply must not exceed the maximum specified operating limit.*

Warning	**Do not energize the P591 using the battery charger with the battery disconnected as this can irreparably damage the unit's power supply circuitry.**

Energize the P591 only if the auxiliary supply is within the specified operating ranges. If a P991 test block is provided, it may be necessary to link across the front of the test plug to connect the auxiliary supply to the P591.

P591 Light Emitting Diodes (LEDs)

On power up the green 'SUPPLY HEALTHY' LED should illuminate and stay on, thus indicating that the P591 is healthy.

Loopback Test with P591

Remove any external wiring from terminals 3, 4, 7 and 8 at the rear of each P591 unit. Loopback the G.703 signals on each unit by connecting a wire link between terminals 3 and 7, and a second wire between terminals 4 and 8.

Measure and record the optical signal strength received by the P591 by disconnecting the optical fiber from the receive port on the rear of the unit and connecting it to an optical power meter. The mean level should be in the range –16.8 dBm to –25.4 dBm. If the mean level is outside of this range check the size and type of fiber being used.

Measure and record the optical output power of the transmit port of the P591 using the optical power meter and length of 50/125 mm optical fiber. The mean value should be –19.8 dBm ±3 dBm.

Ensure that the transmit (Tx) and receive (Rx) optical fibers between the P521 relay and P591 units are connected.

Return to the P521 relay and select "CHANNEL_1" (=ON) in the "Loopback" cell (AUTOMAT. CTRL/Commissioning). The relay will then respond as if it is connected to a remote relay with the current at the remote end equal to and in phase with the current injected at the local end.

Reset any alarm indications and check that no further communications failure alarms are raised. As the loopback alarm is still active it will not reset. Check channel status, propagation delays and communication statistics in "Protection Comms" column (MEASUREMENTS menu).

Final Checks

If removed, the secondary front cover should now be re-fitted to the P591.

4.2.6.7 Communications using P592 Interface Units

The P592 converts the optical output of the P521 relay to an electrical signal for a PCM multiplexer with V.35 interfaces. The unit is housed in a size 20TE case and should be located near to the multiplexer.

Before loopback testing can begin some other checks must be completed.

P592 Visual Inspection

Carefully examine the unit to see that no physical damage has occurred since installation.

The rating information given under the top access cover on the front of the unit should be checked to ensure it is correct for the particular installation.

Ensure that the case earthing connection, top left-hand corner at the rear of the case, is used to connect the unit to a local earth bar using an adequate conductor.

P592 Insulation

Insulation resistance tests are only necessary during commissioning if it is required for them to be done and they haven't been performed during installation.

Isolate all wiring from the earth and test the insulation with an electronic or brushless insulation tester at a dc voltage not exceeding 500 V. The auxiliary dc supply terminals should be temporarily connected together.

Note	*The V.35 circuits of the P592 are isolated from all other circuits but are electrically connected to the outer case. The circuits must not therefore be insulation or impulse tested to the case.*

The insulation resistance should be greater than 100 M at 500 V.

On completion of the insulation resistance tests ensure all external wiring is correctly reconnected to the P592.

P592 External Wiring

Check that the external wiring is correct to the relevant connection diagram or scheme diagram. The connection diagram number appears on the rating label under the top access cover on the front of the P592. The corresponding connection diagram will have been supplied with the Schneider Electric order acknowledgement for the P592.

Note	*It is especially important that the dc supplies are wired with the correct polarity.*

P592 Auxiliary Supply

P592 units operate from a dc only auxiliary supply within the operative range of 19 V to 300 V.

Without energizing the P592 units measure the auxiliary supply to ensure it is within the operating range.

Note	*The P592 interface unit is designed to withstand an ac ripple component of up to 12% of the normal dc auxiliary supply. However, in all cases the peak value of the dc supply must not exceed the maximum specified operating limit.*

Warning	**Do not energize the P592 using the battery charger with the battery disconnected as this can irreparably damage the unit’s power supply circuitry.**

Energize the P592 only if the auxiliary supply is within the specified operating ranges. If a P991 test block is provided, it may be necessary to link across the front of the test plug to connect the auxiliary supply to the P592.

P592 Light Emitting Diodes (LEDs)

On power up the green ‘SUPPLY HEALTHY’ LED should illuminate and stay on indicating that the P592 is healthy.

The four red LEDs can be tested by appropriate setting of the DIL switches on the unit’s front plate. Set the data rate switch according to the communication channel bandwidth available. Set all other switches to 0. To illuminate the ‘DSR OFF’ and ‘CTS OFF’ LEDs, disconnect the V.35 connector from the rear of the P592 and set the ‘DSR’ and ‘CTS’ switches to ‘0’. The ‘OPTO LOOPBACK’ and ‘V.35 LOOPBACK’ LEDs can be illuminated by setting their corresponding switches to ‘1’.

Once operation of the LEDs has been established set all DIL switches, except for the ‘OPTO LOOPBACK’ switch, to ‘0’ and reconnect the V.35 connector.

Loopback Test

With the ‘OPTO LOOPBACK’ switch in the ‘1’ position the receive and transmit optical ports are electrically connected together. This allows the optical fiber communications between the P521 relay and the P592 to be tested, but not the internal circuitry of the P592 itself.

Measure and record the optical signal strength received by the P592 by disconnecting the optical fiber from the receive port on the rear of the unit and connecting it to an optical power meter. The mean level should be in the range -16.8 dBm to -25.4 dBm. If the mean level is outside of this range check the size and type of fiber being used.

Measure and record the optical output power of the transmit port of the P592 using the optical power meter and length of 50/125 mm optical fiber. The mean value should be –19.8 dBm ±3 dBm.

Ensure that the transmit (Tx) and receive (Rx) optical fibers between the P521 relay and P592 units are connected.

Return to the P521 relay and select “CHANNEL_1” (=ON) in the “Loopback” cell (AUTOMAT. CTRL/Commissioning). The relay will then respond as if it is connected to a remote relay with the current at the remote end equal to and in phase with the current injected at the local end.

Reset any alarm indications and check that no further communications failure alarms are raised. As the loopback alarm is still active it will not reset. Check channel status, propagation delays and communication statistics in “Protection Comms” column (MEASUREMENTS menu).

Final Checks

If removed, the secondary front cover should now be re-fitted to the P592.

4.2.6.8 Communications using P593 Interface Units

The P593 converts the optical output of the P521 relay to an electrical signal for a PCM multiplexer with X.21 interfaces. The unit is housed in a size 20TE case and should be located near to the multiplexer.

Before loopback testing can begin some other checks must be completed.

P593 Visual Inspection

Carefully examine the unit to see that no physical damage has occurred since installation.

The rating information given under the top access cover on the front of the unit should be checked to ensure it is correct for the particular installation.

Ensure that the case earthing connection, top left-hand corner at the rear of the case, is used to connect the unit to a local earth bar using an adequate conductor.

P593 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 500 V. The auxiliary dc supply terminals should be temporarily connected together.

Note	*The X.21 circuits of the P593 are isolated from all other circuits but are electrically connected to the outer case. The circuits must not therefore be insulation or impulse tested to the case.*

The insulation resistance should be greater than 100 MΩ at 500 V.

On completion of the insulation resistance tests ensure all external wiring is correctly reconnected to the P593.

P593 External Wiring

Check that the external wiring is correct to the relevant connection diagram or scheme diagram. The connection diagram number appears on the rating label under the top access cover on the front of the P593. The corresponding connection diagram will have been supplied with the Schneider Electric order acknowledgement for the P593.

Note	*It is especially important that the dc supplies are wired with the correct polarity.*

P593 Auxiliary Supply

P593 units operate from a dc only auxiliary supply within the operative range of 19.5 V to 300 V.

Without energizing the P593 units measure the auxiliary supply to ensure it is within the operating range.

Note	*The P593 interface unit is designed to withstand an ac ripple component of up to 12% of the normal dc auxiliary supply. However, in all cases the peak value of the dc supply must not exceed the maximum specified operating limit.*

Danger	**Do not energize the P593 using the battery charger with the battery disconnected as this can irreparably damage the unit's power supply circuitry.**

Caution	**Energize the P593 only if the auxiliary supply is within the specified operating ranges. If a P991 test block is provided, it may be necessary to link across the front of the test plug to connect the auxiliary supply to the P593.**

P593 Light Emitting Diodes (LEDs)

On power up the green 'SUPPLY' LED should illuminate and stay on indicating that the P593 is healthy.

Set the 'X.21 LOOPBACK' switch to 'ON'. The green 'CLOCK' and red 'X.21 LOOPBACK' LEDs should illuminate. Reset the 'X.21 LOOPBACK' switch to the 'OFF' position.

Set the 'OPTO LOOPBACK' switch to 'ON'. The red 'OPTO LOOPBACK' LED should illuminate. Do not reset the "OPTO LOOPBACK' switch as it is required in this position for the next test.

Loopback Test

With the 'OPTO LOOPBACK' switch in the 'ON' position the receive and transmit optical ports are electrically connected together. This allows the optical fiber communications between the P521 relay and the P593 to be tested, but not the internal circuitry of the P593 itself.

Measure and record the optical signal strength received by the P593 by disconnecting the optical fiber from the receive port on the rear of the unit and connecting it to an optical power meter. The mean level should in the range –16.8 dBm to –25.4 dBm. If the mean level is outside of this range check the size and type of fiber being used.

Measure and record the optical output power of the transmit port of the P593 using the optical power meter and length of 50/125 mm optical fiber. The mean value should be –19.8 dBm ±3 dBm.

Ensure that the transmit (Tx) and receive (Rx) optical fibers between the P521 relay and P593 units are connected.

Set the 'OPTO LOOPBACK' and 'X.21 LOOPBACK' switch to 'OFF' and 'ON' respectively. With the 'X.21 LOOPBACK' switch in this position the 'Receive Data' and 'Transmit Data' lines of the X.21 communication interface are connected together. This allows the optical fiber communications between the P521 relay and the P593, and the internal circuitry of the P593 itself to be tested.

Return to the P521 relay and select "CHANNEL_1" (=ON) in the "Loopback" cell (AUTOMAT. CTRL/Commissioning). The relay will then respond as if it is connected to a remote relay with the current at the remote end equal to and in phase with the current injected at the local end.

Reset any alarm indications and check that no further communications failure alarms are raised. As the loopback alarm is still active it will not reset. Check channel status, propagation delays and communication statistics in “Protection Comms” column (MEASUREMENTS menu).

Final Checks

If removed, the secondary front cover should now be re-fitted to the P591.

4.2.7 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 50 Hz. If operation at 60 Hz is required then this must be set in the “Frequency” cell in the OP PARAMETERS menu.

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, see chapter P521/EN CO for appropriate terminal numbers, checking its magnitude using a multimeter. The corresponding reading can then be checked in the MEASUREMENTS/Current/General column and value displayed recorded.

Note	*Some of the relay protection elements may operate during this test, depending upon the relay setting.*

CT Rating (Amps)		Terminals
1	A	49 and 50
1	B	51 and 52
1	C	53 and 54
1	N	55 and 56
5	A	41 and 42
5	B	43 and 44
5	C	45 and 46
5	N	47 and 48

Table 3 - Current input connections

The measured current values displayed on the relay LCD, or a portable PC connected to the front communication port, will be in primary amperes, providing the CT ratio has been set. The values displayed should be equal to the applied current multiplied by the corresponding current transformer ratio set in the “CT Ratio” column (CONFIGURATION menu).

The measurement accuracy of the relay is typically ±0.2% at rated current. However, an additional allowance must be made for the accuracy of the test equipment being used.

5 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.

If the application-specific settings are not available, ignore sections 5.1 and 5.2.

Note	*The trip circuit should remain isolated during these checks to prevent accidental operation of the associated circuit breaker.*
Note	*For additional security the P521 output contacts can be disabled using the commissioning menu. For more information on this feature refer to section 3.5.4.1 of the User Guide, see chapter P521/EN FT.*

5.1 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, or rear EIA(RS)485/K Bus communications port. This method is preferred for transferring function settings as it is much faster and there is less margin for error.
- If a setting file has been created for the particular application and provided on a diskette this will further reduce the commissioning time.
- Enter them manually via the relay's user interface.

5.2 Demonstrate Correct Relay Operation

Test 4.2.7 has already demonstrated that the relay is within calibration, therefore the purpose of these tests are as follows:

- To determine that the primary protection function of the relay, current differential, can trip according to the correct application settings.
- To verify correct setting of any backup phase overcurrent protection.
- To verify correct assignment of the trip contacts, by monitoring the response to a selection of fault injections.

5.2.1 Current Differential Bias Characteristic

To avoid spurious operation of any overcurrent, earth fault, negative sequence overcurrent, thermal overload, broken conductor, under current or breaker fail elements these should be disabled for the duration of the differential element tests. Refer to the User Guide for information on how this can be done. Make a note of which elements need to be re-enabled after testing. The relay should also be set to loopback mode isolating it from the remote end. Refer to section 4.2.6.1.

5.2.1.1 Connect the Test Circuit

The following tests require a variable auto transformer (variac) and two resistors connected as shown in Figure 1. Alternatively an injection test set can be used to supply Ia and Ib.

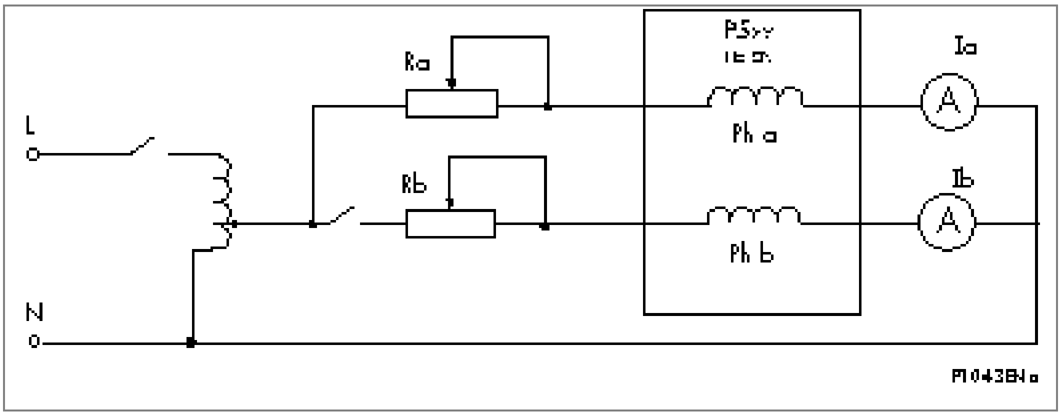

Figure 1 - Connection for bias characteristic testing

A current is injected into the A phase which is used as the bias current and another current is injected into the B phase which is used as differential current. Ia is always greater than Ib.

5.2.1.2 Lower Slope

Make sure that the relay is in loopback mode as described in 4.2.6.1.

Adjust the variac and the resistor to give a bias current of 1 pu in the A-phase.

Note	*1 pu = 1 A into terminals 49-50 for 1 A applications; or 1 pu = 5 A into terminals 41-42 for 5 A applications). The relay will trip and any contacts associated with the current differential protection will operate, this will be accompanied by the "I DIFF" and "I DIFF I-TRIP" alarms. Some LEDs may illuminate and the yellow alarm LED will start to flash. Acknowledge the alarm by pressing the 🕮 key followed by ⓒ key. The yellow LED will stop flashing and become continuously illuminated.*

Operation of the A Phase element will be indicated by an "A" appearing in the "IDiff Trip Flags" cell, (AUTOMAT. CTRL/Commissioning) as shown below.

```
IDiff Trip Flags
TRIP: A
```

This indication will remain until the A-Phase differential current exits the tripping region of the biased differential characteristic.

When the current in the A Phase is established, close the switch and slowly increase the current in the B phase from zero until Phase B trips. This will be indicated by a "B" appearing in the "IDiff Trip Flags" menu, in addition to "A" that is already indicated, as shown below.

```
IDiff Trip Flags
TRIP: A B
```

Record the phase B current magnitude and check that it corresponds to the formula below.

Switch OFF the ac supply, read and clear all alarms.

The formula below can be used to calculate the B phase operate current (enter slope 'k1' in pu form, i.e. percentage/100).

B phase operate current = 0.5 x (s1 + k1) pu +/- 10%

5.2.1.3 Upper Slope

Repeat the test in 5.2.1.2 with the bias current set in the A-phase to be 3 pu.

When the current in A Phase is established, close the switch and slowly increase the current in the B phase from zero until phase B trips. Record the phase B current magnitude and check that it corresponds to the information below.

Switch OFF the ac supply and reset the alarms.

The formula below can be used to calculate the B phase operate current (enter slope 'k1' in pu form, i.e. percentage/100).

B Phase operate current = 0.5 x [(3 x k2) – {(k2 – k1) x Is2 } + Is1] pu +/- 20%

Note:	*For 5 A applications the duration of current injections should be short to avoid overheating of the variac, resistors or injection test set.*

5.2.2 Current Differential Operating Time

Retaining the same test circuit as before, prepare for an instantaneous injection of 3 pu current in the A phase with no current in the B phase (B phase switch open). Connect a timer to start when the fault injection is applied and to stop when the trip occurs. The operating time of the relay should be recorded. Repeat the test for phases B and C, reconfiguring the test equipment accordingly.

The average of the recorded operating times for the three phases should be less than the values shown in Table 4. Switch OFF the ac supply and reset the alarms.

Baud rate (Protection Comms)	Maximum Operating Times
9.6 kb/s	100 ms
19.2 kb/s	80 ms
56 kb/s	45 ms
64 kb/s	45 ms

Table 4 - P521 Instantaneous operating times

Note	*Where an IDMT or DMT delay is set, in the PROTECTION G1/G2/G3/G4 /[87] Current Diff menu column, the expected operating time is typically within +/- 5% of that for the curve equation plus the "instantaneous" delay quoted above.*

Warning	**On completion of the tests any overcurrent, earth fault, negative sequence overcurrent, thermal overload, broken conductor, under current or breaker fail elements which were disabled for testing purposes must have their original settings restored in the appropriate menu columns.**

5.2.3 Backup Phase Overcurrent Protection

If the overcurrent protection function is being used, the I> element should be tested. If not, skip to section 5.3

To avoid spurious operation of any other protection functions, such as current differential, breaker fail etc. these should be disabled for the duration of the overcurrent tests. Make a note of which elements need to be re-enabled after testing.

Note	*If the I> element is set to be enabled on "Backup" only (i.e. when the protection communications fail), it will be necessary to deliberately force a communications channel failure in order to test it. This can be achieved by removing the loopback test, and ensuring that the relay cannot communicate with the remote end relay.*

- Set "Loopback" cell (AUTOMAT. CTRL /Commissioning) to "OFF"
- Observe that the relay raises a COMMS FAIL alarm. This may take up to 10 seconds depending upon the setting of the "Comms Fail Timer" (COMMUNICATIONS menu).

5.2.3.1 Connect the Test Circuit

Determine which output relay has been selected to operate when an > trip occurs by viewing the "tI>" cell in the AUTOMAT. CTRL/Output Relays menu.

The associated terminal numbers can be found in the external connection diagram (chapter P521/EN CO).

Connect the output relay so that its operation will trip the test set and stop the timer.

Connect the current output of the test set to the 'A' phase current input of the relay (terminals 49 and 50 where 1 A current transformers are being used and terminals 41 and 42 for 5 A current transformers).

Ensure that the timer will start when the current is applied to the relay.

5.2.3.2 Perform the Test

Ensure that the timer is reset.

Apply a current of twice the setting in "I>" cell (PROTECTION G1/G2/G3/G4/[50/51] Phase OC) to the relay and note the time displayed when the timer stops.

Check that the red trip LED has illuminated.

5.2.3.3 Check the Operating Time

Check that the operating time recorded by the timer is within the range shown in Table 5.

Note	*Except for the definite time characteristic, the operating times given in Table 5 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 5 must be multiplied by the appropriate TMS or TD setting.*

In addition, for definite time and inverse characteristics there is an additional delay of up to 0.02 second and 0.08 second respectively that may need to be added to the relay's acceptable range of operating times.

For all characteristics allowance must be made for the accuracy of the test equipment being used.

Characteristic	Operating Time at Twice Current Setting and Time Multiplier/Time Dial Setting of 1.0	
	Nominal (Seconds)	Range (Seconds)
DMT	tI>1 setting	Setting ±2%
IEC STI (Short Time Inverse)	1.78	1.60 – 1.96
IEC SI (Standard Inverse)	10.03	9.00 – 11.0
IEC VI (Very Inverse)	13.50	12.2 – 14.5

Characteristic	Operating Time at Twice Current Setting and Time Multiplier/Time Dial Setting of 1.0	
	Nominal (Seconds)	Range (Seconds)
IEC EI (Extremely Inverse)	26.67	24.0 – 29.3
UK LTI (Long Time Inverse)	120.00	108 – 132
CO2 (Short Time Inverse)	1.73	1.56 – 1.90
IEEE MI (Moderately Inverse)	3.80	3.42 – 4.18
CO8 (Inverse)	2.16	1.94 – 2.38
IEEE VI (Very Inverse)	7.03	6.33 – 7.73
IEEE EI (Extremely Inverse)	9.52	8.57 – 10.5
RI	4.52	4.07 – 4.97

Table 5 - Characteristic operating times for I>

Warning **On completion of the tests any current differential, negative sequence overcurrent, thermal overload, broken conductor, under current or breaker fail elements which were disabled for testing purposes must have their original settings restored in the appropriate menu columns.**

5.3 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, or rear communications port (with an appropriate protocol converter connected). 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 relays user interface and compare them with the original application-specific setting record.

6 END TO END TESTS

In section 4.2.6 a loopback test was initiated on the relay fiber optic communications channels, together with the P59x/modem interface units, if installed, to verify correct operation of the communications channel local to the P521 relay whilst completing the remaining tests. In this test the loopback is removed and, if possible, satisfactory communications between P521 relays in the same group will be confirmed.

Note	*The trip circuit should remain isolated during these checks to prevent accidental operation of the associated circuit breaker.*

6.1 Remove the Loopback Test

Caution	**As well as removing the loopback, this section checks that all wiring and optical fibers/pilots are reconnected. If modems, P592 or P593 interface units are installed the application-specific settings will also be applied.**

Check the relay alarms to ensure that no communications failure alarms have occurred whilst the loopback test has been in progress.

Set cell the Loopback cell to 'OFF'.

Restore the communications channels as per the appropriate sub-section below.

6.1.1 Direct Fiber Optic Communications

Remove the loopback test fiber and reconnect the fiber optic cables for communications between relays, ensuring correct placement.

Warning	**When connecting or disconnecting optical fibers care should be taken not to look directly into the transmit port or end of the optical fiber.**

6.1.2 Direct EIA(RS)485 Communications

Remove the 2 short link wires between SK1 terminals 4 and 6 and SK1 terminals 5 and 7.

Caution	**Ensure that all external wiring that has been removed to facilitate testing is replaced in accordance with the relevant connection diagram or scheme diagram.**

6.1.3 EIA(RS)232 Communications

Remove the short link wire between SK1 terminals 1 and 2.

Caution	**Ensure that all external wiring that has been removed to facilitate testing is replaced in accordance with the relevant connection diagram or scheme diagram.**

6.1.3.1 Communications using Modems

Remove “Local Analog Loopback” test following the modem user manual.

6.1.3.2 Communications using P595 Interfacing Device

Remove the short link wires between –X9 terminals 1 and 4 and –X9 terminals 2 and 5.

Caution	**Ensure that all external wiring that has been removed to facilitate testing is replaced in accordance with the relevant connection diagram or scheme diagram.**
Caution	**If isolation transformers are not used between long communications wires, these should be handled as pilot wire circuits to avoid the risk of electric shock.**

6.1.4 Communications using P591 Interface Units

Return to the P591 units.

Caution	**Ensure that all external wiring that has been removed to facilitate testing is replaced in accordance with the relevant connection diagram or scheme diagram.**

If applicable, replace the secondary front cover on the P591 units.

6.1.5 Communications using P592 Interface Units

Return to the P592 units.

Caution	**Ensure that all external wiring that has been removed to facilitate testing is replaced in accordance with the relevant connection diagram or scheme diagram.**

Set the ‘V.35 LOOPBACK’ switch to the ‘0’ position.

Set the ‘CLOCK SWITCH’, ‘DSR’, ‘CTS’ and ‘DATA RATE’ DIL switches on each unit to the positions required for the specific application and ensure the ‘OPTO LOOPBACK’ switch is in the ‘0’ position.

If applicable, replace the secondary front cover on the P592 units.

Note	*V.35 Loopback on the remote P592 can be selected to check the communications between the local relay, the local P592 and the communication link itself.*

6.1.6 Communications using P593 Interface Units

Return to the P593 units.

Caution	**Ensure that all external wiring that has been removed to facilitate testing is replaced in accordance with the relevant connection diagram or scheme diagram.**

Set the ‘X.21 LOOPBACK’ switch to the ‘OFF’ position and ensure the ‘OPTO LOOPBACK’ switch is also in the ‘OFF’ position.

If applicable, replace the secondary front cover on the P593 units.

Note	*X.21 Loopback on the remote P593 can be selected to check the communications between the local relay, the local P593 and the X.21 communication link itself. This setting on the local P593 can also be used to check the communications between the local relay and the local P593 if required.*

6.2 Verify Communications between Relays

Check for correct communications between relays as per the appropriate sub-section below.

6.2.1 Communication Checks for Direct Fiber or P59x Connected Relays

The following communication checks confirm that the optical power at the transmit and receive ports of the local relay are within the recommended operating limits. However, these checks can only be performed with the relays (and P59x interface units if installed) at the other end of the feeder known to be functional and energized.

Measure and record the optical signal strength received by the local P521 relay by disconnecting the optical fiber from the Channel 1 receive port and connecting it to an optical power meter. The mean level should be in the range –16.8 dBm to -25.4 dBm for an 850 nm port. For relays delivered from December 2008 (optical fiber interface card marked with “43 dB”), the mean level should be in the range -6 dBm to -49 dBm for a 1300 nm port. For relays delivered pre-December 2008, the mean level should be in the range –7 dBm to – 37 dBm for a 1300 nm port. If the mean level is outside of this range check the size and type of fiber being used.

Caution	**When connecting or disconnecting optical fibers care should be taken not to look directly into the transmit port or end of the optical fiber.**

Measure and record the optical power of the Channel 1 transmit port using the optical power meter and length of optical fiber. The mean value should be in the range - 16.8 dBm to -22.8 dBm for an 850 nm port. For relays delivered from December 2008 (optical fiber interface card marked with “43 dB”), the mean level should be in the range -3 dBm to -9 dBm for a 1300 nm port. For relays delivered pre-December 2008, the mean level should be in the range -7 dBm to -13 dBm for a 1300 nm port.

Ensure that all transmit (Tx) and receive (Rx) optical fibers are reconnected to the P521, ensuring correct placement.

Reset any alarm indications and check that no further communications failure alarms are raised. Check that the number of valid messages is increasing and that the number of errored messages stops increasing. These cells can be found in the MEASUREMENTS/Protection Comms column.

To reset the protection comms statistics, press c in the “Comms Stats RST” cell.

6.2.2 Communication Checks for Metallic Communications (Direct EIA(RS)485, P595, EIA(RS)232 and Modem Connected Relays)

Caution	**If isolation transformers are not used between long communications wires, these should be handled as pilot wire circuits to avoid the risk of electric shock.**

Ensure that all transmit (Tx) and receive (Rx) leads are reconnected to the P521.

Note	*For EIA(RS)232 communications it must be ensured that the SK1 terminal 3 is also connected. Failure to do this may result in unreliable communications.*

Reset any alarm indications and check that no further communications failure alarms are raised. Check that the number of valid messages is increasing and that the number of errored messages stops increasing. These cells can be found in the MEASUREMENTS/Protection Comms column.

The protection comms statistics can be reset, if necessary, by pressing C in the “Comms Stats RST” cell.

7 ON-LOAD CHECKS

The objectives of the on-load checks are to:

- Confirm the external wiring to the current inputs is correct.
- Measure the magnitude of capacitive current.
- Ensure the on-load differential current is well below the relay setting.
- Check the polarity of the line current transformers at each end is consistent.

However, these checks can only be carried out if there are no restrictions preventing the energization of the plant being protected and the other P521 relays in the group have been commissioned.

Caution	**Remove all test leads, temporary shorting leads, etc. and replace any external wiring that has been removed to allow testing.**
Caution	**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.**

7.1 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.

Caution	**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/Current/General 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. However, if a single dedicated current transformer is used for the earth fault function, it is not possible to check the relay's measured values.*

If no CT ratio has been entered (CONFIGURATION/CT Ratios) 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 1% of the applied secondary currents. However, an additional allowance must be made for the accuracy of the test equipment being used.

If a CT ratio has been entered the currents displayed on the relay should be equal to the applied secondary current multiplied by the corresponding current transformer ratio. Again the values should be within 1% of the expected value, plus an additional allowance for the accuracy of the test equipment being used.

7.2 Measure Capacitive Charging Current

With the feeder energized from one end only, compare the local and remote measured currents in the MEASUREMENTS/Current Diff menu column to confirm that the feeder capacitive charging current is similar to that expected on all three phases.

Check that the s1 setting is higher than 2.5 times the capacitive charging current. If this is not the case notify the Engineer who determined the original settings of the setting required to ensure stability under normal operating conditions.

7.3 Check Differential Current

With the feeder supplying load current check that the relay measurements in the “Current/General” menu column are as expected and that the differential current is similar to the value of the capacitive charging current previously measured for all three phases.

7.4 Check Consistency of Current Transformer Polarity

The load current should be high enough to be certain beyond doubt that the main current transformers are connected with the same polarity to each relay in the group.

There is a possibility on cable circuits with high line capacitance that the load current could be masked by the capacitive charging current. If necessary reverse the connections to the main current transformers and check that the ‘A’ phase differential current in cell “Differential IA” (MEASUREMENTS/Current Diff) is significantly higher than for the normal connection. If the differential current falls with the connection reversed the main current transformers may not be correct and should be thoroughly checked. Repeat the test for phases ‘B’ and ‘C’ using the “Differential IB” and “Differential IC” cells respectively.

8 FINAL CHECKS

The tests are now complete.

Caution	**Remove all test or temporary shorting leads, etc. If you have disconnected any of the external wiring from the relay in order to perform the wiring verification tests, make sure all connections are replaced in accordance with the relevant external connection or scheme diagram.**

If the relay is in a new installation, or the circuit breaker has just been maintained, the circuit breaker maintenance and current counters should be zero. These counters can be reset using the “CB Operation RST” and “ΣAmps (n) RST” cells in the (RECORD/CB Monitoring).

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 LEDs have been reset before leaving the relay.

9 MAINTENANCE

9.1 Maintenance Period

It is recommended that products supplied by Schneider Electric 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.

Schneider Electric protective relays are designed for a life in excess of 20 years.

MiCOM P521 current differential relay is self-supervising and so requires 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.

The operation of the P59x interface units, when installed, is continuously monitored by the P521 relay and a communication failure alarm will therefore be given if a P59x should cease to work properly.

Note	*A communication failure alarm could be caused by the failure of the equipment forming the communication link and can not in itself be conclusive evidence of a faulty P59x interface unit.*

If a Preventative Maintenance Policy exists within the customer’s organization 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

9.2 Maintenance Checks

Although some functionality checks can be performed from a remote location by utilizing the communications ability of the relays, these are predominantly restricted to checking that the relay is measuring the applied currents and voltages accurately, and checking the circuit breaker maintenance counters. Therefore it is recommended that maintenance checks are performed locally (i.e. at the substation itself).

Caution	**Before carrying out any work on the equipment, the user should be familiar with the contents of the Safety and Technical Data chapters and the ratings on the equipment’s rating label.**

9.2.1 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.

9.2.2 Opto-Isolators

The opto-isolated inputs can be checked to ensure that the relay responds to their energization by repeating the commissioning test detailed in section 4.2.3 of this Commissioning and Maintenance Guide.

9.2.3 Output Relays

The output relays can be checked to ensure that they operate by repeating the commissioning test detailed in section 4.2.4 of this Commissioning and Maintenance Guide.

9.2.4 Measurement Accuracy

If the power system is energized, 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 analog/digital conversion and calculations are being performed correctly by the relay. Suitable test methods can be found in section 7.1 of this Commissioning and Maintenance Guide.

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. A suitable test method can be found in section 4.2.7 of this Commissioning and Maintenance Guide. These tests will prove the calibration accuracy is being maintained.

9.3 Equipment Failure

Caution	**Before carrying out any work on the equipment, the user should be familiar with the content of the Safety and Technical Data chapters and the ratings on the equipment's rating label.**

The MiCOM P521 relay is fully digital and performs constant self-diagnosis. Any failure of software or hardware elements is instantly detected. As soon as an internal fault is detected, depending on its type (minor or major), an alarm message is displayed as a priority on the front panel LCD before the fault LED is illuminated (fixed or flashing) and the watchdog relay is closed (if the fault is a major one).

An equipment failure (major or minor) cannot be acknowledged on the front panel (using the dedicated tactile button keypad). Only the disappearance of the cause will acknowledge the fault and hence reset the fault LED.

9.3.1 Minor Fault

A control communications failure would be regarded as a minor fault by the P521. If the control communications are faulty, the protection and automation modules are not affected.

Message:

"COMM.ERROR": Control communication faulty

Cause:

Hardware or software failure of the control communications module.

Action:

Withdraw the active part and return it to the factory for repair.

Alternative: If the control communication is not used, disable communication in the COMMUNICATION/ CTRL Comms menu (CTRL Comms? = No).

Message:

"RAM ERROR" : Battery backed RAM faulty

"BATTERY FAIL": Battery faulty or flat.

Cause:

See section 9.4.3 of this Commissioning and Maintenance Guide. If the message still remains after restart return the module to the factory for repair.

9.3.2 Protection Comms Fault

As soon as a problem with the protection comms is detected the operation of the main protection is stopped. All other protection elements continue to operate and those selected as backup in the current setting group will be enabled.

Message:

"COMMS ALARM CH1": communications channel failure detected.

Cause:

Hardware or software failure of the communications card.

Hardware failure of the communications module retained in the case when the active part is withdrawn.

Failure of the relay at the distant end of the communications link.

Failure of a device in the communications path or break in the communications link.

Caution	**Live parts exposed within the P521 case, when the P521 module is removed.**

Action:

Determine the location of the failure using the P520L loopback test box (see Accessories section).

Initiate a loopback test on the back of each of the relays. If the protection comms alarm resets then the fault is with the communications link not the relays. The relays should assist with diagnosing the location of the fault by indicating the faulty path (Tx, Rx or both). If the protection comms alarm does not reset on one relay it is likely that the relay is faulty.

To diagnose if the fault is in the active (removal) part of the relay or the protection communications card, remove the relay and plug in the P520L loopback test box as shown in Figure 2. It is recommended that the battery is tested, before inserting the test box, by selecting battery test and checking that the green LED illuminates. With the loopback tester inserted select "Loopback Test" using the selector switch and ensure that the green LED illuminates. Initiate a loopback test from the remote relay so that the comms signal passes through the local relay communications card. If the comms fail alarm on the remote relay disappears, then the protection comms card is functioning correctly, hence the problem is with only the active part. If the comms fail alarm does not reset then the local protection comms card is faulty.

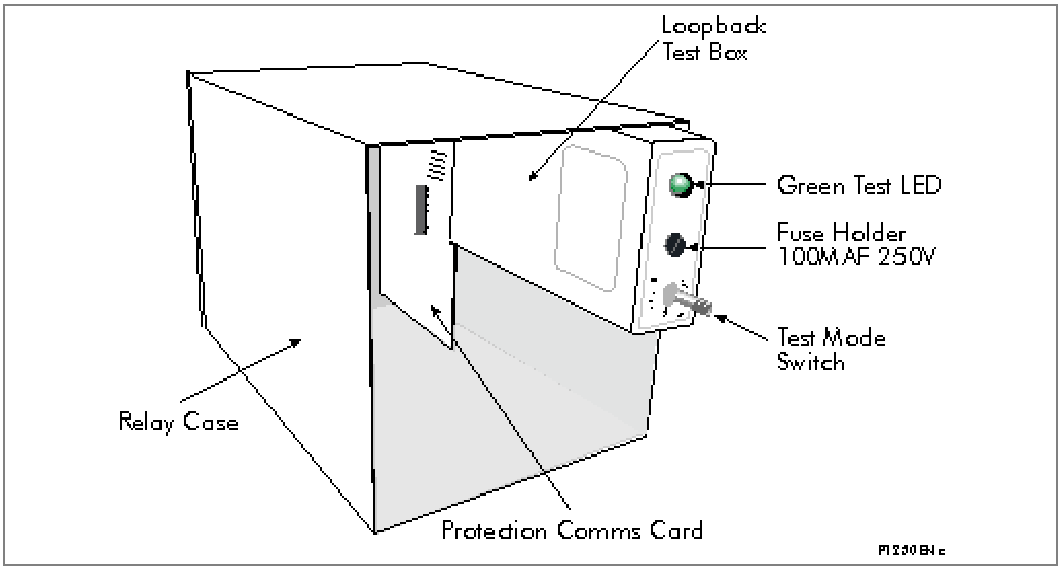

Figure 2 - Application of P520L loopback test box

If the fault is with the active part of the relay, withdraw the active part and return it to the factory for repair.

If the fault is with the communications module the whole relay, including the case, must be returned to the factory for repair.

If the fault is in any other part of the system the relays will automatically resume communication as soon as the link is restored.

9.3.3 Major Fault

Major faults for the MiCOM P521 relay are all software and hardware failures, except the communication faults. As soon as this type of failure is detected the WatchDog (WD) is closed and all operations are stopped (protection, automation, communication).

9.3.3.1 Hardware and Software Faults

Messages:

"SETTING ERROR": Data zone in fault

"EEPROM ERROR CALIBR.": Calibration data faulty

"CT ERROR": Analog channel faulty

“DEFAULT SETTING” : Default settings restored

“PROT COMMS FAIL” : Protection Comms card faulty

Cause:

Hardware or software failure.

Action:

Restart the protection software by interrupting the auxiliary supply for approximately ten seconds. In the case of the “DEFAULT SETTING” and “SETTING ERROR” alarms the in-service settings should be re-applied. If the software fault still remains after restart withdraw the active part and return the module to the factory for repair.

9.4 Method of Repair

9.4.1 Replacing the Active Part

The case and the rear terminals blocks have been designed to facilitate removal of the MiCOM P521 relay without disconnecting the scheme wiring, should replacement or repair become necessary.

Note	*The MiCOM range of relays have integral current transformer shorting switches which will close when the active part is removed from the case.*

Remove the upper and lower flap without exerting excessive force. Remove the external screws. Under the upper flap, turn the extractor with a 3mm screwdriver and extract the active part of the relay by pulling from the upper and lower notches on the front panel of the MiCOM relay.

Then reinstall the repaired or replacement relay following the above instruction in reverse, ensuring that no modification has been made to the scheme wiring.

Note	*The rear protection communications interface is designed to be retained inside the case to avoid disconnection of the communications.*

9.4.2 Replacing the Complete Relay

To remove the complete relay (active part and case) the entire wiring must be removed from the rear connector.

Before working at the rear of the relay isolate all current supplies to the MiCOM relay and ensure that the relay is no longer energized.

DANGER	**NEVER OPEN THE SECONDARY CIRCUIT OF A CURRENT TRANSFORMER SINCE THE HIGH VOLTAGE PRODUCED MAY BE LETHAL AND COULD DAMAGE INSULATION.**

Remove all wiring (communication, logic inputs, outputs, auxiliary voltage, current inputs). Disconnect the relay earth connection from the rear of the relay.

Caution	**If isolation transformers are not used between long communications wires, these should be handled as pilot wire circuits to avoid the risk of electric shock.**

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 upper and lower flaps are installed.

Withdraw the relay from the panel, rack, etc. taking care 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 and communications are replaced.

Once reinstallation is complete the relay should be re-commissioned using the instruction in sections 1 to 8 of this Commissioning and Maintenance Guide.

9.4.3 Changing the Battery

The MiCOM P521 has a battery to maintain recorded data and the correct time when the auxiliary voltage fails. Starting from Hardware B, disturbance, fault and event records are stored on a flash memory card that doesn't need to be backed up by a battery. Therefore battery in the front compartment of the relay are no longer needed. The battery compartment is fitted with a blanking cover. The data maintained include event, fault and disturbance records and the thermal state at the time of supply failure.

The battery is designed for a life of 10 years in standard atmospheric conditions.

"Battery backed RAM memory" message could be the result of a battery failure.

"Battery Fail" message is the result of a battery failure.

To replace the battery follow the following instructions.

- Open the lower flap on the front of the relay
- Gently extract the battery from its socket. If necessary, use a small screwdriver.
- Ensure that 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, ensure that the polarity markings on the battery agree with those adjacent to the socket.

Note *Only use a type 1/2 AA lithium battery with a nominal voltage of 3.6 V.*

- 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 lower flap on the front of the relay.
- 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.

9.4.4 Extracting the Rear Communications Board from the Relay

- Remove the two screws from under the top access panel on the front interface, followed by the two screws from under the bottom access panel.
- Utilizing the extractor cams located under the top and bottom access panels, extract the relay from the casing.
- Remove the 4 mounting screws at the rear of the case that are situated around the communications mounting plate.
- Pull the plate through to the front of the case taking care not to cause damage to the inside of the casing and the communications card.
- Insert the new communications card by carefully pushing the card from the front to the rear of the casing.
- Re-fit the 4 screws to securely hold the communications mounting plate in position.
- Reset the extractor cams to the normal flush state and insert the relay into the case, taking care to align the relay with the communications card connector.
- Re-fit the two screws under the top access panel on the front interface, followed by the two screws under the bottom access panel.

Note	*It is strongly recommended that the tests contained within sections 4.2.6 of this section be repeated once the communications interface has been changed.*

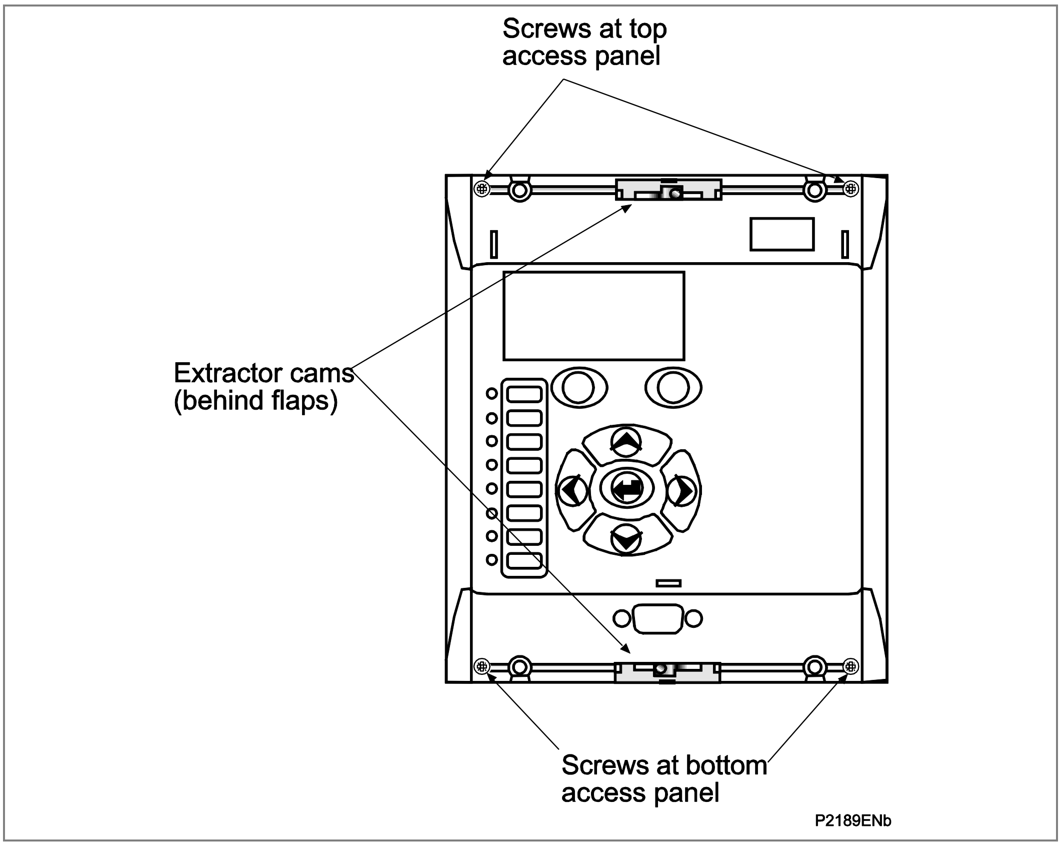

Figure 3 - Screw locations (front view)

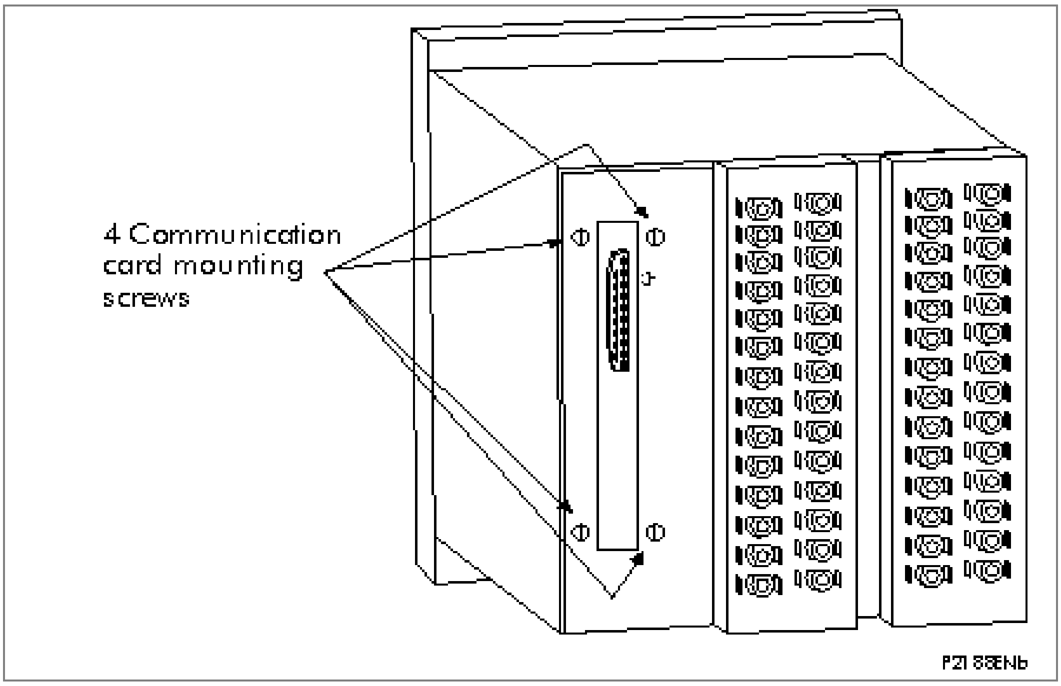

Figure 4 - Screw locations (back view)

9.5 Problem Solving

9.5.1 Password Lost or Not Accepted

Problem:

Password lost or not accepted

Cause:

The MiCOM P521 relay is supplied with the password set to AAAA. This password can be changed by the user (refer to OP PARAMETERS menu in the User Guide of this manual).

Action:

There is an additional unique recovery password associated with the relay which can be supplied by the factory or service agent, if given details of its serial number (under the upper flap of the front panel). With this serial number, contact your Schneider Electric local dealer or Schneider Electric After Sales Dept.

9.5.2 Communication

9.5.2.1 Values Measured Locally and Remotely

Problem:

The measurements noted remotely and locally (via EIA(RS)485 communication) differ.

Cause:

The values accessible on the front face via the Measurement menu are refreshed every second. Those fed back via the communication and accessible by the Schneider Electric setting software generally have variable refreshing frequencies. If the refreshing frequency of the supervision software differs from that of MiCOM P521 relay (1 s), there may be a difference between indicated values.

Action:

Adjust the frequency for refreshing the measurements of the supervision software or of the setting software to 1 second.

9.5.2.2 MiCOM Relay No Longer Responds

Problem:

No response from MiCOM P521 relay when asked by the supervision software without any communication fault message.

Cause:

Mainly, this type of problem is linked to an error in the MiCOM P521 communication parameters.

Action:

Check MiCOM P521 communication parameters (data rate, parity, etc.) are in accordance with the supervision settings.

Check MiCOM P521 network address.

Check that this address is not used by another device connected on the same LAN.

Check that the other devices on the same LAN answer to supervision requests.

9.5.2.3 A Remote Command is Not Taken into Account

Problem:

The communication between the relay and the PC is correct, but the relay does not accept any remote command or file downloading.

Cause:

Generally this is due to the fact that the relay is in a programming situation. This means that the password is active (password by on key pad).

Action:

Check that the password has not been set in the relay within the last 5 minutes.

Notes:

CONNECTION DIAGRAMS

CHAPTER 9

Date:	August 2017
Software version:	13
Hardware Suffix:	B
Connection diagram:	10P52101

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FIGURES

Notes:

1 CONNECTION DIAGRAMS

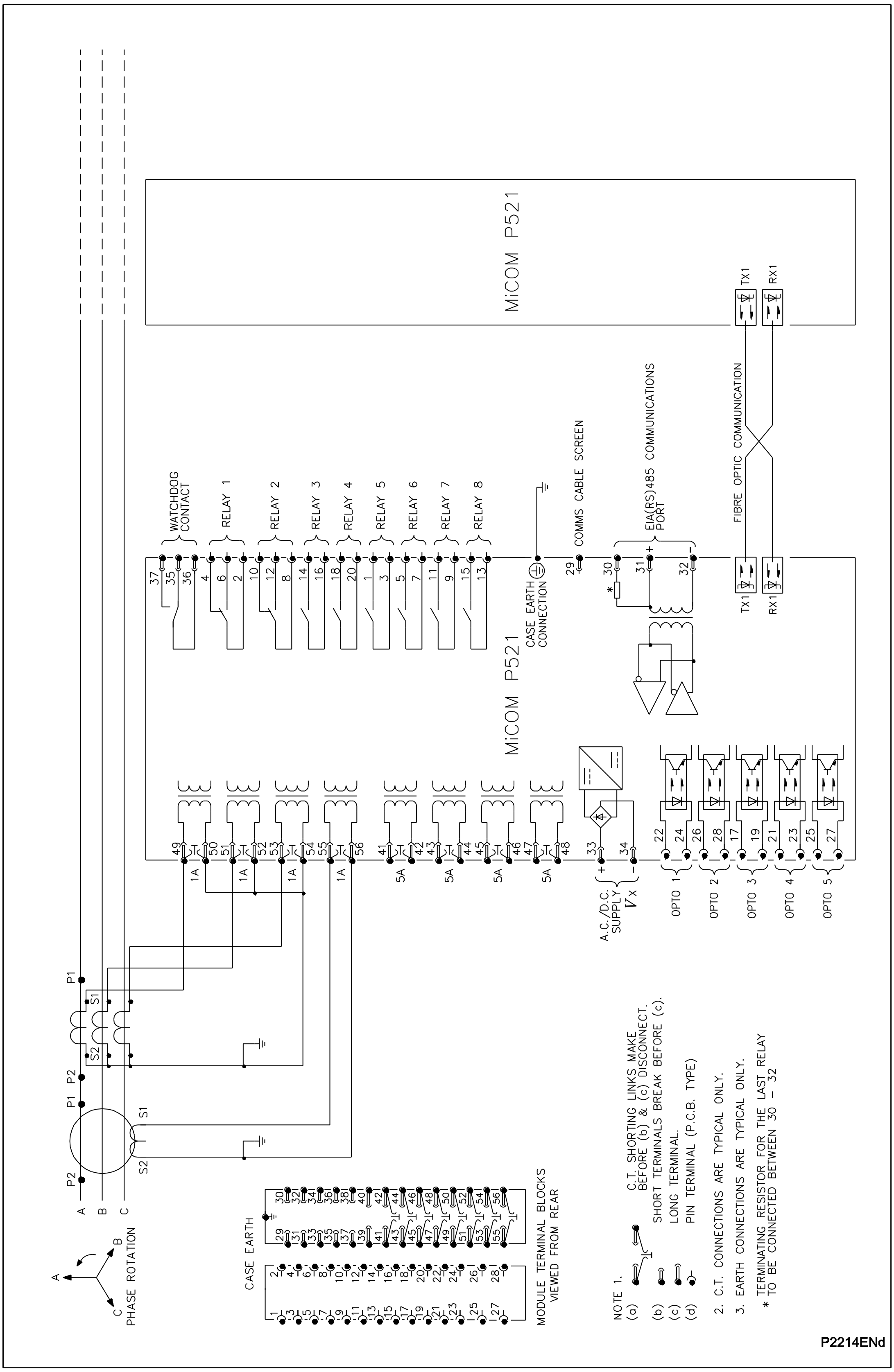

Figure 1 - External connections - with fiber optic communications

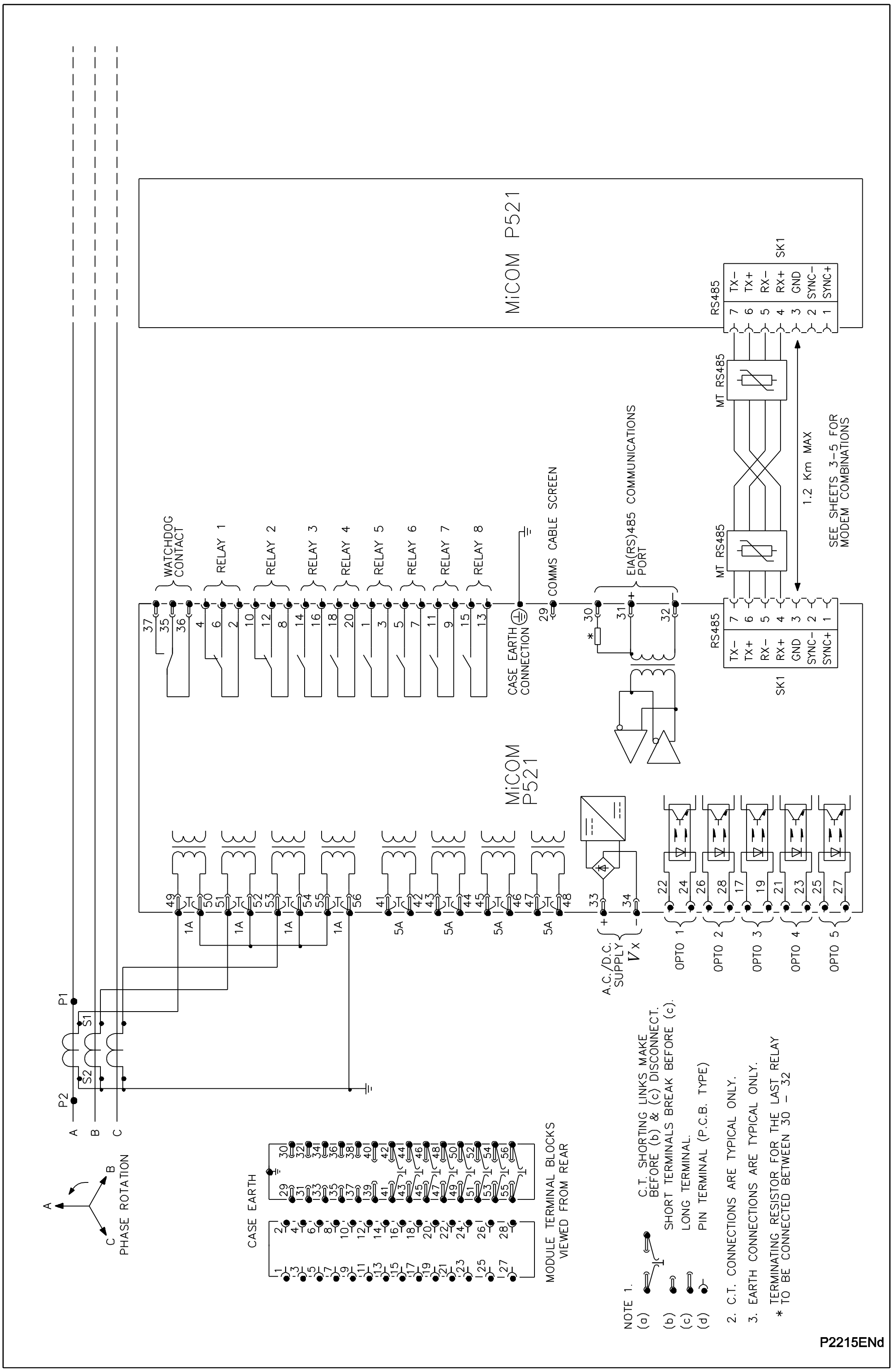

Figure 2 - External connections - with direct EIA(RS)485 communications

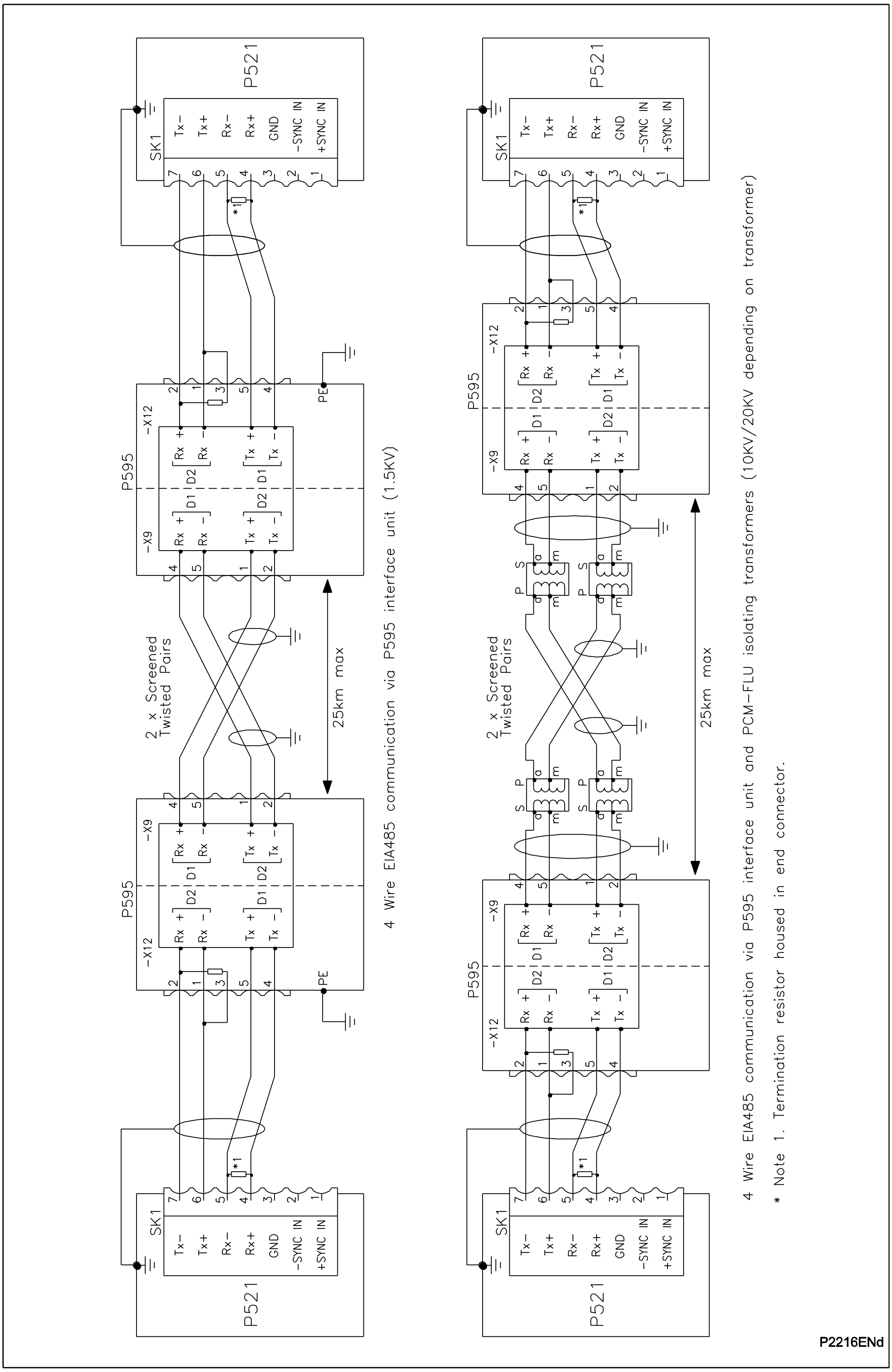

Figure 3 - P521 connection to P595 interface

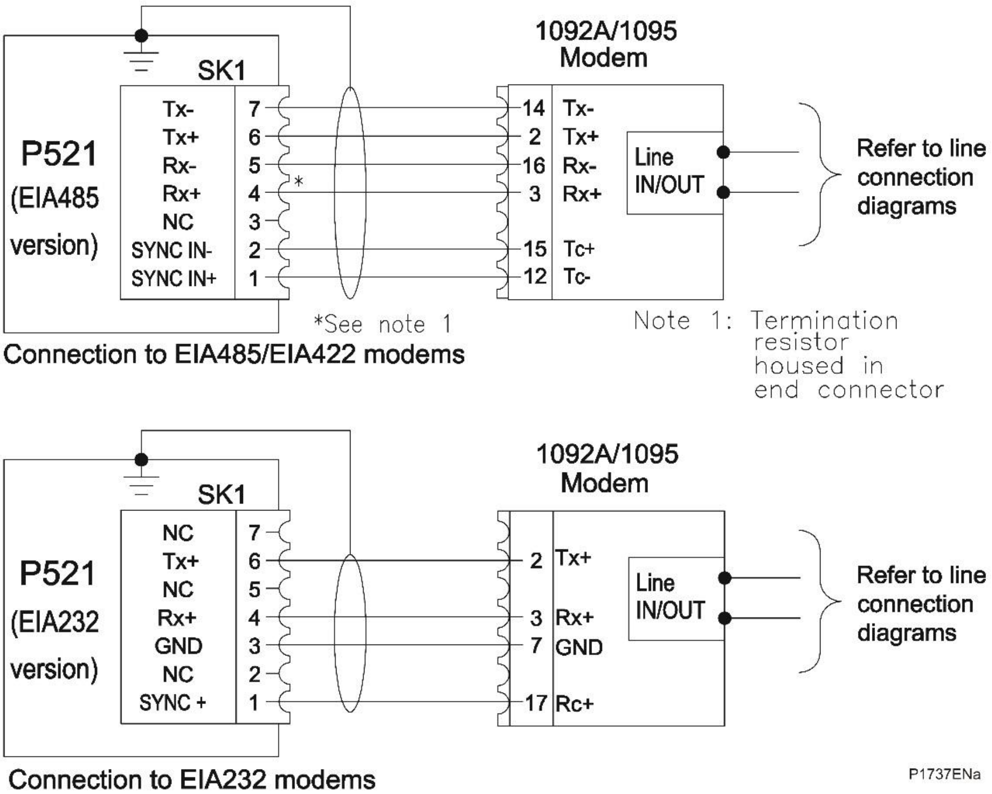

Figure 4 - P521 connection to baseband 1092A and mDSL 1095 modems (see also Figure 6)

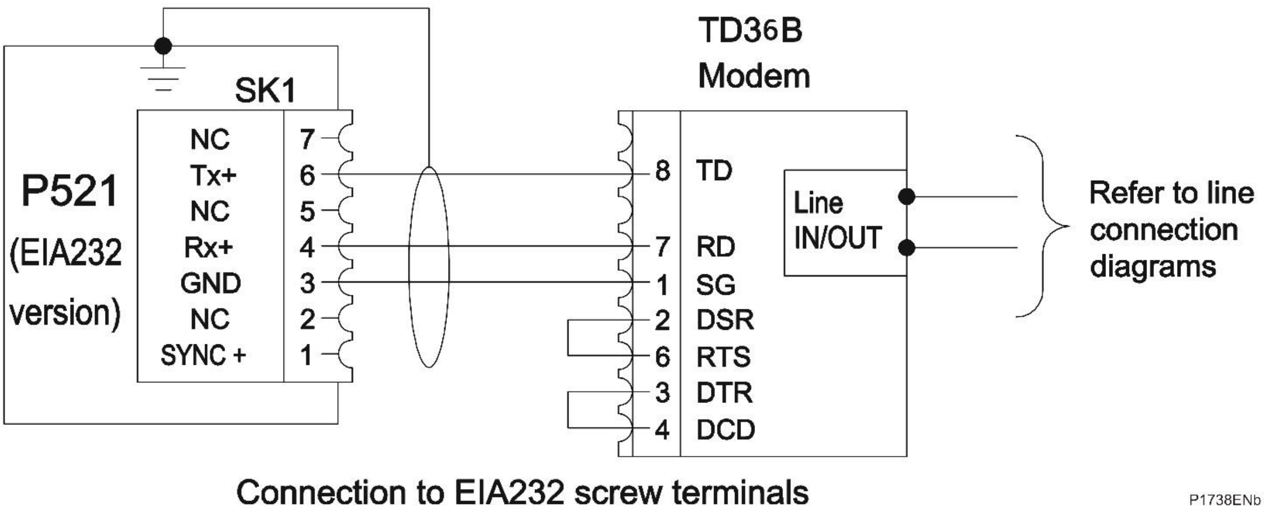

Figure 5 - P521 connection to Westermo TD36B modem (see also Figure 6)

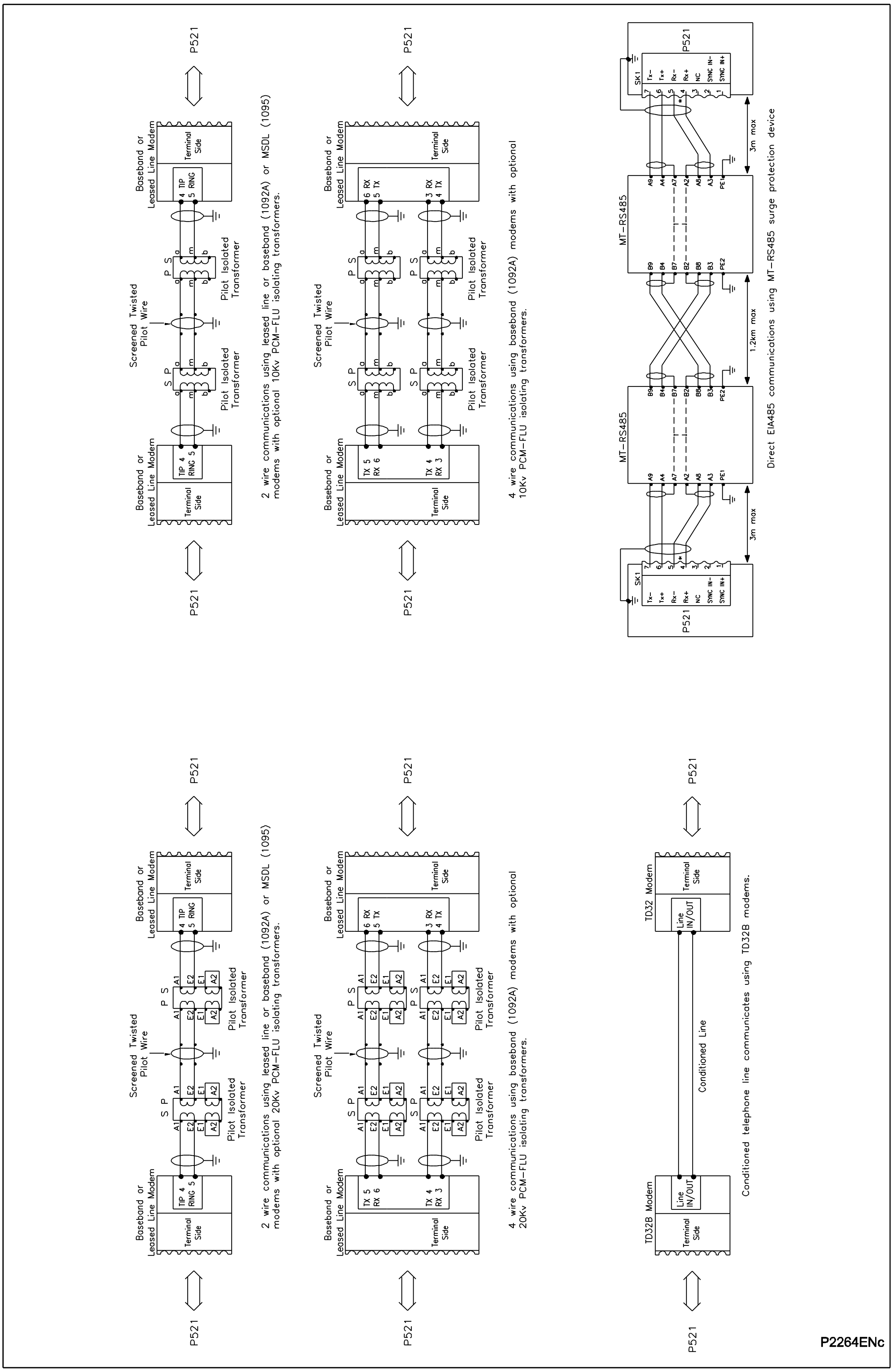

Figure 6 - Line connection diagrams

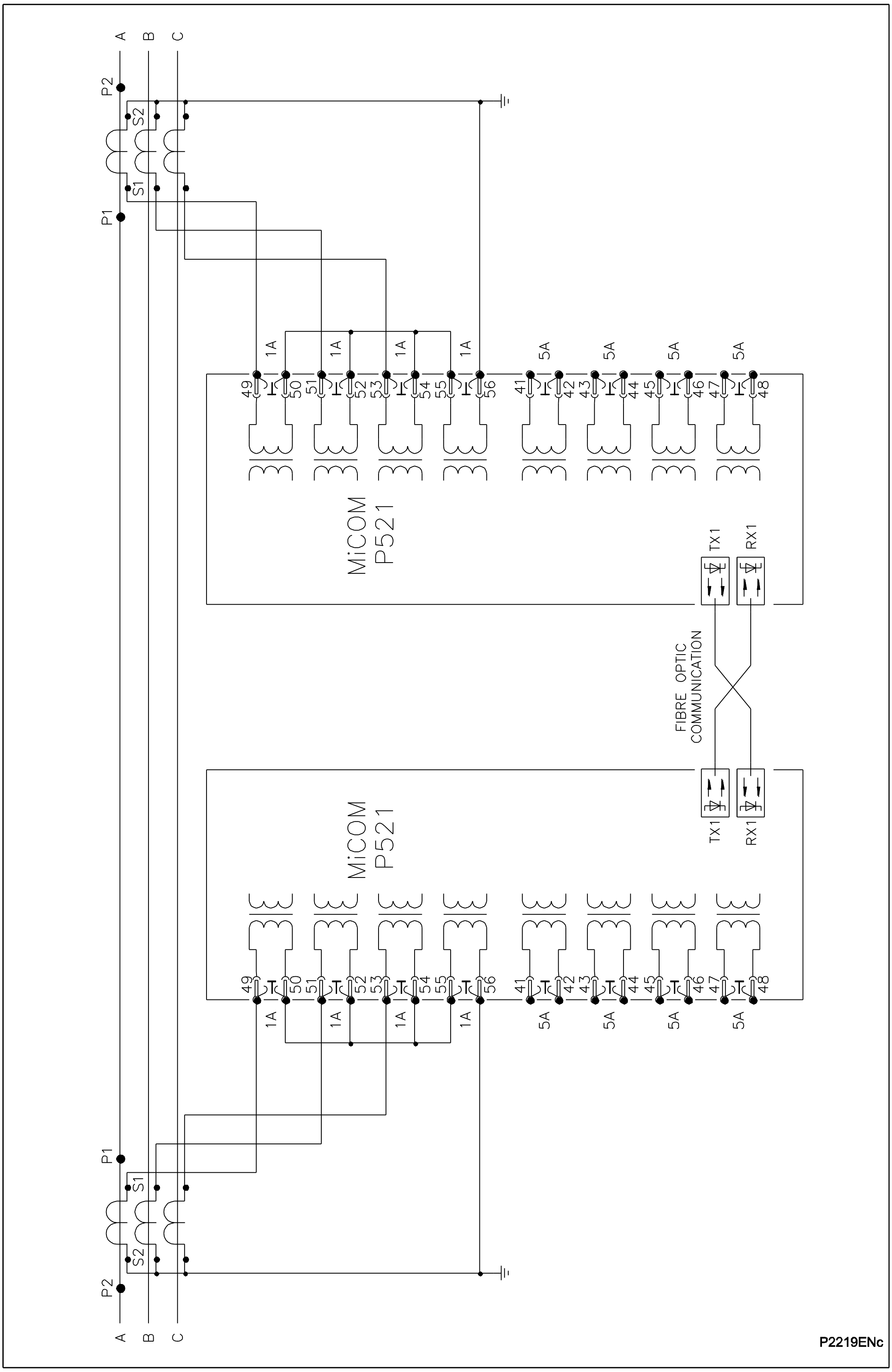

Figure 7 - P521 with residually connected CT's

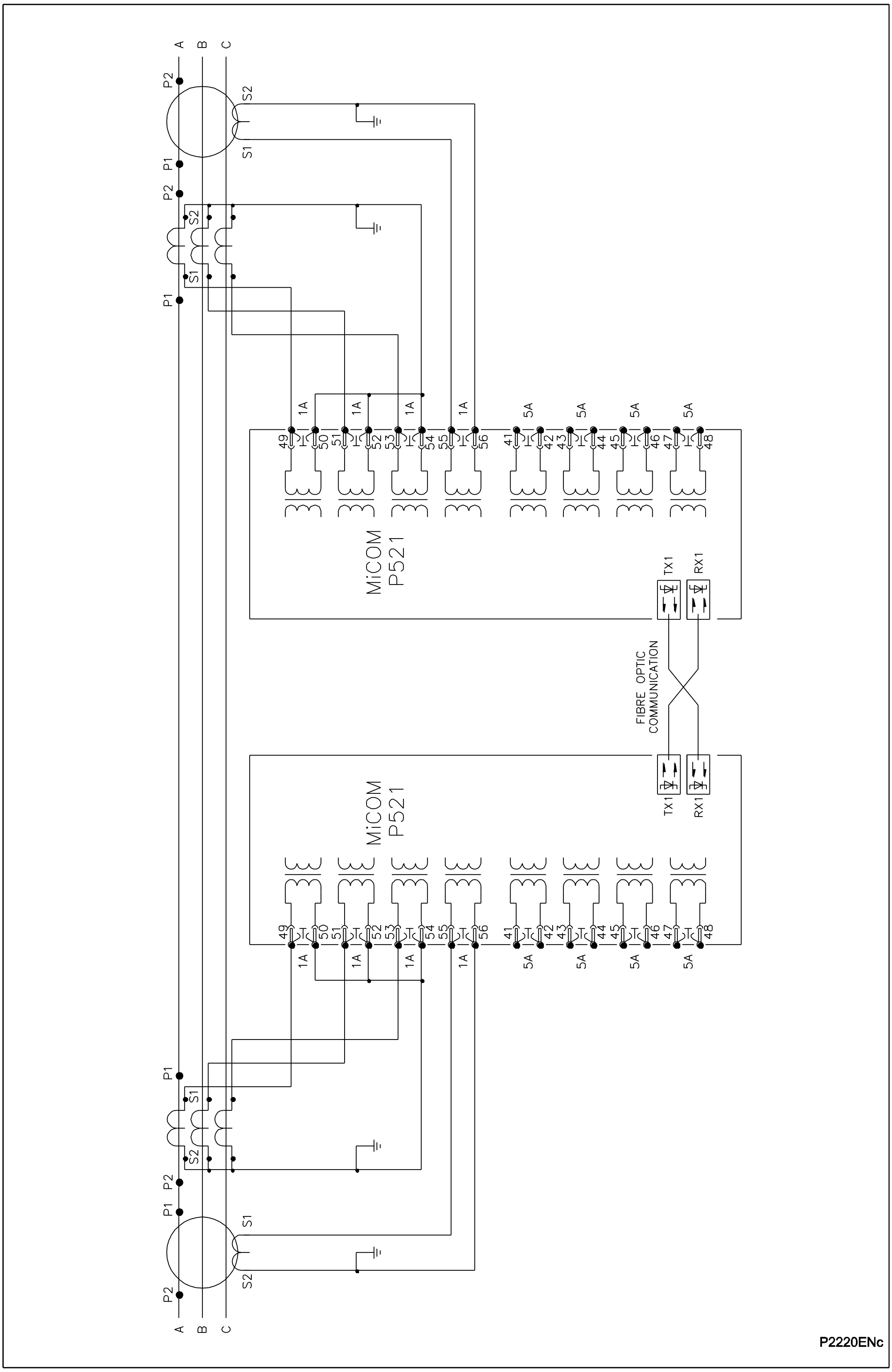

Figure 8 - P521 with core balanced CT's

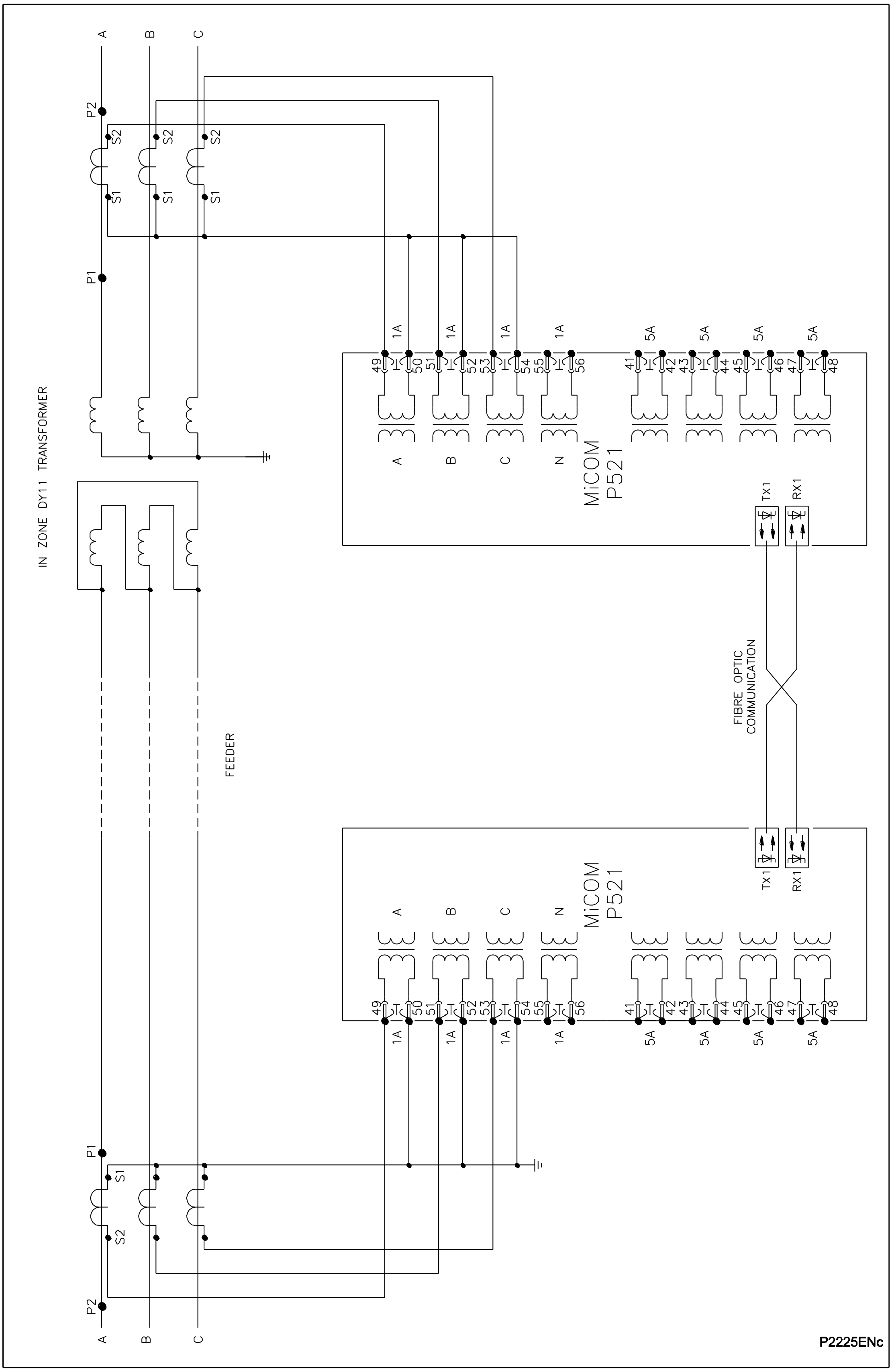

Figure 9 - P521 with DY11 in zone transformer

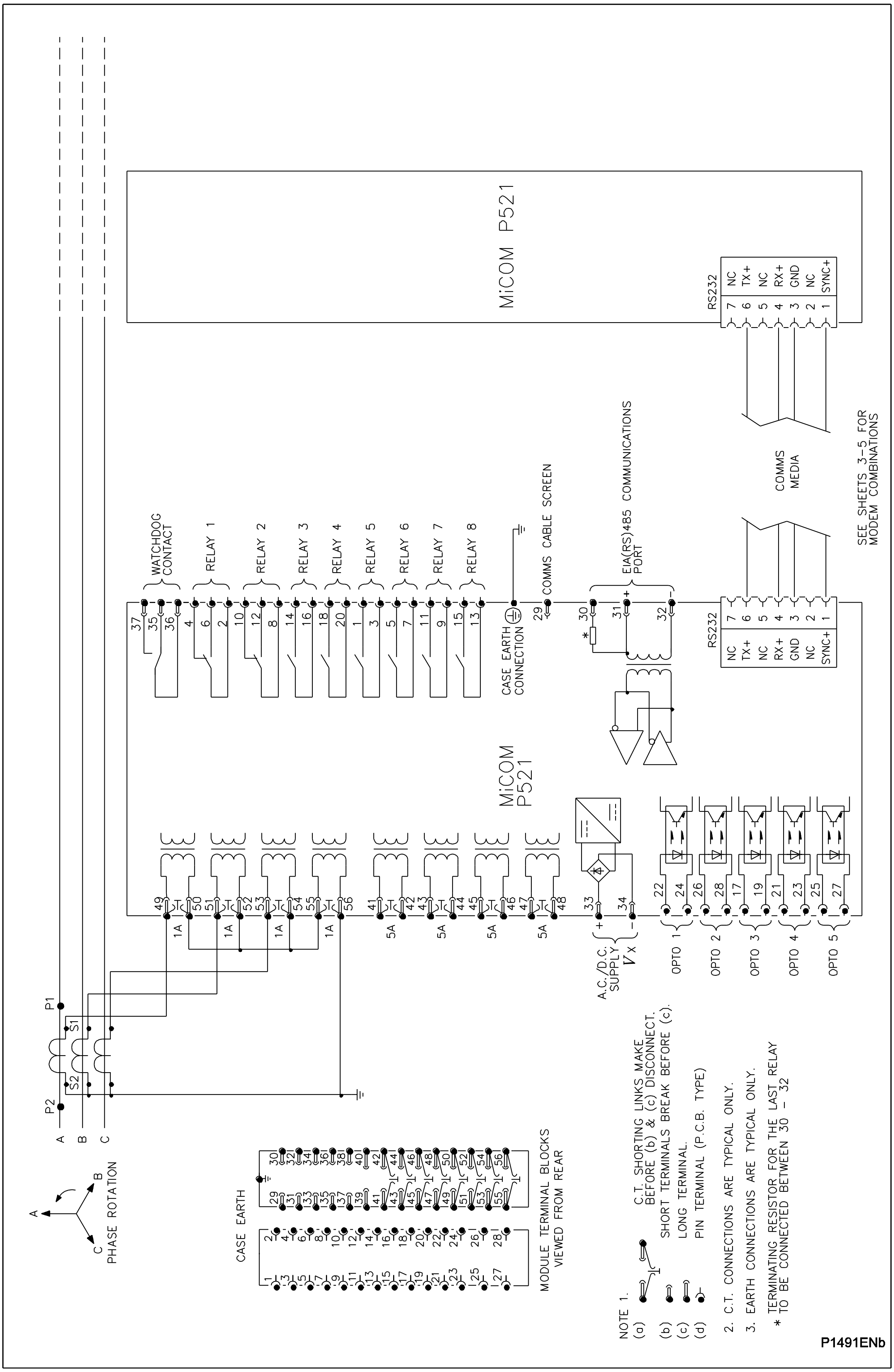

Figure 10 - External connections - with EIA(RS)232 communications

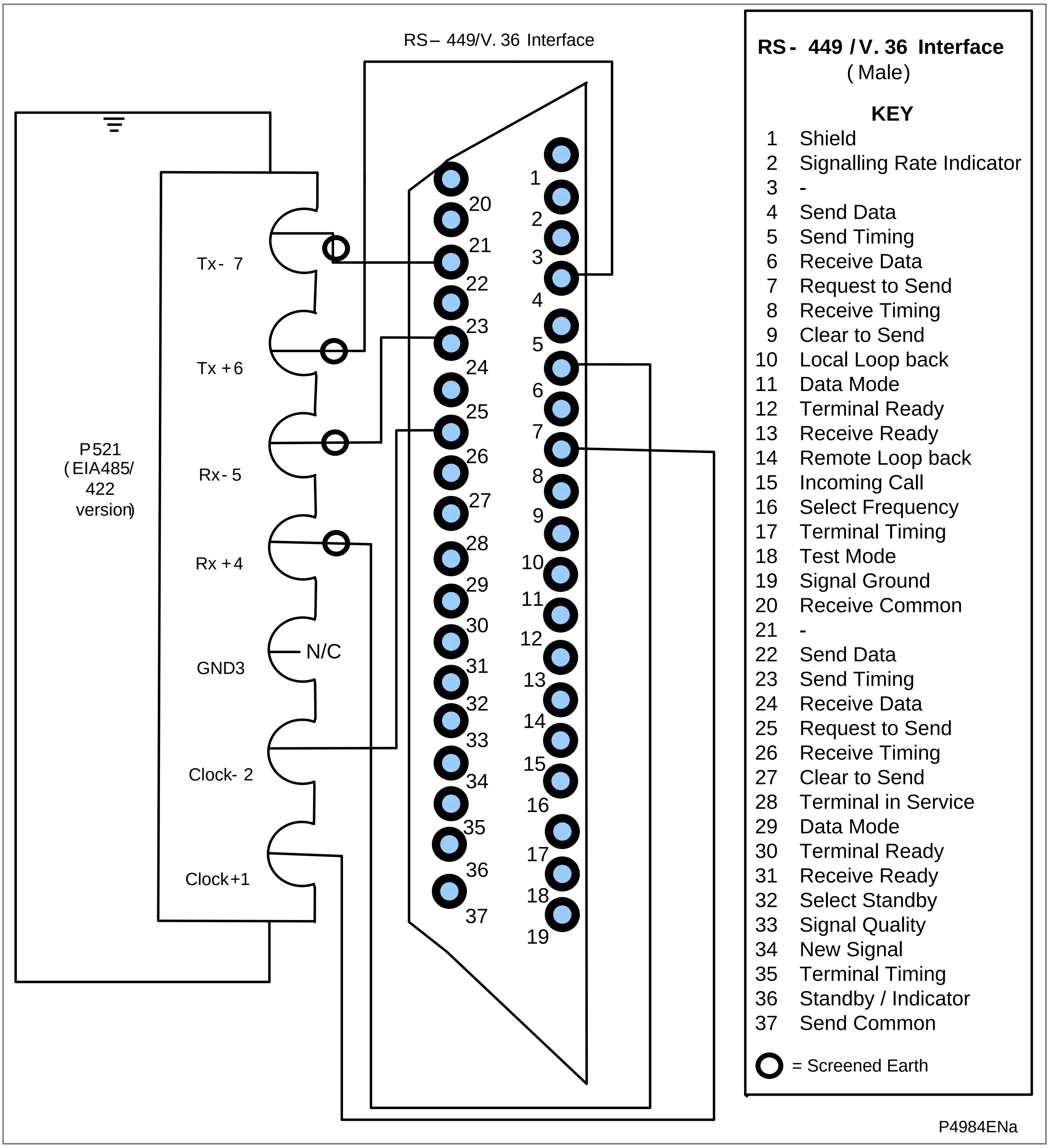

Figure 11 - P521 connection to Keymile Line Runner DTM modem

MODEM CONFIGURATION

CHAPTER 10

Date:	January 2012
Software version:	13
Hardware Suffix:	B
Connection diagram:	10P52101

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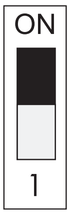
TABLES

FIGURES

1 INTRODUCTION

This chapter outlines the basic setting up procedure for leased line, baseband ‘campus’ and ‘NetLink’ mDSL modems, and P595 device. Although the setting up procedure is specific to these modems it is hoped that the setting principle could be used as a guide for modems of a similar design.

2 DEFINITIONS

Unconditioned pilot wires:	Twisted pair of metallic wire between 19 (0.9 mm) and 26 AWG (0.4 mm). Standard dial-up telephone circuits, leased circuits that run through signal equalization equipment or standard flat modular telephone cable are not acceptable.
Conditioned leased lines:	Leased circuits that run through signal equalization equipment using the standard flat modular telephone cable.
Modem:	Generic name for a converter of digital data to a format suitable for transmission over unconditioned pilot wires or conditioned leased lines.
Baud:	The number of data symbols transmitted every second.
DCE:	Data Communication Equipment i.e. modems, protocol converters and line drivers.
DTE:	Data Terminal Equipment i.e. PCs, terminals and protection relays.
Handshaking:	Confirmation and status signals sent between communicating devices in order to check the data stream. There are two general types, hardware (RTS/CTS) and software (XON/XOFF).
TD:	Transmitted data. Data going from DTE to DCE.
RD:	Received data. Data going from DCE to DTE.
RTS:	Ready To Send. Hardware handshake generated by the DTE to determine if the DCE is ready to receive data. Expected response is from the CTS line.
CTS:	Clear To Send. Hardware handshake generated by the DCE in response to a RTS signal.
DSR:	Data Set Ready. A signal from the DCE used to indicate that it is powered and useable.
DTR:	Data Terminal Ready. A signal from the DTE showing it is powered and ready.
DCD:	Data Carrier Detect. A signal from the DCE showing that a carrier is present and the line is ready for data transmission.
	Switch shown in ON position.

3 LEASED LINE MODEM WESTERMO TD32

The simplest way to set the modem is to use the DIP switch sets. There are five DIP switch sets in total and each sets a different aspect of the modem operation.

Non defined switches are to be set to the off position.

3.1 DIP Switch Set “S1”

S1 sets the operating mode of the modem.

3.1.1 Operating Modes

There are three modem operating modes to choose from. These are:

1. Dial up
2. Leased line answering
3. Leased line originating

For a leased line one modem must be in originate mode (mode 3) to initiate communication and the other in answer mode (mode 2) to wait for communication to be initialized by the originate modem. On standard telephone networks (i.e. conditioned leased lines) both modems should be set to dial-up mode. See switch settings below:

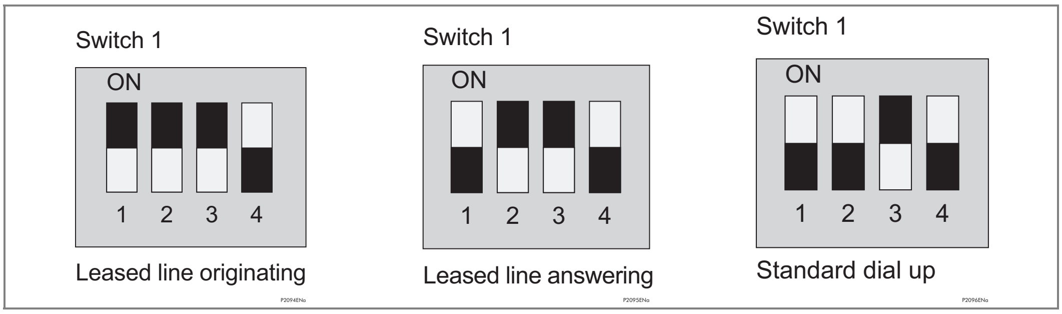


Figure 1 - Standard dial up

3.2 DIP Switch Set “S2”

S2 sets the type of communication between the DCE and the DTE. In this case the modem is the DCE and the MICOM P521 is the DTE.

3.2.1 DCE to DTE Communication Types

There is a choice of 5 communication types. These are:

1. Asynchronous
2. Synchronous using the clock from the P521
3. Synchronous using a clock generated from the local modem
4. Synchronous using a clock recovered from the local modem via the line
5. DTR/DSR disconnected

The P521 electrical protection communications port conforms to 3-wire EIA(RS)232 or 4-wire EIA(RS)485. Consequently the modem should be set as asynchronous with DTR/DSR disconnected.

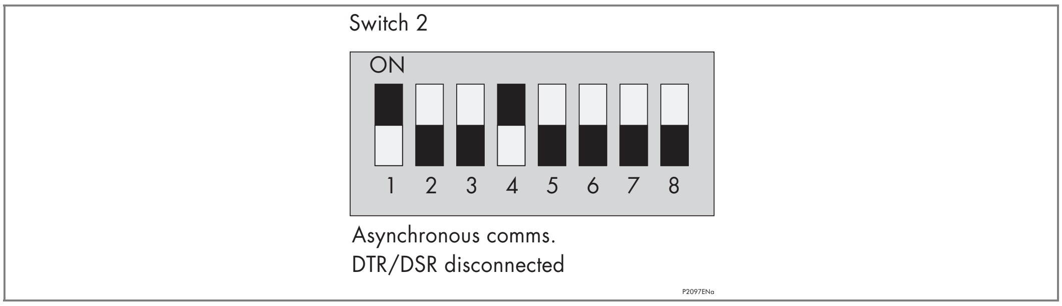


Figure 2 - Asynchronous comms DTR/DSR disconnected

3.3 DIP Switch Set “S3”

S3 is the setting switch that indicates the type of line being used between the modems.

3.3.1 DCE to DCE Communication Hardware

Three line-type options are available. These are:

1. 4-wire connection
2. 2-wire connection
3. Flow control

The choice between 4- and 2-wire connection depends on whether one or two twisted pairs of conductors are available for use between the modems.

For all P521 applications no flow control is required, so the flow control should always be turned off. Flow control provides handshaking between the DCE and the DTE, but this also requires additional signal lines on top of the usual 2 or 4.

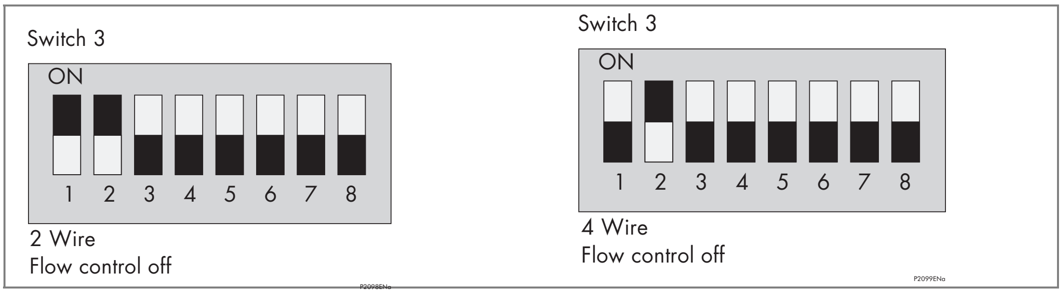


Figure 3 - Flow control off – 2- or 4-wire

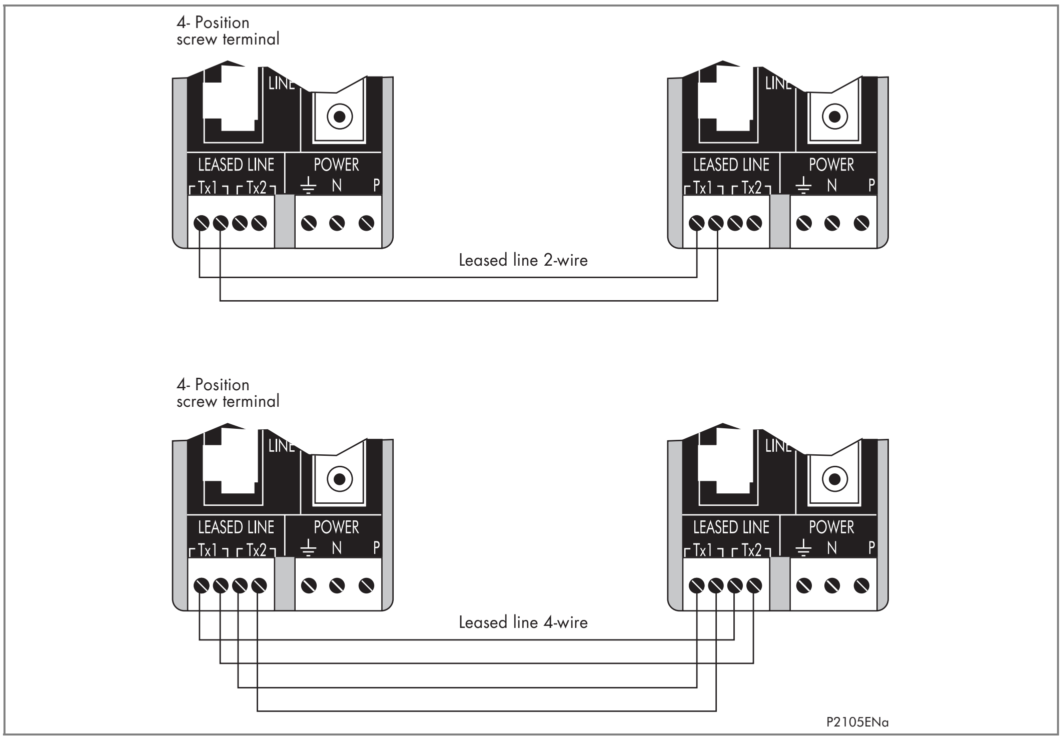


Figure 4 - Typical TD-32 line connections - 1

3.4 DIP Switch Set "S4"

S4 sets the serial speed (input to modem) and format of the data between the modem and the relay.

For optimum performance the TD32 modem should be set at 9.6 kbits/s in direct mode 8 data bits, 1 stop bit and no parity (see switch setting below). Higher baud rates may be available on other modems, however, it is essential that the data rate is common throughout the communications link; i.e. the relay data rate must be the same as the serial speed of the modem and the line modulation (output from modem).

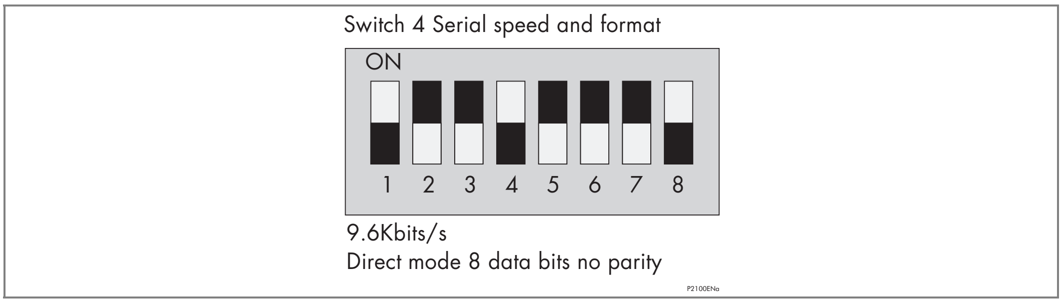


Figure 5 - 9.6 kbits/s Direct mode data bits no parity

3.5 DIP Switch Set "S5"

S5 sets the line modulation (output from modem) used between the modems.

For optimum performance the TD32 modem should be set to V.32 bis 9.6 kbits/s.

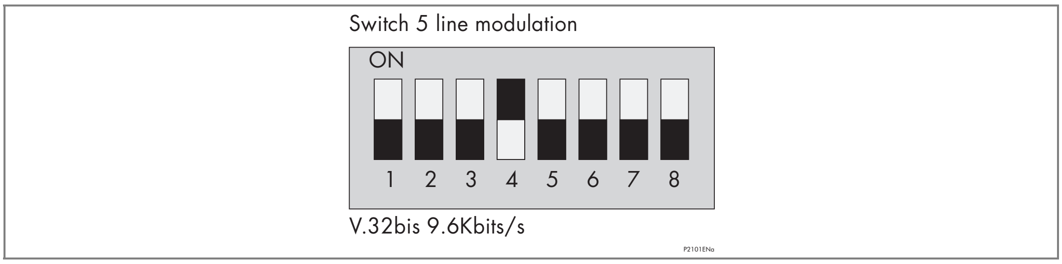


Figure 6 - V.32 bis 9.6 kbits/s line modulation

3.5.1 Control Line Pull-Up

Since the modem will not be making use of the control lines they need to be forced high so they are permanently enabled. This is done by connecting RTS to DSR and DCD to DTR using the connector block at the top of the modem.

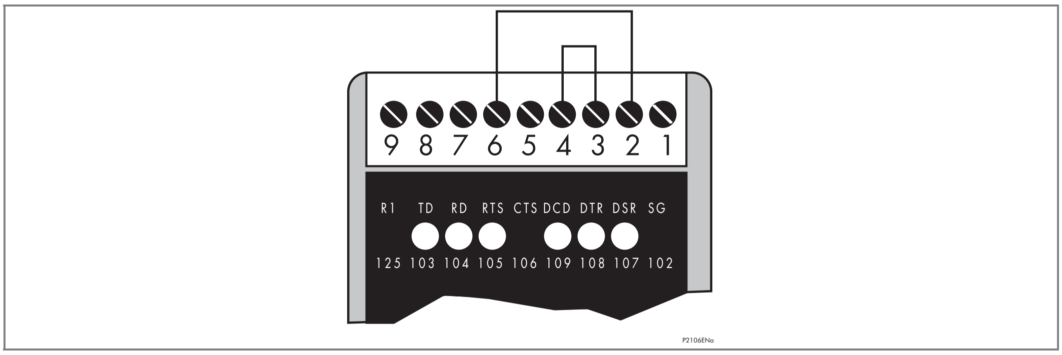


Figure 7 - Using the top connector block RTS to DSR and DCS to DTR

3.6 Line Requirements

The maximum transmission distance depends on the attenuation of the line. The maximum value of attenuation is 30 dBm. To have a good error rate it is recommended to keep the attenuation under 20 dBm which is approximately 20 km.

3.7 Propagation Delay

Typical propagation delay = 24.3 ms.

4 TD-36 MODEM

The TD-32 modem is obsolete and is replaced by TD-36 modem. The setting of DIP switches of TD-36 are shown in Table 1:

Calling Modem				Answering Modem			
DIP Switch		Switch Position	Setting Description	DIP Switch		Switch Position	Setting Description
S1	1	On	19.2 K	S1	1	On	19.2 K
	2	On			2	On	
	3	On			3	On	
	4	Off			4	Off	
	5	On	8N 1S		5	On	8N 1S
	6	On			6	On	
	7	Off			7	Off	
	8	Off			8	Off	
S2	1	On	Leased Line Calling	S2	1	Off	Leased Line Answering
	2	On			2	On	
	3	Off	RS232		3	Off	RS232
	4	On	RS-422/485 4W		4	On	RS-422/485 4W
	5	On	4 Wire Leased Line		5	On	4 Wire Leased Line
	6	Off	Back Up of Leased Line Disabled		6	Off	Back Up of Leased Line Disabled
	7	Off	PSTN Answering		7	Off	PSTN Answering
	8	Off	Use Stored Values		8	Off	Use Stored Values
S3	1	Off	Use Stored Values	S3	1	Off	Use Stored Values
	2	Off	Use Stored Values		2	Off	Use Stored Values
	3	On	Reliable Mode Enabled		3	On	Reliable Mode Enabled
	4	Off			4	Off	
	5	Off	Use Stored Values		5	Off	Use Stored Values
	6	Off	Use Stored Values		6	Off	Use Stored Values
	7	On	Termination Receiver in 4 Wire Mode		7	On	Termination Receiver in 4 Wire Mode
	8	Off			8	Off	
S4	1	Off	Use Stored Values	S4	1	Off	Use Stored Values
	2	Off	Use Stored Values		2	Off	Use Stored Values
	3	On	Data Compression Disabled		3	On	Data Compression Disabled
	4	Off	Use Stored Values		4	Off	Use Stored Values
	5	On	Automatic Line Speed		5	On	Automatic Line Speed
	6	On			6	On	
	7	On			7	On	
	8	On			8	On	
S5	1	On	Termination of R in 4 Wire	S5	1	On	Termination of R in 4 Wire
	2	On			2	On	
	3	Off			3	Off	
	4	Off			4	Off	

Table 1 - TD-36 DIP switches

5 "NETLINK" 1095 MDSL MODEM

The simplest way to set the modem is to use the DIP switch sets. There are three DIP switch sets in total but only DIP switch sets S2 and S3 need to be set, as all of the switches on DIP switch set S1 are reserved for future use and are to be set to the On position.

For DIP switch set S3, non defined switches are to be set to the off position.

5.1 DIP Switch Set "S2"

S2-6 and S2-7 control the clock configuration for the data transmission. One modem must be set as Originating, with Internal clock mode (transmit clock generated internally), and the other modem must be set as Receive, with Receive Recover clock mode (clock recovered from the received data).

Clock Mode	Description	S2-6	S2-7
Internal	Transmit clock generated internally	On	On
External	Transmit clock derived from the P521	Off	On
Receive Recover	Transmit clock derived from the line	On	Off
Disabled	Reserved	Off	Off

Example:

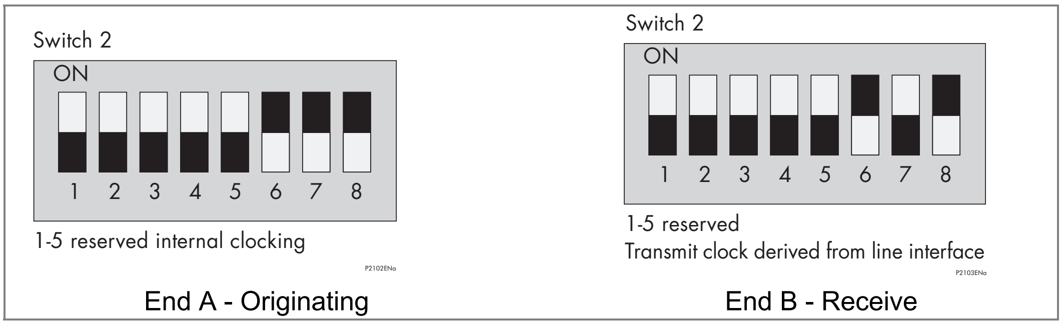


Figure 8 - Clock configuration

5.2 DIP Switch Set "S3"

S3 controls the data rate between the modem and the P521. The most appropriate rate for this is 64 kbits/s. All other data rates are unsuitable for the P521.

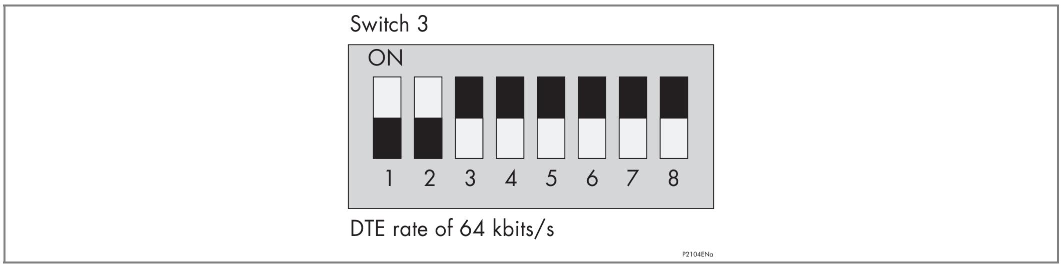


Figure 9 - DTE rate of 64 kbits/s

5.3 Line Requirements

Transmission Distance			
		No Cross Talk	
Link Rate (kbps)	DTE Rates	26 AWG (0.4 mm)	24 AWG (0.5 mm)
		km	km
144	64	6.6	9.4

Table 2 - Transmission distances

5.4 Propagation Delay

Typical propagation delay = 2.3 ms.

6 2-WIRE “CAMPUS” 1092A DRIVER MODEM

The simplest way to set the modem is to use the DIP switch sets. There are 2 DIP switch sets in total.

Non-defined switches are to be set to the off position.

6.1 DIP Switch Set “S1”

S1-1 and S1-2 control the data rate between the modem and the P521. The most appropriate rate for this is 64 kbits/s.

Sync Data Rate	S1-1	S1-2
56 kbps	Off	On
64 kbps	On	Off

Table 3 - Sync data rates

S1-6 and S1-7 control the clock configuration for the data transmission. One modem must be set as Originating, with Internal clock mode (transmit clock generated internally), and the other modem must be set as Receive, with Receive Recover clock mode (clock recovered from the received data).

Clock Mode	Description	S1-6	S1-7
Internal	Transmit clock generated internally	On	On
External	Transmit clock derived from the P521	Off	On
Receive Recover	Transmit clock derived from the line	On	Off
Disabled	Reserved	Off	Off

Table 4 - Clock modes

6.2 DIP Switch Set “S2”

S2-4 selects either 2-wire or 4-wire operation. For 2-wire operation, it should be set Off.

S2-6 allows remote loopback tests to be performed

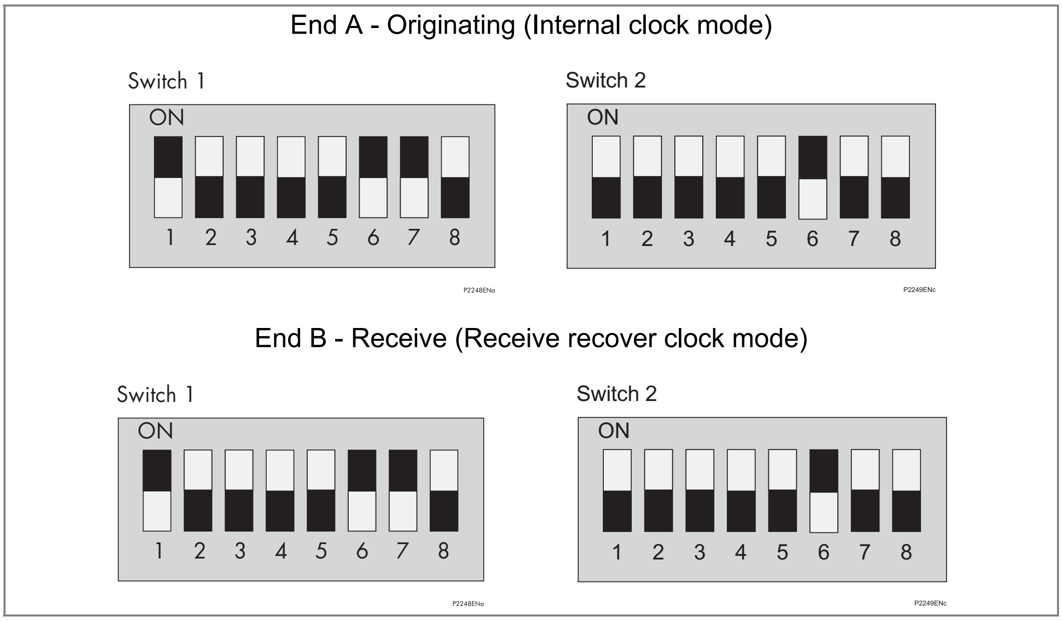


Figure 10 - Modem setting switches

6.3 Line Requirements

Wire Gauge	Wire Diameter	Distance
19 AWG	0.9 mm	17.2 km
22 AWG	0.64 mm	11.5 km
24 AWG	0.5 mm	8 km
26 AWG	0.4 mm	5.5 km

Table 5 - Line requirements

6.4 Relay Settings for 2-Wire 1092A Modem

Relay Setting	Value
Protocol	NRZ
Data Rate	64 K (as recommended above)
Clock Source CH1	External

Table 6 - Relay settings for 2-wire 1092A modem

6.5 Propagation Delay

Typical propagation delay = 1.02 ms.

7 4-WIRE “CAMPUS” 1092A DRIVER MODEM

The simplest way to set the modem is to use the DIP switch sets. There are 2 DIP switch sets in total.

Non defined switches are to be set to the off position.

7.1 DIP Switch Set “S1”

S1-1 and S1-2 control the data rate between the modem and the P521. The most appropriate rate for this is 64kbits/s.

Sync Data Rate	S1-1	S1-2
56 kbps	Off	On
64 kbps	On	Off

Table 7 - Sync data rates

S1-6 and S1-7 control the clock configuration for the data transmission. One modem must be set as Originating, with Internal clock mode (transmit clock generated internally), and the other modem must be set as Receive, with Receive Recover clock mode (clock recovered from the received data).

Clock Mode	Description	S1-6	S1-7
Internal	Transmit clock generated internally	On	On
External	Transmit clock derived from the P521	Off	On
Receive Recover	Transmit clock derived from the line	On	Off
Disabled	Reserved	Off	Off

Table 8 - Clock modes

7.2 DIP Switch Set “S2”

S2-4 selects either 2-wire or 4-wire operation. For 4-wire operation, it should be set On.

S2-6 allows remote loopback tests to be performed

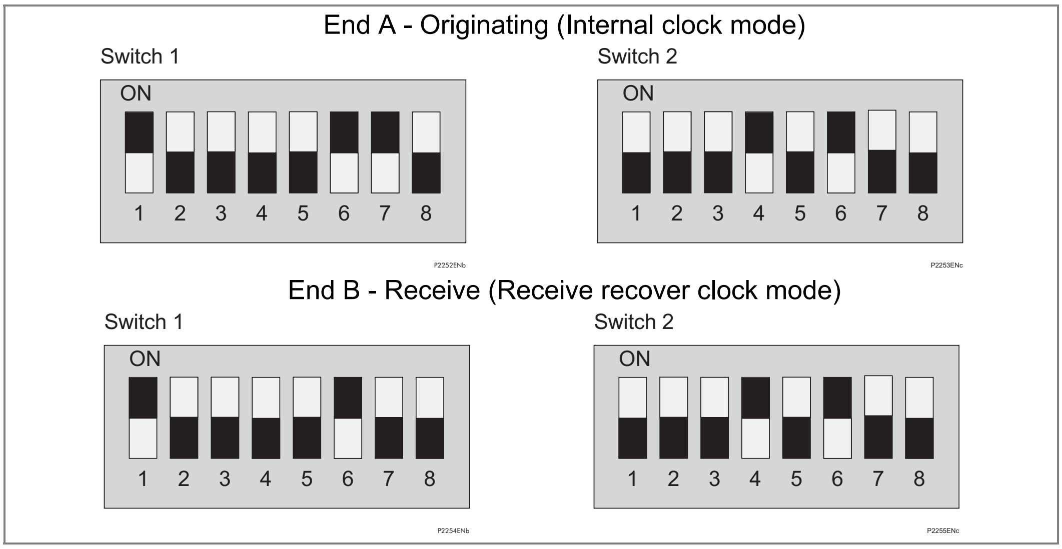


Figure 11 - Modem setting switches

7.3 Line Requirements

Wire Gauge	Wire Diameter	Distance
19 AWG	0.9 mm	18.2 km
22 AWG	0.64 mm	12.1 km
24 AWG	0.5 mm	8.5 km
26 AWG	0.4 mm	5.7 km

Table 9 - Line requirements

7.4 Relay Settings for 4 Wire 1092A Modem

Relay Setting	Value
Protocol	NRZ
Data Rate	64 K (as recommended above)
Clock Source CH1	External

Table 10 - Relay settings

7.5 Propagation Delay

Typical propagation delay = 1.02 ms.

8 LINERUNNER DTM MODEM WITH V36 INTERFACE

The “Campus” 1092A modem from Patton is obsolete and is replaced by LineRunner DTM modem with V36 interface from Keymile. The EIA(RS)485 communication interface of P521 relay should be chosen to work with this modem.

8.1 Connection between Relay and Modem

The connection between P521 and modem is listed below:

P521: Phoenix Contact KGG-MC 1,5/7 Connector	DTM Modem: V.36 (37 Way Male D-type) Connector
Pin 7 : TX -	Pin 22 : Send Data -
Pin 6 : TX +	Pin 4 : Send Data +
Pin 5 : RX -	Pin 24 : Receive Data -
Pin 4 : RX +	Pin 6 : Receive Data +
Pin 2: Receive Clock -	Pin 26 : Receive Timing -
Pin 2: Receive Clock +	Pin 8 : Receive Timing +
Note *All other pins not specified above are not connected.*	

Table 11 - Connection between P521 and modem

8.2 Setting of Modem

The modems come with setting software ASMOS on a CD. The following settings need changing from the default to make them work.

Local Modem Setting:

User Interface -> General Tab -> User Interface Mode : V.36 Sub Bit Rates

User Interface -> General Tab -> XV Interface : Port Enabled

User Interface -> V.36 Config Tab ->User Data Rate : 1x 64Kbit/s

User Interface -> V.36 Config Tab ->Clock Mode : Intern

User Interface -> V.36 Config Tab ->Edge Select : Rising

User Interface -> V.36 Config Tab ->Sub rate Configuration -> Mode (Sub Rate Transmission) : Off (Synchronous)

User Interface -> V.36 Config Tab ->Control Flow -> Request to send : Forced to 1

User Interface -> V.36 Config Tab ->Control Flow -> Data Set Ready : Forced to 1

User Interface -> V.36 Config Tab ->Control Flow -> Data Channel Received : Forced to 1

Line Interface-> General Tab-> Port Pair Mode : 1 Pair

Line Interface-> General Tab-> Span Config ->Min Line Rate: 32x64 K +8 K

Line Interface-> General Tab-> Span Config ->Max Line Rate: 32x64 K +8 K

Remote Modem Settings:

User Interface -> General Tab -> User Interface Mode : V.36 Sub Bit Rates

User Interface -> General Tab -> XV Interface : Port Enabled

User Interface -> V.36 Config Tab ->Edge Select : Rising

User Interface -> V.36 Config Tab ->Control Flow -> Request to send : Forced to 1

User Interface -> V.36 Config Tab ->Control Flow -> Data Set Ready : Forced to 1

User Interface -> V.36 Config Tab ->Control Flow -> Data Channel Received : Forced to 1

9 P595

See separate P595 manual (P595/EN M).

9.1 Propagation Delay

Typical propagation delay = 1.08 ms.

10 WIRE PARAMETERS

Wire Gauge	Capacitance	Resistance
19 AWG	51.5 nF/km	53.45 Ω/km
22 AWG	51.5 nF/km	106.96 Ω/km
24 AWG	51.5 nF/km	169.46 Ω/km
26 AWG	51.5 nF/km	273.86 Ω/km

Table 12 - Wire gauge, capacitance and resistance

Notes:

ACCESSORIES

CHAPTER 11

Date:	January 2012
Software version:	13
Hardware Suffix:	B
Connection diagram:	10P52101

CONTENTS

TABLES

FIGURES

1 INTRODUCTION

This chapter contains technical data for the MT-RS485 surge protection device and the PCM-FLÜ isolating transformers. For information regarding the P59x interface units refer to publication P59x_en_0814b. For information regarding the P595 Interface Device, refer to manual P595/EN M.

2 ACCESSORIES ORDER CODES

Table 1 contains ordering details for all accessories:

Description	Order Code
MT-RS485 Surge Protection Module	MT-RS485
P595 Interface Device	
EIA485 interface (to P521)	P5951510A
850 nm fiber interface (to P521)	P5951540A
"Campus" 1092A baseband modem (Obsolete)	
48 VDC power supply	MODEM1092
AC/DC power supply	MODEM1092/A/B/UI
Option 1: For auxiliary voltages within 38 -60VDC	
Keymile Line Runner DTM modem, DC38…60V	37853600
V36 interface, D-Sub37	37853945
LR DTM Installation Set, LineRunner ASMOS Management Software, LCT-cable, Customer documentation, LineRunner CD	37853090
Option 2: For auxiliary voltages within 88 -264VAC	
Keymile Line Runner DTM modem, AC88…264 V	37853805
V36 interface, D-Sub37	37853945
LR DTM Installation Set, LineRunner ASMOS Management Software, LCT-cable, Customer documentation, LineRunner CD	37853090
Power Cord for DTM plug Europe for AC DTM units (optional)	37125702
Power Cord for DTM plug UK for AC DTM units (optional)	37125800
Isolating Transformer	
10 kV	PCM-FLU10
20 kV	PCM-FLU20
P520L Loopback Test Box	VA0041010
Interface card of P521 (for spare/upgrade)	
EIA232	GN0230002
EIA485	GN0230010
850 nm multi-mode fiber	GN0230004
1300 nm multi-mode fiber	GN0230006
1300 nm single-mode fiber	GN0230008

Note *The P595 Interface Device is identical to the Schneider Electric PZ511 interface except that the P595 has accessible setting switches. The switch settings are detailed in the P595 Interface Device manual, P595/EN M.*

Table 1 - Ordering details for accessories

3 MT-RS485 SURGE PROTECTION DEVICE

3.1 Interface Details

3.1.1 Transmission Rate

Maximum baud rate of 64 kbps.

3.1.2 Transmission Method

Half or full duplex.

3.1.3 Nominal Discharge Current

$I_{d,nom}$ (8/20 µs) : 10 kA.

3.1.4 Output Voltage Limiting

At 1kV/µs : <22 V (sym./asym. [GND]).

<650 V (asym. [PE]).

3.1.5 Response Time

tr : <1 ns (sym./asym. [GND]).

<100 ns (asym. [PE]).

3.2 Environmental Conditions

3.2.1 Temperature range

Operating Temperature : -20°C to +60°C or -4°F to 140°F.

3.2.2 Enclosure protection

IP20 according to DIN VDE 0470 and EN 60529 or IEC 529.

3.3 Mounting and Connection

3.3.1 Weight

Approximately 150g.

3.3.2 Case Design

Suitable for installation on a top-hat rail per DIN EN 50022.

3.3.3 Case Dimensions

50 mm x 55 mm x 75 mm (W x H x D).

3.3.4 Installation Position

Vertical ±180°.

3.3.5 Terminations

Threaded terminal ends M3.

Self-centering, with wire protection for conductor cross sections up to 2.5 mm^2.

4 PCM-FLU 10 KV OR 20 KV ISOLATING TRANSFORMERS

4.1 General Data

PCM-FLU	10 kV (Taps a to m)	20 kV (Taps a to m)
Transformation ratio	1 : 1	1 : 1
Matching	150 Ω : 150 Ω	150 Ω : 150 Ω
Frequency range	6 kHz to 2 MHz	6 kHz to 2 MHz
Operating loss	≤0.4 dB	≤0.4 dB
Common mode symmetry loss	>52 dB at 552 kHz	>52 dB at 552 kHz
DC winding resistance	<0.5 Ω	<0.5 Ω
Isolation level	10 kV for 10 seconds at 50 Hz	20 kV for 10 seconds at 50 Hz

Note *Taps a to b (on both primary and secondary) of the 10 kV isolating transformer should NOT be used for any P521 application. The frequency range for the isolating transformer, when connected a to b, will be limited to 6 kHz, therefore causing unreliable communications at any of the selectable baud rates.*

Table 2 - General data

4.2 Connection Diagrams

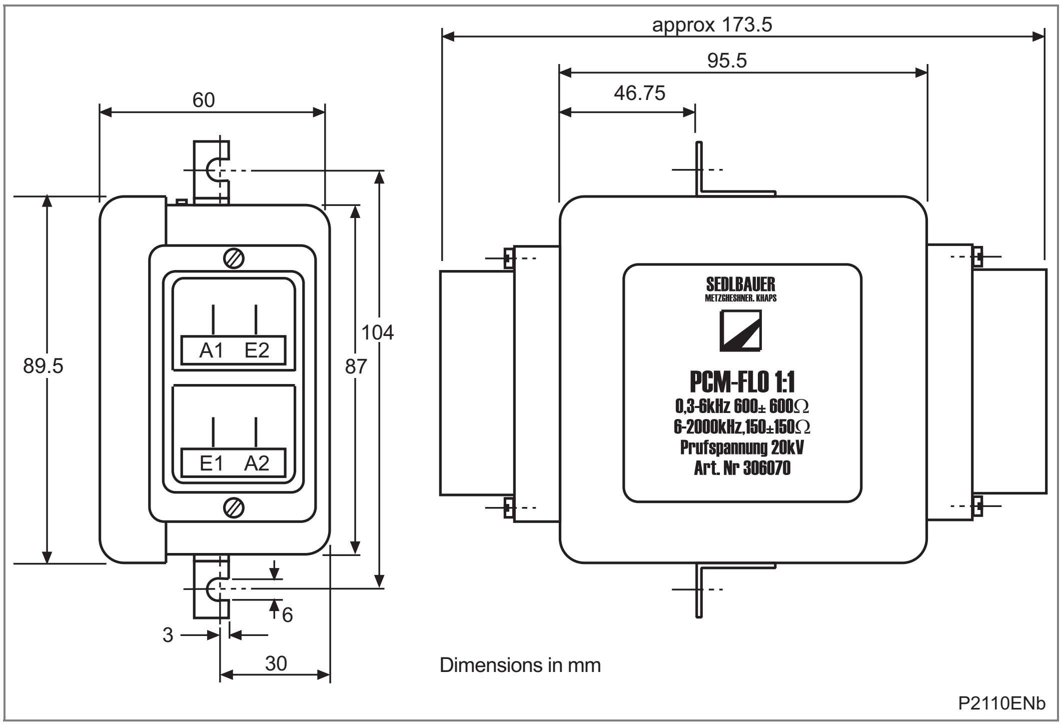


Figure 1 - PCM-FLÜ isolating transformer 20 kV

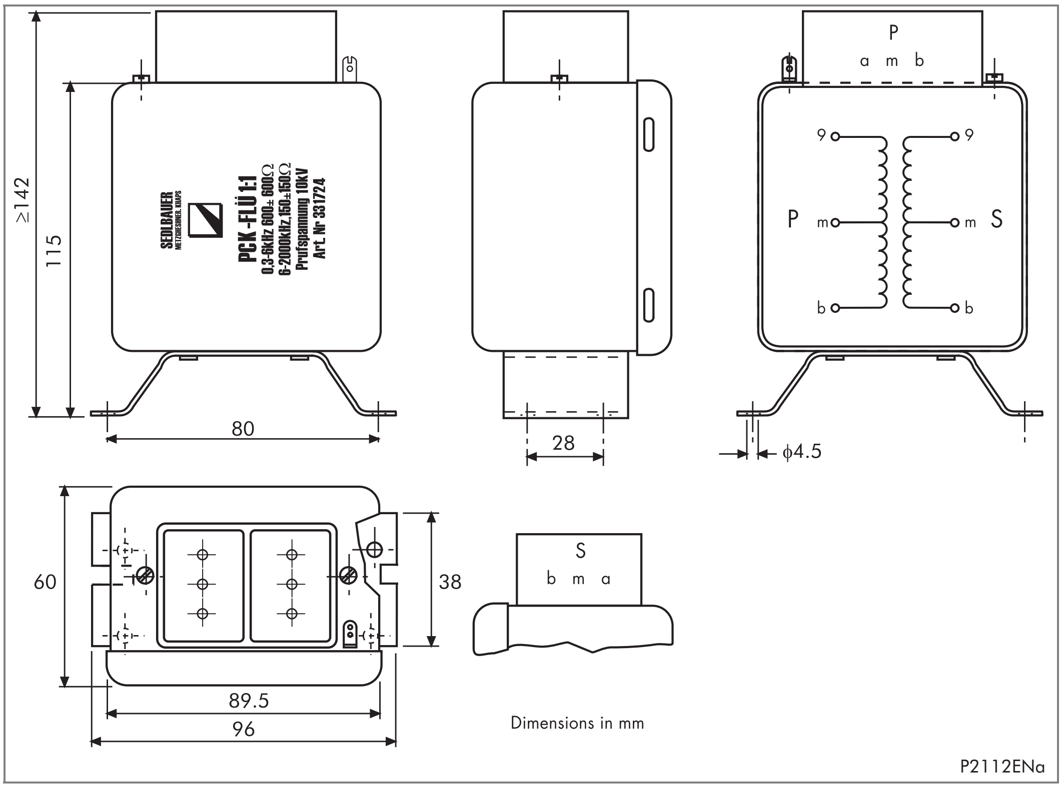


Figure 2 - PCM-FLÜ isolating transformer 10 kV

5 P520L LOOPBACK TEST BOX

Caution	**Before carrying out any work on the equipment, the user should be familiar with the content of the Safety and Technical Data chapters and the rating on the equipment's rating label.**

Caution	**Live parts exposed within the P521 case, when the P521 module is removed.**

Caution	**Before inserting the P520L loopback test box into the P521 case, ensure that supplies above 50 Vrms or 75 Vdc are de-energized.**

5.1 Function of Loopback Test Box

In the unlikely event that a P521 relay has a failure in the protection communications hardware, it is desirable to determine if the fault is located in the active part (withdrawable part) of the relay or in the protection communications card. If the fault is within the active part only, this can be sent back for repair whilst leaving the relay case in situ. If, however, the fault is on the protection communications card the whole relay, including the relay case, needs to be sent back for repair.

The P520L loopback test box facilitates the fault location process by attaching to the protection communications card in the back of the relay case (see Figure 3). For a complete description of the fault location procedure please refer to the "Equipment Failure" section of the Commissioning and Maintenance chapter (P521/*EN CM*).

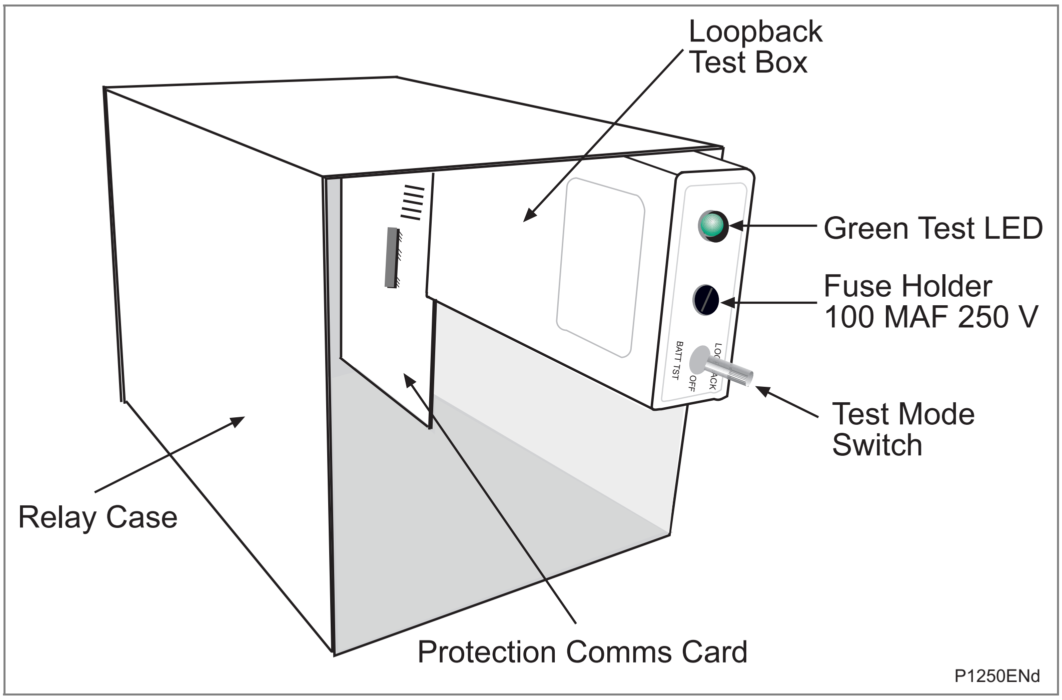


Figure 3 - Application of P520L loopback test box

5.2 General Data

The P520L loopback test box has a 3 position switch:

- BATTERY TEST
- OFF
- LOOPBACK TEST

Selecting the “BATTERY TEST” momentary position will illuminate the green LED if the battery is healthy. It is recommended that the battery is checked before a loopback test is performed.

The “LOOPBACK TEST” option should be selected once the test box is securely attached to the protection communications card. The LED should illuminate if the test box is correctly fitted.

The “OFF” position should be selected during storage of the loopback test box in order to prevent unnecessary battery drain.

5.3 Battery Data

A PP3 (9 V) battery must be used to power the P520L loopback test box.

5.4 Circuit Diagram

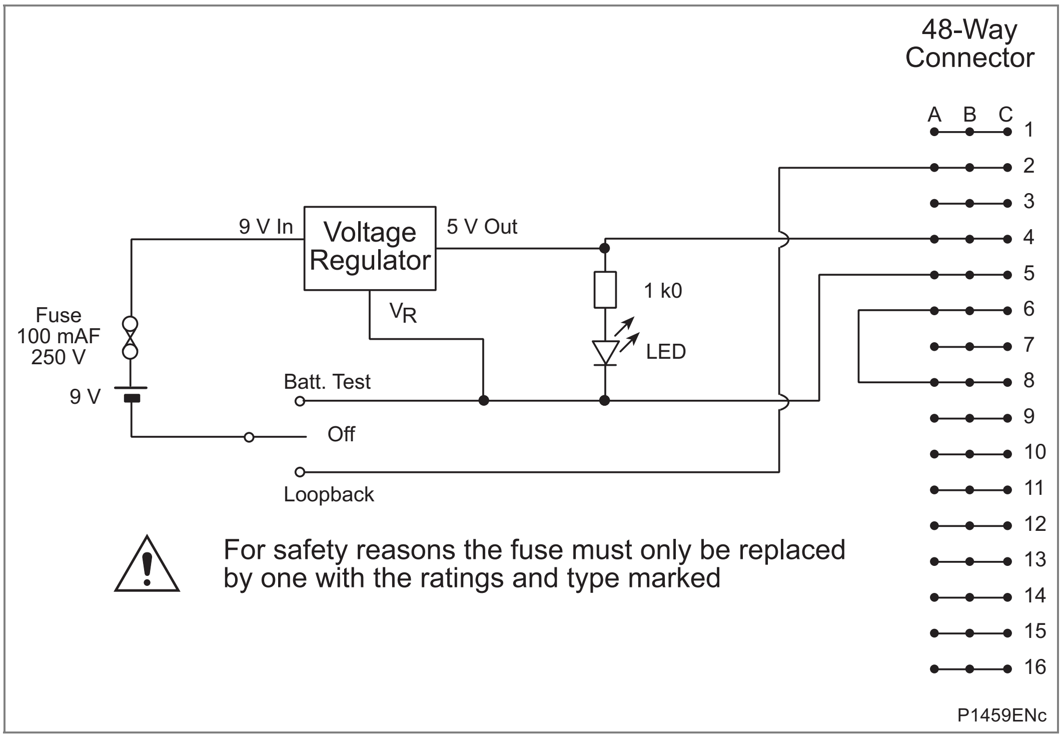


Figure 4 - Circuit diagram for P520L loopback test box

COMMISSIONING RECORDS

CHAPTER 12

Date:	January 2012
Software version:	13
Hardware Suffix:	B
Connection diagram:	10P52101

CONTENTS

1 COMMISSIONING TEST RECORD

Engineer Details

Date:		Engineer:	
Station:		Circuit:	
		System Frequency:	

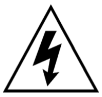
Front Plate Information

Current differential protection relay	P521
Model number	
Serial number	
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:	



Have all relevant safety instructions been followed?	Yes ☐ No ☐

4. PRODUCT CHECKS

4.1 With the Relay De-Energized

4.1.1 Visual inspection

Relay damaged?	Yes ☐ No ☐
Rating information correct for installation?	Yes ☐ No ☐
Case earth installed?	Yes ☐ No ☐
Current transformer shorting contacts close?	Yes ☐ No ☐

4.1.2 Insulation resistance >100 MΩ at 500 V dc	Yes ☐ No ☐

4.1.3 External wiring

Wiring checked against diagram?	Yes ☐ No ☐
Test block connections checked?	Yes ☐ No ☐

4.1.4 Watchdog contact (auxiliary supply off)

Terminals 35 and 36 Contact closed?	Yes ☐ No ☐
Contact resistance	Ω
	☐ Not measured

Watchdog Contact (auxiliary supply on)

Terminals 35 and 36 Contact open?	Yes ☐ No ☐

4.1.5 Measured auxiliary supply	V ac/dc

4.2 With the Relay Energized

4.2.1 Date and time

Clock set to local time?	Yes ☐ No ☐
Time maintained when auxiliary supply removed?	Yes ☐ No ☐

4.2.2 Light emitting diodes

4.2.2.1

Relay healthy (green) LED working?	Yes ☐ No ☐
Warning (orange) LED working?	Yes ☐ No ☐
Alarm (yellow) LED working?	Yes ☐ No ☐
Trip (red) LED working?	Yes ☐ No ☐
All 4 programmable (red) LEDs working?	Yes ☐ No ☐

4.2.3 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 ☐

4.2.4	Output relays			
	Relay 1	Working?		Yes ☐ No ☐
		Contact resistance	(N/C)	Ω ☐ Not measured
			(N/O)	Ω ☐ Not measured
	Relay 2	Working?		Yes ☐ No ☐
		Contact resistance	(N/C)	Ω ☐ Not measured
			(N/O)	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		Ω ☐ Not measured
	Relay 8	Working?		Yes ☐ No ☐
		Contact resistance		Ω ☐ Not measured

4.2.5	Communication standard	MODBUS ☐ IEC 60870-5-103 ☐ DNP 3.0 ☐
	Communications established?	Yes ☐ No ☐
	Protocol converter tested?	Yes ☐ No ☐
4.2.6	Current differential protection communications	
	Type of communications:	Dedicated fiber ☐ Via P59x ☐ EIA(RS)485 ☐ EIA(RS)232 ☐ Modem ☐
4.2.6.1	Direct fiber communication	
	Communication working?	Yes ☐ No ☐
4.2.6.2	Direct EIA(RS)485	

	Communication working?	Yes ☐ No ☐
4.2.6.3	EIA(RS)232	
	Communication working?	Yes ☐ No ☐
4.2.6.4	Communication using modems	
	Unit damaged?	Yes ☐ No ☐
	Communication working?	Yes ☐ No ☐
4.2.6.5	Communication using P595	
	Unit damaged?	Yes ☐ No ☐
	Communication working?	Yes ☐ No ☐
4.2.6.x.1	Visual inspection (P59x units only)	
	Unit damaged?	
	Channel 1 unit	Yes ☐ No ☐
	Rating information correct?	
	Channel 1 unit	Yes ☐ No ☐
	Case earth installed?	
	Channel 1 unit	Yes ☐ No ☐
4.2.6.x.2	Insulation resistance (P59x units only)	
	Channel 1 unit	Yes ☐ No ☐
4.2.6.x.3	External wiring (P59x units only)	
	Wiring checked against diagram?	
	Channel 1 unit	Yes ☐ No ☐
4.2.6.x.4	Measured auxiliary supply (P59x units only)	
	Channel 1 unit	V dc V ac N/A ☐
	All LED's working?	
	Channel 1 unit	Yes ☐ No ☐
4.2.6.x.5	Loopback test	
	Signal strength received by P59x	
	Channel 1 unit	dBm N/A ☐
	Signal strength transmitted by P59x	
	Channel 1 unit	dBm N/A ☐

	Signal Strength within tolerance		Yes ☐ No ☐
	Loopback test applied?		
	Channel 1 unit		Yes ☐ No ☐
	Communications working		Yes ☐ No ☐
4.2.7	Current inputs		
	Displayed Current		Primary ☐ Secondary ☐
	Phase CT Ratio		N/A ☐
	Earth Fault CT Ratio		N/A ☐
	CT Correction Ratio		N/A ☐
	Input CT	Applied value	Displayed value
	IA	A	A
	IB	A	A
	IC	A	A
	IN	A	A
5.	**SETTING CHECKS**		
5.1	**Application-specific function settings applied**?		Yes ☐ No ☐
5.2.1.2	Current differential lower slope pickup		A
5.2.1.3	Current differential upper slope pickup		A
5.2.2	Current differential operating time		
	Current Differential Phase A trip time		s
	Current Differential Phase B trip time		s
	Current Differential Phase C trip time		s
5.2.3	Backup phase overcurrent protection enabled?		Yes ☐ No ☐
5.2.3.2	Applied current		A
5.2.3.3	Expected operating time		s
	Measured operating time		s
6.	**END TO END TESTS**		
6.1	**Remove the loopback test**		
	Communications alarms?		Yes ☐ No ☐
	Loopback test removed?		Yes ☐ No ☐
	All connections restored?		Yes ☐ No ☐
	Application-specific settings applied?		Yes ☐ No ☐
	Cover replaced? (P59x units only)		Yes ☐ No ☐
6.2	**Verify communications between relays**		
6.2.1	Optical port type		850 nm ☐ 1300 nm multi ☐ 1300 nm single ☐

	Signal strength received by P521	dBm N/A ☐
	Signal strength transmitted by P521	dBm N/A ☐
	Signal Strength within tolerance	Yes ☐ No ☐ N/A ☐
	Optical fibers reconnected?	Yes ☐ No ☐
	Alarms reset?	Yes ☐ No ☐
6.2.2	Metallic communications	Direct EIA(RS)485 ☐ P595 ☐ EIA(RS)232 ☐ Modem ☐
	Transmit and receive leads reconnected?	Yes ☐ No ☐
	Alarms reset?	Yes ☐ No ☐

7. ON-LOAD CHECKS

Test wiring removed?	Yes ☐ No ☐
Disturbed customer wiring re-checked?	Yes ☐ No ☐
On-load test performed?	Yes ☐ No ☐

7.1 Confirm current transformer wiring

CT wiring checked?		Yes ☐ No ☐
CT polarities correct?		Yes ☐ No ☐
Phase CT ratio		N/A ☐
Earth fault CT ratio		N/A ☐
Currents:	Applied value	Displayed value
IA	A	A
IB	A	A
IC	A	A
IN	A N/A ☐	A N/A ☐

7.2 Capacitive charging current

Measured capacitive charging current

'A' phase	A
'B' phase	A
'C' phase	A

Differential setting IS1	A

7.3 Differential current checked?	Yes ☐ No ☐

7.4 Consistency of current transformer polarity

Polarity at each end consistent?

'A' phase	Yes ☐ No ☐

‘B’ phase	Yes	☐	No	☐
‘C’ phase	Yes	☐	No	☐

8. FINAL CHECKS

Test wiring removed?	Yes	☐	No	☐
Disturbed customer wiring re-checked?	Yes	☐	No	☐
Commissioning test mode disabled?	Yes	☐	No	☐
Circuit breaker operations counter reset?	Yes	☐	No	☐
Current counters reset?	Yes	☐	No	☐
Event records reset?	Yes	☐	No	☐
Fault records reset?	Yes	☐	No	☐
Disturbance records reset?	Yes	☐	No	☐
Alarms reset?	Yes	☐	No	☐
LED’s reset?	Yes	☐	No	☐
Front cover replaced?	Yes	☐	No	☐

Commissioning Engineer

Date:

Customer Witness

Date:

2 SETTING RECORD

Date:		Engineer:	
Station:		Circuit:	
		System Frequency:	

Front Plate Information

Current Differential Protection Relay	P521
Model Number	
Serial Number	
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 ☐

2.1 OP Parameters

Language	
Description	
Serial Number	
Reference	
Software Version	
Frequency	

2.2 Configuration

2.2.1 Display

Default Display	
Phase A Text	
Phase B Text	
Phase C Text	
E/Gnd Text	

2.2.2 CT Ratios

Line CT primary	
Line CT sec	
E/Gnd CT primary	
E/Gnd CT sec	
CT Correct Ratio	
Vector Comp.	

2.2.3 LED

Functions	LED 5		LED 6		LED 7		LED 8	
Idiff	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Idiff Fail	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
B/up Prot	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Comms Fail	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Direct I-Trip	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
C-Diff I-Trip	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
PIT	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
I>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
tI>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
I>>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
tI>>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
I>>>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
tI>>>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
I>>>>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
tI>>>>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Ie>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
tIe>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Ie>>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
tIe>>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Ie>>>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
tIe>>>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Ie>>>>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No

Functions	LED 5		LED 6		LED 7		LED 8	
tIe>>>>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Therm Trip	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Brkn. Cond.	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
CB Fail	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
tI2>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
tI2>>	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Input 1	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Input 2	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Input 3	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Input 4	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Input 5	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
tAux 1	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
tAux 2	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
CB Alarm	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Equation A	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Equation B	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Equation C	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Equation D	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Equation E	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Equation F	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Equation G	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Equation H	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Prgm IT 1	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Prgm IT 2	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Prgm IT 3	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Prgm IT 4	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
CTS Local	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
CTS Remote	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
CTS Block	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
CTS Restrain	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Convention Mode	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
CDiff Disabled	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No

2.2.4 Group Select

Change Group Input	
Setting Group	

2.2.5 Alarms

Inst. Self-reset?	
Comm.Fail-reset?	
CDiff Disabled Alarm?	

2.2.6 Configuration Inputs

Inputs	
Voltage Input	

2.2.7 Output Relays

Fail Safe RL1	Yes ☐ No ☐

2.2.8 Phase Rotation

Phase rotation	

2.3 Communication

2.3.1 Ctrl Comms (MODBUS Protocol)

Ctrl Comms?	
Baud Rate	
Parity	
Stop Bits	
Relay Address	
Date format	

2.3.2 Ctrl Comms (IEC 60870-5-103 Protocol)

Ctrl Comms?	
Baud Rate	
Relay Address	

2.3.3 Ctrl Comms (DNP3.0)

Ctrl Comms?	
Baud Rate	
Parity	
Stop Bits	
Relay Address	

2.3.4 Protection

Protocol	
Data Rate	
Relay Address	
Clock Source Ch1	
Comm Fail Timer	
Comms Delay Tol	
Char Mod Time	
Frame Mode	

2.4 Protection G1/G2/G3/G4

2.4.1 [87] Current Diff

Functions	Group 1	Group 2	Group 3	Group 4
Current Diff?				
Is1				
Is2				
K1				
K2				
I Diff Delay Type				
tIdiff				
I Diff Curve				
I Diff Tms				
I Diff Time Dial				
PIT Time				
PIT I Disable				
PIT I Selection				
PIT I Threshold				
DIT Rx tDwell				
DIT Alarm				
PIT Alarm				
CTS Is 1				
Inrush Restraint				
High Set				
Harmonic Ratio				
Kr				
Transient Bias				

2.4.2 [50/51] Phase O/C

Functions	Group 1	Group 2	Group 3	Group 4
I>?				
I>				
I> Delay Type				
I> Curve				
I> Tms				
tI>				
Reset Type				
K				
tReset				
Time Dial				
I>>?				
I>>				

Functions	Group 1	Group 2	Group 3	Group 4
tI>> Delay Type				
I>> Curve				
I>> Tms				
tI>>				
Reset Type				
K				
tReset				
Time Dial				
I>>>?				
I>>>				
tI>>>				
I>>>>?				
I>>>>				
tI>>>>				

2.4.3 [50N/51N] E/Gnd

Functions	Group 1	Group 2	Group 3	Group 4
Ie>?				
Ie>				
Ie> Delay Type				
Ie> Curve				
Ie> Tms				
tIe>				
Reset Type				
K				
tReset				
Time Dial				
Ie>>?				
Ie>>				
tIe>> Delay Type				
Ie> Curve				
Ie>> Tms				
tIe>>				
Reset Type				
K				
tReset				
Time Dial				
Ie>>>?				
Ie>>>				
tIe>>>				
Ie>>>>?				
Ie>>>>				

Functions	Group 1	Group 2	Group 3	Group 4
tIe>>>>				

2.4.4 [46] Neg Seq OC

Functions	Group 1	Group 2	Group 3	Group 4
I2>?				
I2>				
I2> Delay Type				
I2> Curve				
I2> Tms				
tI2>				
Reset Type				
K				
tReset				
Time Dial				
t Reset				
I2>>?				
I2>>				
tI2>>				

2.4.5 [49] Therm OL

Functions	Group 1	Group 2	Group 3	Group 4
Therm OL?				
Iθ>				
Te				
k				
θ Trip				
θ Alarm?				
θ Alarm				

2.4.6 [37] Undercurrent

Functions	Group 1	Group 2	Group 3	Group 4
I<?				
I<				
tI<				

2.5 Automat. Ctrl

2.5.1 Trip Commands

Trip Idiff	☐ Yes	☐ No
Direct I-Trip	☐ Yes	☐ No
C Diff I-Trip	☐ Yes	☐ No
PIT	☐ Yes	☐ No
Trip tI>	☐ Yes	☐ No
Trip tI>>	☐ Yes	☐ No
Trip tI>>>	☐ Yes	☐ No
Trip tI>>>>	☐ Yes	☐ No
Trip tIe>	☐ Yes	☐ No
Trip tIe>>	☐ Yes	☐ No
Trip tIe>>>	☐ Yes	☐ No
Trip tIe>>>>	☐ Yes	☐ No
Trip tI<	☐ Yes	☐ No
Trip tI2>	☐ Yes	☐ No
Trip tI2>>	☐ Yes	☐ No
Trip Thermal θ	☐ Yes	☐ No
Trip Brkn. Cond.	☐ Yes	☐ No
Trip tAux1	☐ Yes	☐ No
Trip tAux1	☐ Yes	☐ No
TCS Block	☐ Yes	☐ No
Equ A	☐ Yes	☐ No
Equ B	☐ Yes	☐ No
Equ C	☐ Yes	☐ No
Equ D	☐ Yes	☐ No
Equ E	☐ Yes	☐ No
Equ F	☐ Yes	☐ No
Equ G	☐ Yes	☐ No
Equ H	☐ Yes	☐ No

2.5.2 Latch Functions

Latch Idiff	☐ Yes	☐ No
Latch Direct I-Trip	☐ Yes	☐ No
Latch C Diff I-Trip	☐ Yes	☐ No
Latch PIT	☐ Yes	☐ No
Latch tI>	☐ Yes	☐ No
Latch tI>>	☐ Yes	☐ No
Latch tI>>>	☐ Yes	☐ No
Latch tI>>>>	☐ Yes	☐ No
Latch tIe>	☐ Yes	☐ No

Latch tIe>>	☐ Yes	☐ No
Latch tIe>>>	☐ Yes	☐ No
Latch tIe>>>>	☐ Yes	☐ No
Latch tI<	☐ Yes	☐ No
Latch tI2>	☐ Yes	☐ No
Latch tI2>>	☐ Yes	☐ No
Latch Thermal θ	☐ Yes	☐ No
Latch Brkn. Cond.	☐ Yes	☐ No
Latch tAux1	☐ Yes	☐ No
Latch tAux1	☐ Yes	☐ No
TCS Block	☐ Yes	☐ No
Equ A	☐ Yes	☐ No
Equ B	☐ Yes	☐ No
Equ C	☐ Yes	☐ No
Equ D	☐ Yes	☐ No
Equ E	☐ Yes	☐ No
Equ F	☐ Yes	☐ No
Equ G	☐ Yes	☐ No
Equ H	☐ Yes	☐ No

2.5.3 Blocking Logic 1/2

Functions	Blocking Logic 1		Blocking Logic 2	
Block Idiff	☐ Yes	☐ No	☐ Yes	☐ No
Block tI>	☐ Yes	☐ No	☐ Yes	☐ No
Block tI>>	☐ Yes	☐ No	☐ Yes	☐ No
Block tI>>>	☐ Yes	☐ No	☐ Yes	☐ No
Block tI>>>>	☐ Yes	☐ No	☐ Yes	☐ No
Block tIe>	☐ Yes	☐ No	☐ Yes	☐ No
Block tIe>>	☐ Yes	☐ No	☐ Yes	☐ No
Block tIe>>>	☐ Yes	☐ No	☐ Yes	☐ No
Block tIe>>>>	☐ Yes	☐ No	☐ Yes	☐ No
Block tI2>	☐ Yes	☐ No	☐ Yes	☐ No
Block tI2>>	☐ Yes	☐ No	☐ Yes	☐ No
Block Thermal θ	☐ Yes	☐ No	☐ Yes	☐ No
Block Brkn. Cond.	☐ Yes	☐ No	☐ Yes	☐ No
Block tAux 1	☐ Yes	☐ No	☐ Yes	☐ No

Functions	Blocking Logic 1		Blocking Logic 2	
Block tAux 2	☐ Yes	☐ No	☐ Yes	☐ No
Equ A	☐ Yes	☐ No	☐ Yes	☐ No
Equ B	☐ Yes	☐ No	☐ Yes	☐ No
Equ C	☐ Yes	☐ No	☐ Yes	☐ No
Equ D	☐ Yes	☐ No	☐ Yes	☐ No
Equ E	☐ Yes	☐ No	☐ Yes	☐ No
Equ F	☐ Yes	☐ No	☐ Yes	☐ No
Equ G	☐ Yes	☐ No	☐ Yes	☐ No
Equ H	☐ Yes	☐ No	☐ Yes	☐ No

2.5.4 Logic Select 1/2

Functions	Logic Select 1		Logic Select 2	
Sel tI>>	☐ Yes	☐ No	☐ Yes	☐ No
Sel tI>>>	☐ Yes	☐ No	☐ Yes	☐ No
Sel tI>>>>	☐ Yes	☐ No	☐ Yes	☐ No
Sel tIe>>	☐ Yes	☐ No	☐ Yes	☐ No
Sel tIe>>>	☐ Yes	☐ No	☐ Yes	☐ No
Sel tIe>>>>	☐ Yes	☐ No	☐ Yes	☐ No
tSel 1				

2.5.5 Output Relays

Functions	Setting	Functions	Setting
Trip		Brkn. Cond.	
IDiff		CB fail	
Back-up Prot.		CB Close	
Comms Fail		tAux1	
Direct I-Trip		tAux2	
C-Diff I-Trip		Active Group	
PIT		TCS Block	
I>		Input1	
tI>		Input2	
I>>		Input3	
tI>>		Input4	
I>>>		Input5	
tI>>>		Equ A	
I>>>>		Equ B	
tI>>>>		Equ C	
Ie>		Equ D	
tIe>		Equ E	
Ie>>		Equ F	
tIe>>		Equ G	

Functions	Setting	Functions	Setting
Ie>>>		Equ H	
tIe>>>		Prgm I-Trip1	
Ie>>>>		Prgm I-Trip2	
tIe>>>>		Prgm I-Trip3	
tI<		Prgm I-Trip4	
tI2>		Cts Local	
tI2>>		CTS Remote	
Therm Alarm		CTS Block	
Therm Trip		CTS Res.	
CB Alarm		Mode Convent	
52 Fail		CDiff Disable	

2.5.6 Latch Output Relays

Output 2	☐ Yes	☐ No
Output 3	☐ Yes	☐ No
Output 4	☐ Yes	☐ No
Output 5	☐ Yes	☐ No
Output 6	☐ Yes	☐ No
Output 7	☐ Yes	☐ No
Output 8	☐ Yes	☐ No

2.5.7 Invert Output Relays

Output 2	☐ Yes	☐ No
Output 3	☐ Yes	☐ No
Output 4	☐ Yes	☐ No
Output 5	☐ Yes	☐ No
Output 6	☐ Yes	☐ No
Output 7	☐ Yes	☐ No
Output 8	☐ Yes	☐ No

2.5.8 Inputs 1/2/3/4/5

<table>
<tr><td rowspan="8">Input 1</td><td>☐ None</td><td>☐ Blk Log 1</td><td>☐ θ Reset</td></tr>
<tr><td>☐ Unlatch</td><td>☐ Blk Log 2</td><td>☐ Trip circ</td></tr>
<tr><td>☐ 52a</td><td>☐ Start Dist</td><td>☐ Strt tBF</td></tr>
<tr><td>☐ 52b</td><td>☐ Cold L PU</td><td>☐ Permiss IT</td></tr>
<tr><td>☐ Comms RST</td><td>☐ Log sel 1</td><td>☐ Direct IT</td></tr>
<tr><td>☐ Aux 1</td><td>☐ Log sel 2</td><td>☐ Log Trip</td></tr>
<tr><td>☐ Aux 2</td><td>☐ Change Set</td><td>☐ Log Close</td></tr>
<tr><td>☐ TCS Block</td><td></td><td></td></tr>
<tr><td>Input 2</td><td>☐ None</td><td>☐ Blk Log 1</td><td>☐ θ Reset</td></tr>
</table>

	☐ Unlatch	☐ Blk Log 2	☐ Trip circ
	☐ 52a	☐ Start Dist	☐ Strt tBF
	☐ 52b	☐ Cold L PU	☐ Permiss IT
	☐ Comms RST	☐ Log sel 1	☐ Direct IT
	☐ Aux 1	☐ Log sel 2	☐ Log Trip
	☐ Aux 2	☐ Change Set	☐ Log Close
	☐ TCS Block		
Input 3	☐ None	☐ Blk Log 1	☐ θ Reset
	☐ Unlatch	☐ Blk Log 2	☐ Trip circ
	☐ 52a	☐ Start Dist	☐ Strt tBF
	☐ 52b	☐ Cold L PU	☐ Permiss IT
	☐ Comms RST	☐ Log sel 1	☐ Direct IT
	☐ Aux 1	☐ Log sel 2	☐ Log Trip
	☐ Aux 2	☐ Change Set	☐ Log Close
	☐ TCS Block		
Input 4	☐ None	☐ Blk Log 1	☐ θ Reset
	☐ Unlatch	☐ Blk Log 2	☐ Trip circ
	☐ 52a	☐ Start Dist	☐ Strt tBF
	☐ 52b	☐ Cold L PU	☐ Permiss IT
	☐ Comms RST	☐ Log sel 1	☐ Direct IT
	☐ Aux 1	☐ Log sel 2	☐ Log Trip
	☐ Aux 2	☐ Change Set	☐ Log Close
	☐ TCS Block		
Input 5	☐ None	☐ Blk Log 1	☐ θ Reset
	☐ Unlatch	☐ Blk Log 2	☐ Trip circ
	☐ 52a	☐ Start Dist	☐ Strt tBF
	☐ 52b	☐ Cold L PU	☐ Permiss IT
	☐ Comms RST	☐ Log sel 1	☐ Direct IT
	☐ Aux 1	☐ Log sel 2	☐ Log Trip
	☐ Aux 2	☐ Change Set	☐ Log Close
	☐ TCS Block		
Aux 1 Time tAux1			
Aux 2 Time tAux2			

2.5.9 Brkn. Cond

Brkn. Cond?	
Brkn. Cond. Time tBC	
Ratio I2/I1	

2.5.10 Cold Load pu

Cold Load PU?	☐ Yes	☐ No
tI>?	☐ Yes	☐ No

tI>>?	☐ Yes	☐ No
tI>>>?	☐ Yes	☐ No
tI>>>>?	☐ Yes	☐ No
tIe>?	☐ Yes	☐ No
tIe>>?	☐ Yes	☐ No
tIe>>>?	☐ Yes	☐ No
tIe>>>>?	☐ Yes	☐ No
tI2>?	☐ Yes	☐ No
tI2>>?	☐ Yes	☐ No
t Therm?	☐ Yes	☐ No
Cold Load PU Level		
Cold Load tCL		

2.5.11 CB Fail

CB Fail?	
I< =	
CB Fail Time tBF	
Block I>	
Block Ie>	

2.5.12 CB Supervision

TC Supervision?	
t tripcircuit tSUP	
CB Open S’vision	
CB Open Time	
CB Close S’vision	
CB Close Time	
CB Close Alarm?	
CB Open NB	
Σ Amps(n)?	
Σ Amps(n)	
n	
t Open Pulse	
t Close Pulse	
CB Man Trip Dly	
CB Man Close Dly	

2.5.13 Logic Equations

Equ. A	Boolean	Logic Operand
A.00	☐ = / ☐ = NOT	

Equ. A	Boolean	Logic Operand
A.01	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
A.02	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
A.03	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
A.04	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
A.05	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
A.06	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
A.07	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
A.08	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
A.09	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
A.10	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
A.11	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
A.12	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
A.13	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
A.14	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
A.15	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
T Operate	Ms	
T Reset	ms	

Equ. B	Boolean	Logic Operand
B.00	☐ = / ☐ = NOT	
B.01	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
B.02	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
B.03	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
B.04	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
B.05	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
B.06	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
B.07	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
B.08	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
B.09	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
B.10	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
B.11	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
B.12	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
B.13	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
B.14	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
B.15	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
T Operate	Ms	
T Reset	ms	

Equ. C	Boolean	Logic Operand
C.00	☐ = / ☐ = NOT	
C.01	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
C.02	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	

Equ. C	Boolean	Logic Operand
C.03	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
C.04	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
C.05	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
C.06	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
C.07	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
C.08	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
C.09	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
C.10	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
C.11	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
C.12	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
C.13	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
C.14	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
C.15	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
T Operate	Ms	
T Reset	ms	

Equ. D	Boolean	Logic Operand
D.00	☐ = / ☐ = NOT	
D.01	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
D.02	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
D.03	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
D.04	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
D.05	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
D.06	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
D.07	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
D.08	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
D.09	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
D.10	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
D.11	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
D.12	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
D.13	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
D.14	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
D.15	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
T Operate	Ms	
T Reset	ms	

Equ. E	Boolean	Logic Operand
E.00	☐ = / ☐ = NOT	
E.01	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
E.02	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
E.03	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
E.04	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
E.05	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
E.06	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	

Equ. E	Boolean	Logic Operand
E.07	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
E.08	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
E.09	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
E.10	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
E.11	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
E.12	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
E.13	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
E.14	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
E.15	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
T Operate	Ms	
T Reset	ms	

Equ. F	Boolean	Logic Operand
F.00	☐ = / ☐ = NOT	
F.01	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
F.02	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
F.03	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
F.04	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
F.05	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
F.06	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
F.07	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
F.08	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
F.09	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
F.10	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
F.11	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
F.12	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
F.13	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
F.14	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
F.15	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
T Operate	Ms	
T Reset	ms	

Equ. G	Boolean	Logic Operand
G.00	☐ = / ☐ = NOT	
G.01	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
G.02	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
G.03	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
G.04	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
G.05	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
G.06	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
G.07	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
G.08	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
G.09	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
G.10	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	

Equ. G	Boolean	Logic Operand
G.11	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
G.12	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
G.13	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
G.14	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
G.15	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
T Operate	Ms	
T Reset	ms	

Equ. H	Boolean	Logic Operand
H.00	☐ = / ☐ = NOT	
H.01	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
H.02	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
H.03	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
H.04	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
H.05	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
H.06	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
H.07	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
H.08	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
H.09	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
H.10	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
H.11	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
H.12	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
H.13	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
H.14	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
H.15	☐ OR / ☐ OR NOT / ☐ AND / ☐ AND NOT	
T Operate	Ms	
T Reset	ms	

2.5.14 Program. I-Trip

Program. I-Trip1	☐ tI >	☐ tI2 >	☐ Input 5
	☐ tI > >	☐ tI > >	☐ Equ A
	☐ tI > > >	☐ CB Fail	☐ Equ B
	☐ tI > > > >	☐ Broken Cond.	☐ Equ C
	☐ tIe >	☐ tAux1	☐ Equ D
	☐ tIe > >	☐ tAux2	☐ Equ E
	☐ tIe > > >	☐ Input 1	☐ Equ F
	☐ tIe > > > >	☐ Input 2	☐ Equ G
	☐ Therm Trip	☐ Input 3	☐ Equ H
	☐ tI <	☐ Input 4	
Program. I-Trip2	☐ tI >	☐ tI2 >	☐ Input 5
	☐ tI > >	☐ tI > >	☐ Equ A
	☐ tI > > >	☐ CB Fail	☐ Equ B
	☐ tI > > > >	☐ Broken Cond.	☐ Equ C

	☐ tIe >	☐ tAux1	☐ Equ D
	☐ tIe > >	☐ tAux2	☐ Equ E
	☐ tIe > > >	☐ Input 1	☐ Equ F
	☐ tIe > > > >	☐ Input 2	☐ Equ G
	☐ Therm Trip	☐ Input 3	☐ Equ H
	☐ tI <	☐ Input 4	
Program. I-Trip3	☐ tI >	☐ tI2 >	☐ Input 5
	☐ tI > >	☐ tI > >	☐ Equ A
	☐ tI > > >	☐ CB Fail	☐ Equ B
	☐ tI > > > >	☐ Broken Cond.	☐ Equ C
	☐ tIe >	☐ tAux1	☐ Equ D
	☐ tIe > >	☐ tAux2	☐ Equ E
	☐ tIe > > >	☐ Input 1	☐ Equ F
	☐ tIe > > > >	☐ Input 2	☐ Equ G
	☐ Therm Trip	☐ Input 3	☐ Equ H
	☐ tI <	☐ Input 4	
Program. I-Trip4	☐ tI >	☐ tI2 >	☐ Input 5
	☐ tI > >	☐ tI > >	☐ Equ A
	☐ tI > > >	☐ CB Fail	☐ Equ B
	☐ tI > > > >	☐ Broken Cond.	☐ Equ C
	☐ tIe >	☐ tAux1	☐ Equ D
	☐ tIe > >	☐ tAux2	☐ Equ E
	☐ tIe > > >	☐ Input 1	☐ Equ F
	☐ tIe > > > >	☐ Input 2	☐ Equ G
	☐ Therm Trip	☐ Input 3	☐ Equ H
	☐ tI <	☐ Input 4	
Program. I-Trip5	☐ tI >	☐ tI2 >	☐ Input 5
	☐ tI > >	☐ tI > >	☐ Equ A
	☐ tI > > >	☐ CB Fail	☐ Equ B
	☐ tI > > > >	☐ Broken Cond.	☐ Equ C
	☐ tIe >	☐ tAux1	☐ Equ D
	☐ tIe > >	☐ tAux2	☐ Equ E
	☐ tIe > > >	☐ Input 1	☐ Equ F
	☐ tIe > > > >	☐ Input 2	☐ Equ G
	☐ Therm Trip	☐ Input 3	☐ Equ H
	☐ tI <	☐ Input 4	
Dwell Timer			

2.5.15 CT Supervision

CTS?	
CTS Reset mode	
CTS I1 >	
CTS I2 / I1 >	
CTS I2 / I1 > >	

CTS TIME DLY	
CTS Restrain?	

2.6 Records

2.6.1 Disturb Record

Record Number	
Pre-time	
Disturb Rec Trig	

2.6.2 Time Peak Value

Time Window	

2.6.3 Rolling Demand

Sub Period	
Num of Sub Per	

Commissioning Engineer

Date:

Customer Witness

Date:

VERSION HISTORY

CHAPTER 14

Date:	August 2017
Software version:	13
Hardware Suffix:	B
Connection diagram:	10P52101

CONTENTS

TABLES

Notes:

1 SOFTWARE AND HARDWARE VERSION HISTORY

Software Version		Hardware Suffix	Original Date of Issue	Description of Changes	S1 Compatibility	Technical Documentation
Major	Minor					
1	A	A	July 2003	Original Issue	V2.09 or Later	P521/EN M/B11
1	B	A	October 2003	Current differential blocking logic functionality changed to inhibit protection timer when blocking enabled. This fix prevents the current differential from mal-tripping upon removal of the blocking input	V2.09 or Later	P521/EN M/B11
1	C	A	April 2004	Modification to ensure that the loopback alarm is re-instated following an interruption to the auxiliary supply Enhancement to prevent both manual trip and close commands from operating simultaneously Modification to summation amps function in order to improve measurement accuracy Correction to fault records to include the magnitude of negative sequence current when the I2>> element operates Modification to allow fault records to be acknowledged via remote communications Improvements made to setting group 2 dependencies to ensure all menu cells are displayed correctly Enhancement to allow the contact test, in the commissioning menu, to be operated via remote communications Correction to ensure that the TMS settings are not overwritten with the time dial settings when downloading a setting file via MiCOM S1	V2.09 or Later	P521/EN M/B11
1	D	A	June 2004	Correction to ensure erroneous IDIFF FAIL alarms not generated	V2.09 or Later	P521/EN AD/B21
1	F	A	November 2005	Improved compatibility with P59x units	V2.09 or Later	P521/EN AD/B21
1	G	A	June 2006	Correction to ensure correct CB fail operation when tBFtimer < 180 ms	V2.09 or Later	P521/EN AD/B21
2	A	A	June 2005	k1 setting minimum value changed to 0 % Vector compensation added for transformer applications High Set added for inrush restraint Selective intertripping added Output contact inversion settings added Extended protection communication addresses (increased to 20) Correction to ensure new alarms do cause front panel LCD to jump to alarms display, unless on default display IEC 60870-5-103 GI expanded and sequence corrected	V2.11 or Later	P521/EN M/C31
2	B	A	November 2005	Improved compatibility with P59x units	V2.11 or Later	P521/EN M/C31

Software Version		Hardware Suffix	Original Date of Issue	Description of Changes	S1 Compatibility	Technical Documentation
Major	Minor					
2	C	A	March 2006	IEC 60870-5-103 GI sequence number in end of GI message corrected IEC 60870-5-103 Blocking of P922 relays after time synchronization corrected	V2.11 or Later	P521/EN M/C31
2	D	A	June 2006	Correction to ensure correct CB fail operation when tBFtimer < 180 ms	V2.11 or Later	P521/EN M/C31
3	A	A	March 2007	DNP3.0 protocol option added Phase angle measurements added PIT current check functionality modified, including addition of local current check option External TCS Block function added for H7 compliance Additional Phase label settings added Password reset via front panel added Comms Alarm self reset setting added Transient Bias functionality added to mitigate CT saturation Modified Reference to ‘MiCO’ (front panel and Modbus) and identification to ‘MiCOM P521’ (IEC60870-5-103) Russian language option for front panel added Correction of Vector Compensation groups Yy2 and Yy10	V2.13 or Later	P521/EN AD/C41
4	A	A	July 2007	PIT & DIT Alarm Enabled/Disabled added	V2.13 or later	P521/EN AD/C51
5	A	A	February 2010	New version enabling the setting of 2nd harmonic restraint factor.	Studio 3.1	
5	B	A	June 2010	New version resolving the incompatibility problem between phase 1 and phase 2.	Studio 3.1	
5	C	A	December 2010	Re-branded to SE	Studio 3.1	
5	D	A	January 2011	Fix the bug that communication over rear port using IEC103 caused the master station error	Studio 3.1	
10	A	B	August 2009	Upgraded into Phase 2	Studio 3.1	P521/EN M/C63
11	A	B	February 2010	New version enabling the setting of 2nd harmonic restraint factor.	Studio 3.1	
12	B	B	October 2010	New version with software enhancements: CTS Programmable inter-trip Boolean logic equations	Studio 3.1	
12	C	B	April 2011	Reading and writing of setting are supported when using IEC103 over the rear port Re-branded to SE	Studio 3.1	P521/EN AD/A83
12	D	B	June 2011	The following two problems are resolved: The relay has the chance to trip during external fault occurring or disappearing when the fault current is very high. The inrush blocking feature does not work correctly, the relay still has chance to issue a trip.	Studio 3.1	

Software Version		Hardware Suffix	Original Date of Issue	Description of Changes	S1 Compatibility	Technical Documentation
Major	Minor					
13	A	B	January 2012	Add two protection groups. The numbers of setting groups are 4 groups. General reset command. Event, fault and disturbance records… etc can be cleared by HMI interface and communication protocol (Modbus). Add RL1 fail safe mode. Model number is automatically updated when firmware is upgraded. Correction to ensure remote communications (Modbus Protocol) to reset the thermal state. Modified data model to ensure that all menu cells are correctly displayed in French translation.	Studio 3.1	P521/EN AD/A83 or P521/EN M/B93
13	B	B	April 2013	Improvement of: Event record when trip command and output relay are latched which triggered by the same protection signal. Interaction between relays in case of short DC powering off, Local and remote Inrush block events record (phase C).	Studio 3.1 or later	P521/EN AD/B83
13	C	B	August 2013	New designed Ethernet board (Modbus TCP and IEC 60870-5-103 over Ethernet protocol available)	Studio 3.1 or later	P521/EN AD/B83
13	D	B	December 2013	Improvement of: Timing of "Protection Comms Fail" and "I-Diff Fail" signal in DR Extended protection inhibition duration (additional 10ms) after communication re-establishment.	Studio 3.1 or later	P521/EN AD/B83
13	E	B	August 2014	Improvement of: Driver update for graphical LCD	Studio 3.1 or later	P521/EN AD/B83
13	F	B	October 2016	Improvement of: Improved IEC-60870-5-103 robustness	Studio 3.1 or later	P521/EN AD/B83
13	G	B	August 2017	Improvement of: Addition of SoE for protection trip reset in IEC 60870-5-103 protocol; Broken Conductor time delay tBC minimum setting changed from 1s – 0s Improved internal communication robustness	Studio 3.1 or later	P521/EN M/Ca4

2 SETTING FILE AND RELAY SOFTWARE VERSIONS

2.1 Relay Communication Compatibility Table

Relay software version	Relay software version																										
	1.A	1.B	1.C	1.D	1.F	1.G	2.A	2.B	2.C	2.D	3.A	4.A	5.A	5.B	5.D	10.A	11.A	12.B	12.C	12.D	13.A	13.B	13.C	13.D	13.E	13.F	13.G
1.A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
1.B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
1.C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
1.D	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
1.F	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
2.A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
2.B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
2.C	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
2.D	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
3.A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
4.A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
5.A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
5.B	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5.D	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
10.A	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
11.A	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
12.B	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
12.C	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
12.D	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
13.A	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
13.B	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
13.C	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
13.D	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
13.E	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
13.F	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
13.G	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 1 - Relay Communication Compatibility Table

3 INFORMATION REQUIRED WITH ORDER

P 5 2 1 _ 0 _ _ _ _ _ _ _

E/F CT Rating		
0.1 - 40 Ion		A
0.01 - 8 Ion		B
0.002 - 1 Ion		C
Not used, Default		0
Protection Communication		
EIA (RS) 485 single channel		B
850 nm single channel		C
1300 nm multi-mode/single channel (43 dB)		F
1300 nm single-mode/single channel (43 dB)		G
Auxiliary Power Supply	**Digital Input Voltage**	
48 – 250 Vdc/48-240 Vac Special ENA	24 - 250 Vdc(UK ENA approved+Screws)	T
48 – 250 Vdc/48-240 Vac	105-145 Vdc	H
48 – 250 Vdc/48-240 Vac	110 Vdc	V
48 – 250 Vdc/48-240Vac	220 Vdc	W
24-250Vdc/24-240Vac	24-250Vdc/24-240 Vac	Z
Communication Protocol		
MODBUS		1
IEC 60870-5-103		3
DNP3		4
Modbus TCP/IP (with voltage V&W only)		6
IEC60870-5-103 Eth (with voltage V&W only)		7
Language		
French		0
English/American		1
Spanish		2
German		3
Italian		4
Russian		5
Polish		6
Chinese		D
Platform		
Phase 2		2
Phase 2 with graphic LCD		3
Software version		**xx**
Mounting option		
None (default)		0
Pre-fixed HMI		1
Sealed cover		2
Pre-fixed HMI + Sealed cover		3

Notes:

SYMBOLS AND GLOSSARY

CHAPTER SG

CONTENTS

TABLES

FIGURES

Notes:

1 ACRONYMS AND ABBREVIATIONS

Term	Description
<	Less than: Used to indicate an “under” threshold, such as undercurrent (current dropout).
>	Greater than: Used to indicate an “over” threshold, such as overcurrent (current overload)
A	Ampere
AA	Application Association
AC / ac	Alternating Current
ACSI	Abstract Communication Service Interface
ACSR	Aluminum Conductor Steel Reinforced
ALF	Accuracy Limit Factor
AM	Amplitude Modulation
ANSI	American National Standards Institute
AR	Auto-Reclose.
ARIP	Auto-Reclose In Progress
ASCII	American Standard Code for Information Interchange
ATEX	ATEX is the Potentially Explosive Atmospheres directive 94/9/EC
AUX / Aux	Auxiliary
AWG	American Wire Gauge
BAR	Block Auto-Reclose signal.
BCD	Binary Coded Decimal
BCR	Binary Counter Reading
BDEW	Bundesverband der Energie- und Wasserwirtschaft | Startseite (i.e. German Association of Energy and Water Industries)
BMP	BitMaP – a file format for a computer graphic
BOP	Blocking Overreach Protection - a blocking aided-channel scheme.
BPDU	Bridge Protocol Data Unit
BRCB	Buffered Report Control Block
BRP	Beacon Redundancy Protocol
BU	Backup: Typically a back-up protection element
C/O	A ChangeOver contact having normally-closed and normally-open connections: Often called a “form C” contact.
CB	Circuit Breaker
CB Aux.	Circuit Breaker auxiliary contacts: Indication of the breaker open/closed status.
CBF	Circuit Breaker Failure protection
CDC	Common Data Class
CF	Control Function
Ch	Channel: usually a communications or signaling channel
Check Synch	Check Synchronizing function
CLIO	Current Loop Input Output: 0-1 mA/0-10 mA/0-20 mA/4-20 mA transducer inputs and outputs CLI = current loop input - 0-1 mA/0-10 mA/0-20 mA/4-20 mA transducer input CLO = current loop output - 0-1 mA/0-10 mA/0-20 mA/4-20 mA transducer output
CIP	Critical Infrastructure Protection standards

Term	Description
CLK / Clk	Clock
Cls	Close - generally used in the context of close functions in circuit breaker control.
CMV	Complex Measured Value
CNV	Current No Volts
CPNI	Centre for the Protection of National Infrastructure
CRC	Cyclic Redundancy Check
CRP	Cross-network Redundancy Protocol
CRV	Curve (file format for curve information)
CRx	Channel Receive: Typically used to indicate a teleprotection signal received.
CS	Check Synchronism.
CSV	Comma Separated Values (a file format for database information)
CT	Current Transformer
CTRL	Control - as used for the Control Inputs function
CTS	Current Transformer Supervision: To detect CT input failure.
CTx	Channel Transmit: Typically used to indicate a teleprotection signal send.
CUL	Canadian Underwriters Laboratory
CVT	Capacitor-coupled Voltage Transformer - equivalent to terminology CCVT.
DAU	Data Acquisition Unit
DC	Data Concentrator
DC / dc	Direct Current
DCC	An Omicron compatible format
DCE	Data Communication Equipment
DDB	Digital Data Bus within the programmable scheme logic: A logic point that has a zero or 1 status. DDB signals are mapped in logic to customize the relay’s operation.
DDR	Dynamic Disturbance Recorder
DEF	Directional Earth Fault protection: A directionalized ground fault aided scheme.
df/dt	Rate of Change of Frequency
df/dt>1	First stage of df/dt protection
DFT	Discrete Fourier Transform
DG	Distributed Generation
DHCP	Dynamic Host Configuration Protocol
DHM	Dual Homing Manager
DHP	Dual Homing Protocol
Diff	Differential protection.
DIN	Deutsches Institut für Normung (German standards body)
Dist	Distance protection.
DITA	Darwinian Information Typing Architecture
DLDB	Dead-Line Dead-Bus : In system synchronism check, indication that both the line and bus are de-energised.
DLLB	Dead-Line Live-Bus : In system synchronism check, indication that the line is de-energised whilst the bus is energised.
DLR	Dynamic Line Rating
DLY / Dly	Time Delay
DMT	Definite Minimum Time

Term	Description
DNP	Distributed Network Protocol
DPWS	Device Profile for Web Services
DSP	Digital Signal Processor
DST	Daylight Saving Time
DT	Definite Time: in the context of protection elements: An element which always responds with the same constant time delay on operation. Abbreviation of “Dead Time” in the context of auto-reclose:
DTD	Document Type Definition
DTOC	Definite Time Overcurrent
DTS	Date and Time Stamp
EF or E/F	Earth Fault (Directly equivalent to Ground Fault)
EIA	Electronic Industries Alliance
ELR	Environmental Lapse Rate
EMC	ElectroMagnetic Compatibility
ENA	Energy Networks Association
ER	Engineering Recommendation
ESD	Electrostatic Discharge
FAA	Ageing Acceleration Factor: Used by Loss of Life (LOL) element
FFail	A field failure (loss of excitation) element: Could be labeled 40 in ANSI terminology.
FFT	Fast Fourier Transform
FIR	Finite Impulse Response
FLC	Full load current: The nominal rated current for the circuit.
FLT / Flt	Fault - typically used to indicate faulted phase selection.
Fn or FN	Function
FPGA	Field Programmable Gate Array
FPS	Frames Per Second
FTP	File Transfer Protocol or Foil Twisted Pair
FWD, Fwd or Fwd.	Indicates an element responding to a flow in the “Forward” direction
Gen Diff	A generator differential element: Could be labeled 87G in ANSI terminology.
Gen-Xformer Diff	A generator-transformer differential element: Could be labeled 87GT in ANSI terminology.
GIF	Graphic Interchange Format – a file format for a computer graphic
GND / Gnd	Ground: used in distance settings to identify settings that relate to ground (earth) faults.
GOOSE	Generic Object Oriented Substation Event
GPS	Global Positioning System
GRP / Grp	Group. Typically an alternative setting group.
GSE	General Substation Event
GSSE	Generic Substation Status Event
GUESS	Generator Unintentional Energization at StandStill.
GUI	Graphical User Interface
HMI	Human Machine Interface

Term	Description
HSR	High-availability Seamless Ring
HTML	Hypertext Markup Language
I	Current
I/O	Input/Output
I/P	Input
IANA	Internet Assigned Numbers Authority
ICAO	International Civil Aviation Organization
ID	Identifier or Identification. Often a label used to track a software version installed.
IDMT	Inverse Definite Minimum Time. A characteristic whose trip time depends on the measured input (e.g. current) according to an inverse-time curve.
IEC	International Electro-technical Commission
IED	Intelligent Electronic Device - a term used to describe microprocessor-based controllers of power system equipment. Common types of IEDs include protective relaying devices, load tap changer controllers, circuit breaker controllers, capacitor bank switches, recloser controllers, voltage regulators, etc.
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IIR	Infinite Impulse Response
Inh	An Inhibit signal
Inst	An element with Instantaneous operation: i.e. having no deliberate time delay.
IP	Internet Protocol
IRIG	InterRange Instrumentation Group
ISA	International Standard Atmosphere
ISA	Instrumentation Systems and Automation Society
ISO	International Standards Organization
JPEF	Joint Photographic Experts Group – a file format for a computer graphic
L	Live
LAN	Local Area Network
LCD	Liquid Crystal Display: The front-panel text display on the relay.
LD	Level Detector: An element responding to a current or voltage below its set threshold.
LDOV	Level Detector for Overvoltage
LDUV	Level Detector for Undervoltage
LED	Light Emitting Diode: Red or green indicator on the front-panel.
LLDB	Live-Line Dead-Bus : In system synchronism check, indication that the line is energized whilst the bus is de-energized.
Ln	Natural logarithm
LN	Logical Node
LoL	A Loss of Load scheme, providing a fast distance trip without needing a signaling channel.
LPDU	Link Protocol Data Unit
LPHD	Logical Physical Device
MC	MultiCast
MCB	Miniature Circuit Breaker
MIB	Management Information Base
MICS	Model Implementation Conformance Statement

Term	Description
MIDOS	Modular Integrated DrawOut System
MMF	Magneto-Motive Force
MMS	Manufacturing Message Specification
MRP	Media Redundancy Protocol
MU	Merging Unit
MV	Measured Value
N	Neutral
N/A	Not Applicable
N/C	A Normally Closed or “break” contact: Often called a “form B” contact.
N/O	A Normally Open or “make” contact: Often called a “form A” contact.
NERC	North American Reliability Corporation
NIST	National Institute of Standards and Technology
NPS	Negative Phase Sequence
NVD	Neutral voltage displacement: Equivalent to residual overvoltage protection.
NXT	Abbreviation of “Next”: In connection with hotkey menu navigation.
O/C	Overcurrent
O/P	Output
OCB	Oil Circuit Breaker
OID	Object IDentifier
Opto	An Optically coupled logic input. Alternative terminology: binary input.
OSI	Open Systems Interconnection
PCB	Printed Circuit Board
PCT	Protective Conductor Terminal (Ground)
PDC	Phasor Data Concentrator
Ph	Phase - used in distance settings to identify settings that relate to phase-phase faults.
PICS	Protocol Implementation Conformance Statement
PMU	Phasor Measurement Unit
PNG	Portable Network Graphics – a file format for a computer graphic
Pol	Polarize - typically the polarizing voltage used in making directional decisions.
POR	A Permissive OverReaching transfer trip scheme (alternative terminology: POTT).
PRP	Parallel Redundancy Protocol
PSB	Power Swing Blocking, to detect power swing/out of step functions (ANSI 78).
PSL	Programmable Scheme Logic: The part of the relay’s logic configuration that can be modified by the user, using the graphical editor within MiCOM S1 Studio software.
PSlip	A Pole slip (out of step - OOS) element: could be labeled 78 in ANSI terminology.
PT	Power Transformer
PTP	Precision Time Protocol
PUR	A Permissive UnderReaching transfer trip scheme (alternative terminology: PUTT).
Q	Quantity defined as per unit value
R	Resistance
R&TTE	Radio and Telecommunications Terminal Equipment

Term	Description
RBAC	Role Based Access Control
RCA	Relay Characteristic Angle - The center of the directional characteristic.
REB	Redundant Ethernet Board
REF	Restricted Earth Fault
Rev.	Indicates an element responding to a flow in the “reverse” direction
RMS / rms	Root mean square. The equivalent a.c. current: Taking into account the fundamental, plus the equivalent heating effect of any harmonics.
RP	Rear Port: The communication ports on the rear of the IED
RS232	A common serial communications standard defined by the EIA
RS485	A common serial communications standard defined by the EIA (multi-drop)
RST or Rst	Reset generally used in the context of reset functions in circuit breaker control.
RSTP	Rapid Spanning Tree Protocol
RTD	Resistance Temperature Device
RTU	Remote Terminal Unit
Rx	Receive: Typically used to indicate a communication transmit line/pin.
SBS	Straight Binary Second
SC	Synch-Check or system Synchronism Check.
SCADA	Supervisory Control and Data Acquisition
SCL	Substation Configuration Language
SCU	Substation Control Unit
SEF	Sensitive Earth Fault Protection
Sen	Sensitive
SHM	Self-Healing Manager
SHP	Self Healing Protocol
SIR	Source Impedance Ratio
SLA	Service Level Agreement
SMV	Sampled Measured Values
SNTP	Simple Network Time Protocol
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SOC	Second of Century
SOTF	Switch on to Fault protection. Modified protection on manual closure of the circuit breaker.
SP	Single pole.
SPAR	Single pole auto-reclose.
SPC	Single Point Controllable
SPDT	Single Pole Dead Time. The dead time used in single pole auto-reclose cycles.
SPS	Single Point Status
SQRT	Square Root
SSL	Source Impedance Ratio
STP	Shielded Twisted Pair or Spanning Tree Protocol
SV	Sampled Values
SVC	Sampled Value Model
SVM	Sampled Value Model

Term	Description
TAF	Turbine Abnormal Frequency
TCP	Transmission Control Protocol
TCS	Second of Century
TCS	Trip Circuit Supervision
TD	Time Dial. The time dial multiplier setting: Applied to inverse-time curves (ANSI/IEEE).
TE	Unit for case measurements: One inch = 5TE units
THD	Total Harmonic Distortion
TICS	Technical Issues Conformance Statement
TIFF	Tagged Image File Format – a file format for a computer graphic
TLS	Transport Layer Security protocol
TMS	Time Multiplier Setting: Applied to inverse-time curves (IEC)
TOC	Trip On Close (“line check”) protection. Offers SOTF and TOR functionality.
TOR	Trip On Reclose protection. Modified protection on autoreclosure of the circuit breaker.
TP	Two-Part
TUC	Timed UnderCurrent
TVE	Total Vector Error
Tx	Transmit
UDP	User Datagram Protocol
UL	Underwriters Laboratory
UPCT	User Programmable Curve Tool
UTC	Universal Time Coordinated
V	Voltage
VA	Phase A voltage: Sometimes L1, or red phase
VB	Phase B voltage: Sometimes L2, or yellow phase
VC	Phase C voltage: Sometimes L3, or blue phase
VCO	Voltage Controlled Overcurrent element
VDEP OC>	A voltage dependent overcurrent element: could be a voltage controlled or voltage restrained overcurrent element and could be labeled 51V in ANSI terminology.
VDR	Voltage Dependant Resistor
V/Hz	An overfluxing element, flux is proportional to voltage/frequency: could be labeled 24 in ANSI terminology.
Vk	IEC knee point voltage of a current transformer.
VT	Voltage Transformer
VTS	Voltage Transformer Supervision: To detect VT input failure.
WAN	Wide Area Network
Xformer	Transformer
XML	Extensible Markup Language
XSD	XML Schema Definition

Table 1 - Acronyms and abbreviations

2 COMPANY PROPRIETARY TERMS

Symbol	Description
Courier	Schneider Electric’s proprietary SCADA communications protocol
Metrosil	Brand of non-linear resistor produced by M&I Materials Ltd.
MiCOM	Schneider Electric’s brand of protection relays

Table 2 - Company-proprietary terms

3 ANSI TERMS

ANSI no.	Description
3PAR	Three pole auto-reclose.
3PDT	Three pole dead time. The dead time used in three pole auto-reclose cycles.
52a	A circuit breaker closed auxiliary contact: The contact is in the same state as the breaker primary contacts
52b	A circuit breaker open auxiliary contact: The contact is in the opposite state to the breaker primary contacts
64R	Rotor earth fault protection
64S	100% stator earth (ground) fault protection using a low frequency injection method.

Table 3 - ANSI abbreviations

ANSI no.	Function	Description
Current Protection Functions		
50/51	Phase overcurrent	Three-phase protection against overloads and phase-to-phase short-circuits.
50N/51N	Earth fault	Earth fault protection based on measured or calculated residual current values: • 50N/51N: residual current calculated or measured by 3 phase current sensors
50G/51G	Sensitive earth fault	Sensitive earth fault protection based on measured residual current values: • 50G/51G: residual current measured directly by a specific sensor such as a core balance CT
50BF	Breaker failure	If a breaker fails to be triggered by a tripping order, as detected by the non-extinction of the fault current, this backup protection sends a tripping order to the upstream or adjacent breakers.
46	Negative sequence / unbalance	Protection against phase unbalance, detected by the measurement of negative sequence current: • sensitive protection to detect 2-phase faults at the ends of long lines • protection of equipment against temperature build-up, caused by an unbalanced power supply, phase inversion or loss of phase, and against phase current unbalance
46BC	Broken conductor protection	Protection against phase imbalance, detected by measurement of I2/I1.
49RMS	Thermal overload	Protection against thermal damage caused by overloads on machines (transformers, motors or generators). The thermal capacity used is calculated according to a mathematical model which takes into account: • current RMS values • ambient temperature • negative sequence current, a cause of motor rotor temperature rise
Re-Closer		
79	Recloser	Automation device used to limit down time after tripping due to transient or semipermanent faults on overhead lines. The recloser orders automatic reclosing of the breaking device after the time delay required to restore the insulation has elapsed. Recloser operation is easy to adapt for different operating modes by parameter setting.
Directional Current Protection		
67N/67NC type 1 and 67	Directional phase overcurrent	Phase-to-phase short-circuit protection, with selective tripping according to fault current direction. It comprises a phase overcurrent function associated with direction detection, and picks up if the phase overcurrent function in the chosen direction (line or busbar) is activated for at least one of the three phases.

ANSI no.	Function	Description
67N/67NC	Directional earth fault	Earth fault protection, with selective tripping according to fault current direction. Three types of operation: • Type 1: the protection function uses the projection of the I0 vector • Type 2: the protection function uses the I0 vector magnitude with half-plane tripping zone • Type 3: the protection function uses the I0 vector magnitude with angular sector tripping zone
67N/67NC type 1	Directional current protection	Directional earth fault protection for impedant, isolated or compensated neutral systems, based on the projection of measured residual current.
67N/67NC type 2	Directional current protection	Directional overcurrent protection for impedance and solidly earthed systems, based on measured or calculated residual current. It comprises an earth fault function associated with direction detection, and picks up if the earth fault function in the chosen direction (line or busbar) is activated.
67N/67NC type 3	Directional current protection	Directional overcurrent protection for distribution networks in which the neutral earthing system varies according to the operating mode, based on measured residual current. It comprises an earth fault function associated with direction detection (angular sector tripping zone defined by 2 adjustable angles), and picks up if the earth fault function in the chosen direction (line or busbar) is activated.
Directional Power Protection Functions		

32P	Directional active overpower	Two-way protection based on calculated active power, for the following applications:
		• active overpower protection to detect overloads and allow load shedding
		• reverse active power protection:
		  • against generators running like motors when the generators consume active power
		  • against motors running like generators when the motors supply active power

32Q/40	Directional reactive overpower	Two-way protection based on calculated reactive power to detect field loss on synchronous machines: • reactive overpower protection for motors which consume more reactive power with field loss • reverse reactive overpower protection for generators which consume reactive power with field loss.
Machine Protection Functions		
37	Phase undercurrent	Protection of pumps against the consequences of a loss of priming by the detection of motor no-load operation. It is sensitive to a minimum of current in phase 1, remains stable during breaker tripping and may be inhibited by a logic input.

48/51LR/14	Locked rotor / excessive starting time	Protection of motors against overheating caused by:
		• excessive motor starting time due to overloads (e.g. conveyor) or insufficient supply voltage.
		The reacceleration of a motor that is not shut down, indicated by a logic input, may be considered as starting.
		• locked rotor due to motor load (e.g. crusher):
		  • in normal operation, after a normal start
		  • directly upon starting, before the detection of excessive starting time, with detection of locked rotor by a zero speed detector connected to a logic input, or by the underspeed function.

66	Starts per hour	Protection against motor overheating caused by:
		• too frequent starts: motor energizing is inhibited when the maximum allowable number of starts is reached, after counting of:
		  • starts per hour (or adjustable period)
		  • consecutive motor hot or cold starts (reacceleration of a motor that is not shut down, indicated by a logic input, may be counted as a start)
		• starts too close together in time: motor re-energizing after a shutdown is only allowed after an adjustable waiting time.

ANSI no.	Function	Description
50V/51V	Voltage-restrained overcurrent	Phase-to-phase short-circuit protection, for generators. The current tripping set point is voltage-adjusted in order to be sensitive to faults close to the generator which cause voltage drops and lowers the short-circuit current.
26/63	Thermostat/Buchholz	Protection of transformers against temperature rise and internal faults via logic inputs linked to devices integrated in the transformer.
38/49T	Temperature monitoring	Protection that detects abnormal temperature build-up by measuring the temperature inside equipment fitted with sensors: • transformer: protection of primary and secondary windings • motor and generator: protection of stator windings and bearings.
Voltage Protection Functions		
27D	Positive sequence undervoltage	Protection of motors against faulty operation due to insufficient or unbalanced network voltage, and detection of reverse rotation direction.
27R	Remanent undervoltage	Protection used to check that remanent voltage sustained by rotating machines has been cleared before allowing the busbar supplying the machines to be re-energized, to avoid electrical and mechanical transients.
27	Undervoltage	Protection of motors against voltage sags or detection of abnormally low network voltage to trigger automatic load shedding or source transfer. Works with phase-to-phase voltage.
59	Overvoltage	Detection of abnormally high network voltage or checking for sufficient voltage to enable source transfer. Works with phase-to-phase or phase-to-neutral voltage, each voltage being monitored separately.
59N	Neutral voltage displacement	Detection of insulation faults by measuring residual voltage in isolated neutral systems.
47	Negative sequence overvoltage	Protection against phase unbalance resulting from phase inversion, unbalanced supply or distant fault, detected by the measurement of negative sequence voltage.
Frequency Protection Functions		
81O	Overfrequency	Detection of abnormally high frequency compared to the rated frequency, to monitor power supply quality. Other organizations may use 81H instead of 81O.
81U	Underfrequency	Detection of abnormally low frequency compared to the rated frequency, to monitor power supply quality. The protection may be used for overall tripping or load shedding. Protection stability is ensured in the event of the loss of the main source and presence of remanent voltage by a restraint in the event of a continuous decrease of the frequency, which is activated by parameter setting. Other organizations may use 81L instead of 81U.
81R	Rate of change of frequency	Protection function used for fast disconnection of a generator or load shedding control. Based on the calculation of the frequency variation, it is insensitive to transient voltage disturbances and therefore more stable than a phase-shift protection function. **Disconnection** In installations with autonomous production means connected to a utility, the “rate of change of frequency” protection function is used to detect loss of the main system in view of opening the incoming circuit breaker to: • protect the generators from a reconnection without checking synchronization • avoid supplying loads outside the installation. **Load shedding** The “rate of change of frequency” protection function is used for load shedding in combination with the underfrequency protection to: • either accelerate shedding in the event of a large overload • or inhibit shedding following a sudden drop in frequency due to a problem that should not be solved by shedding.
Dynamic Line Rating (DLR) Protection Functions		

ANSI no.	Function	Description
49DLR	Dynamic line rating (DLR)	Protection of overhead lines based on calculation of rating or ampacity to dynamically take into account the effect of prevailing weather conditions as monitored by external sensors for: • Ambient Temperature • Wind Velocity • Wind Direction • Solar Radiation

Table 4 - ANSI descriptions

4 CONCATENATED TERMS

Term
Undercurrent
Overcurrent
Overfrequency
Underfrequency
Undervoltage
Overvoltage

Table 5 - Concatenated terms

5 UNITS FOR DIGITAL COMMUNICATIONS

Unit	Description
b	bit
B	Byte
kb	Kilobit(s)
kbps	Kilobits per second
kB	Kilobyte(s)
Mb	Megabit(s)
Mbps	Megabits per second
MB	Megabyte(s)
Gb	Gigabit(s)
Gbps	Gigabits per second
GB	Gigabyte(s)
Tb	Terabit(s)
Tbps	Terabits per second
TB	Terabyte(s)

Table 6 - Units for digital communications

6 AMERICAN VS BRITISH ENGLISH TERMINOLOGY

British English	American English
…ae…	…e…
…ence	…ense
…ise	…ize
…oe…	…e…
…ogue	…og
…our	…or
…ourite	…orite
…que	…ck
…re	…er
…yse	…yze
Aluminium	Aluminum
Centre	Center
Earth	Ground
Fibre	Fiber
Ground	Earth
Speciality	Specialty

Table 7 - American vs British English terminology

7 LOGIC SYMBOLS AND TERMS

Symbol	Description	Units
&	Logical "AND": Used in logic diagrams to show an AND-gate function.	
Σ	"Sigma": Used to indicate a summation, such as cumulative current interrupted.	
τ	"Tau": Used to indicate a time constant, often associated with thermal characteristics.	
ω	System angular frequency	rad
<	Less than: Used to indicate an "under" threshold, such as undercurrent (current dropout).	
>	Greater than: Used to indicate an "over" threshold, such as overcurrent (current overload)	
o	A small circle on the input or output of a logic gate: Indicates a NOT (invert) function.	
1	Logical "OR": Used in logic diagrams to show an OR-gate function.	
ABC	Clockwise phase rotation.	
ACB	Anti-Clockwise phase rotation.	
C	Capacitance	A
df/dt	Rate of Change of Frequency protection	Hz/s
df/dt>1	First stage of df/dt protection	Hz/s
F<	Underfrequency protection: Could be labeled 81-U in ANSI terminology.	Hz
F>	Overfrequency protection: Could be labeled 81-O in ANSI terminology.	Hz
F<1	First stage of under frequency protection: Could be labeled 81-U in ANSI terminology.	Hz
F>1	First stage of over frequency protection: Could be labeled 81-O in ANSI terminology.	Hz
f_{max}	Maximum required operating frequency	Hz
f_{min}	Minimum required operating frequency	Hz
f_n	Nominal operating frequency	Hz
I	Current	A
I∧	Current raised to a power: Such as when breaker statistics monitor the square of ruptured current squared (∧ power = 2).	An
I'f	Maximum internal secondary fault current (may also be expressed as a multiple of In)	A
I<	An undercurrent element: Responds to current dropout.	A
I>>	Current setting of short circuit element	In
I>	A phase overcurrent protection: Could be labeled 50/51 in ANSI terminology.	A
I>1	First stage of phase overcurrent protection: Could be labeled 51-1 in ANSI terminology.	A
I>2	Second stage of phase overcurrent protection: Could be labeled 51-2 in ANSI terminology.	A
I>3	Third stage of phase overcurrent protection: Could be labeled 51-3 in ANSI terminology.	A
I>4	Fourth stage of phase overcurrent protection: Could be labeled 51-4 in ANSI terminology.	A
I0	Earth fault current setting Zero sequence current: Equals one third of the measured neutral/residual current.	A
I1	Positive sequence current.	A
I2	Negative sequence current.	A
I2>	Negative sequence overcurrent protection (NPS element).	A
I2pol	Negative sequence polarizing current.	A
I2therm>	A negative sequence thermal element: Could be labeled 46T in ANSI terminology.	
IA	Phase A current: Might be phase L1, red phase.. or other, in customer terminology.	A
IB	Phase B current: Might be phase L2, yellow phase.. or other, in customer terminology.	A
IC	Phase C current: Might be phase L3, blue phase.. or other, in customer terminology.	A
Idiff	Current setting of biased differential element	A

Symbol	Description	Units
If	Maximum secondary through-fault current	A
If max	Maximum secondary fault current (same for all feeders)	A
If max int	Maximum secondary contribution from a feeder to an internal fault	A
If Z1	Maximum secondary phase fault current at Zone 1 reach point	A
Ife	Maximum secondary through fault earth current	A
IfeZ1	Maximum secondary earth fault current at Zone 1 reach point	A
Ifn	Maximum prospective secondary earth fault current or 31 x I> setting (whichever is lowest)	A
Ifp	Maximum prospective secondary phase fault current or 31 x I> setting (whichever is lowest)	A
I_m	Mutual current	A
IM64	InterMiCOM64.	
IMx	InterMiCOM64 bit (x=1 to 16)	
I_n	Current transformer nominal secondary current. The rated nominal current of the relay: Software selectable as 1 amp or 5 amp to match the line CT input.	A
IN	Neutral current, or residual current: This results from an internal summation of the three measured phase currents.	A
IN>	A neutral (residual) overcurrent element: Detects earth/ground faults.	A
IN>1	First stage of ground overcurrent protection: Could be labeled 51N-1 in ANSI terminology.	A
IN>2	Second stage of ground overcurrent protection: Could be labeled 51N-2 in ANSI terminology.	A
Inst	An element with “instantaneous” operation: i.e. having no deliberate time delay.	
I/O	Inputs and Outputs - used in connection with the number of optocoupled inputs and output contacts within the relay.	
I/P	Input	
Iref	Reference current of P63x calculated from the reference power and nominal voltage	A
IREF>	A Restricted Earth Fault overcurrent element: Detects earth (ground) faults. Could be labeled 64 in ANSI terminology.	A
IRm2	Second knee-point bias current threshold setting of P63x biased differential element	A
Is	Value of stabilizing current	A
IS1	Differential current pick-up setting of biased differential element	A
IS2	Bias current threshold setting of biased differential element	A
I_{SEF}>	Sensitive earth fault overcurrent element.	A
Isn	Rated secondary current (I secondary nominal)	A
Isp	Stage 2 and 3 setting	A
Ist	Motor start up current referred to CT secondary side	A
K	Dimensioning factor	
K_1	Lower bias slope setting of biased differential element	%
K_2	Higher bias slope setting of biased differential element	%
K_e	Dimensioning factor for earth fault	
km	Distance in kilometers	
K_{max}	Maximum dimensioning factor	
K_{rpa}	Dimensioning factor for reach point accuracy	
K_s	Dimensioning factor dependent upon through fault current	
K_{ssc}	Short circuit current coefficient or ALF	
K_t	Dimensioning factor dependent upon operating time	
kZm	The mutual compensation factor (mutual compensation of distance elements and fault locator for parallel line coupling effects).	

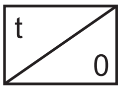
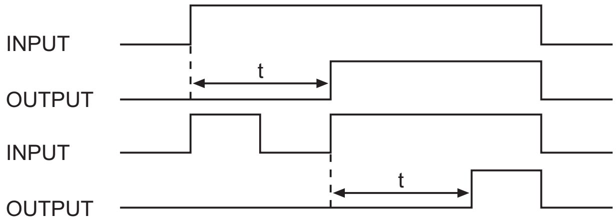
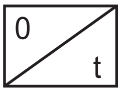
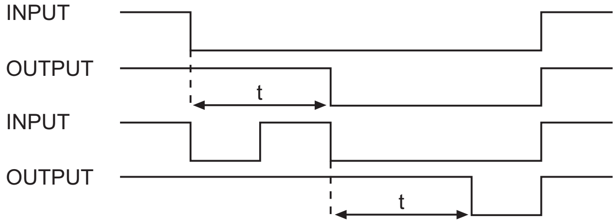
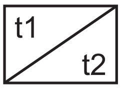
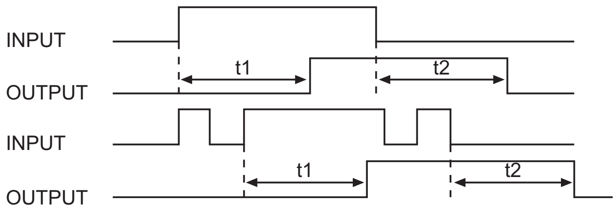
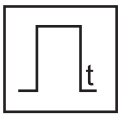
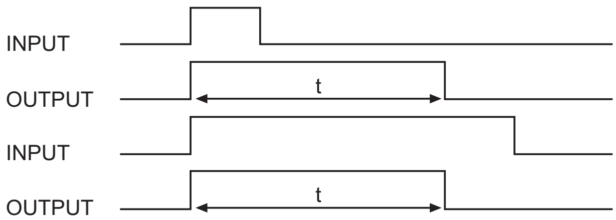
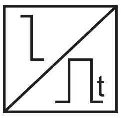
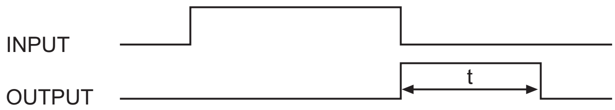
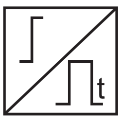
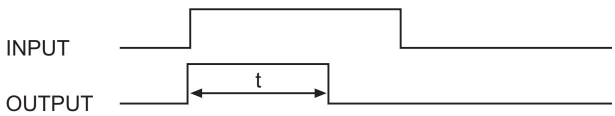
Symbol	Description	Units
kZN	The residual compensation factor: Ensuring correct reach for ground distance elements.	
L	Inductance	A
m1	Lower bias slope setting of P63x biased differential element	None
m2	Higher bias slope setting of P63x biased differential element	None
mi	Distance in miles.	
N	Indication of “Neutral” involvement in a fault: i.e. a ground (earth) fault.	
-P>	A reverse power (W) element: could be labeled 32R in ANSI terminology.	
P>	An overpower (W) element: could be labeled 32O in ANSI terminology.	
P<	A low forward power (W) element: could be labeled 32L in ANSI terminology.	
P1	Used in IEC terminology to identify the primary CT terminal polarity: Replace by a dot when using ANSI standards.	
P2	Used in IEC terminology to identify the primary CT terminal polarity: The non-dot terminal.	
P_n	Rotating plant rated single phase power	W
PN>	Wattmetric earth fault protection: Calculated using residual voltage and current quantities.	
Q<	A reactive under power (VAr) element	
R	Resistance (Ω)	Ω
R< or 64S R<	A 100% stator earth (ground) fault via low frequency injection under resistance element: could be labeled 64S in ANSI terminology.	
R Gnd.	A distance zone resistive reach setting: Used for ground (earth) faults.	
R Ph	A distance zone resistive reach setting used for Phase-Phase faults.	
Rct	Secondary winding resistance	Ω
Rl	Resistance of single lead from relay to current transformer	Ω
Rr	Resistance of any other protective relays sharing the current transformer	Ω
Rrn	Resistance of relay neutral current input	Ω
Rrp	Resistance of relay phase current input	Ω
Rs	Value of stabilizing resistor	Ω
Rx	Receive: typically used to indicate a communication receive line/pin.	
S<	An apparent under power (VA) element	
S1	Used in IEC terminology to identify the secondary CT terminal polarity: Replace by a dot when using ANSI standards.	
S2	Used in IEC terminology to identify the secondary CT terminal polarity: The non-dot terminal. Also used to signify negative sequence apparent power, S2 = V2 x I2.	
S2>	A negative sequence apparent power element, S2 = V2 x I2.	
t	A time delay.	
t’	Duration of first current flow during auto-reclose cycle	s
T1	Primary system time constant	s
TF	Through Fault monitoring	
tfr	Auto-reclose dead time	s
Thermal I>	A stator thermal overload element: could be labeled 49 in ANSI terminology.	
Thru/TF	Through Fault monitoring	
tIdiff	Current differential operating time	s
Ts	Secondary system time constant	s
Tx	Transmit: typically used to indicate a communication transmit line/pin.	
V	Voltage.	V
V<	An undervoltage element: could be labeled 27 in ANSI terminology	V

Symbol	Description	Units
V<1	First stage of undervoltage protection: Could be labeled 27-1 in ANSI terminology.	V
V<2	Second stage of undervoltage protection: Could be labeled 27-2 in ANSI terminology.	V
V>	An overvoltage element: could be labeled 59 in ANSI terminology	V
V>1	First stage of overvoltage protection: Could be labeled 59-1 in ANSI terminology.	V
V>2	Second stage of overvoltage protection: Could be labeled 59-2 in ANSI terminology.	V
V0	Zero sequence voltage: Equals one third of the measured neutral/residual voltage.	V
V1	Positive sequence voltage.	V
V2	Negative sequence voltage.	V
V2>	A negative phase sequence (NPS) overvoltage element: could be labeled 47 in ANSI terminology.	
$V2_{pol}$	Negative sequence polarizing voltage.	V
V_A	Phase A voltage: Might be phase L1, red phase.. or other, in customer terminology.	V
V_B	Phase B voltage: Might be phase L2, yellow phase.. or other, in customer terminology.	V
V_C	Phase C voltage: Might be phase L3, blue phase.. or other, in customer terminology.	V
Vf	Theoretical maximum voltage produced if CT saturation did not occur	V
Vin	Input voltage e.g. to an opto-input	V
V_k	Required CT knee-point voltage. IEC knee point voltage of a current transformer.	V
VN	Neutral voltage displacement, or residual voltage.	V
VN>	A residual (neutral) overvoltage element: could be labeled 59N in ANSI terminology.	V
V_n	Nominal voltage	V
Vn	The rated nominal voltage of the relay: To match the line VT input.	V
VN>1	First stage of residual (neutral) overvoltage protection.	V
VN>2	Second stage of residual (neutral) overvoltage protection.	V
VN3H>	A 100% stator earth (ground) fault 3rd harmonic residual (neutral) overvoltage element: could be labeled 59TN in ANSI terminology.	
VN3H<	A 100% stator earth (ground) fault 3rd harmonic residual (neutral) undervoltage element: could be labeled 27TN in ANSI terminology.	
Vres.	Neutral voltage displacement, or residual voltage.	V
Vs	Value of stabilizing voltage	V
V_x	An auxiliary supply voltage: Typically the substation battery voltage used to power the relay.	V
WI	Weak Infeed logic used in teleprotection schemes.	
X	Reactance	None
X/R	Primary system reactance/resistance ratio	None
Xe/Re	Primary system reactance/resistance ratio for earth loop	None
Xt	Transformer reactance (per unit)	p.u.
Y	Admittance	p.u.
Z	Impedance	p.u.
Z<	An under impedance element: could be labeled 21 in ANSI terminology.	
Z0	Zero sequence impedance.	
Z1	Positive sequence impedance.	
Z1	Zone 1 distance protection.	
Z1X	Reach-stepped Zone 1X, for zone extension schemes used with auto-reclosure.	
Z2	Negative sequence impedance.	
Z2	Zone 2 distance protection.	
ZP	Programmable distance zone that can be set forward or reverse looking.	

Symbol	Description	Units
Zs	Used to signify the source impedance behind the relay location.	
Φal	Accuracy limit flux	Wb
Ψr	Remanent flux	Wb
Ψs	Saturation flux	Wb

Table 8 - Logic Symbols and Terms

8 LOGIC TIMERS

Logic symbols	Explanation	Time chart
	Delay on pick-up timer, t	
	Delay on drop-off timer, t	
	Delay on pick-up/drop-off timer	
	Pulse timer	
	Pulse pick-up falling edge	
	Pulse pick-up raising edge	

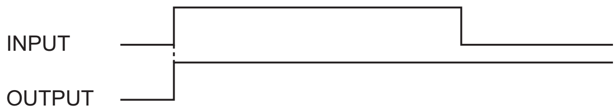
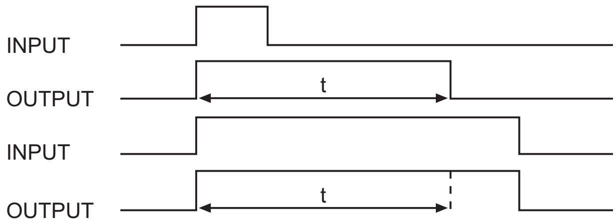
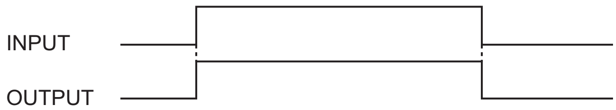
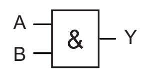
Logic symbols	Explanation	Time chart
Latching	Latch	
Dwell Timer	Dwell timer	
Straight	**Straight (non latching):** Hold value until input reset signal	

Table 9 - Logic Timers

9 LOGIC GATES

AND GATE

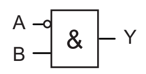
Symbol



Truth Table

IN		OUT
0	1	0
0	1	0
0	1	0
1	0	0
1	1	1

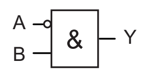
Symbol



Truth Table

IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	0
1	1	0

Symbol

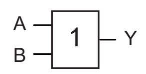


Truth Table

IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

OR GATE

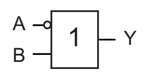
Symbol



Truth Table

IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

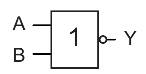
Symbol



Truth Table

IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	0
1	1	1

Symbol

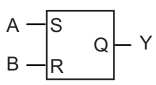


Truth Table

IN		OUT
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

R - S FLIP-FLOP

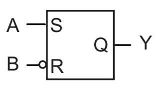
Symbol



Truth Table

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

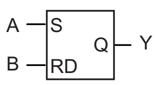
Symbol



Truth Table

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

Symbol



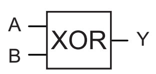
* RD = Reset Dominant

Truth Table

A	B	QN	QN+	Active Mode
0	0			Hold Mode
0	1			0
1	0	0	1	Set
		1		Hold Mode
1	1			0

EXCLUSIVE OR GATE

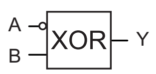
Symbol



Truth Table

IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

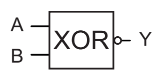
Symbol



Truth Table

IN		OUT
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

Symbol

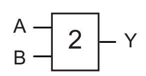


Truth Table

IN		OUT
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

MULTI INPUT GATE

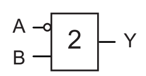
Symbol



Truth Table

IN		OUT
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

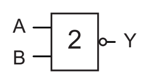
Symbol



Truth Table

IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	0
1	1	0

Symbol

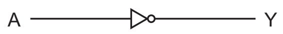


Truth Table

IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

NOT GATE

Symbol



Inverter (NOT)

Truth Table

IN	OUT
A	Y
0	1
1	0

Figure 1 - Logic Gates

Notes:

Customer Care Centre

http://www.schneider-electric.com/CCC

Schneider Electric

35 rue Joseph Monier
92506 Rueil-Malmaison
FRANCE

Phone: +33 (0) 1 41 29 70 00
Fax: +33 (0) 1 41 29 71 00

www.schneider-electric.com

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